S.E.A.W.E.E.D.S. 2026

INTERNATIONAL SYMPOSIUM ON SEAWEEDS

Value Chains, Climate Solutions, and Blue Economy Pathways

5 – 7 March, 2026

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BOOK OF ABSTRACTS

SEAWEEDS 2026

International Symposium on Seaweeds:
Value Chains, Climate Solutions and Blue Economy Pathways

5 – 7 March 2026 | Kochi, India

Book of Abstracts

Kerala University of Fisheries and Ocean Studies (KUFOS)
Kochi, India


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SEAWEEDS 2026

International Symposium on Seaweeds

Value Chains, Climate Solutions and Blue Economy Pathways

5th to 7th March, 2026
Kerala University of Fisheries and Ocean Studies (KUFOS)
Kochi, India

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ZERO HUNGER
CLIMATE ACTION
CLEAN WATER
SUSTAINABLE INDUSTRY
LIFE BELOW WATER
SEAWEEDS &
THE SUSTAINABLE DEVELOPMENT GOALS
GENDER EQUALITY
BIODIVERSITY
HEALTH & WELL-BEING
ECONOMIC GROWTH
SUSTAINABLE DEVELOPMENT GOALS

FOREWORD

Seaweeds have emerged as one of the most promising bioresources, offering solutions that span food security, climate resilience, sustainable aquaculture, coastal livelihoods, and circular bioeconomy innovations. Globally, macroalgae are increasingly recognised for their ecosystem services, including carbon sequestration and nutrient remediation, as well as habitat provisioning and shoreline stabilisation, while simultaneously supporting diverse industrial applications in food, nutraceuticals, pharmaceuticals, and biomaterials. Against this backdrop, "*SEAWEEDS 2026: International Symposium on Seaweeds – Value Chains, Climate Solutions and Blue Economy Pathways*" organised by Kerala University of Fisheries and Ocean Studies (KUFOS), Kochi, India, provides a timely international platform to bring together researchers, policy makers, entrepreneurs, and coastal communities to deliberate on the expanding frontiers of seaweed science and innovation.

The enthusiastic response to this symposium is reflected in the submission of 245 abstracts from 17 countries, underscoring the growing global interest in seaweed resources and their multifaceted applications. The contributions span a broad thematic spectrum, including biodiversity, distribution and ecology; genomics and selective breeding; climate change and conservation; cross-sectoral strategies; functional food and nutraceuticals; aquaculture; industrial applications and value-chain development; circular economy models; sustainable livelihoods; and macroalgal research. Together, these themes highlight the interdisciplinary and transdisciplinary nature of contemporary seaweed research and its relevance to sustainable ocean development.

This Book of Abstracts is more than a compilation of research summaries; it reflects the evolving knowledge landscape of seaweed resources. The studies presented herein collectively contribute to consolidating our knowledge base on seaweed diversity, distribution patterns, and ecological roles, while also advancing our understanding of their ecosystem services, particularly their potential contributions to climate resilience, blue carbon pathways, and nature-based solutions. Importantly, the abstracts also illuminate emerging trajectories in seaweed utilization and valorization, ranging from functional foods and nutraceuticals to bio-industrial applications and integrated multi-trophic aquaculture practices.

For India, where the Blue Economy has become a central pillar of national development strategies, the outcomes of SEAWEEDS 2026 are especially significant. With government initiatives promoting seaweed aquaculture, coastal entrepreneurship, and marine bioresource innovation, the insights emerging from this symposium can help shape a forward-looking roadmap for research, policy, and industry. The exchange of global experiences and local innovations documented in this volume is expected to support evidence-based planning, technology transfer, and capacity building, thereby strengthening India's position in the global seaweed sector.

KUFOS is privileged to host this international gathering and to present this Book of Abstracts as a knowledge resource for the scientific community and stakeholders. We hope that the ideas, collaborations, and innovations reflected in these pages will catalyze new partnerships, inspire young researchers, and contribute meaningfully to sustainable and inclusive seaweed development pathways.

On behalf of KUFOS, I extend my sincere appreciation to all authors and editors for their contributions, to our committed team organizing this event, and to our partners whose contributions have made SEAWEEDS 2026 a truly global and impactful event.

Dr. A. Biju Kumar
Vice Chancellor, Kerala University of Fisheries and Ocean Studies (KUFOS)

PREFACE

It is a profound honour to present the *Book of Abstracts* for the International Symposium SEAWEEDS 2026: Value Chains, Climate Solutions, and Blue Economy Pathways. As the Organizing Secretary, it has been a privilege to coordinate this global gathering hosted by the Kerala University of Fisheries and Ocean Studies (KUFOS), Kochi.

While the global potential of seaweed is vast, the success of this symposium lies in the specific, high-quality scientific contributions of our participants. This volume comprises 245 abstracts from 17 countries, covering 10 diverse thematic sessions, ranging from Algal Biodiversity and Genomics to Circular Economy models and Industrial Value Chains. These papers represent the "cutting edge" of seaweed research and provide a roadmap for sustainable development in the marine sector.

The journey of organizing an international symposium of this magnitude involves the collective effort of many hands. My heartfelt gratitude goes to our Hon'ble Vice-Chancellor and Chairman of SEAWEEDS 2026, for his visionary leadership and constant encouragement. I am also deeply indebted to the members of the Scientific and Technical Committees for their meticulous review of the submissions, and to the entire organizing team at KUFOS for their tireless dedication.

Finally, I wish to thank the authors and delegates. Your research is the foundation of this symposium. It is my hope that this *Book of Abstracts* will not only serve as a record of our proceedings, but also as a catalyst for future innovations, collaborations, and policy shifts in the seaweed sector.

I wish all the participants a scientifically rewarding and memorable experience at SEAWEEDS 2026.

Dr. Radhika Rajasree S.R.
Organizing Secretary, SEAWEEDS 2026
& Dean, Faculty of Ocean Science and Technology
KUFOS, Kochi, India

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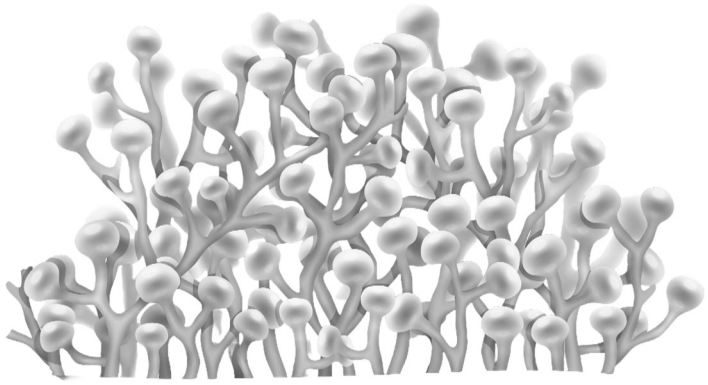

Keynote

KEY 01

THE STATE OF TROPICAL EUCHEUMATOID SEAWEED INDUSTRY: BIODIVERSITY, STRAIN SELECTION, AND CHALLENGES AND INITIATIVES TO SUSTAIN CROP PRODUCTIVITY

Michael Y. Roleda

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The global carrageenan industry is dependent on the commercial production of the red seaweeds collectively known as eucheumatoids. Different eucheumatoid species commercially traded as “cottonii” (e.g., *Kappaphycus alvarezii* and *K. straitus*) and “spinosum” (*Eucheuma denticulatum*), is primarily dependent on the vegetative propagation of at least 66 recognized cultivars but are of a few haplotypes that are >60 years old. The observed loss of vigour, decrease in productivity, and the increased susceptibility of these cultivars to pest and diseases, leading to crop failure are some of the putative consequences of the persistent clonal production of crops with limited genetic diversity. Biodiversity assessment in the Philippines identified newly recognized haplotypes providing a reservoir of unutilized wild genotypes for the development of new cultivars with superior traits. Biobanking and phenotyping of these strains are essential to sustain the carrageenan industry. These initiatives characterize detailed phenotypic traits such as growth, chemistry, and susceptibility to pest and diseases. Selected robust strains are then test planted in field nurseries for further continuous evaluation before they are introduced to seaweed farmers for large-scale commercial production. Active engagement of the academe with different stakeholders (e.g., farmers, traders, processors, local government units, NGOs, and government agencies) through trainings and workshops facilitates the revitalization of farming practices to achieve the target goals.

KEY 02

SEAWEEDS: THE WONDER HERBS OF THE OCEAN

Kajal Chakraborty

Director, ICAR–National Bureau of Fish Genetic Resources, Lucknow

Seaweeds are regarded as the wonder herbs of the ocean, serving as a rich and sustainable source of bioactives with substantial nutraceutical and therapeutic values. Traditionally consumed as staple foods in many Asian countries, seaweeds are considered essential to a healthy diet. Recently, there has been a growing consumer demand for natural bioactive compounds as alternatives to synthetic ingredients, positioning seaweeds as a valuable resource for new functional foods. Seaweeds, a major component of marine flora, produce diverse secondary metabolites that possess bioactivities, including antihypertensive, anti-inflammatory, and anticarcinogenic effects. Phlorotannins, sulfated polysaccharides, and polyphenols from seaweeds have shown promise in inhibiting cancer cell proliferation and exerting anti-inflammatory and anti-diabetic effects. These bioactive compounds can modulate glucose-induced oxidative stress and control the activity of starch-digestive enzymes. The growing concern over side effects from synthetic drugs has spurred interest in naturally sourced bioactive components for treating persistent metabolic syndromes. Bioactive constituents of seaweeds also demonstrate therapeutic potential for diseases such as hypertension, diabetes, and inflammation, and they are increasingly being explored for pharmaceutical applications. Research at the Indian Council of Agricultural Research has led to the development of bioactive molecules with applications in conditions like arthritis, dyslipidemia, non-alcoholic fatty liver disease, hypertension, etc. The growing utilization of seaweeds as bioactive sources, combined with their sustainable cultivation, offers both health benefits and economic opportunities for coastal communities. Despite their underexplored potential, seaweeds are rapidly becoming key resources for pharmaceutical and nutraceutical industries, offering a sustainable alternative to synthetic drugs.

Plenary/ Lead

PLN 01

LACTIC ACID FERMENTATION ENHANCES THE FUNCTIONAL METABOLOME AND ANTIBIOFILM POTENTIAL OF EDIBLE SCOTTISH SEAWEEDS

Roberth Riggs Rondilla[a], Inga Mikneviciute[b†‡] & RuAngelie Edrada-Ebel [*a]

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Fermented foods are increasingly in-demand for their health-promoting properties and extended shelf-life. Seaweeds, abundant in minerals, vitamins, and bioactive metabolites, represent an underexplored resource for functional food development. In this study, two edible Scottish brown seaweeds (*Alaria esculenta* and *Laminaria digitata*) were subjected to lactic acid fermentation. Microbiological and physicochemical analyses confirmed successful fermentation, marked by a pH reduction from 6.0 to 4.5, lactic acid accumulation with the dominance of lactic acid bacteria, while the incidence of foodborne pathogens remained undetected. Metabolomic profiling by 1H-NMR and LC-HRMS revealed specific chemical changes, including the production of oxygenated unsaturated lipids and loliolide, compounds potentially linked to stress and defense responses. Functional analysis highlighted enrichment of essential unsaturated fatty acid metabolism pathways, particularly in L. digitata. Biological assays demonstrated that fermented seaweed extracts inhibited biofilm formation of methicillin-resistant *Staphylococcus aureus* (MRSA), with enhanced effects observed for fermented *L. digitata*. Together, these findings demonstrate the feasibility of lactic acid fermentation to valorise edible seaweeds into safe,

PLN 02

BLUE CARBON BIOREFINERIES: INTEGRATING BIOTECHNOLOGY INTO MACROALGAL VALUE CHAINS FOR CLIMATE-RESILIENT CIRCULAR ECONOMIES

Pavan Jutur

Omics of Algae Group, Industrial Biotechnology International Centre for Genetic Engineering and Biotechnology (ICGEB), New Delhi, India

Macroalgae represent a cornerstone of the burgeoning Blue Economy, offering a non-terrestrial biomass solution that naturally aligns industrial growth with global carbon sequestration goals. This paper explores the transition from traditional, single-stream seaweed processing to a multi-product circular biorefinery framework, optimized through advanced biotechnology.

Central to this evolution is the deployment of tailored enzymatic cocktails, which facilitate the low-energy extraction of high-value compounds—such as hydrocolloids and omega-3 nutraceuticals—without compromising the integrity of the biomass. We further analyze the role of microbial bioconversion in closing the loop, transforming residual polysaccharides and proteins into sustainable biofuels and biofertilizers.

To unlock the full potential of these marine resources, we examine how molecular omics technologies (genomics through metabolomics) are being used to engineer specialized microbial strains and discover novel enzymes that increase yield and specificity. By adopting this cascading, integrated approach, the macroalgal sector can overcome current techno-economic barriers, transforming seaweed into a profitable driver of CO□ removal. Finally, we utilize Life Cycle Analysis (LCA) to validate the environmental viability of these pathways, ensuring that the shift toward a macroalgal-based economy remains a genuine solution for climate mitigation and resource efficiency.

PLN 03

SEAWEED DIVERSITY, CULTIVATION AND ITS UTILIZATION IN INDIA: A WAY FORWARD TO BLUE ECONOMY

V. Veeragurunathan*[ac], P. Gwen Grace [a], S. Gopala Krishnan [a], U. Gurumoorthy[ac], Sundaragnanam K[ac], Archana Baby [a], J. Vidhya Lakshmi [a] & Subasri Rajkiran [a]

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Seaweeds represent a potential bioresource with significant ecological, economic, and biotechnological relevance, positioning them as key resources to strengthen India's blue economy. Seaweeds are categorized according to their pigment composition as *Rhodophyta*, *Phaeophyta* and *Chlorophyta*. They are abundantly distributed along coastal regions owing to favorable environmental conditions. They are rich in diverse biochemical compounds which underpin their wide range of industrial applications and are increasingly recognized as valuable resources for promoting environmental sustainability, enhancing food security, and providing hydrocolloid for nutraceuticals and functional food applications. Cultivation practices encompass clonal vegetative propagation and non-clonal seedling-based systems implemented through floating raft, tube-net, off-bottom monoline, and long-line methods. Biotechnological advances embracing tissue culture, protoplast fusion, hybridization, mutagenesis, molecular characterization, and cryopreservation offer tools for genetic enhancement, disease resistance, and sustainable biomass production. Collectively, sustainable cultivation practices, value-chain diversification, biotechnology integration, and effective disease mitigation can strengthen seaweed aquaculture as a climate-resilient and economically viable component of India's blue economy framework.

PLN 04

INDIA'S ENDURING EFFORTS IN SEAWEED RESEARCH FOR SHAPING INDUSTRY: A STRATEGIC PERSPECTIVE

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"Seaweed" is a colloquial term commonly applied to macroscopic, multicellular, large marine algae that inhabit coastal as well as oceanic waters. Prof. MOP Iyengar was the first Indian algologist who initiated seaweed research in the country [Bull. Madras Govt. Mus. New Ser. Nat. Hist., 1927, 185]. The century following this has witnessed a plethora of research, development, demonstration and deployment in the domain of conventional and more recently applied phycology in India. The efforts of two visionary algologist Dr. Mrs. Francisca Thivy and Prof. V. Krishnamurthy, who were instrumental in establishing India's oldest Phycological Society named 'Seaweed Research and Utilization Association' need to be sincerely acknowledged. These enduring efforts were responsible for the establishment, advancement and progress of domestic seaweed-based industries. At the cusp of its strategic expansion of the seaweed sector in India, this talk is centred around enlisting and discussing the selective research in the last 100 years. The lecture provides a broad-brush stroke picture of information in the areas of seaweed biodiversity, understanding distribution and resource potential, seaweed landing pattern, industry processing and production, landmark discoveries, innovations related to applied phycology and biosecurity concerns. The commercial cultivation of *Kappaphycus alvarezii* in India has provided diversification of livelihood to the fisherfolk those are involved in seaweed gathering. The resilience of the commercial seaweed cultivation section to the COVID-19 pandemic is briefly discussed. Further, the talk delves into the regulatory, governance and policy support through various Government agencies with special reference to the National Institution for Transforming India (NITI Aayog), the apex public policy think tank of the Government of India and the Ministry of Fisheries, Animal Husbandry and Dairying of the Government of India. The role of the private sector in taking this initiative ahead is also discussed. With the strategic perspective, the Indian seaweed industry seems to be a successful example of achieving "triple bottom line" objectives of balanced economic, social and environmental outcome as proposed by the United Nations Department of Economic and Social Affairs (UNDESA) and World Bank (WB).

PLN 05

SEAWEEDS AS STRATEGIC RESOURCES FOR VALUE ADDITION, NUTRACEUTICAL DEVELOPMENT AND BLUE ECONOMY ADVANCEMENT IN INDIA

Suseela Mathew

ICAR- Central Institute of Fisheries Technology (CIFT), Kochi

Seaweeds are recognized as treasure house of bioactive compounds as they produce wide variety of biologically active compounds with different structural features and functional properties. The bioactive compounds of seaweeds include polyphenols, peptides, polysaccharides, dietary fibres, proteins, sterols, carotenoids and numerous other structurally unparalleled secondary metabolites such as monoterpenes, diterpenes, phlorotannins etc. Seaweeds are also rich in micronutrients. The bioactive compounds in seaweeds possess wide range of bioactivities such as antibacterial, antioxidant, anti-inflammatory, antiviral, anti-coagulant and antitumour properties. It has already reported that the regular consumption of marine seaweeds can prolong life expectancy and Japanese believe that their long life is due to the consumption of seaweeds and other marine foods. In India seaweeds are mainly utilized for hydrocolloid production. In the last one decade, there is a shift towards utilizing seaweeds as nutraceuticals in India; however, it has to go a long way. Development of nutraceuticals and value-added products from seaweeds is the need of the hour, for which a lot of effort has to be made by researchers, entrepreneurs and policy makers to utilize the huge untapped resources of seaweeds both cultured and wild in India. Development of nutraceutical products from seaweeds needs suitable technologies, infrastructure development and marketing strategies, with constant efforts from government and private sectors.

PLN 06

TROPICAL SEAWEED CULTIVATION PRACTICES AND THE URGENT NEEDS FOR NEW APPROACHES: THE SPECIAL CASE OF THE EUCHEUMATOIDS

Alan T. Critchley

Verschuren Centre, Sydney, Nova Scotia, Canada

This talk will examine the history behind the cultivation of a particular small sub-set of red seaweeds as biomass, grown at industrial scales, for the extraction of various types of carrageenans. These hydrocolloids have a wide range of applications, but mostly for their rheological properties in processed foods. Future uses need to go beyond rheology into their numerous, biological activities.

Members of the eucheumatoids, in particular *Eucheuma denticulatum* and *Kappaphycus* spp. became as successful as they are, because of the simple techniques required and the relative ease of cultivation, in tropical waters. Consequently, a very small genetic base of these red algae (and their associated micro- and macrobiota) is now cultivated in a circum-tropical belt.

Aspects of the success and failures of this industry will be presented and hopefully serve as precautionary examples for India. Even in a relatively short period, India has experienced severe phyconomic issues with failures of introduced *K. alvarezii* crops. With this, India joins several other case studies for the loss of farmed seaweed crops and the important income to farmers, as also recorded in the Philippines, and Indonesia. Are these phyconomic issues gene pool-related, climate change, pests, or diseases? In some case all, and the parallels to terrestrial agronomy are evident! New commercial entrants to these marine farming activities should perhaps be guided and adopt best practices - but please do not fall into the clearly signposted pitfalls.

Potentially, seaweed farming can be a tremendous economic benefit to economically challenged, coastal communities, but urgent future-proofing of the global eucheumatoid industry is required to provide resilience and ensure on-going, environmental and economic sustainability for future generations. When farming clonal seaweeds, many precautions are required. Seaweed farming cannot be expanded without a number of important issues being addressed otherwise its full potential may never be realised. It is hoped these issues are sufficiently outlined in this talk for future actions to bear fruit.

PLN 07

SEAWEED AQUACULTURE INNOVATIONS FOR CLIMATE CHANGE ADAPTATIONS

AQ Hurtado

ISDA Inc., Iloilo City

Innovation is the process of bringing about new ideas, methods, products, services, or solutions that have a significant positive impact and value. Seaweed farmers in Zamboanga City and Parang Sulu, Philippines combined their indigenous and science-based knowledge to innovate their phyconomic practices in response to climate change, which is the center of this presentation.

There are three innovative phyconomic practices presented here for climate change adaptation, namely: **(1)** Shift from repeatedly propagated to tissue-cultured seedlings as new, improved and climate-resilient progagules for field cultivation; **(2)** Use of seaweed extract biostimulants to improve crop growth, yield, sustainability while also promoting productivity and health (stress resilience); and **(3)** Adaption of eco-friendly and climate-resilient deep-water phyconomic technologies.

Cost and returns analysis and economic indicators of the two phyconomic techniques are likewise discussed here. The three above-mentioned innovative phyconomic practices show high potential for expansion and can be adapted to other farming areas with similar climatic conditions and topography.

LEAD 01

BLUE ECONOMY OF SEAWEEDS FROM INDIAN COAST – POTENTIAL AND PROSPECTS

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Seaweeds are cultivated and exploited commercially for their cell wall polysaccharides such as agar, algin, carrageenan etc and for manure, fodder and bioactive metabolites. Global production of seaweeds in sea (44% of all aquaculture) was estimated at about 35 million tons wet weight, registering annual growth rate of 8% and valued at 16 billion US$ is expected to hit 26 US$ by the end of this year, as projected by the FAO in 2020. The coastal and oceanic economy is popularly known as blue economy. Besides, shipping, marine fishery, tourism, seagrass meadows, exploration of minerals, oil and gas etc., seaweeds through its various ecosystem services constitute 6-7 % of blue economy (Phycoeconomy) without any negative impacts.

India is endowed with 8118 km coastline and bestowed with more than 2.6 lakhs tonnes wet harvestable biomass of seaweeds belonging to 896 species of marine algae belonging to 250 genera. More than 20,000 tonnes of these resources are harvested annually from the wild in India. It is estimated that India can produce one million tonnes of *Kappaphycus alvarezii* that can yield *k* carrageenan besides, providing employment to nearly 2 lakh fishers with an annual income of Rs.1 lakh per individual. The phycoeconomy that can be realized from seaweeds and seaweed based entrepreneurships other than the production of bioethanol, natural pigments, fodder and mineral supplements has been estimated to Rs.3600 annually.

I wish to reiterate that seaweed resources should be renewed periodically through large scale mariculture integrated with finfish and shellfish resources using the cost effective, climate friendly green technologies for enhancing our blue economy and to contain ocean acidification.

LEAD 02

BIOACTIVE SECONDARY METABOLITES FROM SEAWEEDS OF THE INDIAN COAST

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CSIR-Indian Institute of Chemical Technology, Hyderabad

Seaweeds along the Indian coastline are emerging as valuable marine resources rich in bioactive secondary metabolites. Exposed to complex ecological stressors, these macroalgae synthesize diverse compounds, including phenolics, diterpenoids, terpenoids, alkaloids, halogenated metabolites, and sulfated polysaccharides, that exhibit significant biological activities. Studies on green, brown, and red seaweeds from Indian coastal waters have revealed promising antimicrobial, antioxidant, anticancer, antiviral, and anti-inflammatory properties. Recent advances in bioassay-guided screening and analytical techniques have enhanced the discovery of novel metabolites with therapeutic relevance. Despite growing interest, systematic exploration of Indian seaweeds remains limited, highlighting a vast untapped potential for marine-based drug discovery. This abstract emphasizes the importance of Indian coastal seaweeds as sustainable sources of bioactive secondary metabolites and encourages integrated research approaches for their effective utilization in pharmaceutical and biotechnological applications.

LEAD 03

DEVELOPMENT OF SEAWEED BASED FOOD PRODUCTS

Vikas Singh Chauhan

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Food scarcity, global shortages, and drastic environmental changes significantly affect food production, highlighting the critical need for alternative food sources. Seaweeds are one of the important marine living resources that have the potential to be an important food/food ingredient. Seaweeds have garnered significant attention in recent years for their rich profile of bioactive compounds, such as polysaccharides, polyphenols, peptides, and lipids, high content of minerals, vitamins, dietary fibre, essential fatty acids, and amino acids.Though the bioactive potential of extracts and specific components of the seaweeds, e.g., sulfated polysaccharides, has been reported, the application of the whole seaweed biomass, especially from Indian water, as a food or for the development of seaweed based food products has remained largely unexplored. The complex cell wall architecture of the seaweed, polysaccharide-rich biomass, and the characteristic fishy/unpleasant odour of the biomass pose a major challenge in the food application of seaweed biomass. The improvement of the physico-chemical characteristics and sensorial properties can therefore help in promoting the food application of whole seaweed biomass. Recently at CSIR-CFTRI efforts have been made to improve the physico-chemical, nutritional, and sensorial profile of seaweed biomass and develop the seaweed-based food products. An overview of the work carried out at CSIR-CFTRI on development of the two seaweeds i.e., *Gracilaria* sp. and *Gayralia* sp., based food products will be presented.

LEAD 04

TECHNOLOGICAL AND POLICY INTERVENTIONS FOR SEAWEED SECTOR DEVELOPMENT IN INDIA - ICAR-CMFRI'S CONTRIBUTIONS

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Seaweed farming is a sustainable and climate-resilient form of aquaculture that provides an alternative livelihood for coastal communities. According to FAO (2024), global seaweed production reached 36.4 million tonnes (wet weight) in 2022. Eight primary species namely Japanese *Kelp, Eucheuma, Gracilaria, Wakame, Nori, Elkhorn, Sargassum*, and *Spiny Eucheuma* account for 94% of global yield. In India, approximately 67,231 tonnes (wet weight) of seaweed were harvested from natural beds in 2023, mainly comprising *Sargassum, Turbinaria, Gracilaria*, and *Gelidiella* (FRAEED, CMFRI, 2024).

The ICAR-Central Marine Fisheries Research Institute (ICAR-CMFRI) has been pioneering research on seaweed mariculture and utilization in India since 1972, with the Mandapam Regional Station playing a pivotal role in technology development and capacity building. Key achievements include the commercial-scale cultivation of *Gracilaria edulis* using raft and coir-rope net methods, prototype development for agar and alginic acid production, and contributions to small-scale agar industries in Tamil Nadu. The institute has significantly contributed to national policy documents, including those by NITI Aayog and NAAS, and published extensive resources such as taxonomic bulletins and Good Management Practices (GMP) guidelines. Advanced research initiatives include GIS-based identification of 333 potential farming sites covering 24,252 ha, estimation of harvestable biomass and genome sequencing of *Gracilaria edulis* and *G. salicornia.* The institute has developed innovative methods in seaweed farming such as HDPE raft-based tube-net farming and Integrated Multi-Trophic Aquaculture (IMTA) systems.

The ICAR-CMFRI has estimated the carbon sequestration potential of farmed seaweed, with approximately 19 kg of CO□ sequestered per tonne of dry *Kappaphycus alvarezii* per day, equivalent to about 760 kg CO□/day per hectare of cultivated seaweed. Furthermore, the anti-methanogenic properties of seaweeds were evaluated by ICAR-CMFRI in collaboration with ICAR-NIANP. The study revealed a substantial reduction of 31–42% in methane (CH□) production when *K. alvarezii* was included at 3–5% of the dry matter in livestock diets. Similarly, the incorporation of *Sargassum wightii* at 4–5% of dry matter resulted in a 36–48% decrease in CH□ emissions. ICAR-CMFRI has also developed over 12 nutraceutical products targeting lifestyle diseases and advanced micro-propagation techniques for commercially important species. With over 10,000 individuals trained in the past decade, the Mandapam Centre continues to foster socio-economic development through sustainable seaweed farming and value-chain enhancement while addressing ecological and climate-resilience objectives. Large-scale seaweed mariculture is an eco-friendly technology with the potential to substantially improve the livelihoods of coastal fishers, reduce greenhouse gas emissions, and counter ocean acidification. Promoting and supporting such initiatives will be crucial for developing a sustainable and resilient seaweed farming industry in India.

LEAD 05

DECIPHERING THE POTENTIAL OF SEAWEED-DERIVED POLYSACCHARIDES AGAINST INFLAMMATORY DISEASES: INSIGHTS FROM A TELEOST MODEL

Adnan H Gora

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Inflammatory diseases of the intestine are multifactorial disorders driven by multiple factors that include dysregulated immune responses, oxidative stress, and diet-induced impairment of the gut mucosal barrier integrity. Increasing evidence suggests that dietary bioactive compounds can modulate immune homeostasis and serve as complementary strategies to conventional anti-inflammatory therapies. Seaweed-derived polysaccharides, particularly alginate oligosaccharides and β-glucans, have emerged as promising candidates due to their prebiotic, antioxidant, and immunomodulatory properties. However, *in vivo* evidence elucidating their mechanisms of action remains limited.

The lecture focuses on diet-induced inflammation model in zebrafish (*Danio rerio*) to explore how seaweed-derived polysaccharides mitigate intestinal inflammatory responses in vertebrates. A soybean meal-induced enteritis model system was empoyed to mimic inflammatory conditions, and the modulatory effects of alginate oligosaccharides with varying molecular weight fractions and algal β-(1,3)-glucan were evaluated. Integrated transcriptomic, metabolomic, and histomorphological analyses revealed that dietary polysaccharides attenuate inflammation by modulating pro-inflammatory gene expression, regulating complement activation, and influencing oxidative stress pathway. Notably, alginate oligosaccharides enriched in low molecular weight fractions demonstrated superior efficacy in downregulating genes associated with leukocyte recruitment, matrix metalloproteinase activity, and humoral immune responses. Plasma metabolomic profiling further indicated partial restoration of inflammation-associated metabolites and modulation of the arginine biosynthesis pathways. Histological assessments confirmed improved intestinal architecture, including increased goblet cell abundance and villus length, highlighting the role of these seaweed-derived compounds in reinforcing the gut mucosal integrity. Collectively, multi-omics approaches in teleost models provide mechanistic insights into how seaweed-derived polysaccharides regulate immune responses and intestinal barrier function in vertebrates. These results underscore the relevance of marine bioactives as sustainable, diet-based interventions against inflammatory diseases and support their development as functional nutraceuticals targeting gut health in vertebrates.

LEAD 06

SEAWEED DIVERSITY OF INDIA WITH MAJOR EMPHASIS ON TAMIL NADU AND GUJARAT COAST

M.Ganesan

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Although India has more than 8000 km long coastline with 9 maritime states, Tamil Nadu and Gujarat coasts are hot spot for seaweed diversity. Moderate wave action, ideal substratum in intertidal and subtidal regions and nutrient rich seawater support luxuriant growth of seaweeds in these 2 maritime states. The presentation will highlight the nature of different coastal regions in these 2 states, list of economic seaweeds, endangered, threatened and endemic seaweed species and also seaweed species new to Indian coastline.

Along the Tamil Nadu coast, the seaweed diversity estimated in 25 stations along the main land coast and 14 island coasts of Gulf of Mannar, located in the southeast Indian coastline reveled a total number of 256 seaweed species. Out of these, 71 species belong to green algae (Chlorophyceae), 46 species to brown algae (Phaeophyceae) and 139 species to red algae (Rhodophyceae). Among the green algae, the genus *Caulerpa* represents maximum number of 18 species; genus *Codium* represents 7 species, genus *Halimeda* and genus *Ulva* represent 6 species each and the genus *Acrosiphonia, Anastomosans, Boergesenia, Dictyosphaeria, Neomreis, Microdictyon, Struvea, Valonia* and *Valoniopsis* are represented by a single species. In brown algae, the genus *Dictyota* represents 10 species and genus Sargassum represents maximum number of 9 species; *Padina* represens 5 species. Genus *Turbinaria, Dictyopteris* and *Chnoospora* represent 3 species each and the genus *Hormophysa, Hydroclathrus, Iyengaria, Rosenvingea and zonaria* represent single speices each. In red algae, the genus *Gracilaria* represents maximum number of 18 species while genus *Laurencia* represents 11 species. Other major genera in red algae are *Hypnea* (6 species) and *Grateloupia* (5 species). On the other hand, several genera viz., *Asparagopsis Bostrichia, Botryocladia, Chondrococcus, Chondrocanthus, Dasya, Dictyurus, Digenea, Enantiocladia, Griffithsia, Halichrysis, Helminthocladia, Neurymenia, Nitophyllum, Peyssonnelia, Tenaciphyllum, Wrangelia* are represented by single species only.

Assessment of seaweed biodiversity along the Gujarat coast resulted in total 198 species of seaweeds representing all three major groups of Chlorophyta, Phaeophyta and Rhodophyta Among these, 24 species are new reports from Gujarat and 3 (*Solieria chordalis*, *Ahnfeltia plicata* and *Dictyopteris serrata*) from Indian coast. The rhodophyta contained maximum number of species with 109 belonging to 62 genera, followed by chlorophyta with 54 species belonging to 23 genera and phaeophyta with 35 species belonging to 16 genera.

LEAD 07

BRIDGING KERALA AND SHIMANE THROUGH SCIENCE

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This presentation introduces the regional characteristics of Shimane Prefecture and Matsue City, Japan—a coastal area facing the Sea of Japan with a long-standing tradition of utilizing diverse marine resources. Among these is the unique winter-harvested seaweed Uppurui nori, one of the region's notable local specialties. The geographic and ecological features of the region provide a strong foundation for international collaboration in marine and environmental sciences. The partnership between Kerala and Shimane is grounded in the Memorandum of Understanding (MOU) established in 2015 between the Government of Kerala and the Association of Mayors in the San'in Region, represented by Matsue City. With the renewal of this agreement in 2025, academic collaboration has been formally incorporated as a central pillar of the partnership. This visit to the Kerala University of Fisheries and Ocean Studies (KUFOS) aims to strengthen institutional ties and identify concrete opportunities for joint research, educational exchange, and student mobility. In addition, I will introduce my current research at Shimane University in the fields of molecular recognition engineering and functional food science. This work focuses on cyclodextrin-based systems designed to enhance the stability and bioavailability of bioactive lipids. Although originating outside traditional marine science, this approach offers promising interdisciplinary strategies for the high-value utilization of marine bioresources. Through this session, I hope to promote meaningful dialogue and establish a sustainable framework for long-term scientific cooperation between Kerala and Shimane.

Session 1
Algal Biodiversity, Distribution and Ecology
BDE 01-21

BDE 01

SEAWEEDS AS BIOINDICATORS OF MICROPLASTIC POLLUTION ALONG THE ROCKY SHORES OF THE KERALA COAST, INDIA

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Seaweeds are among the most ecologically and economically important aquatic macrophytes, and their increasing utilisation for food, pharmaceuticals, and value-added products has raised growing concerns regarding food safety and environmental contamination. Despite this, information on microplastic (MP) accumulation in natural seaweed populations and the associated risks of human exposure remains limited in India. The present study evaluates the enrichment, characteristics, and polymer composition of microplastics in selected seaweeds from rocky shore ecosystems along the Kerala coast, India. Six commonly occurring seaweed species representing different algal groups were analysed for microplastics, including red algae (*Gracilaria corticata*, *Hypnea musciformis*), brown algae (*Chnoospora minima*, *Sargassum wighitii*), and green algae (*Ulva fasciata*, *Chaetomorpha antennina*). Concurrently, seawater samples from the same habitats were analysed to compare ambient MP abundance. Microplastics were detected in all seaweed species examined, with the highest concentration observed in *C. antennina* (29.03%) and the lowest in *G. corticata* and *S. wighitii* (9.7% each). Fibres constituted the dominant microplastic type (90.32%), followed by fragments (9.67%). Blue-coloured microplastics were most prevalent (48.39%), while yellow particles were least represented (12.9%). The size of microplastics ranged from 0.73 to 2.88 mm, and the dominant polymers identified were polypropylene (PP, 25.81 %) and polyethylene (HDPE, 32.26 % and LDPE (29.03 %). Seawater samples showed comparatively lower microplastic abundance than seaweed samples, highlighting the efficiency of seaweeds in trapping microplastics. The extent of microplastic entrapment appeared to be influenced by thallus morphology, particularly blade thickness, with thinner structures facilitating higher retention. These findings demonstrate the utility of seaweeds as effective bioindicators of microplastic pollution and emphasise the need for routine monitoring of edible seaweeds to support food safety and sustainable coastal management.

BDE 02

LONG-TERM REMOTE SENSING ASSESSMENT OF SEASONAL AND INTERANNUAL VARIABILITY IN SEAWATER FLORA USING SATELLITE-DERIVED BIO-OPTICAL INDICES

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This study presents a long-term remote sensing assessment of seasonal and interannual variability in seawater flora along a 45 km2 coastal stretch from Kunthukal Coast to Pullivasal Island, located near Rameswaram in Tamil Nadu, India. The analysis covers a decadal period from 2016 to 2025, corresponding to the operational availability of Sentinel-2 MultiSpectral Instrument (MSI) Level-2A surface reflectance data. The study employs satellite-derived bio- optical indices to monitor spatial and temporal changes in seawater flora, particularly phytoplankton dynamics in shallow coastal waters. Key indices derived from Sentinel-2 imagery include the Normalized Difference Chlorophyll Index (NDCI) as a proxy for chlorophyll concentration, the Normalized Difference Water Index (NDWI) for water delineation, and turbidity-related band ratios to assess suspended particulate matter. Seasonal variability was examined across the Southwest Monsoon, Northeast Monsoon, and summer periods, while interannual trends were evaluated using time-series statistical approaches, including the Mann–Kendall trend test and Sen's slope estimator. Results indicate pronounced seasonal fluctuations associated with monsoonal forcing, nutrient influx, and hydrodynamic processes, with elevated bio-optical signals during post-monsoon periods. Interannual analysis reveals moderate variability in chlorophyll proxies, suggesting sensitivity to climatic oscillations and localized anthropogenic influences. Spatial distribution patterns highlight nearshore enrichment zones and reef-influenced waters around Pullivasal Island. The study demonstrates the effectiveness of Sentinel-2 imagery for high-resolution (10 m) coastal ecosystem monitoring and provides a robust framework for long-term assessment of marine primary productivity in small-scale coastal environments. The findings contribute to improved understanding of coastal ecological dynamics and support sustainable marine resource management in the Gulf of Mannar region.

BDE 03

TRACE ELEMENT COMPOSITION AND HEAVY METAL CONTAMINATION IN SELECTED SEAWEED SPECIES FROM DIFFERENT GEOGRAPHIC ORIGINS

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Seaweeds are an important dietary source of essential trace elements; however, they may also accumulate toxic heavy metals depending on environmental conditions. This study aimed to evaluate the concentrations of trace elements (B, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Se, and Mo) and heavy metals (Pb, As, and Cd) in three seaweed species (*Asparagopsis taxiformis, Ulva spp.,* and *Ascophyllum nodosum*) collected from different countries and subjected to various processing methods. Samples were analysed using inductively coupled plasma mass spectrometry (ICP-MS). Preliminary results showed significant interspecific variation in trace element concentrations, with certain species exhibiting notably higher levels of Fe, Zn, and Se. Geographic origin had a marked influence on both trace element and heavy metal accumulation. While most samples contained trace elements at nutritionally relevant levels, heavy metal concentrations in some cases exceeded recommended safety limits, highlighting potential health risks. Overall, these findings provide valuable insight into the nutritional value and safety of seaweed and underscore the importance of careful species selection, sourcing, and monitoring for food and dietary supplement applications.

BDE 04

BLOOMBRAIN: A SPECIES-SPECIFIC STACKED ENSEMBLE FOR HIGH-PRECISION LIFE-STAGE CLASSIFICATION IN *Ulva prolifera*

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Recurrent *Ulva prolifera* green tides are triggered by an environmentally driven transition from vegetative growth to reproductive sporulation. Accurate detection of this phase shift is essential for effective early bloom warning. Conventional approaches struggle to distinguish reproductive signatures from generalised abiotic stress responses due to overlapping transcriptional signals. BloomBrain analyses multi-phase expression levels (Log Fold Change) to detect non-linear patterns, accurately separating gametogenesis signals from abiotic stress noise. BloomBrain was trained on 721 transcriptomic profiles derived exclusively from *U. prolifera* life-cycle stages. It integrated three complementary base learners: Random Forest, Gradient Boosting, and Support Vector Machines (SVM), which are aggregated via a logistic regression meta-classifier. To handle significant class imbalance (612 reproductive vs. 109 vegetative genes), class-weighted learning and stratified 10-fold cross-validation were applied, with performance evaluated using ROC-AUC and the Matthews Correlation Coefficient (MCC). The model's robustness was benchmarked against independent abiotic stress datasets to validate its ability to filter stress-induced transcriptional noise from true sporulation signals. BloomBrain demonstrated high predictive performance with an internal accuracy of 87.38% and a ROC-AUC score of 0.9202. Balanced accuracy reached 85.03% while vegetative-phase sensitivity (recall) was 81.65%, ensuring reliable detection of growth-stage markers. An MCC of 0.6039 confirmed stable performance under class imbalance. The benchmarking yielded 75% accuracy in isolating reproductive signatures from stress-induced noise. BloomBrain effectively filters environmental noise, enabling accurate detection of green tide triggers and supporting proactive marine management.

BDE 05

SPATIOTEMPORAL DYNAMICS OF SEAWEED DISTRIBUTION AND ITS BIOMASS IN PULICAT LAKE (2015–2025) USING MACHINE LEARNING TECHNIQUES – SENTINEL 2

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Seaweed is a key component of coastal ecosystems, contributing to marine productivity, carbon sequestration, and local livelihoods. Pulicat Lake, along the Chennai coast of Tamil Nadu, India, is one of the country's largest brackish-water lagoons and hosts diverse seaweed assemblages. Over the past decade, the region has experienced rapid coastal development, hydrological changes, climate variability, and anthropogenic pressures, making it a sensitive hotspot for ecological change. Continuous monitoring of seaweed distribution and biomass is essential for assessing ecosystem health, informing sustainable coastal management, and guiding conservation strategies. This study assesses spatiotemporal changes in seaweed extent and biomass in the Pulicat coastal region for 2015–2025 using an integrated GIS–remote sensing framework with machine learning. Multispectral Sentinel-2 imagery was used to derive seaweed-specific spectral indices and to classify the region with advanced image processing and machine learning techniques implemented in Google Colab. ArcGIS Pro supported spatial analyses, change detection, and map production. In-situ observations, including seaweed biomass measurements and GPS-referenced field samples, were used for calibration and accuracy assessment, enabling robust validation of satellite-derived results. Decadal change-detection analyses revealed significant variations in seaweed distribution and density, driven by environmental factors and human disturbances. The integration of cloud-based computing, high-resolution satellite data, and field observations demonstrates a scalable, cost-effective approach for long-term coastal vegetation monitoring. The findings provide insights into seaweed dynamics over the past decade and illustrate the value of geospatial technologies for marine ecosystem assessment, climate resilience planning, and sustainable coastal resource management.

BDE 06

DIVERSITY AND DISTRIBUTION OF MOLLUSCS ASSOCIATED WITH SEAWEEDS ALONG THE PALK BAY AND GULF OF MANNAR COASTS.

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Seaweeds offer important habitats for various marine organisms by providing substrata and shelter for colonization and as food for the generalist and specialist fauna. In order to find the nature of specific interactions of the population of molluscs with seaweeds, spatial and temporal variations were monitored at five different stations at the Palk Bay and the Gulf of Mannar during post-monsoon, southwest monsoon, and northeast monsoon between February 2023 and August 2024. The investigation revealed that the distribution of seaweed species varies across stations, as does that of mollusc species. The dominant seaweed species were monitored for variation in diversity and abundance of molluscs. There were about 35 species of seaweeds and 41 species of molluscs, specifically gastropods, encountered during the period of study. The abundance varied from 1 to 3740 individuals/1000g of seaweeds. The highest species richness was recorded at Keezhakarai. The species diversity and abundance were recorded during the post-monsoon season. The most dominant species associated with seaweeds was *Cerithium punctatum,* followed by *Cerithium zonatum*. But the brown seaweed *Padina tetrastromatica* sampled from Thonithurai harboured a maximum of 3740 individuals of *Cerithium zonatum* during the Post-monsoon season. Specific seaweed-mollusc associations, i.e., *Hypnea musciformis-Cerithium punctatum*, *Padina tetrastromatica - Cerithium zonatum*, *Padina pavonica-Anachis terpsichore*, *Lobophora variegata-Euplica scripta*, were notable. The study revealed the hitherto unexplored nature of spatial heterogeneity in seaweed-mollusc interaction along this coast.

BDE 07

SEASONAL INFLUENCE OF PHYSICO-CHEMICAL FACTORS ON COMMERCIALLY IMPORTANT MACRO ALGAL DIVERSITY AT SELECTED SITES OF GoMBR, TN, INDIA

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The aim of present investigation focused on survey of macroalgae diversity distribution in three stations Thonithurai (SST), Seeniappa Dharga (SSS) and Kilakarai(SSK) coast covering of Gulf of Mannar Biosphere reserve (GoMBR) coastal waters was carried out for the period of June 2023 – May-2024 including four seasons such as premonsoon, monsoon, post monsoon and summer seasons. The physiochemical parameters of waters such as atmospheric temperature, pH, salinity and conductivity were analysed. A total of 77 seaweed species belonging 44 genera were recorded together with Rhodophyceae, 20 genera (27 sps), followed by Phaeophyceae 13 genus (25 species) and Chlorophyceae 11 genera with 25 species. Maximum number of 58 species was recorded monsoon seasons and 46 species were found in premonsoon, while 33 species recorded in post monsoon seasons. The dominant species belongs to the genera *Sargassum, Caulerpa, Gracilaria corticata, Dictyota, Enteromorpha, Padina, Ulva, Halimeda* were recorded in the study area at particular extent. The distributions of seaweed diversity are highly rich in Kilakarai (SSK) rather than Thonithurai (SST) and Seeniappa Dharga (SSS). The physicochemical parameter of atmospheric temperature of 33.4^{o}C and 26.1^{o}C was recorded at maximum in summer and minimum in monsoon season, respectively. Surface seawater temperature exists ranged between 25.4 to 32.3^{o}C. The salinity varied from 27.5 ppt to 33.5 ppt on monsoon and post monsoon seasons, respectively. The seawater highest pH (8.42) of seawater was recorded at post monsoon and 7.9 is lowest amount of pH in monsoon season. The conductivity of seawater was exhibited maximum 51.5µS/cm in pre monsoon and minimum 42.6µS/cm in monsoon season. The study demonstrated the wide distribution of seaweeds based on their variation of physicochemical attributes and which provides the information about availability of commercial seaweeds to different stakeholders of seaweed beneficiaries.

BDE 08

INTEGRATIVE MORPHOLOGICAL AND MOLECULAR CHARACTERIZATION OF MARINE MACROALGAE ALONG THE SRI LANKAN COAST

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Accurate identification of marine macroalgae remains challenging due to cryptic diversity and environmentally driven morphological plasticity. Integrative taxonomy, combining morphological characters with molecular markers, provides a strong framework for resolving species boundaries and phylogenetic relationships. In this study, 18 macroalgal specimens collected from the coasts of Thalpe (Southern) and Beruwala (Western), Sri Lanka, were analyzed using morphological traits and chloroplast (*rbc*L and *tuf*A) and mitochondrial (*cox*1) markers. Seventeen specimens were identified to the species level, while one specimen was resolved only to the genus level. Phylogenetic analyses using Maximum Likelihood and Maximum Parsimony methods consistently recovered well-supported, species-level monophyletic clades across Rhodophyta, Chlorophyta, and Phaeophyta. The *tuf*A marker showed high discriminatory power within Chlorophyta, revealing cryptic diversity within morphologically similar taxa; specimens initially identified as *Ulva lactuca* and *Caulerpa taxifolia* were molecularly confirmed as *Ulva ohnoi* and *Caulerpa sertularioides*, respectively, based on strong phylogenetic clustering and clear interclade divergence. The *rbc*L marker effectively resolved Rhodophyta lineages, supporting the first molecular records of *Gracilaria khanjanapajiae*, *Grateloupia yinggehaiensis*, and *Chondracanthus saundersii* from Sri Lanka. In Pheophyta, *cox*1 provided reliable species-level resolution with *Sargassum aquifolium* and *Turbinaria ornata* forming strongly supported clades. Overall, these findings highlight the need for multiple-locus, molecular-assisted identification to improve taxonomic precision and overcome limitations of single-marker barcoding approaches. This study provides a robust taxonomic baseline that supports marine biodiversity documentation, conservation planning, and future ecological monitoring of coastal macroalgal resources in Sri Lanka.

BDE 09

DIVERSITY OF SEAWEEDS IN GULF OF KUTCH, GUJARAT, INDIA

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A systematic diversity survey was conducted for four consecutive years (2022 - 2025) in the Gulf of Kutch, Gujarat, India. Seaweed diversity, abundance, and frequency were documented during the month from August to April, and trends in species occurrence and frequency were compared. Diversity was assessed at eight different locations across the Gulf of Kutch. Similarity and evenness at all collection sites were evaluated using various diversity indices. During the survey, altogether 172 seaweed species were documented, among them Rhodophyceae group was found to be dominated. While Chlorophyceae and Pheophyceae were found to be dominating in *Sargassum* and *Cystosierra* were observed in most of the sites. Okha, Nanalayza, and Danipoint were identified as the most diverse coastal locations. Species such as *Asparagopsis, Lobophora, Porphyra,* and *Liagora* were documented recorded during the months of December and January.

BDE 10

TAXONOMIC ASSESSMENT OF INTERTIDAL SEAWEEDS FROM DAKSHINA KANNADA AND UDUPI COAST, INDIA

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Seaweeds are important components of coastal Biodiversity and plays a major role in ecosystem functioning and habitat formation. The present study documented seaweed diversity, distribution, seasonal variations, species abundance of intertidal coasts across Karnataka coast of Dakshina Kannada and Udupi districts. Standard methodology was used for collection, preparation and identification. Species identification was further confirmed using herbarium consultation facility provided at Botanical survey of India, Coimbatore under Experts guidance. Further, molecular approaches were used to identify selected taxa and determine new records. All collected samples were preserved in wet and dry form in 4% formalin and herbarium preservation respectively, using standard methodology. The study revealed total 68 seaweed species comprising 24 Chlorophyta, 25 Rhodophyta, and 19 Pheaophyta, including two additional seaweeds to Karnataka coast. In addition, we documented the symbiotic faunal associations of seaweeds. The findings of this study will contribute biodiversity conservation, ecological and future bioprospecting studies.

BDE 11

PHYTAL FAUNA AND PROTEIN COMPOSITION OF SELECTED SEAWEEDS FROM ANDROTT ISLAND, LAKSHADWEEP

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The present study examines the protein composition and faunal associations of selected seaweeds from the intertidal zone of Androth Island, Lakshadweep, India. Ten seaweed species representing three algal groups—Chlorophyceae, Rhodophyceae, and Phaeophyceae—were analysed for the protein content using standard biochemical estimation methods. Red algae showed comparatively higher protein levels, with *Acanthophora spicifera* recording the maximum value (28%). Among the green algae, *Bryopsis plumosa* exhibited the highest protein concentration (12%), followed by *Halimeda opuntia* (8%) and *H. macroloba* (7.5%). In contrast, brown algae such as *Padina gymnospora* (3%) and *P. pavonica* (2%) demonstrated the lowest protein content. Additionally, eleven morphologically distinct species were surveyed to assess associated faunal diversity. Ecological assessment revealed a diverse assemblage of associated fauna belonging to Coelenterata, Annelida, Arthropoda, and Mollusca, including sea anemones, polychaetes, amphipods, isopods, decapods, copepods, bivalves, and gastropods. The faunal density ranged from 77 to 900 individuals per 100 g of algal biomass, with *Caulerpa scalpelliformis* supporting the highest number of organisms and *Boergesenia forbesii* the least. Amphipods were the most dominant group, reflecting their adaptability to complex algal structures that offer enhanced shelter and feeding opportunities. The study highlights both ecological and nutritional importance of seaweeds from Androth Island.

BDE 12

EPIFAUNAL DIVERSITY ASSOCIATED WITH *Ulva lactuca* (LINNAEUS, 1753) IN THE INTERTIDAL ROCKY SHORES OF THIRUMULLAVARAM, KERALA

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Macroalgae are essential habitat-forming organisms on rocky coasts, increasing structural complexity and related biodiversity. *Ulva lactuca* is a commercially valuable green macroalga widely found along the intertidal shores of Kerala. The current study examines the epifaunal community associated with *U. lactuca* along the rocky intertidal zone of Thirumullavaram, Kollam (08°42' N; 76°34' E), on India's southwest coast. The area is characterised by laterite and granite rock formations, which are exposed to intense wave action, providing suitable substrates for lush algal growth. Sampling was carried out monthly from January to December 2022 during low tide using a 25 cm² quadrat in a random zig-zag pattern. Collected samples were cleaned, wet-weighed, and preserved in 4% formalin for taxonomic identification through standard morphological keys and online databases. The epifaunal assessment of *U. lactuca* identified 27 associated species, with amphipods consistently abundant. Gastropods and bivalves appeared only sporadically. Four species, *Littoraria undulata*, Nereis sp., *Ampithoe kergueleni*, and *Parhyale hawaienis*, were present throughout the year, emphasising their strong ecological relationship with *U. lactuca*. Species richness peaked in April (21 species) and was lowest in July (7 species), reflecting seasonal variations. Diversity indices (Shannon H: 1.213–2.379; Simpson 1–D: 0.656–0.901) indicated a moderately diverse and stable epifaunal community. This research highlights the ecological importance of *U. lactuca* as a vital habitat supporting diverse epifauna in Thirumullavaram. It underscores the necessity for ongoing monitoring and conservation of intertidal macroalgal ecosystems.

BDE 13

EPIFAUNAL DIVERSITY ASSOCIATED WITH *Ulva lactuca* (LINNAEUS, 1753) IN THE INTERTIDAL ROCKY SHORES OF VARKALA, KERALA

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Rocky intertidal ecosystems are strongly influenced by macroalgae, which function as ecosystem engineers by modifying habitat structure and promoting associated biodiversity. *Ulva lactuca* is a green macroalga belonging to the phylum Chlorophyta, and it exhibits considerable morphological plasticity and can occur in attached, sessile, or free-floating forms. The current study examines the epifaunal community associated with *U. lactuca* along the rocky intertidal zone of Varkala, Thiruvananthapuram, on India's southwest coast. Sampling was carried out monthly from January to December 2022 during low tide using a 25 cm² quadrat in a random zig-zag pattern. Collected samples were cleaned, wet-weighed, and preserved in 4% formalin for taxonomic identification through standard morphological keys and online databases. The epifaunal assessment of *U. lactuca* identified 6 associated species *(Littoraria undulata*, *Eunice antennata*, *Dynamella tuberculata*, *Perna viridis*, *Ampithoe kergueleni*, and *Parhyale hawaienis)* with amphipods consistently abundant. Three epifaunal species - Eunice *antennata*, *Ampithoe kergueleni*, and *Parhyale hawaiensis* - were recorded consistently throughout the study period, indicating a strong and persistent ecological association with *Ulva lactuca*. The calculated diversity indices (Shannon–Wiener index, H′ = 1.595; Simpson's diversity index, 1–D = 0.7392) reflect a moderately diverse and relatively stable epifaunal community associated with the macroalgal habitat. The findings of the present study emphasize the ecological significance of *U. lactuca* as a key habitat-forming species that supports a diverse assemblage of epifaunal organisms in the rocky intertidal zone of Varkala.

BDE 14

POTENTIAL AREAS MAPPING OF *Enteromorpha* sp. IN ESTUARIES OF KARNATAKA

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Seaweed has vast utilization benefits, in terms of food, cosmetics, fertilizers, and extraction of industrial gums and chemicals. Moreover, in integrated multi-trophic aquaculture (IMTA), seaweed can be utilized as an inorganic extractive species. *Enteromorpha sp*. are green macroalga from Ulvaceae family known for its tubular structure and ability to thrive in various marine, estuarine and brackish environments. It is rich in marine minerals, bioactive compounds, its rapid growing character is a key futuristic for Business incubation and coastal entrepreneurship. 3 species of Genus *Enteromorpha* reported in Mangrove area of Karnataka namely *Enteromorpha clathrata (Roth) J.Ag., Enteromorpha compress (Linnaeus) Nees, and Enteromorpha intestinalis (Linnaeus) Nees.* With an aim of study Mangroves ecosystem in Karnataka and its associates, along with seaweed species are documented and listed. Potential area is calculated with the help of open source QGIS. The entire coastal Karnataka, comprising three districts, namely Uttara Kannada, Udupi Districts and Dakshina Kannada will be covered. Nethravathi, Kali, Sharavati, Agnashini, Gurupur, Udyavar, Shambhavi, Pavanje, Sita-Swarna, Haladi, Chakra, Kollur and Baidur rivers adjoining the Arabian sea creating the estuaries across the coastal region will be part of the study area. The study results reviled that District wise available *Enteromorpha* potential area is 2330.5, 467.8 and 490.64 hectares in Uttara Kannada, Udupi and Dakshina Kannada District respectively.

BDE 15

POST-MONSOON SCENARIO OF SEAWEED ECOSYSTEM IN THE ROCKY SHORE OF THIKKODI, SOUTHWEST COAST OF INDIA

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Seaweeds are ecologically and economically important plants of marine ecosystem. They are the primary producers and provide shelter, nursery grounds and food sources for marine organisms. Seaweeds are abundant in intertidal zones, especially in the rocky coasts and extend to depths of 30 to 40m. The greatest varieties of red seaweeds are found in tropical waters, while brown seaweeds are more common in cooler, temperate waters. Rocky coasts are found in southern and northern parts of Kerala and are characterised by the presence of granite and laterite rocks. Laterite rocks support abundant growth of seaweeds. The coast of Thikkodi (Lat. 11°29'42''N & 75°32'15''E), south-west coast of India provides a very good habitat for seaweeds, especially during post monsoon. Present study was conducted during November 2025 and observed that green alga, *Caulerpa peltata* formed the dominant species. Other green seaweeds include *C. sertularioides*, *C. taxifolia, Ulva lactuca*, etc. Most dominant red algae are *Gracilaria corticata* and *Amphiroa* sp. Other red algae include *Gelidium* sp. and *Gracilaria verrucosa*. *Padina major*, *P. gymnospora*, *Dictyota dichotoma* and *Sargassum whitii* are the brown algae present in sub-tidal zones of the rocky coast of Thikkodi. *Caulerpa* sps. are showing decaying stage in some parts. Red and brown algae are growing abundantly. It is also observed that this seaweed ecosystem provides habitat for many invertebrates such as gastropods, amphipods and brittle stars and also contributing carbon to the aquatic ecosystem.

BDE 16

GEOGRAPHICAL RANGE EXPANSION OF *Temnopleurus toreumaticus* (LESKE, 1778) (ECHINODERMATA) IN THE MACRO ALGAL ECOSYSTEM OF NORTH MALABAR, SOUTH WEST COAST OF INDIA

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Seaweed or macro-algal ecosystem provides habitat for many invertebrates and vertebrates. Sea urchins are one of the major grazers in seaweed ecosystems, feeding especially on fleshy green seaweeds. This study examines the geographical expansion of the black sea urchin, *Temnopleurus toreumaticus* in the macro-algal ecosystem of Thikkodi rocky coast, south west coast of India. It is found in the Indo-West Pacific region, characterized by its dark, often reddish-brown banded spines and distinctively sculpted, pitted plates. It belongs to the Phylum: Echinodermata, Class: Echinoidea Order: Camarodonta, Family: Temnopleuridae, Genus: *Temnopleurus* and Species: *Temnopleurus toreumaticus*. This species was recorded from Andhra Pradesh, Odisha, West Bengal and Andaman Islands, Gujarat, Maharashtra, Goa and Karnataka. There are no previous reports of T*. toreumaticus* from the sea, along Kerala region. A recent study reported the occurrence of this species from the upper regions of estuarine waters of north Kerala. This geographical expansion is attributed to the changing environmental conditions and adaptations to specific biological factors. The dominant green algae in the rocky coast of Thikkodi are the mixed beds of *Caulerpa peltata, C. taxifolia* and *C. sertularioides*. Sea urchins are often considered as the enemy of seaweeds. If left unchecked, sea urchins can destroy entire green algal resources of the study area, creating barren areas with low, unproductive algae that support fewer species. Geographic range expansion is a species-level trait with important evolutionary consequences. It is concluded that a broad geographic range buffers species against extinction caused by local disturbance events.

BDE 17

EXPLORING SEAWEED DIVERSITY ALONG THE KANYAKUMARI COAST: A REVIEW TOWARDS SUSTAINABLE UTILIZATION

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The Kanyakumari coast situated at the confluence of the Arabian Sea, the Bay of Bengal, and the Indian Ocean, represents a critical biodiversity hotspot for marine macroalgae. This review synthesizes recent research to document the taxonomic diversity and abundance of seaweeds in this unique ecological niche. Published information indicate the presence of over 100 species belonging to Rhodophyta (Red Algae-53 species), Chlorophyta (Green Algae-32 species), and Ochrophyta (Brown Algae-21 species), with red algae consistently exhibiting the highest species richness. Another detailed taxon list for two stations in Kanyakumari also confirm the high red-algal richness at local scales. Dominant genera such as *Caulerpa*, *Chaetomorpha*, *Gracilaria*, *Sargassum, Ulva* and *Padina* inhabit intertidal and subtidal zones. These taxa along with the recently discovered native species, *Hypnea indica* underscore the region's vast biological potential. Published studies indicate considerable scope for the sustainable utilisation of seaweed resources along the Kanyakumari coast, supported by the natural abundance of agar-, alginate- and carrageenan-yielding taxa. Experimental and regional assessments highlight their potential for applications in nutraceuticals, biofertilizers, and pharmaceutical bioactives. The coastline also exhibits favourable conditions for site-specific mariculture, with scope for monoline and raft-based cultivation of selected commercial species, offering livelihood diversification for coastal communities. While large-scale farming remains limited, existing evidence supports Kanyakumari's suitability as a resource and cultivation zone within a broader southern Tamil Nadu seaweed value chain. However, anthropogenic pressures and fluctuating salinity levels present significant conservation challenges. An integrated management framework, combining community-led cultivation with biotechnological innovation, is essential for preserving Kanyakumari's seaweed germplasm.

BDE 18

INCIDENTAL BIOMASS OF SEA LETTUCE (*Ulva lactuca*) IN SHORE SEINE FISHERIES: UTILIZATION OPPORTUNITIES VERSUS HABITAT CONCERNS

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The present study documents the regular incidental occurrence of the green macroalga *Ulva lactuca,* commonly known as sea lettuce in the traditional shore seine (Karamadi) fisheries along the coastal villages of Kanniyakumari district, Tamil Nadu. Field survey conducted revealed that *U. lactuca* is the only seaweed species consistently encountered in the nets with an average of 1.5 kg (wet weight) per fishing operation. With two to five shore seine operations were conducted daily in a single village, which represents the considerable landing of this species in the study region. Due to limited awareness regarding its economic value, the biomass is discarded at landing sites on a regular basis. Globally, *Ulva lactuca* is known to be rich in proteins, dietary fiber, essential minerals, vitamins, and bioactive compounds, and is widely utilized as food, feed, biofertilizer, and functional ingredient in several international markets. However, no seaweed harvesting or cultivation practices currently exist in the study area, resulting in complete underutilization of this resource. The study highlights the potential to convert this incidental biomass into a value-added resource through awareness creation, capacity building, and promotion of small-scale seaweed farming by engaging local women and men as alternative livelihood options. Integrating traditional shore seine fisheries with community-based seaweed utilization and cultivation could reduce wastage, enhance income diversification, and support sustainable coastal resource management in Kanyakumari district. On the other hand, the recurrent removal of *U. lactuca* through shore seine operations may alter natural resource availability which underscoring the need to balance utilization with habitat conservation

BDE 19

COMPETITIVE EXCLUSION OF SEAWEEDS BY THE INVASION AND PROLIFERATION OF COLONIAL ZOANTHID, *Palythoa mutuki* (CNIDARIA: ANTHOZOA: ZOANTHARIA: SPHENOPIDAE)

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As the global sea surface water temperature increases, some zooxanthellate species have extended their habitat ranges. *Palythoa mutuki,* commonly known as g*reen button polyps.* is one such example of a range-extending animal. Massive colonies of this zoantharian were found in the sub-tidal rocky coast of Thikkodi (75°32'15"E), southwest coast of India, which harbours wide variety of seaweeds. Since, a zoantharian-dominated ecosystem could indicate an unhealthy status, the documentation of its occurrence is crucial for subsequent studies. These colonies are bright, button-like appearance and reported from Indo-Pacific region and are known for the highly toxic substancepalytoxin. It belongs to the Phylum: Cnidaria, Subphylum: Anthozoa, Class: Hexacorallia, Order: Zoantharia, Family: Sphenopidae, Genus: *Palythoa* and Species *P. mutuki. The* study area is dominated by the green algae, *Caulerpa peltata, C. sertularioides*, *C. taxifolia, Ulva lactuca*, etc. The deeper regions are dominated by red algae such as *Gracilaria corticata* and *Amphiroa* sp., *Gelidium* sp. and *Gracilaria verrucosa*. *Padina major*, *P. gymnospora*, *Dictyota dichotoma* and *Sargassum whitii* are the brown algae present in sub-tidal zones. *P. mutuki* is present in the upper region of the rocky reef, where, *Caulera* spp. are abundantly growing. Highly proliferating and encrusting zoanthid polyps covers the rocky habitat, resulting in the competition for space and excluding the seaweeds from the habitat. Since the seaweed ecosystem provides habitat for many invertebrates and contributing carbon to the aquatic ecosystem, any changes in the community structure of seaweeds consequently affecting the entire system, creating a disturbance in ecosystem dynamics.

BDE 20

BALANCING NATIVE AND INTRODUCED SEAWEED SPECIES FOR ECOSYSTEM STABILITY AND SUSTAINABLE BLUE GROWTH

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Seaweed farming is gaining recognition in India as a promising component of the blue economy, offering sustainable livelihood opportunities for coastal communities. At present, organized cultivation is largely dominated by the monocultures of the exotic carrageenophyte, *Kappaphycus alvarezii* due to its rapid growth, established farming techniques, and strong industrial demand. However, reliance on a single introduced species raises resource- management concerns, including ecological homogenization, genetic erosion of native flora, and vulnerability of coastal ecosystems to biological invasion and disease outbreaks. To address this, farming of native seaweed tax may be considered. India harbours over 800 recorded macroalgal taxa, *Gracilaria edulis*, *Gelidiella acerosa*, *Sargassum* spp., and *Turbinaria* spp., which remain underutilized despite their commercial value and ecological importance. Indigenous carrageenophytes such as *Hypnea musciformis*, *Acanthophora spicifera, Sarconema filiforme* offer environmentally compatible alternatives for *Kappaphycus alvarezii.* Being naturally adapted to local hydrographic regimes, these native species are ideal for habitat complexity, nutrient sequestration, and the stability of coastal trophic food webs. Diversification of cultivated species will also favour ecological homogenization and economic vulnerability. Priority actions include, promoting climate-resilient native strains through selective breeding and region-specific cultivation protocols, establishing national germplasm repositories and genetic banks to conserve intraspecific diversity, standardizing farming technologies and post-harvest value chains. Transitioning from single-species dominance toward diversified utilization of native macroalgal resources will strengthen ecosystem services, enhance climate resilience, and ensure long-term sustainability of India's coastal bioresources.

BDE 21

SEAWEED ASSOCIATED FAUNA OF LAKSHADWEEP ARCHIPELAGO

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The present study explored the ecological importance of macroalgae and their associated faunal communities within the coral atoll ecosystem of Kavaratti Island, Lakshadweep. The results highlight the essential role of seaweeds as key habitat-forming components in coral reef systems. A total of fifteen seaweed species were recorded, reflecting the rich macroalgal diversity of the region. The associated fauna comprised of Amphipoda, Anomura, Brachyura, Gastropoda, Nudibranchia, Polychaeta, Sipuncula, and Tanaidacea, with the assemblage strongly dominated by Amphipoda (73%), followed by Brachyura and Sipuncula (7% each), Polychaeta (6%), Gastropoda (5%), Nudibranchia (4%), and Anomura and Tanaidacea (1% each). The findings further demonstrate that the structural complexity of macroalgal thalli strongly influences faunal diversity and composition: species with intricate morphologies supported higher richness and evenness, while simpler algal forms tended to host more specialized assemblages, such as the exclusive association of amphipods with *Colpomenia sinuosa*. These macroalgal–faunal relationships, primarily commensal or mutualistic in nature, are nevertheless highly sensitive to environmental stressors. Climate change through rising sea surface temperatures, ocean acidification, and intensified storm events poses significant risks to both algal biomass and the integrity of dependent faunal communities. Protecting macroalgal habitats and their ecological linkages is therefore critical for effective marine spatial planning and biodiversity conservation in vulnerable regions like the Lakshadweep Archipelago. The study underscores the need for sustained ecological monitoring and adaptive management strategies to safeguard these ecosystems under changing climatic conditions.

Session 2
Genomics and Selective Breeding
GSB 01-06

GSB 01

TRANSCRITPOME-BASED SIGNATURES OF BLEACHING STRESS IN THE GREEN MACROALGA *Ulva conglobata*

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Bleaching constitutes a severe physiological derailment in marine macroalgae, yet its transcriptional architecture remains largely unresolved. We performed the comparative RNA-Seq analysis of *Ulva conglobata* thallus collected from the Western Indian coastline under 2 conditions - phenotypically normal (UCN) and bleached (UCB). *De novo* transcriptome reconstruction uncovered pronounced structural perturbations associated with bleaching, with UCB assemblies displaying extensive transcript fragmentation, diminished contiguity, and a conspicuous depletion of long, high-confidence transcripts relative to UCN. Using a rigorously curated co-assembled reference transcriptome, annotation was computed using ENTAP against the NCBI NR and UniProt–SwissProt databases. Further, Differential Expression (DE) analysis identified 10,887 significant DEGs ($|log2FC| \geq 2$; $p \leq 0.05$), revealing a pronounced transcriptional bias toward activation under bleaching stress (7,373 up-regulated versus 3,514 down-regulated transcripts). Gene Ontology enrichment analyses showed that bleaching triggers a coordinated up-regulation of proteostasis and bioenergetic functions, including ribosome biogenesis, protein folding, ubiquitin-mediated turnover, and ATP-dependent metabolic processes. In contrast, pathways normally sustained in healthy thalli—antioxidant defence, nitrogen assimilation, genome maintenance, membrane transport, and cell wall biogenesis—were among the most strongly suppressed in bleached specimens, particularly glutathione-based detoxification and amino acid biosynthesis. Together, these patterns indicate that bleaching in *U. conglobata* reflects a systemic transcriptional reprogramming in which short-term stress mitigation is prioritized over metabolic balance and cellular integrity. The combined insights and datasets generated here offer a foundational molecular framework for macroalgal bleaching and establish a valuable transcriptomic resource to support future functional, ecological, and climate-resilience studies in coastal primary producers.

GSB 02

NEURASEA: A PROTEOMIC FRAMEWORK FOR ASSESSING THERMAL RESILIENCE IN RHODOPHYTE AQUACULTURE

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Thermal stress increasingly threatens rhodophyte aquaculture, causing major losses in growth and productivity. Cultivar selection remains largely empirical, failing to predict physiological tolerance. NeuraSea is a machine learning framework that utilizes coding DNA Sequences (CDS) to output a calibrated Thermal Resilience Score (TRS) for robust cultivar selection. The model was trained on a paired dataset of 476 rhodophyte CDS and corresponding protein sequences (337 extremophiles and 139 mesophiles), using a 38-feature biophysical vector that includes 20 amino acid frequencies, five physicochemical properties (e.g., isoelectric point and aliphatic index), and codon optimization metrics (GC/GC3). The model combines Random Forest and XGBoost in a calibrated ensemble and was evaluated using 5-fold cross-validation. NeuraSea operates in two modes: Mode 1 enables single-sequence prediction, while Mode 2 supports high-throughput comparative screening. Performance was further validated using an independent dataset of mesophilic and extremophilic species. The framework achieved a mean ROC-AUC of 0.826 and an average precision of 0.924. At the optimized operating threshold (0.614), the model showed balanced discrimination, with a sensitivity of 0.783, specificity of 0.770, and a Matthews correlation coefficient of 0.519. SHAP analysis identified isoelectric Point (pI) shifts, aspartic Acid (freq_D) salt bridges, and GC3 enrichment as the primary molecular drivers of heat tolerance. Mode 1 identified key local markers and predicted a high TRS (97.7%) for *Porphyridium*, while Mode 2 enabled comparative stratification, clearly distinguishing susceptible *Polyopes* (22.6% TRS) from resilient *Kappaphycus* (94.8% TRS). These results position NeuraSea as a scalable framework for advancing climate-resilient rhodophyte selection.

GSB 03

ISOLATION AND GENOMIC CHARACTERIZATION OF AN ALGINATE LYASE- PRODUCING *Ralstonia pickettii* NCMN-AL3 ASSOCIATED WITH MARINE MACROALGA *Sargassum swartzii*

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Alginate lyases are important biocatalysts used to depolymerize alginate, a major structural polysaccharide in brown algal cell walls with wide industrial relevance. In this work, a marine alginate lyase-producing bacterium was isolated from the brown alga *Sargassum swartzii* collected at Beyt Dwarka, Gujarat, India. Algal thalli and leaves were rinsed with phosphate-buffered saline and enriched in a medium containing alginate as the sole carbon source at 37°C for 48 hours. Following serial dilutions and plating on alginate agar, twenty pure bacterial isolates were obtained. Initial screening using Gram's iodine flooding allowed visualization of zones of alginate degradation, and a subsequent screening step measured enzyme activity by the dinitrosalicylic acid assay. The isolate exhibiting the highest alginate lyase activity was selected for whole-genome sequencing on the Oxford Nanopore MinION platform, with de novo assembly performed using FLYE and downstream genome analysis carried out via BV-BRC. Phylogenetic analysis identified this strain as *Ralstonia pickettii* NCMN-AL3, closely related to *Ralstonia pickettii* strain CW2 329.17. The draft genome is 5.28 Mb, organized into three contigs with a GC content of 63.67%, and encodes 5,149 protein-coding sequences, 59 tRNA genes, and 9 rRNA genes. Genome mining further revealed an alginate lyase gene, algL (EC 4.2.2.3), located on contig_1 and encoding a 321- amino acid protein. This study expands marine-derived microbial resources bearing alginate lyases for prospective applications in food, pharmaceutical, and biofuel sectors.

GSB 04

METABO-TRANSCRIPTOMIC INSIGHTS INTO THE THERAPEUTIC POTENTIAL OF THE BROWN SEAWEED *Padina boergesenii* FROM THE GUJARAT COASTLINE

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Padina boergesenii, a brown seaweed belonging to the Dictyotaceae family, holds important medicinal value owing to its pharmaceutically active bioactive compounds. Secondary metabolites produced by seaweeds have substantial importance in the pharmaceutical and herbal medicine industries. The biosynthesis of active metabolites in *P. boergesenii* are regulated and controlled by genes, but their specific roles are still not fully understood. To elucidate in detail, chemical and transcriptome analyses were conducted to identify the biosynthesis pathways and related candidate genes of the active ingredients. The chemical analysis revealed that the main components such as terpenoids and alkaloids, which displayed potential ability to treat hypertension through molecular docking. Moreover, the de novo transcriptome sequencing assembly annotated a total of 15,808 unigenes. A total of 1386 CDS were associated with 11 categories of metabolic pathways. Further, in the category of secondary metabolite biosynthesis, terpenoid backbone biosynthesis accounted for the largest proportion (19.17%) of CDS, followed by ubiquinone and other terpenoid-quinone biosynthesis (10.95%), tropane, piperidine and pyridine alkaloid biosynthesis (8.21%), and isoquinoline alkaloid biosynthesis (6.24%). Current research is helpful to explore the biosynthetic pathway of bioactive components and their regulation mechanism to further explore the antihypertensive effect of *P. boergesenii*.

GSB 05

HOLOBIONT SIGNATURES OF SALINITY STRESS IN THE COASTAL BROWN SEAWEED *Sargassum swartzii*

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Sargassum swartzii, an indigenous brown seaweed abundant along the Gujarat coastline and collected from Beyt Dwarka, was investigated to understand holobiont-mediated responses to salinity stress. Seaweed samples were subjected to controlled *in-vitro* salinity gradients (25, 35 and 45 ppt) for 6 days, and the associated microbiome was profiled through shotgun metagenome sequencing on the Illumina NovaSeq platform. *De novo* assembly was performed using CLC Genomics Workbench v25.1, followed by functional screening of carbohydrate-active enzymes (CAZy) and microbial taxonomic elucidation using BLAST against 16S rRNA gene reference database. Treatment-wise CAZy profiling revealed distinct shifts in functional enzyme families. GT2, a major glycosyltransferase group abundant in control holobionts (mean ≈ 7.38), showed a marked reduction under salinity stress (mean ≈ 2.84), indicating suppressed cell-wall biosynthetic activity. Conversely, GT4 displayed strong stress-associated elevation (mean ≈ 7.25 vs 4.45 in controls), suggesting compensatory carbohydrate remodeling. GH23 and CBM50 families associated with chitin and peptidoglycan turnover showed moderate but consistent adjustments across treatments, reflecting flexible restructuring of microbial carbohydrate-processing pathways under salinity challenge. Taxonomic analysis identified dominant microbial associates including *Herpetosiphon gulosus*, *Anaerostipes faecalis*, *Pyrinomonas methylaliphatogenes*, *Absiella tortuosum*, *Sulfobacillus harzensis*, *Granulicatella elegans*, and halotolerant taxa such as *Pyrobaculum ferrireducens*, *Desulfofundulus kuznetsovii*, *Halococcus hamelinensis*, and *Tepiditoga spiralis*. These organisms, together with CAZy-functional reprogramming, highlight a coordinated holobiont response contributing to salinity resilience. This study provides one of the first integrated holobiont-level molecular frameworks for *S. swartzii* under salinity stress and generates valuable genomic and functional resources for future seaweed resilience research.

GSB 06

EVALUATION OF METHODOLOGIES FOR OPTIMIZING THE ISOLATION OF HIGH QUALITY INTACT RNA FROM BROWN SEAWEED

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Sargassum wightii, a dominant brown seaweed distributed along the Indian coastline, is an ecologically and economically important species, yet molecular studies in this alga are limited due to difficulties in obtaining intact RNA. Isolation of high-quality RNA from marine macro algae is challenging due to the presence of complex polysaccharides, polyphenols, pigments, and secondary metabolites that interfere with nucleic acid extraction and downstream molecular analyses. In the present study, a robust and reproducible RNA isolation protocol from *S. wightii* tissues was optimized to obtain high-quality RNA suitable for transcriptome sequencing. Fresh and healthy thalli were thoroughly washed to remove epiphytes and salts, followed by rapid freezing in liquid nitrogen to preserve RNA integrity. Total RNA was extracted using both traditional and Kit based methods. A Modified CTAB method followed by $LiCl_2$ precipitation for RNA extraction was compared with two kit-based methods (RNeasy Power Soil Total RNA kit from QIAGEN and Primodia Nucleosieve plant RNA Extraction kit). Primodia Nucleosieve plant RNA kit gave good RNA integrity number (RIN) and concentration compared to the other two methods. The extracted RNA exhibited optimal A260/280 ratios ranging from 1.8 to 2.0 and the RIN value ranging from 5 to 8.6. The results using kit showed distinct, intact ribosomal RNA bands indicating good purity and less degradation. The RNA yield fulfilled the requirement for cDNA library preparation and high-throughput transcriptome sequencing. This optimized RNA isolation protocol enables reliable transcriptomic sequencing and analysis of *Sargassum wightii, thus* providing a valuable methodological foundation for gene expression profiling and functional genomics studies in brown macroalgae.

Session 3
Climate Change and Conservation
CCC 01 – 08

CCC 01

CARBONIC ANHYDRASE-MEDIATED CO2 SEQUESTRATION IN SEAWEED AND ASSOCIATED BACTERIA

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Industrialisation, the extensive use of fossil fuels, and other anthropogenic activities have led to a rise in CO_2 concentration in the atmosphere. This has led to global warming and ocean acidification, posing a significant threat to life on Earth. To mitigate this, an economically and environmentally friendly method is carbon sequestration and storage mediated by the Carbonic Anhydrase (CA) enzyme. CA is a key physiological enzyme in biological systems, catalysing the reversible conversion of CO2 to bicarbonate, and is found in bacteria, fungi, plants, including micro- and macroalgae, and animals, both vertebrates and invertebrates. This study examines the abundance of CA in seaweeds and their associated bacterial communities. CA enzyme was successfully isolated and purified from selected seaweed species collected from the coastal waters of the Goa region. The enzyme purity and concentration were assessed spectrophotometrically. In parallel, bacteria associated with these seaweed species were isolated, cultured, and processed to extract CA, and the enzyme yield was similarly quantified. Preliminary observations indicate the presence of measurable CA activity in both seaweed tissues and their associated microbial communities. The combined CA-mediated pathways highlight the seaweed and associated microbial systems as nature-based solutions for mitigating elevated CO2 levels in industrial applications.

CCC 02

SEAWEED-DERIVED GREEN HYDROGEN FOR ANTARCTIC AND ARCTIC MICROGRIDS: PATHWAYS, CHALLENGES, AND IMPLICATIONS

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Cold and polar regions face unique energy challenges due to extreme climates, logistical constraints, and reliance on imported fossil fuels which exacerbate environmental fragility and operational costs. This study investigates the potential for sustainable green hydrogen production, offering a pathway to energy transition in the Arctic and Antarctic. We assess the feasibility of an integrated system from seaweed cultivation to biomass harvesting and conversion technologies, including dark fermentation, thermochemical gasification, and microbial electrolysis cells. Environmental advantages including carbon neutrality, rapid growth, high carbohydrate content, nutrient bio-sequestration, and minimal land-use requirements—are systematically assessed against technical barriers, including year-round cultivation limitations, energy-intensive processing requirements, and infrastructure constraints. The strategic potential of seaweed-derived hydrogen is examined for diverse polar applications: research station operations, energy supply for remote coastal communities, and logistics support for scientific and commercial activities. Critical analysis of policy frameworks, international governance structures (Antarctic Treaty System, Arctic Council), and ethical considerations for sustainable marine resource extraction in sensitive polar ecosystems is provided. Findings indicate that despite significant technological hurdles and regulatory complexities, seaweed-based hydrogen production represents a promising pathway toward energy autonomy in polar regions, offering synergies between climate change mitigation objectives and responsible utilisation of marine biological resources. Further research priorities and implementation strategies are identified, aligning climate action with the principles of the circular blue bioeconomy.

CCC 03

CARBON AND NITROGEN ACCUMULATION BY *Chaetomorpha* THROUGH VEGETATIVE PHYSIOLOGY AND SPORE SETTLEMENT: AN ECOLOGICAL IMPLICATION

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Carbon cycling in the coastal ecosystem is strongly influenced by autotrophic organisms that function as carbon sinks under varying nutrient conditions. Nitrogen limitation is also a key factor in determining the growth and development of seaweeds. The present study evaluates the carbon accumulation efficiency of *Chaetomorpha* under varied ammonia and nitrate conditions. 15, 60, and 100 µM of nitrate and ammonia. The amount of CO_2 available in water and the total carbon content were estimated subsequently. Field-collected samples were acclimatized under laboratory condition was cultured for vegetative physiological analysis and spore settlement of provided substrate. Spore settlement experiments were conducted to examine the reproductive propagation and surface colonization to assess the density-dependent effects under nitrogen-driven carbon accumulation. The estimation of carbon content in the water suggested that increased ammonia is highly susceptible to more carbon reduction in water compared to an elevated nitrate concentration of 100 µM. Spore settlement assessments indicated that increased nitrogen concentrations dominate the settlement especially in 60 µM nitrate. The combined carbon accumulation with reproductive success highlights the functional importance of *Chaetomorpha* in manipulating the carbon dynamics, and nutrients highly controlled the physiology and spore settlement. Findings from this study suggests that studied green seaweed may serve as ecologically relevant component in carbon buffering and sustainable management of eutrophic aquatic ecosystems.

CCC 04

FRAMEWORKS FOR QUANTIFYING AND MONITORING CARBON SEQUESTRATION IN SEAWEED AQUACULTURE FOR CARBON MARKETS

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Seaweed culture is often promoted as a "blue carbon" solution, but most claims today focus solely on biomass growth (for example, cultivation of *Kappaphycus alvarezii* has been reported to sequester about 643.80 tonnes of CO□ per hectare per year) and do not account for long-term carbon storage or support genuine carbon crediting. This paper proposes a practical methodology for measuring and monitoring carbon sequestration in a seaweed farming system that is compatible with emerging carbon market requirements. The framework outlines clear boundaries and eligibility conditions covering the farm, sediments, and product chain. It also provides an easy way to convert seaweed growth and its use into the actual amount of CO□ removed, while transparently handling fate fractions, uncertainty, and non-permanence. The proposed framework includes the following: (i) field measurements of biomass yield and carbon content, (ii) surveys of farmer practices and product destinations, and (iii) monitoring of sediment and end-use to estimate the portion of seaweed carbon that remains stored long-term and the portion that is released quickly. From these components, step-by-step equations are provided to calculate net removals that are suitable for use in voluntary carbon market methods. The expected result is a farmer-friendly, science-based MRV template that can be tested in Indian seaweed farms. This template can also serve as a foundation for future blue carbon standards, potentially helping to generate new sources of climate finance while preventing over-crediting and greenwashing.

CCC 05

BLEACHING THRESHOLD AND PROGRESSION IN *Kappaphycus alvarezii* EXPOSED TO ACIDIC AND ALKALINE PH EXTREMES

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Seaweed aquaculture is gaining global importance as a sustainable source of hydrocolloids, functional foods, feed ingredients and bioeconomy products. In India, commercial cultivation is expanding along the Tamil Nadu and Gujarat coasts, driven by increasing demand for value-added seaweed biomass and livelihood opportunities for coastal communities. However, productivity remains constrained by recurrent crop health issues, among which bleaching-like discoloration and frond deterioration are increasingly reported by farmers. Bleaching is typically associated with environmental stress, yet field-relevant evidence on pH-driven bleaching onset and threshold levels remains limited for cultured seaweeds. Coastal farming waters can experience abrupt pH shifts due to eutrophication-linked alkalinity changes, discharge mixing, and localized acidification episodes, potentially disrupting pigment stability, photosynthetic efficiency, and thallus integrity. This study aims to determine bleaching onset time, severity progression, and threshold pH conditions in *Kappaphycus alvarezii* through a 15-day controlled exposure trial. Healthy, uniform thalli will be maintained under standardized culture conditions with duplicate replicates per treatment. Experimental pH treatments will include acidic stress (pH 4.0, 5.0, 5.5), normal seawater control (pH 8.5) and alkaline stress (pH 9.0, 9.5, 10.0). Bleaching response will be assessed daily using a semi-quantitative bleaching severity index supported by consistent photo documentation, along with monitoring of key water quality parameters. The study is expected to identify minimum pH thresholds triggering visible bleaching and estimates time-to-bleach under acid and alkaline stress regimes. The findings will support farm-level risk assessment, early-warning monitoring and future development of mitigation guidelines for resilient seaweed cultivation in India.

CCC 06

TRADITIONAL ECOLOGICAL KNOWLEDGE AND CLIMATE RESILIENCE: INDIGENOUS WEATHER FORECASTING IN THE SEAWEED FARMING COMMUNITIES OF SIBUTU, TAWI-TAWI, PHILIPPINES

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Traditional weather forecasting remains a vital adaptive strategy for coastal communities whose livelihoods are tied to environmental stability. This study examines the role of Traditional Ecological Knowledge (TEK) in the seaweed farming industry of Sibutu, Tawi-Tawi, Philippines. Using a mixed-methods approach, 100 farmers, primarily experienced Muslim males (93% with more than 7 years in the field) were surveyed to analyse indigenous meteorological practices. Results reveal a significant shift in knowledge: while 93% are veteran farmers, only 42% remain proficient in traditional forecasting, with many now relying on PAGASA (49%) and television (46%). Despite the rise of modern technology, traditional practitioners utilize a sophisticated multi-modal system of indicators. Key predictors include astronomical bodies (34%), such as lunar halos signalling typhoons; animal behaviour (22%), like bird flocking; and plant phenology (20%), such as the blooming of *Chromolaena odorata*. Marine signals, including the abundance of *Ulva* sp. and *Enhalus acoroides*, are also used to track seasonal wind transitions. These indicators are critical for managing ice-ice disease, which 96% of farmers attribute to adverse weather. Findings show that traditional cues trigger vital operational decisions, including early harvesting (82%) and adjusting cultivation depth. Because the Southwest Monsoon and Easterly winds are identified as the most destructive periods, the study concludes that integrating TEK with scientific modelling is essential. Formally codifying these indigenous indicators into community-based early warning systems will ensure climate adaptation strategies are technically sound and culturally grounded for the Sibutu community.

CCC 07

REVIEW ON THE ROLE OF SEAWEED ECOSYSTEMS IN CLIMATE CHANGE MITIGATION AND ADAPTATION

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Seaweeds are emerging as powerful nature-based solutions for addressing climate change while supporting sustainable livelihoods and coastal economies. Seaweeds assist in preserving blue carbon by capturing atmospheric CO through rapid biomass production and by allowing easier for carbon to be retained in marine sediments and deep-sea systems for a long time. This helps to mitigate global warming. This study emphasizes the significance of seaweed ecosystems in climate change mitigation, coastal adaptation, and economic value generation. Seaweed farms and natural beds enhance the climate's resilience by slowing down coastal erosion and purifying water quality by absorbing pollutants like heavy metals and dyes into their cell walls and taking up additional nutrients like nitrogen and phosphorus. They also assist marine biodiversity by making food webs more stable, protecting against climate and environmental stress, and increasing the diversity of microbes. Seaweed-based value chains provide substantial economic prospects, encompassing livelihood improvement for coastal communities and the production of low-carbon food, biofertilizers, and bioproducts. The addition of seaweed farming to blue carbon accounting systems and national climate initiatives may assist India in keeping its support under the Global Biodiversity Framework and the Blue Economy Policy. The study highlights seaweeds as dual-benefit climate solutions that integrate mitigation and adaptation with inclusive economic growth. Sustained investments, enabling governance frameworks, and scientific monitoring are essential to scale seaweed-based climate interventions. By promoting seaweeds as blue carbon assets, India can become a worldwide innovator in finding sustainable solutions for the marine climate while also improving coastal resilience and livelihoods.

CCC 08

SEAWEED-CORAL INTERACTION: A STUDY WITH REFERENCE TO GULF OF KUTCH, GUJARAT, INDIA

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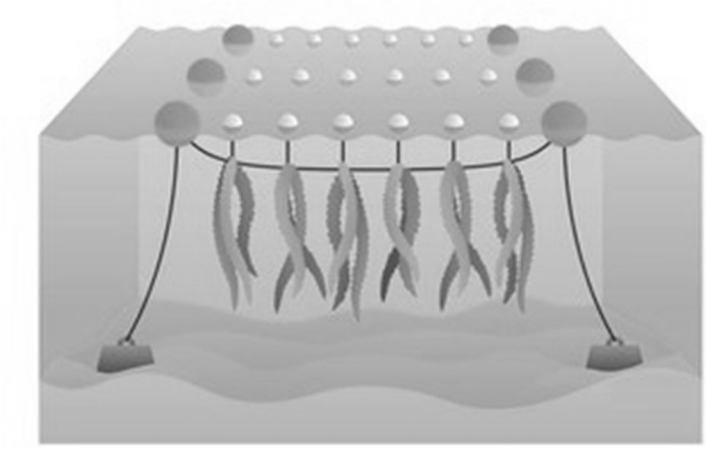
Generally, tropical reefs are considered to be declining due to presence of seaweed, which commonly replaces corals. Many studies show a negative association between seaweeds and corals. A study assessing the frequency, abundance, and diversity of corals and seaweeds was conducted dynamically at three different coral diversity hotspots in the Gulf of Kutch, namely Okha, Poshitra, and Narara. Seaweed abundance was observed to be 5–11 fold higher at Okha and Narara. However, coral cover was found to be higher as compared to seaweed density at Poshitra. Species belonging to the Phaeophyceae group were found to be dominant at all three survey sites. Seaweeds were also observed to dynamically suppress coral cover in several patches across all three study sites. Seaweed genera such as *Sargassum*, *Iyengaria*, *Polysiphonia*, *Ulva*, *Cystoseira*, *Uniotia*, and *Caulerpa* were dominant. While, Coral genera, including *Acropora*, *Pocillopora*, *Porites*, *Favites*, and *Montipora* were dominant at Narara and Poshitra.



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ASS 01

EMPLOYMENT POTENTIAL OF FISHERWOMEN IN POST HARVESTING OPERATIONS OF SEAWEED IN INDIA

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Seaweed cultivation in India is rapidly transitioning from small scale to a strategic pillar of Blue Economy backed by government investment and scientific research. In India the Gulf of Mannar, Gulf of Kutch, Calh Bay, Hanshadweep and Bay Island are the important areas of seaweed culture. The areas stretch along the 6100km long coastline of the country. India is home to over 700 species of seaweed, with an annual natural harvestable biomass of 0.26 million tonnes. Through coastal surveys and remote sensing, the institute (CMFRI) has mapped 24,252 hectares of potential seaweed farming zones across 333 locations within 1 km of the low-tide line. These areas are estimated to have an annual production potential of 10 million tonnes per year. The studies revealed that women have a prominent role in most activities in seaweed harvesting, nearly 5000 women are estimated to depend on seaweed related activities in India. play multi-faceted roles including productive, reproductive and community responsibilities but their contribution often go unrecognized or remain largely invisible. They dominate activities like cleaning, sun drying, sorting, grading, processing into value added product and marketing. Since the domain of seaweed collecting industry mainly dominated by women, special efforts should be taken for its optimum exploitation and market expansion through diversified product development and their popularization. Today seaweed cultivation techniques have been standardized, improved and made economically viable. Corporate backed by institutional and financial support led to the expansion of seaweed farming, through self-help groups (SHG) model.

ASS 02

COEXISTENCE STRATEGIES FOR OFFSHORE ENERGY, SEAWEED AQUACULTURE, AND ECO-TOURISM

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Spatial competition among offshore tourism, renewable energy infrastructure, and marine food production systems increasingly challenges sustainable ocean governance and threatens to fragment Infrastructure development. This paper presents a novel integrated coexistence framework that demonstrates how traditionally competing sectors can function synergistically within shared marine spaces through multi-use platform design. We propose a tripartite system in which seaweed cultivation is strategically co-located with offshore solar and wind energy installations, while experiential eco-tourism activities leverage these infrastructures as educational and research assets. Concurrently, ORE platforms serve as physical anchors for mariculture and "industrial-heritage" hubs for educational eco-tourism. Our framework demonstrates that seaweed farming enhances overall system performance through multiple ecosystem services—including bioremediation, carbon sequestration, and biodiversity enhancement—thereby improving the environmental outcomes of offshore renewable energy sites while generating additional economic value streams. Drawing on emerging global case studies and marine spatial planning principles, we evaluate the socio-economic implications, including livelihood diversification for coastal communities, expansion of the blue economy value chain, and alignment with the Sustainable Development Goals (particularly SDGs 7, 12, 13, and 14). The framework critically assesses governance mechanisms, risk management protocols, and multi-stakeholder participation models necessary for operationalising coexistence at scale. Our findings suggest that shifting from mono-functional to multifunctional offshore landscapes can reduce spatial footprints by up to 40%, improve economic resilience through portfolio diversification, and transform offshore zones into multifunctional climate-positive production landscapes. This approach offers a scalable, evidence-based pathway for sustainable ocean development, particularly relevant for coastal nations developing national Blue Economy strategies and seeking to maximise returns from limited marine spatial resources.

ASS 03

FROM COAST TO CARBON SINK: REVIEWING SEAWEED-BASED MITIGATION IN INDIA'S BLUE ECONOMY

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India's extensive 11,099 km coastline supports diverse seaweed resources, particularly in hotspots such as Tamil Nadu and Gujarat where species like *Gracilaria*, *Sargassum* and *Kappaphycus* occur naturally or are widely cultivated. As the nation strives to reduce greenhouse gas (GHG) emissions and mitigate accelerating climate change, seaweed emerges as a strategic marine resource with considerable potential to strengthen India's blue economy. Although nearly 865 seaweed taxa have been documented, only a fraction has been comprehensively studied and remain unexplored. Seaweeds, such as red (Rhodophyta), brown (Phaeophyta) and green (Chlorophyta) groups, supply commercially important bioactive compounds such as agar, algin and carrageenan that support global food, pharmaceutical, cosmetic and agricultural industries. Despite this commercial versatility, India contributed less than 1% of global seaweed production, generating 33,345 tons annually with a market value of US$ 24.03 million in 2023. Beyond economic significance, seaweeds function as a vital nature-based climate mitigation solution due to their rapid carbon uptake up to 35 times faster than tropical rainforests and a net sequestration rate of ~3,017 tons CO□ per day. Wild and cultivated seaweeds show high carbon assimilation capacities, with mariculture systems sequestering 57.64 t CO□ ha^{-1} yr^{-1}, surpassing mangroves and contributing to long-term storage through sediment burial or seaweed-based products. These attributes position seaweed systems as key contributors to India's net-zero ambitions by 2070. Seaweed-based products that store carbon or replace emission-intensive materials offer additional mitigation potential but require further research and verification. A strategically balanced framework of seaweed-based approaches, supported by rigorous research and implementation frameworks, is essential to advance India's transition from coast to carbon sink.

ASS 04

FROM STATIC PAPERS TO SMART ANSWERS: AN AI CHATBOT FOR SEAWEED RESEARCH LITERATURE

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Seaweed, a collective term for large marine macroalgae, plays a critical role in global food, industrial, and biotechnological sectors. With production reaching 35-37 million tonnes annually and projected to grow rapidly in the coming decade, the seaweed sector is becoming a key component of the blue economy worldwide. This rapid expansion has also led to a vast and continuously growing global scientific literature that is increasingly difficult to navigate efficiently. Despite this growth, no dedicated, globally focused conversational AI system exists to support literature-driven discovery in seaweed research. To address this gap, we developed the first domain-specific AI-powered chatbot designed exclusively for global seaweed research literature emanated from India. The system is built using a Retrieval-Augmented Generation (RAG) architecture that combines semantic document retrieval with a locally deployed large language model. The system integrates automated document ingestion, embedding generation, and semantic vector search using the LangChain framework and ChromaDB. Research papers are processed through a structured pipeline that includes PDF extraction, text chunking, and high-dimensional embedding generation, enabling semantic-level similarity-based retrieval. Retrieved document segments are dynamically injected into a locally deployed large language model via Ollama, ensuring grounded, context-aware response generation while minimizing hallucinations. The chatbot delivers accurate, literature-based responses within approximately 2-3 seconds, even for complex, multi-part scientific queries, significantly improving the efficiency of literature exploration. By transforming static research repositories into an interactive knowledge-discovery platform, this system accelerates access to domain-specific insights and supports evidence-based decision-making. Beyond academic use, the platform has broad societal implications, including applications in sustainable seaweed cultivation, industrial processing, and biotechnological innovation. This work represents a foundational step toward AI-assisted knowledge ecosystems for the rapidly growing global seaweed sector.

ASS 05

SEAWEED REVOLUTION: WOMEN RISE WITH EVERY WAVE

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Seaweed farming in India is booming, requiring no land, water, fertilizers, or pesticides. It boosts the economy, reduces carbon footprint, improves water quality, and provides sustainable livelihoods. Marine plants and macro-algae that live in rivers, lakes, or other water bodies are collectively called seaweed. Seaweed is prized for its polysaccharides, bio-stimulants, and bioactive compounds, making it useful in many industries. Total Global algae production 38 million tonnes; 3 % (1.3 million tonnes) comes from capture and 97 % (36.5 million tonnes) comes from aquaculture. Algae contribute about 17 % of global fisheries and aquaculture production. Over 10,000 seaweed species exist worldwide. India has an Exclusive Economic Zone (EEZ) of > 2 million km2 and an 8,118 km coastline, supporting ~ 4 million livelihoods. Research institutes (MOEF&CC-NCSCM, ICAR-CMFRI, CSIR-CSMCRI) have classified areas into green (> 1 km from CRZ-IA), amber (up to 1 km from CRZ-IA), and blue (within CRZ-IA & ESA) zones. A total of 24,707 ha is suitable for farming, split into 3,999.37 ha (green), 14,076.77 ha (amber), and 6,631 ha (blue). The government (PMMSY, NFDB) is promoting seaweed cultivation in the Sundarbans (Bay of Bengal) to provide sustainable livelihoods, especially for women, focusing on edible and industrial algae like Ulva sp. The government has launched initiatives like PMMSY to promote cultivation, targeting 1.12 million tonnes production in 5 years. Seaweed farming offers a sustainable and profitable alternative for coastal communities, reducing reliance on traditional fishing and diversifying livelihoods. It generates income and employment, with immense potential for empowering women. Globally, 18% of women are employed in capture fisheries (34 million fishers), and 15% are engaged in aquaculture (22 million). These "seaweed women" have advanced the sustainability of seaweed farming for over four decades, showcasing their dedication and resilience. The roles of women in seaweed farming are complex, involving hands-on farming and small-scale processing to produce value-added products. However, challenges such as lack of awareness, research and development, and a comprehensive policy framework need to be addressed. Efforts to improve the seaweed value chain and promote seaweed cultivation as a viable livelihood will focus on enhancing R&D and technology transfer, promoting women's involvement through FFPOS, cooperatives, and SHGs, and supporting industrial product diversification to meet domestic demand. This can create opportunities for women and coastal communities, providing a new perspective on sustainable livelihoods.

ASS 06

MAPPING THE GLOBAL SEAWEED RESEARCH LANDSCAPE: INSIGHTS FROM THIRTY YEARS OF LITERATURE

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Seaweeds (~12,000 species), the largest vegetated planetary marine ecosystems (6 to 7.2 million km^2) occur in all of the world's seas and oceans, ranging from the poles to the tropics, and from the shoreline to a depth of >300m. Together with a three-fold growth in the production and utilization of seaweeds (~38 million tonnes in 2022 from over 50 countries) as a result of its potential uses in human nutrition, pharmaceuticals, cosmetics, and carbon sequestration, the scholarly research landscape on these taxa have also significantly increased over the past decades. Our intention through this study was to map the global seaweed research landscape covering a 30-year period between 1995 and 2025, using the Scopus© abstract and citation database, and *Biblioshiny* – an open-access, web-based graphical interface. Seaweed research experienced exponential growth (12.21% $year^{-1}$) over the study period, with a steady rise in scientific outputs from 28 publications in 1995, to a peak of 909 articles in 2024, and a slight decline to 887 in 2025. Decade-wise analysis shows significant expansion, with 269 publications in the decade between 1990–2000, 977 between 2000-2010, 3,442 between 2010-2020, and 5,059 between 2020 and 2025. *Journal of Applied Phycology* emerged as the most published outlet, followed by *IOP Conference Series: Earth and Environmental Science*, and *Marine Drugs*. The CSIR-Central Salt and Marine Chemicals Research Institute (CSMCRI), Bhavnagar, India, was the world's leading contributor to seaweed research, followed by Hasanuddin University, Indonesia, and Pukyong National University, South Korea. Country-wise citation analyses identified India as the leading contributor, followed by P.R. China, South Korea, the USA, and Ireland. *Ascophyllum nodosum* (434 papers), *Kappaphycus alvarezii* (415 papers), and *Ulva lactuca* (358 papers) were the most extensively studied taxa. Authorship analysis revealed the contributions of 26,780 unique authors, with Wang Q (Jinan University, China) and Wang S (Yangzhou University, China) as the most prolific (72 publications each) authors publishing seaweed-related research. Overall, our findings underscore the rapid expansion and evolving global landscape of seaweed research, and highlights the research outputs, trends, and impacts.

ASS 07

RIDING THE BLUE WAVE: MAPPING INDIA'S SEAWEED RESEARCH LANDSCAPE

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From exploratory surveys and taxonomic studies in the 1920s and 1930s, India's seaweed research landscape has grown over the last 100 years to become a truly multidisciplinary science focusing on areas such as aquaculture, biochemistry, bioactive compounds, ecology, nutraceuticals, and toxicology. India currently harvests around 33000 tonnes (wet weight year^{-1}) of seaweeds, contributing to only less than 1% of the global seaweed production. Driven primarily by the Pradhan Mantri Matsya Sampada Yojana (PMMSY), India has an ambitious plan to produce around 9.7 million tonnes of seaweeds by the year 2030. The future expansion of India's seaweed industry including farming and utilization will have to be supported by a strong research community producing relevant science and knowledge on par with global standards. Using the Scopus© abstract and citation database in combination with 'Biblioshiny'– an open-access, web-based graphical interface, we carried out a bibliometric analysis to map India's seaweed research landscape (509 articles) covering a 56-year period between 1969 and 2025. The annual scientific outputs indicate sporadic publications prior to the year 2000, followed by a gradual increase, a noticeable growth after 2008, and a peak in 2025 (59 articles). While average citations per year reached a peak in 2008, it has subsequently declined since 2022, suggesting a recent shift towards less-cited research outputs. Species-level analysis revealed *Kappaphycus alvarezii*, *Sargassum wightii*, and *Gracilaria edulis*, as the most frequently investigated taxa, and 'aquaculture', 'antioxidant activity' and 'antibacterial activity' the three most investigated topics. *Journal of Applied Phycology* emerged as the most preferred outlet for Indian seaweed researchers, followed by the *Indian Journal of Geo-Marine Sciences*, *Aquaculture International*, *Botanica Marina*, and *Journal of Environmental Biology*. The CSIR – Central Salt and Marine Chemical Research Institute (CSMCRI) dominated institutional contributions, with additional, but significant inputs from the Academy of Scientific and Innovative Research (AcSIR), Annamalai University, ICAR–Central Marine Fisheries Research Institute (CMFRI), and Bharathidasan University. Overall, the study highlights evolving research priorities, identifies key publication trends, influential authors, institutions, highly cited articles, and frequently studied species, shaping seaweed research in India.

ASS 08

SEAWEEDS AS A STRATEGIC RESOURCE FOR BLUE ECONOMY

Suman Mallick

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The immense potential of the green gem of the ocean, the seaweeds have been harnessed by various sectors such as pharmaceuticals, cosmeceuticals, aquaculture, animal feed industries due to its enriched chemical constituents. Unfortunately, the climate crisis has great impact over the conservation of natural seaweeds by increased frequency of natural calamities. The drift seaweeds or beach cast seaweeds can address the greatest crisis of shipping industries due to biofouling. The presence of bioactive compounds such as phenolics, halogenated metabolites and polysaccharide derivatives can be utilised for designing eco-friendly anti fouling agents from the drift seaweeds or beach cast seaweeds, along with blue economy relevance. Seaweed-derived antifouling compounds fit as a high- value co-product which can further applicable to zero-waste marine biorefinery frameworks, where residual biomass is further valorized into energy, agricultural, or material applications. Taking lessons from the potentiality to prevent foulers from the marine sponges, seaweeds can be regarded as potential candidate to solve the ecological crisis. Such eco-friendly innovations will not only contribute to enrich the blue economy, but also conserve the marine ecosystem from the detrimental impact of leaching from synthetic antifouling agents and livelihood developments of fisherman community. The study will depict the potential utilization of natural resources to fight back the ecological crisis strengthening the circular blue economy contributing to ecological restoration of the marine world.

ASS 09

UNLOCKING INDIA'S BLUE BIOECONOMY: A REVIEW OF SEAWEED INNOVATION, ENTERPRISE DEVELOPMENT, AND VALUE CHAIN INTEGRATION

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Seaweeds, or marine macroalgae, are increasingly recognized as pivotal biological resources within the global Blue Economy, offering sustainable pathways for biomass production without the need for arable land, freshwater, or synthetic fertilizers. Despite India's extensive 11,098.81 km coastline and rich biodiversity of approximately 844 species, the nation's contribution to global seaweed production remains disproportionately low compared to regional leaders such as China and Indonesia. This review evaluates the systemic gap between India's immense resource potential and its current industrial performance, characterized by a transition from traditional wild harvesting to high-tech, mechanized aquaculture and bio refining. Through a synthesis of global trends and an analytical deep dive into the emerging Indian enterprise landscape, this study examines how startups are operationalizing scientific advancements. We explore key innovation clusters, including biorefining and mechanization (e.g., Sea6 Energy and Aquagri), digital value chains and traceability (e.g., Climacrew), sustainable biomaterials (e.g. Zerocircle), and functional foods and biotechnology (e.g., Zaara Biotech and Zcorp Organic). Moreover, the role of specialized environmental solutions, such as Integrated Multi-Tropic Aquaculture (IMTA) and carbon sequestration, was analyzed as a driver of ecological and economic resilience. The review identifies critical technical and systemic barriers, such as reliance on a single exotic species (*Kappaphycus alvarezii*), lack of disease-resistant straints, and underdeveloped offshore technologies. This review proposes a strategic roadmap designed to catalyze an innovation-driven seaweed industry. By emphasizing the necessity of academia-industry synergy and targeted policy interventions, the framework outlines a path to transform India's vast blue territories from underutilized resources into the foundation of a resilient, sustainable, and circular bioeconomy.

ASS 10

USING ARTIFICIAL INTELLIGENCE TO IDENTIFY IMPORTANT SARGASSUM SEAWEEDS ALONG THE INDIAN COAST

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Sargassum is an ecologically and economically important brown seaweed widely distributed along the Indian coastline. It is a major source of alginate, a valuable compound extensively used in food processing, pharmaceuticals, cosmetics, and several industrial products. Accurate identification of Sargassum species is essential for biodiversity documentation, resource management, and sustainable utilization. However, traditional identification methods based on morphology are often challenging because many species exhibit highly similar external features and considerable variation in form due to environmental influences. These factors frequently lead to misidentification and inconsistencies in taxonomic records. The present study investigates the application of Artificial Intelligence (AI) and digital image analysis as a rapid, cost-effective, and non-destructive approach for identifying Sargassum species. Fresh seaweed samples collected from different coastal locations were photographed under standardized lighting conditions, and the images were processed using Python-based image analysis tools with OpenCV. Important morphological characteristics such as vesicle (air bladder) shape, leaf margin patterns, frond dimensions, and branching angles were automatically extracted and quantified. These features were then analyzed using statistical and machine-learning techniques to identify species-specific patterns and improve classification accuracy. The results indicate that vesicle morphology and leaf edge characteristics are particularly effective in distinguishing closely related species. This AI-assisted morphometric approach offers a rapid, low-cost, and scalable alternative to molecular barcoding. This AI-based framework can support researchers, industry professionals, policymakers, and students in improving species identification, conservation planning, and sustainable management of economically important seaweed resources in India.

ASS 11

SEAWEEDS RESEARCH IN INDIA IN RETROSPECT AND PROSPECTS

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Seaweeds are used in processed foods, pharmaceuticals, cosmetics, paints, paper, cardboard, and the mining industry for various commercial purposes. Though India has the potential to produce around 9.7 million tonnes of seaweed per year, its current production is limited to just 34,000 tonnes. The Government of India aims to boost production to 1.12 million tonnes by 2025 via the PMMSY scheme. Globally, 35 million tonnes (wet weight) of seaweeds, worth around $16.5 billion, are produced annually. India has a rich diversity of about 844 seaweed species, but its seaweed production depends on the cultivation of a few native varieties. The government of India is seeking to tap the vast potential of seaweeds in India. For the first time, the Centre has issued guidelines for the import of live seaweeds to increase domestic production. Centre issues guidelines on import of live seaweeds, used in food, pharma, cosmetics, paints, paper and mining industries. India has a vast coastline of about 11,098.81 km extending on the east and west coasts, including the Andaman and Nicobar Islands in the Bay of Bengal and the Lakshadweep Islands in the Arabian Sea. In recent years, seaweeds have gained importance in India due to the rapid growth of the seaweed industry in the country. The cultivation of seaweed in Japan dates back 500 years, and that of other seaweeds to 40 years. Commercial seaweed cultivation in Southeast Asia is currently based primarily on *Eucheuma*, although *Gracilaria* spp. are also being cultivated. In India, seaweed cultivation is centred on the cultivation of the principal agarophytes Gelidiella acerosa, *Kappaphycus alvarezii,* and *Gracilaria edulis*. It aims to present a comprehensive overview of the cultivation of all economically important seaweeds, viz., agarophytes, carrageenophytes, and edible seaweeds, as well as other aspects of seaweeds, their biological resources, and biofertilizers.

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FFN 01

STRUCTURAL CHARACTERIZATION AND FUNCTIONAL BIOEVALUATION OF FUCOIDAN ISOLATED FROM THE BROWN ALGA *Sargassum swartzii*

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Seaweeds are rich sources of bioactive metabolites, and fucoidan a sulfated polysaccharide from brown algae has gained attention for its therapeutic potential. The present study aimed to isolate, characterize, and evaluate the antioxidant and in vivo safety properties of fucoidan extracted from the brown seaweed *Sargassum swartzii*. Extraction using hot water and ethanol precipitation yielded 2.00 ± 0.15 % (dry weight) of crude fucoidan. Biochemical evaluation indicated high carbohydrate (50.25 ± 0.18 %), sulfate (36.38 ± 0.04 %), and low protein (1.16 ± 0.04%) contents. Phytochemical screening confirmed the presence of tannins, saponins, terpenoids, steroids, carbohydrates, and glycosides, while alkaloids and flavonoids were absent. UV–visible spectroscopic analysis showed a peak at 265 nm, suggesting fucose-associated chromophores, and FTIR spectra revealed characteristic bands of sulfate and carbohydrate functional groups including fucose, D-glucose, and D-mannose, validating the structural identity of fucoidan. The antioxidant potential was significant, as demonstrated by concentration-dependent DPPH radical scavenging (72.36 ± 2.24 %), reducing power (83.17 ± 3.33 %), and total antioxidant activities (69.3 ± 1.16 %). Anti-inflammatory assays showed BSA denaturation inhibition (76.2 %) and proteinase inhibition (64.1 %). Toxicity evaluation using Artemia nauplii demonstrated excellent biocompatibility, with 100% survival up to 250 µg/ml and 98 ± 1.29% survival at 1000 µg/ml. Morphological observations showed only slight aggregation around the gut region at higher concentrations. Furthermore, pretreatment with fucoidan improved nauplii survival against H2O2-induced oxidative stress, confirming its protective role. These findings suggest that fucoidan from *S. swartzii* possesses strong antioxidant, anti-inflammatory efficacy and supporting its potential use in developing natural therapeutic and nutraceutical applications.

FFN 02

EFFECT OF BIOPROCESSING ON PHYSICOCHEMICAL CHARACTERISTICS OF SEAWEED *Gracilaria debilis*

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Gracilaria debilis is a nutrient-rich red seaweed, but its rigid cell wall structure and strong marine odour limit its direct use as a food ingredient. This study examined how controlled fermentation can enhance the physicochemical, nutritional, structural, and sensory qualities of *Gracilaria debilis*. Proximate analysis showed improvements in key nutrients after fermentation, with protein increasing from 6.67% to 9.32%, crude fat from 1.44% to 1.53%, and dietary fibre from 38.34% to 39.43%, while moisture and ash content remained comparable. FTIR spectroscopy of raw and fermented seaweed biomass showed a similar profile with phenolic, alcohols, amides, and alkyl halides as the major functional groups. SEM revealed a transition from compact, intact cell structures in raw biomass to a highly fragmented and porous surface after fermentation due to microbial enzymatic degradation. GC–MS fatty acid analysis showed an increase in total lipid content (1.44% → 1.53%) and changes in fatty acid distribution, with SFA rising (89.31% → 95.46%), MUFA decreasing (10.47% → 2.79%), and PUFA increasing (0.19% → 1.71%). Amino acid profiling showed an improvement in nutritional quality, with essential amino acids increasing from 30.94% to 46.12%, particularly valine (10.22% → 14.16%) and leucine (6.07% → 12.85%). Protein content also increased (6.67% → 9.32%). E-nose analysis showed a 45.04% reduction in odour intensity, indicating decreased unpleasant volatiles after fermentation. Overall, fermentation significantly enhanced nutrient availability, amino acid enrichment, lipid composition, structural breakdown, and sensory acceptability, making fermented *G. debilis* biomass a promising dietary ingredient for value-added functional food applications

FFN 03

OPTIMISED DES EXTRACTION AND RESIN PURIFICATION OF BROWN SEAWEED PHENOLICS

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This study aimed to optimize the extraction of phenolics by deep eutectic solvents (DES) by Response surface Methodology (RSM) and to purify using macroporous resin, to quantify phenolic compounds and evaluate their antioxidant activity study in the extract, and to assess the cytotoxicity of the eluates by evaluating cell viability in 3T3-L1 cell line using MTT. Brown seaweed, collected from mandapam coast, Tamil Nadu, India, was washed and dried. The sample extraction with DES solvents were optimised using RSM through 17 experimental runs. The extracts were further evaluated for total phenolic content and potential antioxidant activity. The phenols from the extract were eluted out using macroporous resins with static adsorption and desorption. The desorbed phenolic eluates were subjected to negative mode ionisation in HRMS/MS. The toxicity of the phenol rich eluate was tested for its cell viability against 3T3- L1 cell lines using MTT assay. In the current study, the optimisation of DES extraction using RSM indicated optimal conditions at 120 ^{0}C extraction for 249 mins. The extracts exhibited high phenolic content in total phenolic assay had strong antioxidant activity in DPPH and FRAP assay. The extracts were purified using macroporous resin. The resulting eluates were analysed to negative mode in HRMS/MS were phenols like gallic acid, ferulic acid, different phlorotannins like eckols, fucophlorethols were identified. Eluates were tested for cytotoxic activity against 3T3-L1 cell lines, proving cell viability. Phlorotannins are exclusive phenolic compound in brown seaweed which can be further explored in the field of food and medicine.

FFN 04

Ulva lactuca AS FUNCTIONAL FOOD INGREDIENT: EVALUATION OF NUTRITIONAL, ANTIOXIDANT AND ANTIDIABETIC PROPERTIES

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Ulva lactuca (sea lettuce) is an underutilized green seaweed with strong potential as a functional food and nutraceutical resource due to its high dietary fibre and bioactive phytochemical content. However, detailed nutritional and nutraceutical assessment, along with validation of their biological functionality remain critical for value-addition. In this study, nutritional and nutraceutical profiling of *Ulva lactuca* was done. Further, the phenolic compounds from *U. lactuca*, were subsequently characterized by LC–ESI–QTOF–MS/MS and evaluated for antioxidant and antidiabetic activities. *U. lactuca* biomass contained 60.1% total dietary fibre (47.7% insoluble and 12.4% soluble), 67.0% carbohydrates, and high levels of essential minerals, particularly magnesium (690.5 mg/100 g), calcium (136.5 mg/100 g) and iron (7.57 mg/100 g), indicating its nutritional value as a functional ingredient. The solvent extract exhibited a total phenolic content of 70 mg gallic acid equivalents (GAE)/100 g and total flavonoids of 47 mg quercetin equivalents (QE)/100 g, with strong antioxidant activity (total antioxidant capacity 325 mg AAE/100 g and DPPH IC50 = 1.5 mg/mL). LC–ESI–QTOF–MS/MS analysis revealed a diverse phenolic profile, including phenolic acids (gallic, syringic, sinapic, chlorogenic and rosmarinic acids), flavonoids (quercetin, isorhamnetin, kaempferol and luteolin glycosides, gallocatechin), and stilbenes (resveratrol and its glucoside), along with caffeoyl and galloyl conjugates. The phenolic-rich fraction showed significant antidiabetic potential, inhibiting α-amylase (IC50 = 1.41 mg/mL) and α-glucosidase (IC50 = 0.44 mg/mL). Overall, *U. lactuca* represents a promising marine resource for development of antioxidant- and antidiabetic-enriched functional foods and nutraceuticals.

FFN 05

INHIBITION OF A-AMYLASE AND A-GLUCOSIDASE BY *Gracilaria edulis* AND ITS APPLICATION IN LOW GLYCEMIC INDEX FOOD PRODUCT

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Diabetes is a growing public health issue, and managing postprandial hyperglycemia is crucial in its control. Consuming low-glycemic index (GI) foods and inhibiting carbohydrate-hydrolyzing enzymes such as α-amylase and α-glucosidase are effective strategies. Seaweeds are high in dietary fiber, polyphenols, and other bioactive that exhibit antidiabetic and antioxidant properties. *Gracilaria edulis* (red seaweed) with a low glycemic index (*in vitro* assay) was selected for incorporation in food product. Processed *G. edulis* was evaluated for nutrient composition, antidiabetic and antioxidant activity, and used for product development. Yoghurt was formulated with 5–30 g seaweed incorporation. The formulation containing 25 g seaweed showed good sensory acceptability and low *in vitro* GI and was further analyzed for nutrient composition, antidiabetic, antioxidant activity, and functional properties. Based on sensory evaluation, consumer acceptability, and *in vitro* GI, selected variations and their standards were evaluated using animal and human models. Seaweeds contained valuable amounts of essential nutrients and phytonutrients with promising antidiabetic and antioxidant activities. The glycemic index of G. edulis and U. reticulata was classified as low. Seaweeds were found safe up to 5000 mg/kg body weight. Seaweed-incorporated yoghurt showed the most prominent reduction in fasting blood glucose. The *in vivo* GI of yoghurt was low in healthy subjects. Seaweed and seaweed-incorporated products possess high dietary fiber content with low glycemic index and glycemic load. A Low-GI product yoghurt was successfully developed using seaweeds offering potential for the benefit of the diabetic population.

FFN 06

DEVELOPMENT OF A NOVEL PLANT BASED INTERMEDIATE MOISTURE FOOD (IMF) FROM BROWN SEAWEED

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The present invention provides a novel method for preparing a plant-based intermediate moisture food (IMF) product derived from *Sargassum* sp., a brown seaweed, and the resulting product thereof. Seaweed is the primary component in this product, while additional ingredients (including humectants, hydrocolloids, starches, and flavouring agents) are added to achieve specific sensory, textural, and nutritional properties. Seaweeds are first blanched to prevent off tastes from interfering with their appealing quality, then homogenized with all of the beneficial nutrients that are available, and finally, refrigerated and dried in two stages under humidity. The final results have a jerky-like texture with low water activity of <0.80, and stability at ambient conditions due to low moisture content of 10 - 40% and retention of seaweed-derived nutrients. The prepared seaweed based Intermediate Moisture Food with tensile strength 15.17N, Hunter colour values being 15.92, 0.49, and 0.62 for lightness (L^*), redness (a^*) and yellowness (b^*) respectively shows an overall acceptability score of 7.1. This describes how seaweeds can be integrated into ready-to-eat and meal replacement products for both retail and institutional distribution channels.

FFN 07

ENZYMES COUPLED WITH WATER TEMPERATURE AS AN ECO-FRIENDLY EXTRACTION TECHNIQUE FOR OBTAINING BIOACTIVE COMPOUNDS FROM BROWN SEAWEEDS

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The study aimed to develop an eco-friendly green extraction technique as an alternative to conventional methods for obtaining bioactive compounds from brown seaweeds: *Sargassum polycystum*, *Turbinaria ornata*, and *Rosenvingea intricata*. Four extraction conditions were evaluated: (A) cellulase + hot water, (B) xylanase + hot water, (C) Alcalase + hot water, and (D) a combination of all three enzymes + hot water, over a 3-hour duration. The crude extracts were analyzed for yield percentage, antioxidant properties (total phenolic content, total flavonoid content, FRAP, DPPH scavenging activity, and DNA nicking assay), cytotoxicity, and antimicrobial activity. Results demonstrated that the combined enzyme treatment (D) produced significantly higher extract yields, with *Turbinaria ornata* showing the highest yield (16.66%), followed by *Sargassum polycystum* (16.14%) and *Rosenvingea intricata* (15.65%). Antioxidant capacity was species-dependent: *T. ornata* exhibited the highest TPC, TFC, and FRAP values, while *R. intricata* showed the strongest dose-dependent DPPH radical scavenging activity. The DNA nicking assay confirmed the extract's protective effect against oxidative damage. Antimicrobial activity was also highest in *R. intricata* extracts under the combined enzyme treatment, correlating with other assay results. This study demonstrates that a synergistic combination of cellulase, xylanase, and Alcalase with hot water provides an efficient, scalable, and eco-friendly method for extracting bioactive compounds from brown seaweeds, with potential applications in pharmaceuticals and nutraceuticals.

FFN 08

SENSORY CHARACTERIZATION AND CONSUMER PERCEPTION OF RAW GREEN SEAWEED (*Ulva lactuca*): USING PANEL EVALUATION AND E-NOSE ANALYSIS

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A rapidly growing population across countries drives the search for alternative food to meet the nutritional demand. In this context, advances in aquaculture make seaweed a sustainable and nutrient-rich option. Globally, seaweed is consumed as a vegetable, but its use in Indian cuisine is limited because of low awareness and its sensory characteristics. This study enlightens the sensory characteristics and consumer acceptance towards raw green seaweed (*Ulva lactuca*) using both subjective and objective methods of analysis. The subjective method uses a questionnaire where 25 semi-trained panellists evaluated the visual observation involving chromatic attributes, olfactory, visual appeal, odour effectiveness, and overall acceptability. Panellists showed mixed perceptions of seaweed as algal, unappealing, pungent, unpleasant, and fishy odours. Odour intensity ranged from moderate to intense, which influenced the reluctance to consume seaweed. Though an objective method, sensory profiling with an E-nose (Electronic nose) identified volatile compounds such as ethanethiol,2-mercaptoethanol,1-propanol, thiophene,1butanamine,1-hyroxy-2-propanone and heptadecanal with its subsequent sensory descriptors as significantly correlated with the fishy. pungent and strong odour. Combining both methods shows that the characteristics of seaweed reduce consumer acceptance in its raw or unprocessed form. However, panellists have a favourable view of processed products, such as incorporating seaweed as a functional ingredient in nutritional supplements, snacks, savoury, bakery products, ready-to-eat products and beverages.

FFN 09

SEAWEED-DERIVED LAMINARIN AS A THERAPEUTIC CANDIDATE FOR TYPE 2 DIABETES: AN *IN-SILICO* INVESTIGATION OF *PI3K/AKT* PATHWAY MODULATION AND DUAL-TARGET ENGAGEMENT

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Type 2 Diabetes Mellitus (T2DM) represents a critical global health challenge, with obesity contributing to approximately 43% of cases. The PI3K/AKT signalling pathway regulates glucose uptake, glycogen synthesis, and lipid metabolism. Pathway dysregulation, including impaired insulin receptor substrate phosphorylation, excessive mTOR activation, or GSK3β overactivity, drives insulin resistance. Downregulation of PI3KCα and AKT2 further compromises insulin signalling, exacerbating metabolic dysfunction. Seaweeds harbour bioactive compounds, including polysaccharides, polyphenols, and carotenoids with therapeutic potential. Laminarin, a seaweed-derived polysaccharide, demonstrates notable anti-obesity and hypoglycemic effects. This computational study investigated Laminarin's molecular interactions with critical PI3K/AKT pathway proteins (Reactome: R-HSA-74752.4), targeting both upregulated (GSK3β, mTOR) and downregulated (PI3KCα, AKT2) proteins. Molecular docking using Schrödinger's Maestro Glide XP revealed strong binding affinities. For upregulated targets, GSK3β exhibited a GScore of −6.233 kcal/mol (ΔGbind: −51.494 kcal/mol), while mTOR showed superior binding with a GScore of -11.615 kcal/mol (ΔGbind: −79.599 kcal/mol). Downregulated targets demonstrated PI3KCα with GScore −10.271 kcal/mol (ΔGbind: −103.823 kcal/mol) and AKT2 with GScore −8.646 kcal/mol (ΔGbind: −70.021 kcal/mol). Subsequent 100 ns molecular dynamics simulations using Desmond assessed complex stability through RMSD, RMSF, secondary structure analysis, and hydrogen bonding. Ligand-protein interaction analysis revealed sustained interactions exceeding 70% simulation trajectory duration. Results demonstrate Laminarin's robust binding affinity and exceptional dynamic stability across PI3K/AKT pathway targets, particularly with PI3KCα (highest ΔGbind) and mTOR. This multi-targeted approach offers novel opportunities for developing functional foods and therapeutic agents for anti-diabetic and anti-obesity applications. Further in vitro and in vivo validation is warranted for clinical translation.

FFN 10

SCOBY-MEDIATED FERMENTATION ENHANCES NUTRITIONAL QUALITY AND FOOD SAFETY OF THE BROWN SEAWEED *Turbinaria conoides*

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Seaweeds are excellent sources of bioactive compounds for inclusion as food or feed ingredients. However, concerns regarding its heavy metal accumulation, poor digestibility, and lower bioaccessibility of nutrients can hinder its wider application in the food or feed sector. Fermentation can possibly improve seaweed functionality and safety. In this study, a symbiotic culture of bacteria and yeast (SCOBY) was used to ferment the edible brown seaweed, *Turbinaria conoides*. A comprehensive analytical approach involving proximate composition, biochemical assays, heavy metal analysis and untargeted metabolomics was employed to investigate the effects of SCOBY fermentation on seaweed. The results revealed a significant reduction in heavy metal concentrations in the fermented seaweed, highlighting its potential for ensuring food safety. The untargeted metabolomic analysis further revealed an elevation in polyphenolic compounds, organic acids, vitamers, sugar acids, and their derivatives, corroborating the biochemical assay outcomes. Key metabolites that differed significantly between fermented and non-fermented seaweed such as organic acids, sugar derivatives and vitamin D derivatives were identified using chemometric analysis. Subsequent enrichment analysis revealed alterations in metabolomic pathways such as phenylalanine metabolism, citric acid cycle, starch and sucrose metabolism. This study highlights the potential of SCOBY fermentation as a sustainable bioprocessing strategy and offers insights into the compositional and metabolomic changes in fermented seaweed biomass.

FFN 11

DEVELOPMENT OF PROTEIN ANALOGUES USING EDIBLE SEAWEEDS FOR NCDS

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Edible seaweeds are underutilized nutritious foods with nutraceutical and functional properties. These seaweeds are rich source of energy, carbohydrates, high protein, healthy fats, micro minerals, essential vitamins, antioxidants, phyco-colloids and beneficial dietary fiber for human nutrition and diseases. There is constant increase in the incidence of non-communicable diseases and its risk factors. Nutritional insecurity, sedentary lifestyle and ignorance of balanced diet, faulty dietary habits and social habits add value to the current situation. Seaweeds can be an alternate to protein analogues for changing dietary habits to satisfy food and Nutritional security. The results of this preliminary study showed that Caulerpa spp. and were used for determination of their nutritional parameters, acceptability and antioxidant activity. *Gracilaria edulis* contains 49g and 6g of healthy fats, rich Protein of 9.99 g and healthy benefitting dietary fibre of 6.2g/100g. It consists of 3000mg of calcium, then *Caulerpa* spp (Carbohydrate 49.8 g/100g; Fat 6.18 g/100g; Protein 4.6 g/100g; Dietary fibre 3.61 g/100g and Calcium 1701 mg/ 100g). Antioxidant activity was high in *Gracilaria edulis* when compared to *Caulerpa* spp. The overall acceptability of developed protein analogues using these algal species shows better sensory attributes. Developed protein analogues from analogues from seaweeds are vital source of alternate food for NCDs prevention.

FFN 12

INFLAMMATION-ALLEVIATING EFFICACY OF *Sargassum wightii* EXTRACT IN LPS-INDUCED ACUTE INFLAMMATORY RAW 264.7 MOUSE MACROPHAGES

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Inflammation is a fundamental biological response to stimuli such as microbial invasion, tissue injury, and chemical irritants. However, persistent or chronic inflammation can result in tissue damage and contribute to the development of several pathological conditions, including rheumatoid arthritis, cardiovascular diseases, and cancer. Marine macroalgae are recognized as rich sources of bioactive compounds with potent anti-inflammatory properties and minimal adverse effects. *Sargassum wightii*, a brown seaweed abundantly distributed along the Indian coastline, has emerged as a promising candidate for natural anti-inflammatory therapeutics. The present study investigates the anti-inflammatory potential of *S. wightii* using in vitro and molecular biology approaches. An ethyl acetate: methanol (1:1) extract of *S. wightii* (EMS) was evaluated for its ability to modulate acute inflammatory responses in lipopolysaccharide (LPS)-induced RAW 264.7 mouse macrophage cells. EMS exhibited strong inhibitory activity against key pro-inflammatory enzymes, cyclooxygenase (COX) and 5-lipoxygenase (5-LOX), with IC_{50} values of 116.95 µg/mL and 246.70 µg/mL, respectively. Additionally, EMS significantly suppressed cellular nitrite production and myeloperoxidase activity in a dose-dependent manner, with maximum inhibition observed at 100 µg/mL. Gene expression analysis revealed that EMS treatment downregulated major pro-inflammatory mediators, including IL-1β, IL-6, and TNF-α, while upregulating anti-inflammatory cytokines such as IL-10 and TGF-β. This modulation was associated with suppression of the NF-κB signaling pathway. Collectively, these findings demonstrate that *S. wightii* exerts anti-inflammatory effects through a multitarget regulatory mechanism. The study underscores the therapeutic potential of *S. wightii* as a natural anti-inflammatory agent and supports its further development for medicinal and nutraceutical applications.

FFN 13

NUTRACEUTICAL POTENTIAL OF INDIGENOUS BROWN SEAWEEDS FROM THE MANDAPAM COAST FOR SUSTAINABLE AQUACULTURE APPLICATIONS

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The intensifying demand for sustainable aquaculture systems has catalyzed research into marine macroalgae as functional feed ingredients with nutraceutical properties. This study comprehensively evaluated four indigenous brown seaweeds - *Dictyopteris delicatula, Spatoglossum asperum, Stoechospermum marginatum,* and *Sargassum wightii* - collected from the Mandapam coast of Tamil Nadu, India, to assess their potential as bioactive resources for aquaculture. Seaweed biomass underwent solvent extraction using 70% acetone, 80% ethanol, and an ethyl acetate–ethanol (1:1) mixture to optimize extraction efficiency. The ethyl acetate- ethanol combination demonstrated superior yields, with *S. asperum* achieving maximum extraction (11.79 ± 0.76%) after 3 hours. Nutritional profiling revealed that *S. marginatum* possessed the highest protein (12.68 ± 0.14%) and ash content (14.46 ± 0.02%), while all species exhibited modest lipid levels (1.31–2.03%). Antioxidant capacity assessments indicated that *D. delicatula* extracts contained elevated total phenolic and flavonoid contents, whereas *S. asperum* demonstrated superior DPPH radical scavenging activity across all extraction conditions. DNA nicking assays confirmed significant protective effects against oxidative damage, particularly in *S. marginatum* and *S. wightii* extracts. Antibacterial screening revealed that ethanol extracts exhibited potent inhibitory activity against *Bacillus cereus* and *Pseudomonas aeruginosa*. These findings collectively demonstrate that indigenous brown seaweeds possess substantial nutraceutical value characterized by robust antioxidant properties, antimicrobial efficacy, and favorable nutritional profiles, thereby supporting their integration into aquafeeds to enhance fish health, immunity, and production sustainability.

FFN 14

EFFECT OF FOLIAR APPLICATION OF SEAWEED SAP ON THE GROWTH, PRODUCTIVITY AND ENERGETICS OF POTATO-GREEN GRAM CROPPING SYSTEM IN RED LATERITIC SOILS OF WEST BENGAL.

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Conventional cultivation systems need to be improved to accomplish sustainable production. Among many viable options, the use of seaweed extracts containing almost all major and minor plant nutrients, amino acids, vitamins and growth promoters like cytokinins and auxins may be a possible option for sustainability in present context. Considering that, present experiment was conducted at the agriculture farm of Visva- Bharati University, Sriniketan, Bolpur, West Bengal during the *rabi* and *pre-kharif* season of 2021-22 to find out the impact of *Sargassum, Solieria* and *Gracilaria* seaweed sap on the growth, yield and quality improvement on potato-green gram cropping system and the energetics of the whole system. Different concentration of sap (0.5%, 1%, 2.5%, 5%, 7.5%,10%) were sprayed on the foliage of potato with a reduced dose of fertilizer (75%) of the RDF. It was observed that 10% *Sargassum* sap + 75%RDF gave the best growth parameters followed by 10% SG sap +75%RDF and are statistically at par with each other. For green gram, best results were derived in the residual plots of treatment 10% SG sap +75%RDF. In potato, highest yield (34 t/ha) was observed in 10%SG sap. Energetics calculations showed that the treatment 10% SG sap +75%RDF gave the best energy use efficiency in potato cultivation. Similarly green gram gave best yield as well as better energy use efficiency in the 10% SG sap treatments.

FFN 15

DEVELOPMENT AND EVALUATION OF A SEAWEED-DERIVED SALT ALTERNATIVE FROM *Acanthophora spicifera* FOR HYPERTENSION MANAGEMENT

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Hypertension remains a major global public health challenge and a leading risk factor for cardiovascular diseases, strongly linked to excessive dietary sodium intake. Addressing this concern, the present study explores *Acanthophora spicifera*, a red seaweed, as a potential natural salt substitute with reduced sodium content and added functional health benefits. The research involved systematic collection, processing, and formulation of seaweed-based salt, followed by comprehensive physicochemical, nutritional, and biochemical characterization. Nutritional and functional properties were assessed, with antioxidant potential evaluated through DPPH radical scavenging activity, total antioxidant capacity, and hydrogen peroxide scavenging assays. Product safety was ensured by quantifying heavy metal concentrations using Atomic Absorption Spectroscopy (AAS). Sodium chloride levels were determined via Mohr's method, while iodine content was estimated through iodometric titration. Additional analyses included yield percentage, dietary fiber quantification, and mineral profiling using Inductively Coupled Plasma Mass Spectrometry (ICP-MS). The findings revealed that *Acanthophora spicifera*–derived salt contained significantly lower sodium levels compared to conventional table salt, while being enriched with essential minerals such as potassium, magnesium, calcium, and iodine. Importantly, the seaweed salt demonstrated considerable antioxidant activity, suggesting its potential role in mitigating oxidative stress and supporting cardiovascular health. Overall, this study highlights the promise of *Acanthophora spicifera* as a functional food ingredient and a healthier salt alternative. The combination of sodium reduction, mineral enrichment, and antioxidant properties underscores its application in dietary interventions aimed at hypertension management and improved cardiovascular well-being.

FFN 16

BIOCHEMICAL CHARACTERIZATION OF RED SEAWEEDS FOR FUNCTIONAL FOOD AND NUTRACEUTICAL APPLICATIONS

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To assess and characterize red seaweeds for their bioactive compounds by analysing its lipid and protein content. Ten species of red seaweeds, collected from the Mandapam coast of Rameshwaram, India, were washed, cleaned, dried, and powdered prior to analysis. Total lipid content was estimated using a Soxhlet extraction method, while protein content was determined using a N/protein analyzer. The extracted lipids were subjected to methylation and analyzed using Gas Chromatography - Mass Spectrometry (GC–MS) to determine the fatty acid composition. Total phenolic content was quantified using the Folin–Ciocalteu method. In addition, the antioxidant potential of the phenolic extracts was assessed using radical scavenging assays, including DPPH and FRAP. Red seaweeds exhibited significant nutritional and bioactive potential, with protein content ranging from 7 to 17 % and lipid content between 0.1 and 0.6 % on a dry weight basis. Despite the low total lipid content, the seaweeds were rich in essential fatty acids. Fatty acid profiling revealed palmitic acid (C16:0) as the predominant fatty acid, followed by oleic acid (C18:1). The monounsaturated fatty acid and polyunsaturated fatty acid content ranged from 2 to 31% and 0 to 3%. The atherogenic and thrombogenic indices, calculated from the fatty acid composition, ranged from 0.04 to 20 and 3.6 to 42, respectively. Furthermore, the total phenolic content and radical scavenging activity demonstrated notable antioxidant potential. These findings highlight the suitability of red seaweeds as sources of health-promoting bioactive compounds, supporting their potential application in nutraceutical and functional food formulations.

FFN 17

VEGAN FUNCTIONAL GUMMIES: UTILIZING PROTEIN HYDROLYSATES FROM *Gracilaria edulis* AND *Kappaphycus alvarezii*

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The sustainable expansion of nutrition requires alternative ingredients that reduce reliance on conventional resources and promote blue-economy. Seaweeds from blue-origin macroalgae serve as excellent sources of proteins, fiber, and antioxidants, yet remain underutilized despite their immense nutritional and functional potential. Red seaweeds such as *Kappaphycus alvarezii* and *Gracilaria edulis*, sourced from coastal farms, represent underexploited reservoirs of proteins and bioactive compounds amid growing demand for sustainable, plant-based nutrition. This study establishes a standardized enzymatic hydrolysis protocol to achieve high-yield protein hydrolysate extraction from these species. Key parameters such as pH, temperature, enzyme concentration, and hydrolysis time were optimized to maximize protein recovery, enhanced solubility, digestibility, and antioxidant activity, all while maintaining amino acid integrity. Extracted hydrolysates were characterized through biochemical assays for protein content and amino acid profiles. Vegan functional seaweed gummies were developed by integrating these hydrolysates with agar-agar gelling agents, natural sweeteners, and monk fruit extracts, ensuring low-glycemic properties and preservative-free stability. Physicochemical analyses verified ideal texture, colour, and proximate composition, while sensory evaluations by consumer panels confirmed high acceptability. This scalable bioprocessing approach promotes efficient seaweed utilization, yielding innovative, palatable, high-protein snacks for nutraceutical markets and advancing sustainable marine biotechnology.

FFN 18

SEAWEED-DERIVED PROTEIN AS A FUNCTIONAL FOOD INGREDIENT: NUTRITIONAL POTENTIAL AND PROCESSING STRATEGIES

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The demand for suitable protein sources has increased interest in seaweed as promising contributors to human and animal nutrition. Among macroalgae, red seaweeds such as *Porphyra*, *Palmaria palmata*, and *Gracilaria* species, along with green seaweeds like *Ulva* and *Enteromorpha*, are recognized for their relatively high protein content, often ranging from 15 to 35 percent on a dry weight basis. Studies conducted along the Indian coastline further indicate that species including *Ulva lactuca*, *Gracilaria edulis*, *Hypnea musciformis*, and *Kappaphycus alvarezii* possess notable protein levels, making them attractive local resources for nutritional applications. This review highlights the potential of seaweed-derived proteins with emphasis on protein-rich species and recent advances in extraction technologies. Advances in protein extraction methods have improved the feasibility of utilizing seaweed proteins in food and feed systems. Conventional alkaline extraction followed by isoelectric precipitation is widely used, while newer approaches such as enzyme-assisted, ultrasound-assisted, and microwave-assisted extraction have enhanced yield and preserved functional quality. These technologies enable the recovery of protein concentrates and bioactive peptides with desirable properties for product formulation. In human nutrition, seaweed proteins are being explored for incorporation into functional foods, protein-enriched snacks, and plant-based alternatives. In animal diets, seaweed meals and protein fractions have shown positive effects on growth, gut health, immunity, and product quality across livestock and aquaculture species.

FFN 19

SULPHATED POLYSACCHARIDES FROM SEAWEEDS: PRODUCTION STRATEGIES, BIOACTIVITY AND APPLICATION POTENTIAL

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Seaweeds are increasingly recognized as sustainable and renewable sources of structurally complex biopolymers with significant functional value. Among these, sulphated polysaccharides represent a major class of marine macromolecules that contribute to the physiological functions of seaweeds and exhibit diverse biological activities relevant to human health. These polysaccharides are widely distributed across macroalgal taxa, with red, brown, and green seaweeds serving as primary reservoirs. Key sulphated polysaccharides include carrageenans and agarans from red seaweeds, fucoidans from brown seaweeds, and ulvans from green seaweeds. Their chemical diversity arises from variations in monosaccharide composition, degree and position of sulphation, glycosidic linkages, and molecular weight, which collectively influence their functional properties. The production of seaweed-derived sulphated polysaccharides involves conventional hot-water and acid extraction techniques, alongside emerging green technologies such as enzyme-assisted, ultrasound-assisted, and microwave-assisted extraction, aimed at improving yield, structural integrity, and environmental sustainability. Advances in purification and characterization techniques have further enabled improved understanding of structure–function relationships. Extensive in vitro and in vivo studies demonstrate that sulphated polysaccharides exhibit a wide range of bioactivities, including antioxidant, anti-inflammatory, anticoagulant, antiviral, immunomodulatory, and prebiotic effects. These multifunctional properties are strongly associated with sulphation patterns and molecular architecture. Consequently, sulphated polysaccharides have gained considerable attention for applications in functional foods, nutraceuticals, pharmaceuticals, wound dressings, and biomedical materials.

FFN 20

SEAWEED-BASED FUNCTIONAL FOOD SPREADS: FORMULATION STRATEGIES, NUTRITIONAL POTENTIAL, AND TECHNOLOGICAL ADVANCES

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The global shift toward sustainable food systems and health-oriented diets has accelerated the development of functional foods that deliver targeted nutritional and physiological benefits. Within this context, food spreads have emerged as versatile semi-solid matrices that enable efficient delivery of functional ingredients, controlled lipid composition, and broad consumer acceptance. The global food spread market is valued at USD 33.5 billion in 2025 and is projected to reach USD 59.5 billion by 2035 registering a compound annual growth rate of 5.9% over the forecast period. Their compatibility with both hydrophilic and lipophilic compounds, extended shelf life, and convenience of use make spreads attractive platforms for the innovation of functional foods. Concurrently, seaweeds have gained prominence as marine-derived ingredients owing to their high nutritional density and functional versatility. Seaweeds are rich sources of structurally diverse polysaccharides, including alginates, agar, and carrageenan, as well as polyphenols, carotenoids, proteins, and essential trace minerals. These polysaccharides act as natural hydrocolloids, imparting water-holding capacity, gelation, emulsification, and textural stabilization in food systems. When incorporated into spread formulations, seaweed-derived polysaccharides enhance viscosity and spread ability, improve emulsion stability, reduce syneresis, and enable partial fat replacement in reduced-calorie products. This review critically examines recent advances in seaweed-based functional food spreads, with an emphasis on seaweed species selection, processing strategies that influence nutrient retention and bioactive stability, and formulation approaches that govern rheological behaviour, sensory quality, and oxidative stability.

FFN 21

DEVELOPMENT OF NUTRIENT-ENRICHED SEAWEED LAVERS INCORPORATING MARINE PROTEINS FROM *Stolephorus indicus* AND *Metapenaeus dobsoni*

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Ulva lactuca, a common native seaweed in India, was used to develop a nutritious laver snack fortified with marine-derived protein powders from *Metapenaeus dobsoni* (shrimp) and *Stolephorus indicus* (anchovy). Four laver formulations were evaluated: Li (Indian spice seasoned laver), La (anchovy-fortified laver), Ls (shrimp-fortified laver), and a commercial laver as control. Protein-fortified lavers showed the highest protein content (44.13 ± 0.90% to 45.79 ± 0.12%), while Li exhibited the highest ash content (15.66 ± 0.31%). Physicochemical properties, antioxidant activity, FTIR, ICP-MS, and sensory attributes were assessed. Li showed superior antioxidant activity (75.24 ± 0.32%) and phenolic content (0.79 ± 0.004 mg GAE/g). FTIR confirmed the presence of amide and lipid groups, and heavy metal levels were within safe limits. Sensory evaluation indicated a preference for Li, while Ls was favoured over La among fortified samples. Anchovy-fortified laver showed high levels of essential amino acids, including leucine (21.91 ± 0.01 mg/g), methionine (13.13 ± 0.04 mg/g), and histidine (17.89 ± 0.47 mg/g).

FFN 22

FUCOIDAN AS A NUTRACEUTICAL IN AQUACULTURE: GLOBAL RESEARCH TRENDS FROM BIBLIOMETRIC ANALYSIS (2000–2025)

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Fucoidan, a sulphated polysaccharide derived from brown seaweeds, is gaining increasing attention, particularly in the aquaculture sector. Between 2000 and 2025, approximately 2,476 publications have reported on fucoidan supplementation in fish. Scientific documentation on fucoidan use in aquaculture shows a steady upward trend, especially from 2010 to 2024, highlighting growing interest in seaweed-derived sulphated polysaccharides as bioactive dietary supplements. Most publications on the utilisation of fucoidan as a dietary additive originate from South Korea, Portugal, Egypt, India, and Iran. Available studies mainly focus on the effects of dietary fucoidan on immunity and disease resistance, followed by growth and nutrition, with comparatively limited emphasis on stress mitigation. The major fish species studied include Nile tilapia, red sea bream, large yellow croaker, carps, and zebrafish, indicating a predominance of tropical species. Studies consistently demonstrate that fucoidan supplementation enhances growth performance, often in a dose-dependent manner. Fucoidan also acts as a potent immunostimulant by increasing serum lysozyme activity, respiratory burst, and phagocytic capacity, thereby improving survival against pathogens such as *Aeromonas hydrophila*. In addition, fucoidan enhances antioxidant defence by elevating superoxide dismutase and catalase activities while reducing lipid peroxidation, mitigates toxicity from contaminants such as aflatoxin B1 and chlorothalonil, and improves intestinal health and gut microbiota composition. Collectively, these attributes highlight fucoidan as a sustainable and effective functional additive for modern aquaculture systems. However, the aquaceutical effects of dietary fucoidan are closely linked to its structural composition, particularly fucose and sulphate content, highlighting the crucial role of extraction methods in determining efficacy.

FFN 23

FOOD APPLICATIONS OF *Kappaphycus*: A REVIEW ON CARRAGEENAN AND FUNCTIONAL PROPERTIES

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Kappaphycus spp. (Rhodophyta) is a red seaweed widely cultivated in tropical coastal regions and valued for its nutritional and industrial significance. Carrageenan, a structurally diverse sulphated polysaccharide derived from the cell walls of these algae, has attracted considerable attention due to its functional and technological properties, making it a key ingredient in the food industry. This review summarizes current knowledge on the food applications of *Kappaphycus*, with emphasis on carrageenan types, functional properties, nutritional composition, and technological relevance. Three major forms of carrageenan kappa (κ), iota (ι), and lambda (λ) are found in red algae, with *Kappaphycus alvarezii* serving as the primary commercial source of κ-carrageenan. Owing to its gelling, thickening, stabilizing, and emulsifying properties, κ-carrageenan is extensively used in dairy, meat, seafood, bakery, confectionery, and beverage products, where it improves texture, quality, and shelf life. In addition, *Kappaphycus* contains bioactive compounds, dietary fibre, essential minerals, and antioxidants, enhancing its potential as a functional food ingredient. Recent developments in edible and biodegradable packaging films derived from seaweed hydrocolloids are also discussed, highlighting their favourable gas barrier and mechanical properties. Furthermore, the role of *Kappaphycus* in supporting sustainable food production is emphasized, given its low input requirements and minimal environmental footprint.

FFN 24

Ulva lactuca BASED FUNCTIONAL HYDRATION DRINK: A SUSTAINABLE MARINE APPROACH TO ELECTROLYTE AND MICRONUTRIENT REPLENISHMENT

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The increasing demand for natural, non-stimulant functional beverages has intensified interest in marine derived ingredients combined with traditional medicinal herbs and probiotics. The present study reports the formulation and quality assessment of a probiotic enriched,marine herbal functional health drink developed using *Ulva lactuca* as a mineral and dietary fiber rich base, supplemented with ginger (*Zingiber officinale*), tulsi (*Ocimum tenuiflorum*), and amla (*Phyllanthus emblica*). *Ulva lactuca* biomass was subjected to standardized pre-treatment, followed by aqueous infusion for the extraction of minerals and ulvan rich polysaccharides. Ginger and tulsi extracts were incorporated during the infusion stage to enhance digestive functionality and sensory acceptability, probiotic fermentation was carried out using lactic acid bacteria. Amla extract was added post-fermentation to enhance vitamin C content and antioxidant potential. In addition to formulation, a comprehensive shelf-life study was conducted under refrigerated storage conditions (4 ± 1 °C) to evaluate microbiological safety, probiotic viability, physicochemical stability, and nutritional retention over time. Key parameters assessed included pH, titratable acidity, total soluble solids, probiotic lactic acid bacteria counts, total plate count, yeast and mold count, coliforms, and changes in vitamin C and mineral content during storage. The product maintained microbiological safety and acceptable physicochemical quality throughout the refrigerated storage period, with probiotic counts remaining within functional ranges for a defined shelf life. The study demonstrates the feasibility of integrating marine macroalgae, selected medicinal herbs, and probiotics to develop a non-stimulant, micronutrient-dense functional beverage with defined shelf-life stability

FFN 25

BROWN SEAWEED *Sargassum tenerrimum*–MEDIATED SILVER NANOPARTICLES: A PROMISING NUTRACEUTICAL APPROACH

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Seaweeds are increasingly recognized as functional foods and sources of nutraceuticals due to their rich bioactive composition and health-promoting properties. In this study, silver nanoparticles (AgNPs) were green-synthesized using the aqueous extract of the brown seaweed *Sargassum tenerrimum* and evaluated for their nutraceutical potential through antimicrobial and antidiabetic in vitro assays. The formation of AgNPs was confirmed by UV–Visible spectroscopy, Fourier Transform Infrared (FT-IR) spectroscopy. Scanning Electron Microscopy (SEM). The biosynthesized AgNPs exhibited broad-spectrum antimicrobial activity against food- and health-related pathogens, including Gram-negative (*Pseudomonas aeruginosa* and *Escherichia coli*) and Gram-positive (*Bacillus cereus* and *Staphylococcus aureus*) bacteria. Cytotoxicity studies demonstrated that the nanoparticles were biocompatible and non-toxic at lower concentrations. In antidiabetic evaluation, AgNPs significantly enhanced glucose uptake in L6 myotube cells in a dose-dependent manner. These findings highlight the potential of *S. tenerrimum*-derived nanoparticles as a value-added nutraceutical ingredient supporting the role of seaweeds in functional food development.

FFN 26

AGAR AND ALGINIC ACID CONTENT FROM RHODOPHYCEAE AND PHAEOPHYCEAE SPECIES AVAILABLE ON THE GUJARAT COAST

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The Gujarat coast is a rich seaweed habitat dominated by Rhodophyceae and Phaeophyceae, important sources of agar and alginate. Overexploitation of natural stocks has reduced wild populations, creating the need to identify high-yielding alternative species. Phycocolloid yield and quality are influenced by environmental factors such as salinity, temperature, and nutrient levels, making regional evaluation essential for sustainable utilization. This study estimated agar and alginic acid content in seaweeds collected from the intertidal region, with samples processed in triplicate. Agar from red algae was extracted, while alginic acid from brown algae with yields calculated on a dry weight basis. Standard extraction procedures were followed to ensure consistency and accuracy of yield estimation. Among red algae, *Gracilaria edulis* showed the highest agar yield, whereas *Erythrocladia irregularis* had the lowest. Of brown algae, *Sargassum wightii* recorded maximum alginic acid yield, and *Iyengaria stellata* the minimum. The study reveals significant interspecific variation and identifies promising species for sustainable commercial utilization.

FFN 27

COMPARATIVE EVALUATION OF KAPPA-CARRAGEENAN AS A FUNCTIONAL MARINE HYDROCOLLOID IN BISCUITS, WHITE BREAD, AND BUNS: IMPACT ON NUTRITIONAL, TEXTURAL, AND STRUCTURAL PROPERTIES

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Kappa carrageenan, a hydrocolloid of marine origin from the seaweed *Kappaphycus alvarezii*, is a multifunctional additive used in biscuits, white bread, and buns, improving the fiber and mineral content. Comparing the studies reveals that 6% kappa carrageenan is optimal for biscuits to give 20.57% dietary fiber, with hardness levels increased from 16.06 N to 33.3 N to extend the shelf-life to 63 days. A 4% addition to white bread gives 9.40% fiber and significantly improves minerals such as magnesium by 188%, potassium by 77%, while slightly decreasing the hardness of the crumb from 92.6 N to 92.3 N. Buns require 6% levels to attain a sensorial perception, yielding 32.40% moisture and 2.46% fiber, with a 7-day shelf-life. Regardless of the bread type, kappa carrageenan improves the oxidative stability of the bread, with 33% DPPH content in buns and 33% DPPH content, as well as 0.63mg GAE/100g phenolic compounds in the biscuits, with the pore areas increasing from 172.97 mm² to 464.97 mm². These results indicate that while an improvement in nutritional profile and water retention is consistently accompanied by kappa-carrageenan hydration, the textural effect is two-fold: reinforcement in biscuits and softening in bread.

FFN 28

INDIAN BROWN SEAWEEDS AS SUSTAINABLE MARINE RESOURCES FOR FUNCTIONAL FOODS AND NUTRACEUTICALS

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Indian brown seaweeds (Phaeophyceae) are a sustainable and renewable marine resource with great potential for developing functional foods and nutraceutical products. Widely distributed along the Indian coastline, genera such as *Sargassum*, *Turbinaria*, *Padina*, *Dictyota*, and *Spatoglossum* are rich in important nutrients and contain diverse bioactive compounds. Brown seaweeds have a number of interesting properties: they contain valuable bioactive compounds, including polysaccharides such as (fucoidan, laminarin, and alginates), carotenoids (fucoxanthin), sterols, polyunsaturated fatty acids, peptides, vitamins and minerals, all of which collectively contribute to their health-promoting properties. Numerous studies have shown that bioactives derived from Indian brown seaweeds exhibit a wide range of biological activities, including antioxidant, anti-inflammatory, anti-microbial, anti-diabetic, anti-obesity, anti-cancer, and immunomodulatory effects. Their incorporation into food systems offers promising opportunities for clean-label functional ingredients and natural nutraceutical formulation. Additionally, the sustainable use of biomass from brown seaweed supports the global interests towards marine-based health products and development of blue economy. However, challenges such as variability in chemical composition, limited bioavailability, potential safety risks associated with excessive accumulation of iodine and heavy metal, as well as lack of standardization and regulatory guidelines remain key barriers to the commercialization of these products. This review provides a comprehensive overview of the bioactive composition, therapeutic potential, functional food applications, and future prospects of Indian brown seaweeds, emphasizing their role as sustainable marine resources for improving human health and supporting nutraceutical innovations.

FFN 29

ACTIVE BIO-GLAZING: A SEAWEED BASED EDIBLE CONCEPT FOR IMPROVING FROZEN FISH QUALITY

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Frozen fatty fish often lose quality during storage due to lipid oxidation and freezer burn, leading to rancid odor, dehydration, and reduction in nutritional value. Conventional ice glazing is widely used to reduce moisture loss, but it provides only physical protection and does not actively prevent oxidative deterioration. This abstract proposes an innovative concept called active bio-glazing; an edible protective coating developed from seaweed-derived materials. The proposed bio-glaze uses alginate or carrageenan as a natural film-forming base combined with seaweed antioxidants such as phlorotannins. When applied as a thin coating on frozen fish, the layer is expected to function as both an oxygen barrier and a natural antioxidant system that helps slow the oxidation of omega-3 fatty acids. By converting a passive ice glaze into a functional preservation layer, this concept aims to improve sensory quality, maintain nutritional stability, and extend frozen shelf life. The key innovation of this proposal is the integration of edible seaweed film technology with active antioxidant protection specifically designed to replace conventional ice glazing in seafood processing. This idea is supported by existing research on seaweed-based edible films and marine antioxidants in food preservation. The concept also aligns with blue economy principles by utilizing renewable marine biomass for sustainable and value-added seafood processing.

FFN 30

SEAWEED BASED NUTRITIONAL SUPPLEMENTATION FOR PERFORMANCE ENHANCEMENT IN ATHLETES: A PROSPECTIVE MULTI-DISCIPLINARY RESEARCH SECTOR IN INDIA

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Application of seaweeds or macro-algae in athletic performance is a burgeoning area of research interest globally due to their rich nutritional profile. It contains potent antioxidants such as polyphenols, flavonoids, carotenoids and sulfated polysaccharides, which have strong free radical scavenging activity and the ability to enhance antioxidant defenses. Seaweeds also contains plenty of nutrients, including iodine, protein, vitamins, minerals, fiber and antioxidants that suits an athlete's diet, which can support athletic performance. The use of seaweed derived supplements has gained increasing attention in sports nutrition due to their potential to support metabolic regulation. Consumption of seaweeds can also support recovery and immune function in athletes. Practical application of seaweeds can be integrated into sports nutrition in various forms, including supplements, snacks and food additives and can consume in dried form, as powders, or in ready-to-eat products. Nutrient Nutritional benefits of seaweeds can help athletes to maintain energy levels, improve recovery times and enhance overall health. While the potential benefits of seaweeds in sports health are promising, further multidisciplinary research including biology, biochemistry, physical education and medical aspects is needed to explore their efficacy, particularly in the context of athletic performance. In India, such research is in infant stage. Future studies should focus on the most beneficial and the long-term effects of supplementation on the enhancement of athletic performance and health. Their rich nutrient composition and bioactive properties make them a valuable addition to sports nutrition, supporting energy levels, recovery and overall well-being in athletes.

FFN 31

INCORPORATION OF BROWN SEA WEED (*Sargassum wightii*) AND EARTHWORM AS SUSTAINABLE INGREDIENTS FOR HIGH-PROTEIN AND FUCOIDAN RICH FUNCTIONAL FISH FEED

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The growing demand for sustainable aquaculture has created an urgent need for alternative feed ingredients that reduce dependence on conventional fish meal while enhancing nutritional and functional properties. This study focuses on the incorporation of brown seaweed *(Sargassum wightii)* and earthworm meal as sustainable ingredients in the formulation of a high-protein, fucoidan-rich functional fish feed. Earthworm meal serves as an excellent source of high-quality protein, essential amino acids, and minerals, making it a viable substitute for fish meal. *Sargassum wightii*, abundantly available along the Indian coastline, is rich in bioactive polysaccharide such as fucoidan, which exhibit immunostimulatory, antioxidant, and growth-promoting properties. The goal of combining terrestrial and marine bioresources is to support environmentally sustainable aquaculture methods while strengthening immunological response, improving fish growth performance, and improving feed nutritional quality. This functional feed formulation uses underutilized and renewable natural resources, which is consistent with the concepts of the circular bioeconomy. Seaweeds play a vital role in sustainable aquaculture due to their rapid growth, high nutrient content, and minimal requirement for external inputs. The study emphasizes the potential of earthworm and *Sargassum wightii* as affordable, environmentally acceptable substitutes for the creation of next-generation functional aquafeed.

FFN 32

SEAWEED-FORTIFIED READY-TO-COOK PANCAKE MIX: DEVELOPMENT AND SENSORY EVALUATION

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The present study aimed to develop a nutritionally enriched ready-to-cook pancake mix incorporating the edible red seaweed *Kappaphycus alvarezii.* Three formulations were prepared using combinations of wheat with ragi and oats, wheat with ragi, and wheat with oats, each were fortified with seaweed powder with a concentration of 2%,3%,5%. Sensory evaluation was conducted to assess appearance, texture, flavour, taste, and overall acceptability. Among the formulations, the wheat–ragi–3% concentration seaweed blend obtained the highest sensory in a 9-point hedonic scale scores, particularly for its soft texture, improved mouthfeel, and overall acceptability. Incorporation of seaweed significantly enhanced the dietary fibre and mineral content of the product, thereby improving its functional properties. The study demonstrates the feasibility of utilizing *Kappaphycus alvarezii* in cereal-based convenience foods to develop value-added functional products with enhanced nutritional benefits.

FFN 33

FORMULATION AND SENSORY EVALUATION OF *Kappaphycus alvarezii*-ENRICHED WAFFLE MIX

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The increasing demand for functional foods has encouraged the development of nutrient-enriched convenience products that support balanced nutrition and improved health. In this study, a ready-to-cook seaweed waffle mix was developed using *Kappaphycus alvarezii*, a red seaweed rich in minerals, dietary fibre, and bioactive compounds. Three formulations (250 g each) were prepared with varying levels of seaweed powder (2%, 3%, and 5%) combined with cereal bases comprising wheat flour blended with oats and/or ragi. Batter consistency was optimized through controlled addition of milk and water, followed by a resting period prior to cooking in a waffle maker. Sensory evaluation assessed appearance, texture, flavour, and overall acceptability using 9-point hedonic scale scores. The formulation containing 5% seaweed powder with a wheat and oats base demonstrated superior sensory characteristics, particularly in taste and texture, without imparting undesirable marine flavour. As seaweed is known for its high mineral and dietary fibre content, increasing levels of incorporation further enhance the functional and nutritional properties of the developed product.

FFN 34

MARINE MEETS NATURE: DEVELOPMENT OF NUTRIENT-RICH SEAWEED-INFUSED DATES AND NUT BITES

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The increasing demand for functional and nutrient-enriched snack foods has encouraged the incorporation of marine bioresources into conventional food formulations. The present study aimed to develop seaweed-infused dates nut bites as a value-added functional snack using *Kappaphycus alvarezii* as the fortifying ingredient. Dates were selected as the base material due to their natural sweetness and binding properties, while nutritionally rich ingredients such as almond, pistachio, walnut, cashew, and sesame seeds were incorporated to enhance the overall nutritional profile. Seaweed powder derived from *Kappaphycus alvarezii* was added at varying concentrations of 0%, 5%, 10%, and 15% to evaluate its effect on sensory attributes and consumer acceptability. The dates nut bites were prepared by uniformly blending all ingredients and shaping them into bite-sized portions. Sensory evaluation was conducted to assess appearance, texture, flavour, taste, and overall acceptability. The results indicated that seaweed incorporation significantly influenced the sensory characteristics of the product. Among the different treatments, the formulation containing 10% *Kappaphycus alvarezii* was found to be the most acceptable, exhibiting balanced taste, desirable texture, and improved overall palatability. Lower levels of seaweed showed limited functional improvement, while higher inclusion levels resulted in a slightly dominant seaweed flavour that reduced sensory scores. The study demonstrates that controlled incorporation of *Kappaphycus alvarezii* can enhance the functional potential of dates-based nut bites without adversely affecting sensory quality. The developed product offers a promising ready-to-eat functional snack enriched with dietary fibre, healthy fats, and bioactive compounds, while also promoting the sustainable utilization of marine resources.

FFN 35

A NOVEL FUNCTIONAL BEVERAGE: SEAWEED MILKSHAKE ENRICHED AT DIFFERENT CONCENTRATIONS

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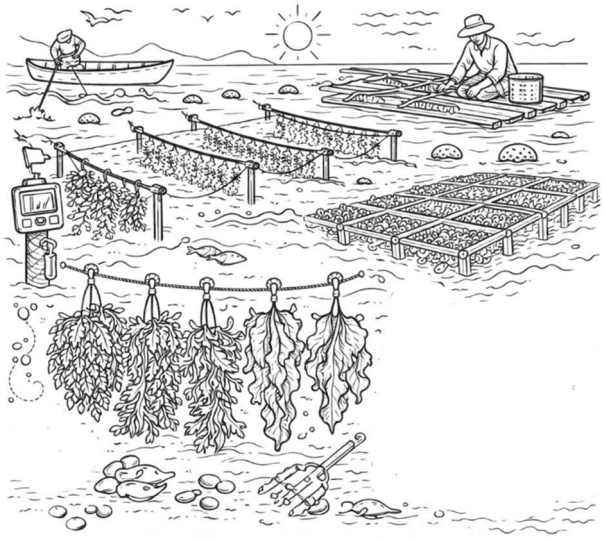
The present study aimed to develop a novel functional dairy beverage by incorporating *Kappaphycus* seaweed into a milkshake formulation at three different concentrations (0.5%, 1%, and 1.5%). *Kappaphycus* was selected due to its high carrageenan content and richness in dietary fibre, minerals, antioxidants, and bioactive compounds, making it a sustainable marine ingredient for nutritional enhancement of dairy beverages. The formulated milkshakes were evaluated for physicochemical properties, nutritional attributes, and sensory acceptability. Sensory evaluation was conducted using a 9-point hedonic scale to assess colour, flavour, texture, mouthfeel, and overall acceptability. Increasing *Kappaphycus* concentration resulted in a progressive enhancement of dietary fibre and mineral content while maintaining acceptable viscosity and appearance. Milkshakes containing 0.5% and 1% *Kappaphycus* recorded higher hedonic scores, whereas the 1.5% formulation exhibited increased thickness that slightly affected mouthfeel and consumer preference. The study demonstrates the potential of carrageenan-rich *Kappaphycus* in developing value-added functional dairy beverages with enhanced nutritional benefits and good consumer.



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AQU 01

SEAWEED-DRIVEN NUTRIENT RECYCLING AND BIOMASS VALORIZATION IN SHRIMP AQUACULTURE: AN IMTA APPROACH USING *Gracilaria foliifera*

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The rapid intensification of *Penaeus vannamei* farming has raised serious environmental concerns due to nutrient accumulation, declining water quality, and stress-related health issues in shrimp. Integrated multitrophic aquaculture (IMTA) using seaweeds as inorganic extractive species offers a sustainable solution by recycling nutrients while enhancing productivity. This study evaluated the co-culture potential of red seaweeds, particularly *Gracilaria foliifera* and *Kappaphycus alvarezii*, with *P. vannamei* under zero-water exchange and pond-based semi-intensive systems along the Maharashtra coast. Optimization trials identified an optimal *G. foliifera* stocking density of 1–3.5 g L^{-1}. Subsequent co-culture experiments with varying shrimp densities (20–100 nos. m^{-2}) revealed that stocking *P. vannamei* at 20–60 nos. m^{-2} with *G. foliifera* (3.5 g L^{-1}) resulted in significantly higher growth performance, yield, and feed efficiency compared to monoculture, while maintaining stable water quality. Pond-based trials further confirmed enhanced nutrient removal (49–77% for nitrogenous compounds), improved shrimp growth (weight gain up to 812.7%, SGR up to 3.94% day^{-1}), and reduced physiological stress, and normal hepatopancreatic histology in co-cultured shrimp. While *K. alvarezii* exhibited higher biomass increment, *G. foliifera* consistently outperformed in nutrient remediation and shrimp health enhancement. Co-cultured seaweeds showed improved proximate composition and elevated phenolic content with higher antioxidant activity compared to wild-harvested samples. Overall, the co-culture of *P. vannamei* with *G. foliifera* emerges as an effective IMTA strategy that enhances environmental sustainability, shrimp welfare, and secondary biomass value, offering a scalable solution for eco-friendly shrimp aquaculture aligned with Sustainable Development Goals.

AQU 02

A COMPARATIVE STUDY ON GROWTH OF *Kappaphycus alvarezii* CULTIVATED IN CIRCULAR AND SQUARE RAFTS

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In India*, Kappaphycus alvarezii* (Doty) is the sole alga being commercially cultivated for *kappa* carrageenan production and is utilized for the socioeconomic upliftment of coastal rural population. Annual import for carrageenan is 1800–2000 M tons year^{-1} and its demand is reported to be increased by 5–6% every year in India. There is tremendous demand for κ-carrageenan in food, beverage, and consumer product manufacturing industries because of its thickening and stabilizing natures. Currently, commercial farming is widely carried out in the following three methods, namely floating bamboo raft, tube net, and monoline method. SRAF™ Circular HDPE rafts are floating structures with round framework, bracing and horizontal pipes with their geometry allowing enhanced water circulation both around and beneath the raft. This configuration optimized the delivery of nutrients, enhanced survival in rough waves and ensured more consistent light exposure, supported robust seaweed development. The circular raft design can hold fourfold quantity of seaweeds than commercial (2X2) square rafts, making it equivalent to four (2X2) square rafts. It is space-efficient and suitable for large-scale farming in deeper waters. It remained structurally stable during monsoon and supported both horizontal and vertical cultivation. Its hydrodynamic shape reduced epiphyte load, grazing, and drifting losses, while enabling co-culture of upto four seaweed species simultaneously, thereby increasing productivity and overall system sustainability. Comparison of cultivation experiments of *K. alvarezii* were carried out using the SRAF circular raft and conventional square bamboo raft in Munaikadu trials over three cycles to check the efficiency in growth and carrageenan properties of *K. alvarezii.* The circular raft consistently outperformed the square raft, achieving an average daily growth rate (DGR) of 3% per day across three 35-day cycles compared to 2% per day for the three 45-day cycles in square raft. Yield (kg) per metre in the circular raft reached 3.3 kg /m (Cycle I), 3.2 kg/m (Cycle II), and 3.7 kg/m (Cycle III), resulting in a four-fold biomass increase, whereas the square raft showed only 2.5-to-3-fold increases.

AQU 03

SEEDLING PRODUCTION FOR COMMERCIALLY IMPORTANT RED ALGA *Gracilaria debilis* (FORSSKÅL) BØRGESEN.

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Red algal genera *Gelidium*, *Gelidiella*, *Pterocladia*, *Gracilaria* are the principal source of agar. Among the phycocolloids, agar had higher retail prices (US$18 kg−1) while compared to other seaweed hydrocolloids such as alginates (US$12 kg−1) and carrageenans (US$10.4 kg−1). Globally Agar manufacturing industries annually consume over 1,25,200 dry tons of agarophytes to produce 14500 t of agar. Agar having a market value of US$246 million (Porse and Rudolph, 2017). World's agar production is mainly depended on genus *Gracilaria* which share 91% raw material for agar production. In India, 32 *Gracilaria* species reported and *Gracilaria* edulis being utilized for food grade agar production. *Gracilaria debilis* is an economically important red algae rarely distributed in India and yielded pharmaceutical grade agar and through its commercial cultivation, a fisherman will earn Rs11,000-13,000/month (Veeragurunathan et al. 2019). In order to produce a large number of seedlings in short period of time, clonal propagation technique was deployed. Seedlings of *G. debilis* was made into 2, 2.5, and 3cm sizes were made from the mother plants of *G. debilis,* which grown for 90 days using net bag method in open sea. Daily growth rates (DGR), Extensive growth rate (EGR) and Survivability rate were measured in 30, 45, 60 and 90 days. Among three different sized seedlings studied, 3cm fragments showed maximum 3.5% of DGR, 5.52% of EGR and 95% of survivability rate. After 90 days, grown seedlings were tied in 1x1m floating raft and cultivated for 45 days and harvested. 1.6% DGR and 1.2 kg. fr. wt/m^2 biomass yield was reported.

AQU 04

TURNING LOSS INTO SEEDSTOCK: HATCHERY-BASED DEVELOPMENT OF DISLODGED *Sargassum aquifolium* GERMLINGS IN THE PHILIPPINES

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Seedstock loss during early recruitment remains a major constraint in *Sargassum* aquaculture, limiting the development of resilient seaweed value chains. In *Sargassum aquifolium*, dislodged germlings typically fail to reattach, resulting in high mortality and reduced nursery efficiency. This study presents preliminary observations on sustaining the growth of dislodged germlings under controlled hatchery conditions in Northern Mindanao, Philippines. Fertile receptacles were induced to release gametes, yielding approximately 70,000 eggs from 200 receptacles. Zygotes settled within 48 hours and developed rhizoids; however, about 20% of germlings were dislodged during water management. These dislodged germlings were cultured in floating systems and remained viable, with higher growth rates observed in aerated 500-L conical tanks (0.009 mm day−1) compared to static glass jar cultures (0.003 mm day−1). Epiphyte accumulation constrained growth in non-aerated systems. The results demonstrate the potential of floating hatchery systems to recover otherwise lost germlings, improving nursery efficiency and seedstock availability. This approach supports climate-adaptive *Sargassum* cultivation by reducing production losses, enhancing resource-use efficiency, and contributing to sustainable blue economy pathways. Further optimization and scale-up are needed to integrate this strategy into commercial nursery operations.

AQU 05

HARNESSING *Sargassum* REPRODUCTIVE BIOLOGY TO ADVANCE SUSTAINABLE MARICULTURE AND BLUE ECONOMY PATHWAYS IN NORTHERN MINDANAO, PHILIPPINES

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Sargassum supports major seaweed value chains but faces increasing harvesting pressure in the Philippines. This study examined the reproductive biology and cultivation potential of four *Sargassum* species to guide climate-resilient mariculture in Naawan, Northern Mindanao, Philippines. Morphological analysis identified two monoecious species (*Sargassum aquifolium* and *S. ilicifolium*) and two dioecious species (*S. carpophyllum* and *Sargassum* sp.), with monoecious taxa exhibiting greater reproductive flexibility. All species released eggs between 20–30 °C, with *Sargassum* sp. showing the highest desiccation tolerance (95% egg release after 60 min). Nutrient enrichment suppressed egg release across species. Monoecious species tolerated a broader salinity range (20–40 PSU), although all species exhibited optimal performance at ambient salinity (30–32 PSU). Among the four species, *S. ilicifolium* recorded the highest fecundity (2.33 million eggs; 622 eggs receptacle−1) and germination rate (99.07%), followed by *S. aquifolium* (1.13 million eggs; 855 eggs receptacle−1; 94.18%), *S. carpophyllum* (0.73 million eggs; 345 eggs receptacle−1; 66.64%), and *Sargassum* sp. (0.38 million eggs; 500 eggs receptacle−1; 67.75%). Reproductive structures from the mid-sections of primary branches (B1–B2) contributed most to high fecundity and germination. Settlement was higher in *S. aquifolium*, *S. ilicifolium*, and *S. carpophyllum* (11.2–14.3%) and lowest in *Sargassum* sp. (5.1%). Recruitment varied by substrate, with *S. ilicifolium* favoring jute twine (9.8–17.0 ind cm−2), *S. aquifolium* performing best on wool yarn (7.0–9.8 ind cm−2), and *S. carpophyllum* and *Sargassum* sp. preferring clay bricks (3.45 and 3.0 ind cm−2, respectively). These findings provide species- and substrate-specific benchmarks for hatchery seedstock production, reducing reliance on wild stocks and supporting climate-adaptive *Sargassum* mariculture within sustainable blue economy pathways.

AQU 06

OPTIMIZING SEEDLING LOGISTICS FOR THE SEAWEED VALUE CHAIN: EFFECTS OF TRANSPORTATION DURATION ON THE GROWTH AND HEALTH OF RED SEAWEED *Kappaphycus striatus*

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Seaweed farming drives the blue economy in Tawi-Tawi, Philippines, yet the need for inter-island transport frequently subjects propagules to desiccation and handling stress. This study evaluated how transportation duration (0, 12, 24, 36, and 48 hr) influences the specific growth rate (SGR), ice-ice disease incidence, and dry yield of *Kappaphycus striatus*. Using a modified fixed-off bottom method over a 30-day cultivation cycle, results showed that transport time significantly impacted SGR at Day 10 and Day 30 ($p < 0.05$). The control group (0 hr) achieved the highest growth at 4.61 ± 0.18%, whereas the 48-hr group fell to just 0.93 ± 0.49% by the trial's end. Notably, growth rates stabilized at Day 20 across all treatments, suggesting a mid-cycle physiological plateau. However, ice-ice disease was most prevalent during the first week and at Day 20 ($p < 0.05$). Propagules transported for 48 hr reached 100% disease occurrence within just four days, highlighting acute stress. While disease levels eventually leveled off between Day 10 and Day 30—indicating some capacity for recovery—transportation exceeding 24 hours ultimately caused a 62.7% reduction in SGR compared to the control. These results demonstrate that seedling logistics must be restricted to a 24-hour window to maintain propagule vigor. Shortening shipment times and establishing recovery protocols are vital for securing yields and stabilizing the seaweed value chain in remote island provinces.

AQU 07

UTILIZATION OF *Ulva lactuca* AS A NATURAL FLOCCULATING AGENT IN BIOFLOC SYSTEM

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Biofloc Technology (BFT) relies on the efficient aggregation of microorganisms and organic matter to maintain water quality and provide supplemental nutrition. While traditional carbon sources facilitate microbial growth, they often lack the structural properties required for optimal aggregation. The present study evaluates the efficacy of seaweed (*Ulva lactuca*) powder as a novel, eco-friendly flocculating agent using three critical indicators: flocculating ability, floc volume (FV), and total heterotrophic count (THC), leveraging its natural hydrocolloids properties to enhance the physical and biological characteristics of biofloc. The results demonstrated that seaweed powder has improved flocculating ability, producing denser and more stable aggregates compared to traditional carbohydrate (Jaggery)-based controls. Additionally, the complex polysaccharides present within the seaweed increased the floc volume in seaweed based biofloc system. Furthermore, the seaweed-enriched treatments exhibited a significantly higher Total Heterotrophic Count, suggesting that the powder provides a superior surface area and nutritional substrate for beneficial bacteria, thereby enhancing ammonia-nitrogen remediation. Hence, incorporating seaweed powder into biofloc systems offers a dual benefit: improving the physical architecture of the flocs and stimulating heterotrophic growth. This research highlights seaweed powder as a sustainable alternative to synthetic flocculants, promoting a circular economy approach in high-intensity aquaculture.

AQU 08

PHYSIOLOGICAL AND METABOLIC MODULATION IN PEARL SPOT (*Etroplus suratensis*) FED DIETS SUPPLEMENTED WITH BROWN MACROALGA *Sargassum wightii*

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The present study evaluated the effects of graded dietary inclusion of the brown macroalga *Sargassum wightii* on growth performance, digestive efficiency, muscle nutrient deposition, and blood biochemical responses in the Pearl spot (*Etroplus suratensis*), a commercially important brackish-water cichlid. A 90-day feeding trial was conducted using 200 healthy juveniles (initial weight ~6 ± 0.5 g), randomly assigned to five iso-nitrogenous and iso-caloric diets containing *S. wightii* at 0% (control), 5%, 10%, 15%, and 20% inclusion levels. Fish fed the 5% *S. wightii* diet exhibited significantly improved ($p < 0.05$) growth performance, survival, and feed efficiency, whereas higher inclusion levels resulted in reduced growth. Muscle proximate composition showed significantly elevated protein, lipid, carbohydrate, ash, and moisture contents in the 5% group, indicating enhanced nutrient assimilation. Digestive enzyme activities (protease, amylase, and lipase) were also significantly improved at moderate inclusion levels. Blood biochemical analysis revealed balanced serum protein, albumin, and globulin levels, reduced creatinine, and stable urea concentrations in fish fed the 5% diet, reflecting improved metabolic and renal status. Lipid profile parameters showed favourable modulation at moderate inclusion, while excessive inclusion (20%) resulted in elevated cholesterol and LDL levels. Increased GPT and GOT activities at higher inclusion levels suggested metabolic stress. Overall, dietary inclusion of *S. wightii* at 5% optimally enhanced growth, digestive capacity, and physiological homeostasis, highlighting its potential as a functional feed ingredient for sustainable aquaculture.

AQU 09

IMPACT OF ICE-ICE DISEASE ON THE MINERAL CONTENT OF RED SEAWEED *Eucheuma denticulatum*

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The cultivation of red seaweed, specifically *Eucheuma denticulatum*, is a vital component of the blue economy in the Philippines, yet it remains highly susceptible to ice-ice disease. This study investigated the shifts in mineral and heavy metal composition associated with ice-ice infection in samples collected from seaweed farms in Sibutu, Tawi-Tawi, Philippines. Healthy and infected thalli were analyzed using inductively coupled plasma optical emission spectrometry (ICP-OES, PerkinElmer, Optima 2100 DV) to quantify concentrations of macro-elements (K, Na, Ca, Mg, P, S) and trace metals (Mn, Zn, Cu). Statistical analysis using an independent samples t-test revealed significant physiological disruptions in diseased tissues. A highly significant loss ($p < 0.05$) of Potassium (K) was observed in infected samples (728.37 ± 39.61 ppm) compared to healthy thalli (1016.30 ± 42.26 ppm). Similarly, Sodium (Na) levels significantly declined ($p < 0.05$), indicating a collapse of cellular membrane integrity and the subsequent leakage of essential osmolytes. Conversely, infected tissues exhibited a highly significant ($p < 0.05$) accumulation of Calcium (Ca) (19.70 ± 0.37 ppm) relative to healthy samples (15.67 ± 0.39 ppm), likely reflecting stress-induced physiological responses or structural alterations in the carrageenan matrix. No significant differences ($p > 0.05$) were detected for Magnesium, Phosphorus, Sulphur, or trace metals such as Manganese, Zinc, and Copper. These findings suggest that ice-ice disease primarily targets electrolyte homeostasis in *E. denticulatum*. Understanding these elemental shifts is crucial for developing diagnostic markers for early disease detection and for maintaining the quality of seaweed value chains amid climate-induced stressors.

AQU 10

EFFECT OF INCLUSION OF *Gracilaria tenuistipitata* MEAL ON THE GROWTH PERFORMANCE OF *Penaeus monodon*

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This study assessed the potential of red seaweed, *Gracilaria tenuistipitata* as a dietary ingredient and evaluated its effect on the growth performance of *Penaeus monodon* at the post- larval stage. Seaweeds collected from its natural habitats were analyzed for their proximate composition, amino acid profile, fatty acid profile, and mineral content prior to the experiment. The amino acid profile of *G. tenuistipitata* revealed that it is a good source of essential amino acids like threonine, phenylalanine, isoleucine, lysine, and methionine. The seaweed revealed higher content of palmitic acid and C20:3n3 among saturated and unsaturated fatty acids, respectively. Mineral analysis showed high levels of macro-minerals (Mg, Ca, K, Na) and trace minerals (Al, Si, Fe, Mn), with lower amounts of Cu and selenium without any traces of toxic elements like Cd, As, Pb. Four isocaloric and isonitrogenous experimental diets were formulated which contain 43% crude protein and 4.5% crude lipid, with the experimental feeds contained seaweed meal at 0%, 1.5%, 3%, and 4.5%. Results of the 45-day feeding trial indicated that shrimp survival (97.5 ± 1.4%), weight gain (464 ± 17%), and specific growth rate (8.77 ± 0.2% d-1) were significantly ($P < 0.05$) highest in the 4.5% seaweed dietary group, followed by the 3%, 1.5%, and control group. The feed conversion ratio was also significantly ($P < 0.05$) lower in the 4.5% group (1.2 ± 0.08) than other groups, indicating improved feed utilization in the shrimp. Analysis of post fed composition of experimental shrimp revealed that the protein and total ash content in the whole body were significantly ($P < 0.05$) higher in the treatment groups compared to the control. The results of the present study demonstrated that red seaweed, *Gracilaria tenuistipitata* meal has the potential for inclusion in the diet of *P. monodon* and its inclusion at 4.5% found to be optimal for improved growth performance.

AQU 11

FACADE AND ROOFTOP INTEGRATED SEAWEED FARMING: A NOVEL SYSTEM FOR SUSTAINABLE FOOD, HEAT MITIGATION, AND URBAN COMMUNITIES

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Urban environments face converging crises of food insecurity, rising temperatures, and limited green space. This study proposes a novel integrated system combining façade-mounted and rooftop seaweed cultivation to address these challenges simultaneously. Unlike conventional urban agriculture focused on land-based crops, this system leverages vertical building surfaces and unused roof areas for macroalgae production, creating a closed-loop architecture that generates food, reduces ambient temperatures, and strengthens community resilience. The proposed design utilizes modular bioreactor panels installed on building exteriors, coupled with rooftop raceway ponds or photobioreactors, creating a continuous cultivation circuit. Seaweed's high growth rates, minimal freshwater requirements, and exceptional carbon sequestration capacity make it uniquely suited for dense urban contexts. The system provides three core benefits: (1) sustainable protein and biofertilizer production with minimal land use, (2) evaporative cooling and shading effects that mitigate urban heat island intensity, and 3) opportunities for community engagement through harvesting cooperatives and educational programming. Preliminary thermal modelling suggests facade-integrated cultivation can reduce surface temperatures by 4–8°C, while lifecycle analysis indicates positive net energy balance compared to conventional building cladding. This paper presents the engineering framework, cultivation protocols for seaweed species, and a pilot implementation strategy for coastal cities. By transforming buildings from passive energy consumers into active food- producing ecosystems, this approach offers a scalable pathway toward regenerative urban development.

AQU 12

ROOFTOP REEFS: INTEGRATED SEAWEED–ORNAMENTAL FISH CULTURE FOR COASTAL PROSPERITY

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Open-sea seaweed farming along the Indian coastline frequently suffers from cyclonic disturbances, high wave energy, and poaching, resulting in 20–50% crop losses and restricting participation of smallholder and marginalized coastal communities. To address these challenges, the present study proposes RoofTop Reefs, a climate-resilient, low-cost, rooftop-based integrated cultivation system that combines ornamental seaweeds and marine fish. The system integrates aesthetically appealing seaweeds, such as *Gracilaria spp., Asparagopsis taxiformis*, and *Ulva lactuca*, with ornamental marine fish, including *Amphiprion spp*. and gobies, using a nutrient-recycling, closed-loop approach. Cultivation was carried out in 100L aerated seawater tanks maintained at optimal salinity (30–35 ppt) and temperature (25–30°C). Nutrient-rich effluent from fish tanks was diverted to seaweed tanks, where macroalgae assimilated dissolved nitrogen and phosphorus, serving as natural biofilters before the water was recirculated back to the fish tanks. The system is designed to be accessible and affordable for SHG-led micro-enterprises, generating economically sustainable dual-income streams from seaweed biomass for agar and feed applications, as well as from ornamental fish sales. Water use was reduced by nearly 90%, nutrient discharge was minimized, and additional benefits, such as carbon sequestration and educational value, were observed. Overall, this rooftop-based integrated culture model offers an environmentally sound and economically viable blue-economy pathway to support resilient coastal livelihoods under changing climatic conditions.

AQU 13

SCALING SEAWEED FARMING: THE ROLE OF NITROGEN UPTAKE KINETICS IN TROPICAL SEAWEEDS

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Tropical seaweed cultivation has become a major aquaculture activity with revenues touching $34 billion in recent years. They are efficient photosynthesizers, thereby reducing atmospheric CO_2 and fixing it as carbohydrates (up to 50% dry weight). This ability presents the possibility of using tropical seaweeds as an industrial feedstock for producing not only food ingredients, but also biomaterials, industrial chemicals and crude oil, while mitigating anthropogenic CO_2 from the atmosphere. Tropical seaweed cultivation has been carried out in the Philippines and Indonesia for more than five decades, but knowledge of crop physiology and methods of cultivation are still primitive and adaptive in nature. Understanding nutrient dynamics of seaweeds is key to developing interventions that improve farm yields. We have developed a laboratory-scale system to study tropical seaweed physiology and scaled-down nutrient measurement protocols to enable accurate estimation of nutrient uptake rates. Using these techniques, the uptake rate of ammonium by *Kappaphycus alvarezii* was found to be 29.9 µg/g SW/hr. Further, experiments with excess feeding of nitrogen confirmed the presence of an internal store to the capacity of 21.7 µg/g SW. The kinetic curve hinted at an active ammonium uptake mechanism in *Kappaphycus*. Similar protocols for both *Gracilaria salicornia, Gracilaria edulis* and *Eucheuma denticulatum* are in various stages of completion. Extension of these methods to tropical green seaweeds such as *Ulva* sp., is helping us understand differential physiological responses to prevent/mitigate fouling in ocean farms.

AQU 14

STANDARDIZATION OF INVITRO PROPAGATION OF THE COMMERCIALLY IMPORTANT RED SEAWEED *Gracilaria edulis* THROUGH TISSUE CULTURE.

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Red seaweeds of the genus *Gracilaria* are globally valued for their commercial importance, particularly as a primary source of agar and as a raw material for food, pharmaceutical, and biotechnological industries. *Gracilaria edulis*, one of the most economically significant species along the Indian coast, is traditionally propagated through vegetative fragments and natural spore production. However, these conventional methods often lead to inconsistent biomass yield, slow growth rates, seasonal limitations, and susceptibility to environmental fluctuations. To address these challenges, tissue-culture-based in vitro propagation provides a promising alternative for the year-round production of healthy, uniform, and high-quality planting material. The present project aims to standardize a reliable, reproducible, and scalable protocol for the in vitro propagation of *G. edulis* using tissue culture techniques. The study focuses on optimizing key factors such as explant selection, surface sterilization methods, nutrient media composition, growth regulator combinations, and culture conditions including temperature, salinity, photoperiod, and light intensity. Particular emphasis will be placed on achieving efficient callus induction and the subsequent regeneration of plantlets to facilitate mass multiplication independent of natural reproductive cycles. Further, the growth performance, morphology, and physiological responses of regenerated plantlets will be assessed to determine their suitability for field-level cultivation. The expected outcome is the development of a standardized tissue culture protocol capable of producing disease-free, genetically stable, and rapidly growing *G. edulis* propagules. Successful establishment of this technique will enhance seaweed farming productivity, reduce reliance on wild stocks, and ensure a consistent supply for agar-based industries. This work will also support sustainable aquaculture practices and contribute to expanding seaweed biotechnology initiatives in India.

AQU 15

SYNERGISTIC SEAWEED-SHRIMP INTEGRATION: TRANSFORMING SUSTAINABLE AQUACULTURE IN INDIA

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Seaweed, a unique bio-resource with economic. ecological, and societal applications, is gaining considerable attention globally. Seaweed farming is one of the fastest growing aquaculture sectors in the world. Even with a coastline of 11,099 km, the aquaculture production of seaweed is currently scanty in India, contributing less than one percent to the global seaweed production. However, India is one of the major producers of shrimp in the world and accordingly the commercial shrimp aquaculture has resulted in generation of large quantities of nutrient rich effluents, posing huge threat to the environment. Even though shrimp aquaculture wastewater can be treated by different methods, bioremediation involving seaweed is considered as an ecologically sustainable and economically viable option. This review explores seaweed-shrimp integration as a tool to augment seaweed production and as a bioprospecting strategy for sustainable shrimp aquaculture in India. Shrimp aquaculture wastewater can be bioremediated by integrating seaweed into shrimp farming, either by co-culture with shrimp or by monoculture of seaweed in the effluents. The integration of seaweed-shrimp culture can be carried out in different land-based aquaculture systems like pond culture, tank culture, biofloc culture, recirculatory aquaculture system etc. The pond culture can be conducted in the existing earthen shrimp ponds or other unutilized resources such as abandoned shrimp ponds, saline affected coastal soils, inland saline water etc. The integration of seaweed with shrimp aquaculture can result in optimal resource utilization, increased profitability of aquaculture practice, enhanced production of seaweed biomass and reduction of ecological footprint of shrimp aquaculture.

AQU 16

SEAWEED SEED BANKS: ENSURING SUSTAINABLE AQUACULTURE THROUGH PROPAGULE PRESERVATION

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Aquaculture of seaweeds is a growing and essential contributor to both sustainable coastal development and the development of the Blue Economy in India. Seaweed cultivation in India has a suitable area of approximately 23,970 ha. Despite the availability of such significant acreage for the cultivation of seaweeds; there exists significant barriers to scaling the cultivation efforts in the country due to an ongoing reliance on the collection of wild seedling resources. This reliance creates pressure on the local wild seabed; it also creates seasonal inconsistencies in material availability for growing operations and prevents farmers from accessing the materials necessary for year-round farming activities. The significant demand for seaweed-based products combined with an additional layer of rapidly expanding seaweed farms within India creates a severe need for the establishment of seaweed seed banks to encourage sustainable cultivation and fast-scale growth in the future. Seaweed seed banks focus on the systematic collection, preservation, multiplication, and distribution of high-quality propagules, spores, and vegetative fragments in controlled environments. The establishment of such facilities will ensure a reliable and constant supply of planting materials, support a selective breeding and strain improvement process, conserve genetic diversity and relieve harvesting pressures on wild seaweed stock. By establishing region specific seaweed seed banks, the future growth, biosecurity, and environmentally responsible farming practices required to develop an enhanced seaweed farming sector will be maximized in India.

AQU 17

ARTIFICIAL INTELLIGENCE FOR SEAWEED MONITORING: INTEGRATING DIGITAL SENSORS, MACHINE LEARNING, AND PERFORMANCE METRICS

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The rapid growth of seaweed aquaculture requires scalable and affordable monitoring systems that are responsive to both farm-level and ecosystem-level management needs. This study evaluates how artificial intelligence can integrate heterogeneous digital data streams into operational seaweed monitoring for detection and forecasting, serving as a decision support tool (DST). The review synthesizes key sensors and data sources relevant to seaweed farms, including multispectral and SAR satellite imagery, UAVs and other underwater-operated systems, in situ environmental and spectral sensors, and farm log data. It also outlines machine learning models suited to major monitoring tasks: supervised classifiers and deep segmentation networks for farm and canopy detection, regression and time series models for growth and yield prediction, and vision and spectroscopic models for health, disease, and quality assessment. The present work proposes a structured evaluation framework that spans algorithmic, operational, and management outcome metrics, combining accuracy and Intersection over Union (IoU) with spatial coverage, latency, cost-effectiveness, and contributions to management indicators. By mapping sensor-model combinations to specific monitoring objectives and constraints, the paper also identifies priority research gaps and pathways for deploying AI-enabled seaweed monitoring that supports both farm productivity and ecosystem-based management in the rapidly expanding seaweed culture sector

AQU 18

SHRIMP–SEAWEED SYNERGIES IN CO-CULTURE: GROWTH, PHYSIOLOGY, NUTRIENT DYNAMICS, AND BIOACTIVE ENHANCEMENT

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Seaweeds, with their strong bioremediation capacity, offer a sustainable solution to mitigate the impacts of shrimp farming intensification and have potential for co-culture systems. This study evaluated the co-culture of *Penaeus vannamei* with *Gracilaria foliifera* and *Kappaphycus alvarezii* in terms of growth, nutrient dynamics, physiology, and bioactive enhancement under semi-intensive pond conditions along the Maharashtra coast. A 56-day pond experiment was conducted in a completely randomised design (duplicate) with three treatments: shrimp monoculture (C), shrimp co-cultured with *K. alvarezii* (T1), and shrimp co- cultured with *G. foliifera* (T2). Seaweed monolines were stocked at 1 g/L on day 30. *Gracilaria foliifera* exhibited superior nutrient uptake, significantly reducing nitrate (up to 90.1%), nitrite (72.1%), total ammonia nitrogen (57%), and phosphate (75.1%), resulting in improved water quality. Co-cultured shrimp, particularly in T2, showed enhanced growth performance, with the highest final weight (19.13 g), weight gain (812.74%), specific growth rate (3.94% day−1), and yield (0.12 kg/m3). Physiological assessments revealed reduced oxidative stress (lower SOD and CAT levels), an improved immune status (higher serum protein, lower glucose and cortisol levels), healthier tissue histology, and higher muscle protein content compared to monoculture shrimp. While *K. alvarezii* achieved higher biomass increment (104.2%) and daily growth rate (1.19% day−1), *G. foliifera* contributed more effectively to water quality improvement and shrimp performance. Seaweeds from co-culture ponds exhibited higher crude protein, lipid content, phenolic compounds, and antioxidant activity (DPPH and FRAP) than wild-harvested samples. Overall, shrimp–seaweed co-culture enhanced growth, reduced nutrient load, improved physiological health, and enhanced seaweed bioactive potential.

AQU 19

PHOTOSYNTHESIS, LIGHT HARVESTING, AND AQUATIC ADAPTATION IN MARINE ALGAE

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Marine algae perform photosynthesis by utilizing sunlight, seawater, dissolved carbon dioxide (CO2), and minerals to produce energy-rich sugars and oxygen. Unlike land plants, seaweeds absorb CO2 and nutrients directly from seawater across their entire surface, making water chemistry and light availability central to their physiological function. Variations in external and internal water conditions strongly influence CO2 uptake, molecular movement, and biochemical balance within algal tissues. Light absorption and harvesting represent a critical area of study. Deeper-growing seaweeds maximize dim light by increasing pigment diversity, particularly phycobilins, while intertidal species regulate pigment density in response to daily and seasonal cycles of sunlight and shade. These adaptive strategies directly affect biophotonic capture, altering internal chemical pathways and energy choices. Understanding these mechanisms can guide species-specific selection for medicinal applications. Seaweeds lack true roots and instead anchor themselves using holdfasts, while many species, such as kelp, develop gas bladders (pneumatocysts) to float toward optimal light zones. As photosynthesis occurs over the entire algal surface, structural adaptations serve to maintain continuous light–water interaction rather than localized activity. This distributed photosynthetic process requires further investigation into influencing environmental and physiological factors. The intensity, duration, and spectral quality of light play decisive roles in determining biochemical outcomes relevant to drug production. This research motivation thesis also encourages the development of specialized equipment to study light modulation in marine systems. Additionally, dissolved nutrients such as nitrogen, phosphorus, and trace minerals are essential for algal survival and metabolic efficiency. Focused research on nutrient–light–water interaction is necessary to evaluate medicinal quality within a biophotonic medicine–based scientific framework.

AQU 20

FEASIBILITY OF *Kappaphycus alvarezii* CULTIVATION IN INTERTIDAL ZONE ON THE GUJARAT COAST, INDIA

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Cultivation of *Kappaphycus alvarezii* in pilot scale at 6 different cultivar sites (viz. Okha, Arambhada, Beyt Dwarka, Baradiya, Madhavpur and Sutrapada) on the coast of Gujarat was performed to check the site suitability for mass scale seaweed cultivation. The % DGR (Daily Growth Rate) criteria was set for the economic evaluation, tested for three consecutive seasons for two years (2024 and 2025). Among six seaweed cultivation sites, three (Beyt Dwarka, Okha and Sutrapada) exhibited promising results and could be considered as sites for mass-scale cultivation.

AQU 21

CULTURE OF THE EDIBLE GREEN SEAWEED *Ulva fasciata* UNDER A MULTILAYER SYSTEM

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Ulva fasciata is an economically important green edible seaweed which is widely, but seasonally distributed along the coastal waters of south Tamil Nadu. It has been gaining significant interest due to its potential value as animal feed, human food, medicinal value, as biofuel and also for wastewater bioremediation. The fundamental active constituent of Ulva spp. is the soluble fiber ulvan, which is distributed in the cell wall structures of the thallus, a gelling sulfated polysaccharide with biological activities including immunomodulating, antiviral, antioxidant, antihyperlipidemic and anticancer. *Ulva fasciata* is considered a strong candidate for tank-based cultivation due to its fast growth rate, high nutrient uptake capabilities, robust nature, and suitability for high stocking densities. These characteristics make it ideal for large-scale aquaculture Due to the aforementioned values of *Ulva*, exploitation of this native species in the natural ecosystem has increased; however, the interest for farming is only for the exotic species *Kappaphycus alvarezii*, which is a red alga. Over the decade, green seaweed and related applications have witnessed huge commercial demand requiring an effective seaweed culture system. As there is a requirement for species diversification, the first and foremost aim of the study was to identify a suitable species for tank-based culture. In view of this, an attempt was made to culture the edible green seaweed *Ulva fasciata* using a multilayer system. In this system, seaweed was cultured for a period of 50 days and a three-fold increase in biomass (1kg to 3kg) could be obtained.

AQU 22

SEAWEED-DERIVED POLYPHENOLS AS A FUNCTIONAL INTERVENTION FOR ENHANCING STRESS RESILIENCE AND HEALTH IN MUD CRAB (*Scylla* spp.) CULTURE

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Mud crab (*Scylla* spp.) aquaculture is frequently constrained by stress-induced immunosuppression, oxidative damage, and disease outbreaks, particularly during transport, moulting and high-density fattening operations in Recirculating Aquaculture Systems (RAS). The limited availability of species-specific functional additives and growing concerns over chemical inputs highlight the need for natural, marine-based solutions. Mud crabs are naturally adapted to mangrove-dominated ecosystems rich in plant- and algae-derived polyphenolic compounds. Therefore, seaweed-derived polyphenols—particularly phlorotannins from brown macroalgae—represent an ecologically compatible and habitat-aligned functional additive with high potential to enhance stress resilience and health in mud crab aquaculture. Seaweed polyphenols exhibit strong antioxidant, anti-inflammatory, antimicrobial, and immunomodulatory activities, with mechanisms directly relevant to crustacean stress physiology. Phlorotannins and related phenolic compounds effectively scavenge reactive oxygen species, enhance endogenous antioxidant enzyme systems (superoxide dismutase, catalase, glutathione peroxidase), and support innate immune parameters such as phenoloxidase activity and hemocyte function. In mud crabs, incorporation of seaweed-derived polyphenols through dietary supplementation or system-based applications has the potential to mitigate oxidative stress during critical production phases, improve survival, and stabilise physiological performance. This poster explores the functional role of seaweed-derived polyphenols in mud crab aquaculture, highlighting candidate macroalgal sources, extraction and delivery strategies, and their relevance to sustainable farming systems. This work positions seaweed polyphenols as a natural, eco-compatible solution to enhance resilience and productivity in mud crab culture.

AQU 23

NUTRIENT BUDGETING IN SHRIMP–SEAWEED CO-CULTURE SYSTEMS: PARTITIONING OF NITROGEN AND PHOSPHORUS FOR SUSTAINABLE AQUACULTURE

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Integrated shrimp (*Penaeus vannamei*) and seaweed (*Gracilaria* sp.) co-culture systems offer a promising approach to improve nutrient management and environmental sustainability in intensive shrimp aquaculture. This study quantified nutrient budgeting in a tank-based co-culture, comparing five shrimp stocking densities from 20 to 100/ m^2 with monoculture controls to assess nutrient partitioning, carbon sequestration, recovery efficiencies, and system performance. Total nitrogen (N) and phosphorus (P) flows were estimated through mass balance analysis, identifying the major sources and sinks of nutrients within the system. Shrimp feed was the dominant source of nitrogen input (88%), while phosphorus (97%). Partitioning patterns revealed that a large proportion of both N and P was retained in sediments (31% and 50%, respectively), remaining nutrients distributed among shrimp, seaweed, and water compartments. Nutrient recovery efficiency (NRE and PRE) was higher in co-culture treatments than in shrimp monoculture, indicating more effective assimilation of waste nutrients by seaweed. Water quality improved consistently under co-culture conditions, with significant reductions in dissolved inorganic nitrogen and phosphate. Co-cultured seaweed showed enhanced carbon sequestration in their biomass compared to the monoculture. These findings demonstrate that shrimp–seaweed co-culture can reduce nutrient loads, improve resource use efficiency, and mitigate environmental impacts supporting broader adoption of to achieve circular nutrient flows and sustainable shrimp production.

AQU 24

POTENTIAL APPLICATION OF SEAWEEDS IN BACTERIAL DISEASE MANAGEMENT IN AQUACULTURE

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Bacterial diseases remain one of the most critical challenges in aquaculture, leading to significant economic losses and threatening sustainability of global fish farming. Conventional control strategies, particularly the widespread use of antibiotics, have raised serious concerns regarding antimicrobial resistance, environmental pollution, and food safety. As a result, there is growing interest in eco-friendly alternatives that can effectively manage bacterial pathogens without compromising aquatic health. Seaweeds, a diverse group of marine macroalgae rich in bioactive compounds such as sulfated polysaccharides, phlorotannins, terpenoids and peptides, offer a promising natural alternative for disease management. Seaweed-based compounds possess broad spectrum antibacterial activity; disrupt bacterial quorum-sensing; and assist host immune responses, resulting in less virulence of pathogens and decreased infection rates. Seaweed extracts and other functional feed additives have shown effectiveness against key aquaculture bacterial pathogens including species of *Vibrio*, *Aeromonas* and *Pseudomonas*. In addition to direct antibacterial effects, seaweed promotes improvements in gut health, water quality and stress resistance of farmed species. Incorporating seaweed-based interventions into aquaculture operations provides a natural and sustainable alternative to synthetic chemicals, aligning with global efforts to reduce antibiotic dependence and promote circular bioeconomy practices. Thus, seaweed represents a promising multifunctional tool for bacterial disease management, offering both therapeutic and preventive benefits that can advance sustainable aquaculture development.

AQU 25

NEED FOR A MARINE SPATIAL PLANNING FOR SEAWEED AQUACULTURE IN THE LAKSHADWEEP ARCHIPELAGO

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The Lakshadweep archipelago comprises a chain of oceanic coral atolls that exhibit pronounced diversity in ecological settings and oceanographic regimes, shaped by variations in lagoon morphology, reef geomorphology, hydrodynamics, exposure to monsoonal forcing, and island-specific anthropogenic pressures. These heterogeneous environmental conditions create a mosaic of habitats that strongly influence the structure, productivity, and spatial distribution of marine biota, including seaweed assemblages. Despite this ecological heterogeneity, comprehensive understanding of seaweed diversity and assemblage structure in relation to island specific ecological regimes in Lakshadweep remains fragmented and outdated, with limited integration of habitat level and spatial perspectives. This knowledge gap becomes particularly significant in the context of the rapid expansion of seaweed aquaculture in India over the last decade. While seaweed farming has emerged as a promising blue economy activity supporting coastal livelihoods, its expansion has also been associated with the introduction of non-native, invasive, and potentially pathogenic seaweed strains in several regions of the country, posing ecological risks to sensitive reef-associated ecosystems. In ecologically fragile and geographically isolated systems such as Lakshadweep, unregulated introduction of exotic cultivars may threaten native seaweed diversity, alter ecosystem functioning, and compromise reef resilience. Safeguarding indigenous seaweed resources of the Lakshadweep region therefore necessitates a clear understanding of the natural growth potential, habitat preferences, and spatial distribution of native seaweed taxa across different islands and reef zones. Such knowledge is essential to identify ecologically suitable areas for seaweed farming that minimize environmental conflicts while enhancing livelihood opportunities for island communities. Marine spatial planning offers a structured and ecosystem-based approach to balance conservation priorities with sustainable aquaculture development, reduce user conflicts, and ensure long-term socioecological resilience. The present study synthesizes secondary data compiled from published literature on seaweed diversity, distribution, and habitat associations across the Lakshadweep islands. Based on this synthesis, a spatially informed protocol for marine spatial planning of seaweed farming in the Lakshadweep archipelago has been developed. This protocol provides a decision-support framework that can assist policymakers, planners, and resource managers in promoting sustainable expansion of seaweed aquaculture while avoiding deleterious impacts on this fragile coral reef ecosystem.

AQU 26

DIETARY FUCOIDAN IN FISH: ROLES AND APPLICATION IN AQUACULTURE

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The rapid growth of aquaculture has increased the need for sustainable and functional dietary supplements that boost fish growth, health, and productivity while reducing the use of synthetic additives. Fucoidan is a sulfated polysaccharide from marine brown algae. It has a high content of L-fucose and sulfate ester groups, which support its various biological activities. Recently, dietary fucoidan has attracted more attention as a useful feed additive in aquaculture because of its growth-promoting, antioxidant, and immune-supporting properties. Studies and controlled feeding trials show that adding fucoidan to aquafeeds improves growth performance, feed efficiency, survival rates, and overall health in several fish species. Fucoidan also helps gastrointestinal health by increasing the height, width, and surface area of intestinal villi, which boosts nutrient absorption. It raises intraepithelial lymphocyte counts and lowers intestinal bacteria, leading to better gut integrity and immune defense. In addition to gut health, fucoidan has antimicrobial, anti-inflammatory, antioxidant, antiviral, anticancer, and immune-stimulating effects, which together improve disease resistance and stress tolerance in fish. Recent assessments by the FAO on seaweed-derived bioactive compounds recognize fucoidan as a promising natural ingredient for developing sustainable aquafeeds, supporting eco-friendly and health-focused aquaculture systems. Positive results from dietary fucoidan supplementation have been seen in both freshwater and marine species, including rohu, Nile tilapia, goldfish, and red sea bream. Although current research is limited to specific species and dosage levels, existing evidence strongly supports dietary fucoidan as a practical and sustainable functional additive for modern aquaculture.

AQU 27

SEAWEED POLYSACCHARIDE FROM BROWN ALGAE AS FUNCTIONAL FEED ADDITIVES IN AQUACULTURE

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Brown seaweed polysaccharides are gaining significance as sustainable functional feed additives in aquaculture due to their bioactive and technological properties. Alginate, laminarin, and fucoidan are the most researched polysaccharides, with important applications in aquatic animal nutrition and feed formulation. Alginate is a linear anionic polysaccharide made of β-D-mannuronic and α-L-guluronic acid residues. It is commonly used as a feed binder and encapsulating material. Alginate improves pellet water stability, reduces nutrient loss, and enables controlled delivery of probiotics, enzymes, vaccines, and immunostimulants through microencapsulation systems. Laminarin is a β-(1→3)-glucan storage polysaccharide with strong immunostimulatory and antioxidant properties. It shows anti-inflammatory, anticoagulant, antitumor, and anti-apoptotic activities. Its bioactivity can be improved by sulfation and better processing methods. Dietary laminarin can boost innate immune responses, increase antioxidant enzyme activity, and improve disease resistance in aquatic animals. Fucoidan is a sulfated fucose-rich polysaccharide with antimicrobial, antiviral, antioxidant, anti-inflammatory, and prebiotic effects. Feeding trials indicated that 0.2% fucoidan increased intestinal villus length and digestive enzyme activities, while 3% kelp powder improved intestinal crypt depth and gut health. Seaweed-based diets enhanced growth performance, intestinal structure, immune-related gene expression, and gut microbial communities. Overall, brown seaweed polysaccharides like alginate, laminarin, and fucoidan are promising sustainable functional feed additives. They improve feed quality, intestinal health, immune responses, and growth performance. They may also reduce the need for synthetic additives and antibiotics in aquafeeds, promoting eco-friendly and resilient aquaculture production systems.

AQU 28

SYSTEM-LEVEL DESIGN OF ULVA-BASED POST-BIOFILTER POLISHING TO REDUCE WATER EXCHANGE IN INDOOR MUD CRAB (*Scylla olivacea*) RECIRCULATING AQUACULTURE SYSTEMS

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Indoor recirculating aquaculture systems (RAS) used for mud crab (*Scylla olivacea*) culture require frequent water exchange to control the accumulation of nitrogenous metabolites, elevated microbial load, and progressive deterioration of physicochemical water quality. In brackish water–based indoor systems, such routine water replacement leads to substantial loss of saline water, increased dependence on seawater procurement, and elevated operational costs, thereby limiting system sustainability. Reuse of culture water while maintaining optimal water quality remains a key bottleneck in intensive indoor mud crab RAS. To address this challenge, a controlled experimental study was conducted comparing a conventional indoor mud crab RAS (control) with an Ulva-integrated post-biofilter polishing system (treatment). The macroalgal module functioned as an efficient biological nutrient sink by assimilating dissolved inorganic nitrogen, including ammonia, nitrite, and nitrate, thereby reducing nitrogen accumulation downstream of conventional biofilters. Photosynthetic activity of *Ulva* contributed to carbon dioxide sequestration, improved dissolved oxygen availability, and pH stabilization, collectively enhancing the rearing environment for mud crabs. Nutrient competition by the macroalgae also reduced microbial proliferation in recirculating water, supporting improved biosecurity and system stability. The assimilation of excess nutrients resulted in the bioconversion of metabolic wastes into harvestable macroalgal biomass, enabling effective reuse and enrichment of culture water rather than its disposal. Integration of *Ulva*-based post-biofilter polishing demonstrated strong potential to maintain water quality within acceptable limits resulting in a marked reduction in water exchange demand relative to the control. resulting in a marked reduction in water exchange demand relative to the control. This approach offers a practical pathway to lower seawater demand, reduce operational costs, and improve resource-use efficiency, contributing to the development of sustainable indoor mud crab RAS.

AQU 29

DIETARY INCORPORATION OF *Sargassum wightii* AS A FINISHING FEED ENHANCES UMAMI ATTRIBUTES AND FLESH QUALITY OF MUD CRAB (*Scylla* SPP.) DURING FATTENING

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Mud crab (*Scylla* spp.) fattening in India frequently faces challenges related to inconsistent flesh quality, weak flavour intensity, and reduced market acceptability, leading to price depreciation and export rejection in premium international markets. These issues are commonly associated with high-density fattening systems, including indoor and recirculating units, that depend on nutritionally suboptimal finishing feeds incapable of enhancing sensory attributes of crab meat. Improving flesh flavour and texture, rather than increasing biomass alone, has therefore become essential for producing premium-grade mud crab. The present study evaluates dried brown macroalga *Sargassum wightii* as a functional finishing feed aimed at enhancing umami intensity and flesh quality during the final phase of mud crab fattening. *S. wightii* is naturally rich in umami-eliciting compounds such as free glutamates, mannans, and taste-active nucleotides, which play a key role in flavour perception, moisture retention, and textural firmness of crustacean muscle. Inclusion of dried *Sargassum* during the final 10–14 day finishing phase was assessed against conventional fish-based feeds under controlled indoor fattening conditions. Crabs receiving *Sargassum*-enriched finishing diets exhibited improved flesh firmness, enhanced moisture retention, elevated hepatopancreas lipid reserves, and significantly higher umami perception compared to control-fed crabs. Sensory evaluation supported these findings, indicating superior consumer preference and flavour acceptability. Analytical profiling further suggested modulation of muscle metabolites associated with glutamate–nucleotide synergism, a key biochemical driver of umami enhancement. This study demonstrates a practical strategy to improve flesh quality and restore market confidence in mud crabs produced under indoor fattening systems.

AQU 30

SYNERGISTIC EFFECTS OF GREEN (*Ulva* spp.) BROWN (*Sargassum* spp.) SEAWEED BIOACTIVES ON VITELLOGENESIS AND ROE QUALITY IN ORANGE MUD CRAB (*Scylla olivacea*)

Shreya V.S, Roobi Shaban C.P, Amina S, Sandra Santhosh, Geethu Vimal, Sona Shibu, Dharunya K, Jebaraj H, Sai Praneeth Kilari, Sneha Suresh, Bavithra, Dinesh Kaippilly,
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Female orange mud crab (*Scylla olivacea*) is a premium aquaculture commodity in Asian and export seafood markets, where mature, roe-rich females are highly valued for traditional crab roe dishes and nutraceutical soups. The quantity, colour, texture, and nutritional quality of roe directly determine market acceptance. Vitellogenesis, the process governing yolk protein synthesis and deposition in developing oocytes, is therefore a critical determinant of reproductive success and commercial value in female mud crabs. The present study investigated the synergistic effects of green seaweed (*Ulva* spp.) and brown seaweed (*Sargassum* spp.) bioactives on vitellogenesis, ovarian development, and roe quality in *Scylla olivacea*. Broodstock females were fed experimental diets formulated with dried, powdered seaweed supplements incorporated at functional inclusion levels, consisting of a control diet without seaweed, *Ulva*-supplemented diet, *Sargassum*-supplemented diet, and a combined *Ulva* + *Sargassum* diet. *Sargassum* was incorporated as a feed additive due to its high content of phlorotannins, fucoidan, minerals, and long-chain fatty acids, while *Ulva* served as a complementary source of ulvan, pigments, and bioavailable micronutrients. Crabs receiving the combined seaweed diet exhibited significantly elevated vitellogenin levels, accelerated ovarian maturation, increased oocyte diameter, and improved gonadosomatic index compared to single-seaweed and control treatments. Roe from the combined treatment showed superior colour, firmness, and biochemical composition, with higher protein and lipid content, resulting in improved egg viability and hatchability. The observed enhancement in reproductive performance was attributed to the synergistic antioxidant, metabolic, and immunomodulatory effects, which reduced oxidative stress, improved hepatopancreatic function, and supported efficient yolk deposition.

AQU 31

DEVELOPMENT OF A BRACKISH WATER AQUAPONIC SYSTEM INTEGRATING MUD CRAB (*Scylla serrata*) WITH MANGROVE ASSOCIATE (*Acanthus ilicifolius*) AND SEAWEED (*Ulva lactuca*) FOR NUTRIENT RECYCLING, HEALTH ENHANCEMENT, AND SUSTAINABLE COASTAL AQUACULTURE

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Mud crab (*Scylla serrata*) culture in brackish-water RAS is constrained by chronic physiological stress by nitrogen accumulation, behavioural instability, reduced feed intake, and the absence of natural estuarine cues, impairing welfare and survival. Biofiltration improves nitrification efficiency but does not sufficiently control nitrate build-up, leading to prolonged sub-lethal stress and increased operational costs associated with water exchange and filtration management. This study evaluated a functionally integrated brackish-water aquaponic system combining mud crab with the mangrove associate *Acanthus ilicifolius* and the green seaweed *Ulva lactuca*, each incorporated with a defined ecological and functional role. *A. ilicifolius* functioned as a habitat- mimicking biological module providing a stabilizing root–water interface and mangrove-derived environmental cues, while *U. lactuca* served as a low-cost, passive nutrient-polishing unit assimilating nitrate and phosphate generated following microbial nitrification. The system was experimentally tested under indoor RAS conditions using three treatments a control, a mangrove-integrated system, and a fully integrated mangrove–seaweed system by assessing water quality dynamics, nitrogen mass balance, crab growth and molting performance, feed intake, survival, immune indicators, and seaweed biomass production and nutrient uptake. The fully integrated mangrove–seaweed system exhibited lower nitrate and phosphate accumulation, with *U. lactuca* achieving effective nutrient removal and conversion of dissolved inorganic nitrogen into harvestable biomass, thereby reducing reliance on frequent water exchange and intensive filtration. Improved control of chronic nitrogen exposure resulted in enhanced behavioural stability, higher feed intake, improved molting success, stronger immune responses, and superior survival of mud crabs compared to the control system.

AQU 32

UTILIZATION OF SECONDARY RAW MATERIAL FROM SEAWEED (*Sargassum wightii*) AS A FISH FEED INGREDIENT IN AQUACULTURE

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The sustainable expansion of aquaculture requires the identification and utilization of alternative feed ingredients that reduce reliance on conventional resources while promoting circular bio-economy principles. Seaweed processing industries generate substantial quantities of secondary raw materials and residual biomass, which remain underutilized despite their nutritional and functional potential. The present study evaluates the feasibility of using secondary raw material derived from the brown seaweed *Sargassum wightii* as a fish feed ingredient in aquaculture. The seaweed residue obtained after the extraction process was subjected to comprehensive biochemical analysis to determine moisture, crude protein, crude lipid, ash and carbohydrate content, by using standard AOAC methods. The secondary raw material residue was also used to extract the oil to analysis the Fatty acids by GCMS and fat-soluble vitamins by HPLC. The secondary raw material of *S. wightii* is expected to exhibit a characteristic nutritional profile with moderate protein content, low lipid levels, and high ash and carbohydrate fractions, typical of brown seaweeds. The lipid fraction is anticipated to contain essential fatty acids and bioactive compounds, while vitamin analysis is expected to reveal the presence of key fat-soluble vitamins beneficial for fish physiology and immune function. This study provides baseline nutritional data supporting the valorization of *Sargassum wightii* secondary raw material as a sustainable and functional feed ingredient. The findings highlight its potential role in reducing feed costs, minimizing waste, and enhancing sustainability in aquaculture systems.

AQU 33

ASSESSMENT OF GROWTH OF SEAWEEDS, *Kappaphycus alvarezii*, *Ulva lactuca*, AND *Gracilaria* SP. IN LAND BASED CULTURE SYSTEMS WITH DIFFERENT SALINITY GRADIENTS

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Salinity is a key environmental factor influencing the physiological stability and productivity of marine macroalgae. The present study investigated the growth of three economically important seaweeds *Kappaphycus alvarezii*, *Ulva lactuca*, and *Gracilaria* spp. when exposed to different salinity extremes. Experimental cultures were subjected to a range of hypo-saline and hyper-saline conditions, and growth responses were monitored through visual assessment, pigmentation, and survival rates over the exposure period. Results indicated species-specific tolerance limits, with *Ulva lactuca* exhibiting relatively higher resistance to salinity fluctuations, while *Kappaphycus alvarezii* showed slow growth in early days due to lower salinity levels. *Gracilaria* spp. demonstrated moderate tolerance, with gradual progressive growth at both low and high salinity levels. The growth was altered with exposure duration and deviation from optimal salinity, reflecting impaired photosynthetic performance and cellular stress. These findings highlight differential adaptive capacities among seaweed species and emphasize the role of salinity stress in growth dynamics

AQU 34

AN INTEGRATED MULTI-TROPHIC AQUACULTURE APPROACH WITH SELECTED SEAWEEDS IN SHRIMP FARMING WITH BLACK TIGER SHRIMP *Penaeus monodon*

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Integrated multi-trophic aquaculture (IMTA) is an eco-friendly approach that enhances nutrient recycling and improves system sustainability by combining species from different trophic levels. The present study evaluated the performance of selected seaweeds—*Kappaphycus alvarezii*, *Ulva lactuca*, and *Gracilaria* spp. cultured in integration with the black tiger shrimp *Penaeus monodon*. Seaweeds were assessed for their capacity for nutrient uptake, growth performance, and water quality regulation. Changes in key physicochemical parameters, including dissolved nutrients, were monitored with seaweed biomass growth along with shrimp growth. Results indicated that integrated seaweed cultivation significantly reduced inorganic nutrient concentrations, thereby improving water quality within the culture system. Among the species studied, *Ulva lactuca* showed rapid growth and efficient nutrient absorption, while *Gracilaria* spp. and *Kappaphycus alvarezii* exhibited moderate growth rate under IMTA conditions. Shrimp survival and growth rate were showed better in integrated systems. The study demonstrates that incorporating seaweeds into shrimp farming can help in improve the utilization of nutrients and metabolites, providing additional income through seaweed biomass production.

AQU 35

GROWTH RESPONSE OF *Kappaphycus alvarezii* IN CONTROLLED INDOOR AND OPEN-WATER CULTURE SYSTEMS

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Kappaphycus alvarezii is one of the most commercially important red seaweeds cultivated worldwide for carrageenan production. The present study evaluates the growth performance of *Kappaphycus* under indoor (controlled tank-based) and outdoor (open water) culture systems to understand the influence of physicochemical parameters on biomass production. In the indoor culture system, growth was monitored under regulated conditions of light, temperature, salinity, and nutrient availability, minimizing environmental stress and epiphytic infestation. The outdoor culture system involved open-water cultivation using long-line and bag methods, where seaweed was exposed to natural variations in light, water movement, and nutrients flux. Results indicated that *Kappaphycus* cultured outdoors generally exhibited higher growth rates due to enhanced light availability and continuous water exchange, while indoor systems showed stable and consistent growth with reduced environmental variability. However, indoor culture proved advantageous for stock production and experimental studies due to better control over water quality and reduced biotic stress. The findings suggest that while outdoor culture is more suitable for large-scale commercial production, indoor systems can play a crucial role in nursery management and sustainable seaweed farming practices. Integrating both systems may optimize productivity and ensure year-round availability of high-quality planting material.

AQU 36

INTEGRATED SEAWEED–COPEPOD CULTURE: A SUSTAINABLE APPROACH FOR EFFLUENT TREATMENT

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Copepods are considered nutritionally superior live feeds, as marine finfish larvae naturally feed on them as one of their important live feed organisms. Their superiority over traditional live feeds in hatchery rearing of finfish larvae has been widely reported, largely due to their rich content of essential fatty acids such as EPA and DHA. Copepod feeding largely depends on microalgae and other non-conventional feed ingredients such as rice bran, wheat bran, soy flour and yeast. However, the use of non-conventional feed ingredients often results in the deterioration of water quality due to the release of excess nutrient waste. To address this challenge, there is a need for efficient strategies to control and utilize these nutrients. In this context, seaweeds (marine macroalgae) can serve as effective biofilters, as they have the ability to absorb inorganic nutrients and animal metabolic by-products. Several seaweed species like *Ulva, Gracilaria*, *Sparus aurata, Euchema denticulatum* etc. have been used in aquaculture systems to remove ammonia and inorganic nutrient loads. It will help to increase seaweed biomass, provide diversified income, reduce eutrophication and enhancing water quality. Based on the nutrient uptake ability, this topic dealt with bio-filteration potential of seaweed to treat the effluent water from copepod culture.

AQU 37

COMPARATIVE STUDY OF NUTRIENT TREATMENTS IN THE TANK CULTIVATION OF *Gracilaria corticata*

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Seaweeds are widely distributed across the globe; however, their commercial cultivation is predominantly concentrated in Eastern and South-Eastern Asia. In addition to their traditional use as food, seaweeds have diverse applications in food and non-food sectors, including food additives, animal feed, pharmaceuticals, nutraceuticals, cosmetics, textiles, biofertilizers, biostimulants, bio-packaging, and biofuel production. Among commercially important genera, *Gracilaria* is recognized as a principal source of agar, a valuable hydrocolloid with extensive industrial applications. The present study evaluated the influence of different nutrient media on the viability, growth, and pigmentation of *Gracilaria corticata* under controlled tank culture conditions. Experiments were conducted in 20-L transparent containers filled with 15 L of seawater and maintained under continuous circulation. Partial water exchange was carried out at 15-day intervals. Three experimental groups were established, a control without nutrient supplementation and two treatments supplemented with distinct nutrient formulations. Results indicated significant variation in growth performance among treatments. The group supplemented with non-metallic chemical elements and additional mineral nutrients demonstrated superior growth and enhanced pigmentation compared to the control and the other nutrient treatment. These findings highlight the importance of optimized nutrient supplementation for improving biomass production and culture performance of *G. corticata* in tank-based systems.

AQU 38

SOCIO-ECONOMIC IMPACT OF SEAWEED FARMING ON COASTAL COMMUNITIES IN INDIA

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India possesses over 384 identified sites covering 24,707 hectares suitable for seaweed farming across its 11,099 km coastline. Seaweed farming is currently practiced along Indian coasts and plays a major role in improving India's blue economy. In India seaweed grows along the coasts of Tamil Nadu and Gujarat, as well as around the Lakshadweep and Andaman and Nicobar Islands. The seaweed farming improves livelihood by providing employment and income, and by supporting industrial supply chains and local economies. Seaweed farming offers Women are key beneficiaries, gaining employment in a safe, sustainable environment through Self Help Groups (SHGs). Generates employment in cultivating, harvesting, processing, and distributing seaweed products and generates a stable income compared to fluctuating fisheries markets, thereby strengthening financial security. It provides income during non-fishing. Seaweed farming provides significant economic benefits by creating job opportunities, offering an additional source of income for coastal communities, and contributing to foreign exchange earnings. Seaweed farming acts as a high-return, low-barrier livelihood significantly boosting income for particularly women in coastal communities while offering environmental benefits like shoreline protection and water purification. Government initiatives, notably the Pradhan Mantri Matsya Sampada Yojana (PMMSY) provide financial assistance for rafts and processing and creating extensive employment. Seaweed farmers demonstrate adaptive capacity by modifying cultivation techniques to counter climate change. Common adaptations of farmers include altering planting schedules and spacing, adopting superior, stress-resistant seeds and utilizing deeper water farming methods. Harvested seaweed has diverse markets including food, pharmaceuticals, fertilizers and animal feed.

AQU 39

REIMAGINING THE ESTUARINE MARGIN: LIVELIHOOD-DRIVEN CULTIVATION OF *Kappaphycus alvarezii* IN VELLAR ESTUARY FOR GENDER-EQUITABLE SEAWEED ECONOMIES

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India's 11,099 km coastline offers substantial potential for seaweed cultivation Within the Blue Economy framework; however, production remains concentrated in high-energy open coastal waters, while estuarine systems and the communities dependent on them remain underexplored. This study evaluates estuarine seaweed farming as both a biophysical enterprise and a livelihood intervention through experimental raft cultivation of *Kappaphycus alvarezii* in the Vellar Estuary, Tamil Nadu, India (May–July 2024). Growth performance, water quality, salinity dynamics, and biotic interactions such as predation were monitored daily to assess environmental suitability and crop stability. The species demonstrated sustained growth and structural integrity under moderate salinity fluctuations (18–32 PSU), confirming seasonal estuarine viability. Sheltered hydrodynamic conditions reduced raft damage and maintenance costs by approximately 20% relative to open-coastal farms. Raft structures additionally functioned as microhabitats for juvenile finfish and shellfish, indicating localized ecological enhancement. Beyond biophysical performance, estuarine farming exhibited clear socio-economic advantages, including low capital requirements, short 45–60-day culture cycles, and proximity to fishing villages, which collectively lower entry barriers for women and landless youth by reducing dependence on offshore vessels and male-dominated labour networks. The production cycle coincides with the seasonal monsoon fishing ban, providing structured income substitution rather than distress-driven migration. Integrating environmental feasibility with decentralized livelihood access, estuarine seaweed cultivation represents a scalable, climate-resilient strategy for diversifying coastal incomes and reducing pressure on capture fisheries. The findings position Vellar Estuary as a model system for inclusive and spatially diversified Blue Economy transitions in India.

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IVC 01

GREEN FRACTIONATION OF *Ulva lactuca VIA* INTEGRATION OF SUPERCRITICAL FLUID AND SUBCRITICAL WATER EXTRACTION METHODS– A SUSTAINABLE BIOREFINERY APPROACH

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Ulva lactuca, a widely distributed green macroalga, is gaining significance due to its rapid growth and excellent nutritional value. The present study explored to biovalorize *U.lactuca* by integrating green extraction techniques. Supercritical carbon dioxide modified with ethanol was employed to extract pigments and phenolic compounds from *U.lactuca* biomass. Impact of increasing pressure on recovering bioactives was analyzed in detail by assuming as a batch process. The pressure was set at 200 bar initially and was increased at the rate of 50 °C/45 min till it attained 350 bar. It was observed that the maximum recovery was observed in the initial pressure range (200 bar) suggesting that extraction was mostly a surface phenomenon. In vitro profiling also pointed that extracts obtained at 200 bar conditions had the highest bioactivity with highest carotenoid content. The residue left after the supercritical fluid extraction was subjected to subcritical water extraction (SWE). The process has resulted in the simultaneous production of different co-products such as mineral and antioxidant enriched liquid fraction and biopolymers. The findings of the study highlighted the significance of sequential integration of green extraction techniques towards the production of two or more value added products from the same biomass

IVC 02

BIOACTIVE SULFATED POLYSACCHARIDES FROM *Hypnea valentiae*: ANTIOXIDANT, ANTIMICROBIAL, AND ANTICOAGULANT ACTIVITIES WITH IN SILICO INSIGHTS.

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The present study aimed to extract polysaccharides from *Hypnea valentiae* and evaluate their biological applications. The extracted carrageenan was characterized using FT-IR, ^13C-NMR, and Atomic Force Microscopy (AFM). Its antimicrobial, antioxidant, and anticoagulant activities were assessed, and the larvicidal efficacy of the methanolic seaweed extract was tested against *Aedes aegypti* larvae at varying concentrations. Molecular docking studies were performed using GLIDE docking in Schrödinger software to gain insights into the interactions between macromolecules and target proteins. Antibacterial activity demonstrated notable zones of inhibition at different concentrations, with the highest activity observed at 40 mg/mL against bacterial pathogens. Carrageenan exhibited strong antioxidant potential, with overall radical scavenging activity of 70.1 ± 0.61% at 250 µg/mL. Effective DPPH radical inhibition (65.74 ± 0.58%) was recorded at 160 µg/mL, while hydroxyl radical scavenging activity (65.72 ± 0.60%) was observed at 125 µg/mL. The anticoagulant activity of the carrageenan fraction was evaluated using Activated Partial Thromboplastin Time (APTT) and Prothrombin Time (PT) assays. *H. valentiae* carrageenan exhibited higher APTT activity (106.50 IU at 25 µg/mL) compared to PT (57.86 IU at 25 µg/mL), similar to the activity of heparin sulfate. Additionally, the methanolic extract demonstrated significant larvicidal activity against A. aegypti, with an LC□□ value of 99.675 µg/mL. Overall, this study highlights the bioactive potential of carrageenan derived from *H. valentiae*, supported by both in vitro assays and in silico docking results, which showed binding scores ranging from –7 to –6 kcal/mol against multiple targets. These findings suggest that carrageenan could serve as a promising alternative for antimicrobial, antioxidant, anticoagulant, and mosquitocidal applications. However, further investigations, including clinical validation, are necessary to confirm its therapeutic efficacy.

IVC 03

FROM BLUE BIOMASS TO CLEAN WATER: SEAWEED-DERIVED BIOCHAR AS A DUAL-ACTION FILTERING MEDIUM FOR MICROBIAL AND DYE REMOVAL

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The discharge of microbially contaminated and dye-laden effluents represents a growing threat to aquatic ecosystems and public health. Seaweed-derived biochar presents a sustainable and low-cost filtration solutions for water treatment applications within a circular bioeconomy framework. This study evaluates the effectiveness of seaweed biochar derived from brown seaweed, *Sargassum wightii* as an efficient filtration medium for the reduction of microbial load and synthetic dyes under controlled laboratory conditions. Biochar produced through pyrolysis of seaweed biomass was assessed for its antimicrobial activity at 1%, 5%, 10% level against *Escherichia coli*, *Salmonella* spp., and *Enterococcus* spp. using standardized spiking studies. The biochar demonstrated significant reductions in bacterial counts, achieving multi-log reductions following treatment. In addition, the dye adsorption potential of the biochar was examined using 14 representative dyes, showing substantial removal efficiency of neutral red, brilliant green and crystal violet which might be attributable to its porous structure and surface functional groups. The combined ability of seaweed-derived biochar to mitigate microbial contamination and remove dyes highlights its promise as a low-cost, eco- friendly filtration material for wastewater treatment, aquaculture effluents, and coastal water remediation. These findings emphasize the potential of seaweed-based biochar as an innovative and sustainable solution for improving water quality while valorising marine biomass resources.

IVC 04

UTILIZATION OF MACROALGAE FOR THE MANAGEMENT OF EAF SPOT OF TUBEROSE INCITED BY *Alternaria polianthi*

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Tuberose (*Polianthes tuberosa L.))* is one of the major commercial flower crops cultivated in Tamil Nadu. Although it has been cultivated for a long time, the significant increase in productivity is yet to be achieved. It is well recognized that the disease constitutes a major constraint in increasing the flower production. The incidence of leaf spot disease caused by the fungal pathogen *Alternaria polianthi* is a severe problem that leads to reduced growth and flower yield. *In vitro* study was carried out on the efficacy of various solvent extracts of the different seaweeds against *Alternaria polianthi* by agar well method. The methanol extracts of *S. myricocystum* (0.3%) were found to be superior in inhibiting the mycelial growth 2.67cm with 70.33per cent inhibition over control. GC-MS analysis of promising seaweed extracts from *S. myricocystum* revealed the presence of various volatile compounds and secondary metabolites *viz.,* squalene, ethanone, and phytol, each contributing to the observed antifungal properties. In pot culture experiment, the impacts of various seaweed extracts were examined to combat the leaf spot in tuberose. The results revealed that minimum disease severity of leaf spot (21.65 PDI) was recorded in foliar spray of *S.myricocystum* (3%) 45 and 60 days after planting. Field experiment showed that foliar spray of *S. myricocystum* @ 3% two spray at 45 and 60 DAP reduced disease incidence of leaf spot (26.14 PDI) and yield 11.67t/ha with BC ratio 1:2.82.

IVC 05

DEVELOPMENT OF SEAWEED-DERIVED CARBON NANODOTS AS A SUSTAINABLE MATERIAL FOR FOOD PACKAGING APPLICATIONS

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Marine macroalgae represent a promising renewable precursor for the synthesis of functional carbon-based nanomaterials. Carbon dots (CDs) possess nanoscale size, unique optical properties, antioxidant and antimicrobial activity, good biocompatibility, low toxicity, and the ability to enhance mechanical strength, making them suitable for food packaging applications. In the present study, CDs were synthesised from the red seaweed, *Kappaphycus alvarezii*, using a hydrothermal method. The chemical structure of the synthesised CDs was analysed using Fourier-transform infrared (FTIR) spectroscopy and nuclear magnetic resonance (NMR), while their morphology and size distribution were examined by scanning electron microscopy (SEM) and transmission electron microscopy (TEM). The optical properties of the CDs were evaluated using UV–visible absorption and fluorescence spectroscopy. The UV-Vis absorption spectrum of the CDs exhibited two distinct peaks at 210 nm and 283 nm, which can be assigned to the π - π* and n - π* electronic transitions, respectively. The radical scavenging efficiency of the CDs was 25.6% in the DPPH assay, which demonstrates their antioxidant potential. The results confirm the successful formation of fluorescent carbon nanodots with characteristic functional groups, indicating their potential suitability for further exploration in food packaging applications.

IVC 06

INTERACTIVE EFFECTS OF *Ascophyllum nodosum* SEAWEED EXTRACT AND ARBUSCULAR MYCORRHIZAL FUNGI ON GROWTH, FRUIT YIELD AND QUALITY, AND WATER PRODUCTIVITY OF TOMATO UNDER WATER STRESS

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Tomatoes and other agricultural products are severely impacted by the abiotic stress triggered by drought. To encourage healthy growth and development in plants, farmers often use plant growth regulators like seaweed extract or Arbuscular mycorrhizal fungi (AMF), both of which find extensive application in horticulture. The effects of *Ascophyllum nodosum* seaweed extract (ASE) and Arbuscular mycorrhizal fungi (AMF) on the development, yield, and quality of tomatoes (*Solanum lycopersicum*) under extreme water-deficit stress were investigated in this study. The impact of applying Arbuscular mycorrhizal fungi (AMF) to the soil with varying amounts of *Ascophyllum nodosum* seaweed extract (ASE) was analyzed. In three soil moisture systems (50%, 75%, and 100% field capacity [FC]), ASE was administered at five dosages (0, 1.25, 2.5, 3.75-, and 5-mL L^{-1}) with Arbuscular mycorrhizal fungi (AMF) and a control where no seaweed extract or AMF was applied. Data was recorded on tomato growth, fruit yield and quality of the harvested fruit. The quality of tomato fruits increased (fruit pH, total soluble solids, and firmness) when soil moisture was reduced to 50% FC, despite the fact that fruit yield and growth were reduced by 59%. Higher tomato yield (964.3 g $plant^{-1}$ fruit yield) was attained when ASE was adjusted at 5 mL L^{-1} with AMF and soil moisture was 100% FC. 75% FC yielded (921.3 g $plant^{-1}$ fruit yield) very similarly to 100% FC when ASE was administered at 5 mL L^{-1} with AMF, indicating that the optimal soil moisture level is between 75% and 100% FC. At a 75% FC soil moisture level, the ASE with AMF dose generated very close irrigation water productivity, and at a 100% FC soil moisture level, the productivity was adequate. The findings from this research suggest that applying 5 mL L^{-1} of *Ascophyllum nodosum* SWE to the soil along with AMF for tomato growing in conditions of moderate to abundant soil moisture availability is a good idea.

IVC 07

EXTRACTION OF CELLULOSE NANOCRYSTALS FROM BROWN SEAWEED *Dictyota bartayresiana* AND THEIR CHARACTERIZATION

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This study investigates the potential of the brown macroalgae *Dictyota bartayresiana* as a novel source for the production of cellulose nanocrystals (CNC). To the best of our knowledge, this is the first report on the extraction of CNC using the acid hydrolysis method. Cellulose nanocrystals (CNC) are an intriguing class of bio-based nanoscale materials, desirable for a wide range of applications due to their remarkable physicochemical properties, which include biocompatibility, biodegradability, renewability, low density, and improved mechanical properties. The physicochemical properties of the CNCs were further characterized using various methods, including Fourier Transform Infrared Spectroscopy (FTIR), CHNS elemental analysis, X-ray Diffraction (XRD), Transmission Electron Microscope (TEM) and Thermogravimetric analysis (TGA). FTIR analysis revealed that, non-cellulosic compounds removed through chemical treatment, while CHNS analysis indicated a sulfur content of approximately 0.59%. XRD analysis revealed that CNC had 62% crystallinity index, and TEM analysis affirmed that the resulting CNC displayed an average width of approximately 26 nm and a length extending to 520 nm. Furthermore, TGA results demonstrated the improved thermal stability of the extracted CNC, highlighting their suitability of advanced material applications.

IVC 08

MARINE BIOPROSPECTING OF SEAWEED-ASSOCIATED HALOTOLERANT BACTERIAL METABOLITES FOR ANTICANCER PRECLINICAL STUDIES

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Seaweeds act as dynamic marine biofactories and host diverse halotolerant bacterial communities that represent an underexploited resource for marine bioprospecting. Targeting the seaweed–microbiome interface offers a sustainable strategy for identifying structurally novel secondary metabolites with therapeutic relevance. This study focuses on marine bioprospecting of seaweed-associated halotolerant bacteria for the discovery and evaluation of anticancer metabolites. Seaweed samples were collected from intertidal regions of Kovalam and Mandapam along the southeast coast of India. Associated halotolerant bacteria were isolated and identified using 16S rDNA sequence analysis. Secondary metabolites were extracted using solvent-based methods, purified by HPLC, and structurally elucidated by NMR spectroscopy. Anticancer activity of the purified compound was assessed using the sulforhodamine B (SRB) assay against human cancer cell lines A549 (lung), AW1356 (oral), SK-OV-3 (ovarian), MDA-MB-231 (breast), and Hep-G2 (liver). Compound S1(catechol hydrazide) exhibited significant, dose-dependent cytotoxicity across all tested cell lines within the concentration range of 10–80 µg/mL. Mechanistic analysis revealed induction of programmed cell death, with S1 triggering necrosis and late apoptosis in A549 cells at 5 and 10 µg/mL, while inducing 49% early apoptosis in MDA-MB-231 cells at 5 µg/mL. This study highlights the value of seaweed-driven marine bioprospecting in identifying potent anticancer leads from halotolerant bacterial metabolites and underscores the translational potential of seaweed-associated microbial resources for sustainable cancer therapeutics.

IVC 09

CINNAMON ESSENTIAL OIL–ALGINATE BASED FILMS AS ANTIMICROBIAL AND ANTI–QUORUM SENSING AGENTS FOR FOOD SAFETY APPLICATIONS

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Biodegradable films are increasingly explored as sustainable carriers for natural bioactive compounds aimed at improving food safety and extending shelf life. In parallel, the virulence and persistence of many foodborne bacteria are regulated by quorum sensing (QS), a cell-to-cell communication mechanism that controls collective bacterial behaviour. Cinnamon essential oil (CEO) is well known for its antimicrobial potential; however, its practical application in foods is limited. In this study, cinnamon oil was extracted from cinnamon sticks using steam distillation method and alginate was obtained from brown seaweed *Turbinaria conoides* by alkaline extraction. Incorporation of CEO into alginate-based films represents a promising strategy to enhance stability and functional performance. The antimicrobial and QS inhibitory properties of CEO and alginate–CEO films were evaluated. Antibacterial activity was assessed against major food-associated pathogens, including *Escherichia coli*, *Listeria monocytogenes*, *Staphylococcus aureus* and *Shigella sonnei*. The anti-QS potential was investigated using the pigmented bacterium *Pseudomonas aeruginosa* as a model system, based on inhibition of pigment production without affecting bacterial viability. The results demonstrated that Alginate CEO films effectively inhibited the growth of tested pathogens with inhibition diameters 6.3 mm, 5.8 mm, 5.9 mm and 6.5 mm respectively. The films showed distinct anti-quorum sensing activity as evidenced by reduced pigment production in *P. aeruginosa*. Overall, the findings indicate that alginate-based films containing CEO can act as dual-function systems, combining antimicrobial and quorum sensing inhibitory properties. These films show strong potential for application as natural, food-grade packaging to control foodborne microorganisms and reduce microbial spoilage through interference with bacterial communication.

IVC 10

MARINE DERIVED BIOACTIVE PRIMARY CAROTENOID PIGMENT FROM BROWN SEAWEED: BIOLOGICAL AND TOXICOLOGICAL EVALUATION

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Marine brown seaweeds are a significant source of natural pigments with important biological and safety implications. This study focused on isolating the primary carotenoid pigment (*Bs*-cp) from brown seaweed. The extracted *Bs*-cp was characterized using Thin-layer chromatography (TLC), UV-visible spectroscopy (UV-Vis), Fourier-transform infrared (FTIR) spectroscopy, and High-performance liquid chromatography (HPLC). TLC analysis revealed a single band with an Rf value of 0.47. UV-Vis spectrum showed a characteristic peak at 457 nm, while FTIR spectroscopy verified the functional groups of the *Bs*-cp. HPLC further confirmed the *Bs*-cp identify through its retention time. Additionally, the isolated *Bs*-cp exhibited antioxidant activity via the DPPH assay, with the highest inhibition recorded at 100 µg/mL. Antibacterial assays demonstrated potent inhibition effects, particularly at specific concentrations. Toxicity assays using the brine shrimp *Artemia salina* as a model organism demonstrated low toxicity effects. The *Bs*-cp exhibited LC_{50} value well above therapeutic concentrations, confirming their safety profile. The *Bs*-cp showed strong antioxidant and antibacterial properties together with excellent toxicity profiles, indicating the potential for safe biomedical applications. These stable bioactive derived from brown seaweed are effective alternatives for pharmaceuticals.

IVC 11

VALORISATION OF *Sargassum myriocystum* INTO ALGINATE–NANOCELLULOSE ACTIVE PACKAGING FILM FOR SEAFOOD SHELF-LIFE ENHANCEMENT

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The high perishability of seafoods, especially fish fillets, demands the development of sustainable and functional packaging materials with improved shelf-life extension and reduced plastic waste. In this study, a fully seaweed-valorised active nanocomposite packaging film was developed using sodium alginate extracted from the brown seaweed *Sargassum myriocystum*, while the residual biomass was utilised to isolate cellulose nanocrystals (CNC). The successful extraction and structural integrity of sodium alginate were confirmed by 1H NMR spectroscopy, revealing characteristic guluronic and mannuronic acid units. CNC obtained from algal residue exhibited high crystallinity and a nanoscale morphology, enabling it to serve as an effective nanofiller in the polymer matrix. Sodium alginate and CNC were subsequently combined with a polymer base to fabricate an active nanocomposite film incorporating natural bioactive agents to impart antioxidant and antimicrobial properties. The developed films demonstrated enhanced mechanical strength, improved barrier performance, and effective inhibition of microbial growth and oxidative degradation. Application studies on fish fillets showed reduced spoilage indicators and extended shelf life compared to conventional packaging. This work highlights a sustainable circular biorefinery approach and demonstrates the potential of seaweed-derived nanocomposite films for advanced seafood packaging applications.

IVC 12

VALORIZATION OF *Sargassum siliquosum* INTO HIGH-PERFORMANCE BIOCHAR AND ALGINATE COMPOSITES FOR MULTI-POLLUTANT WASTEWATER TREATMENT

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Azo dyes and toxic heavy metals, such as Cr(VI), represent persistent and hazardous pollutants in industrial effluents, posing severe risks to human health, ecosystems, and agricultural productivity. This study utilizes the pelagic brown seaweed *Sargassum siliquosum* as a versatile marine biomass for developing low-cost, eco-friendly adsorbents to address two dual environmental challenges: harmful algal blooms and wastewater contamination. Two sustainable materials were synthesized: (i) $ZnCl_2$-activated biochar (BCA-800) produced through pyrolysis, and (ii) alginate-alginate residue (EA-AR) composite beads prepared from extracted alginate and post-extraction residues using $CaCl_2$ crosslinking. BCA-800 exhibited a high surface area (674.63 m^2/g) and abundant functional groups, confirmed through comprehensive characterization (BET, XRD, Raman, FT-IR, proximate and elemental analysis, Boehm titration, SEM-EDX, pHpzc, and zeta potential). The biochar achieved a maximum methyl orange adsorption capacity of 150.06 ± 2.45 mg/g with 99.5 ± 0.62% removal efficiency. Adsorption followed pseudo-first- and pseudo-second-order kinetics, with both Langmuir and Freundlich isotherms contributing to dye uptake. Thermodynamic analysis indicated a spontaneous, slightly exothermic, and nearly thermoneutral process, governed by multiple mechanisms. The EA-AR composite beads demonstrated exceptional Cr(VI) removal (>90%) at pH 2 for concentrations up to 200 mg/L, achieving a removal of 99.31 ± 0.71% under optimal conditions. XPS and elemental mapping revealed Cr(VI) absorption, accompanied by partial reduction to Cr(III), indicating the involvement of both ion exchange and redox mechanisms. Both materials retained high performance over five regeneration cycles and showed environmental safety in phytotoxicity assays. Overall, *S. siliquosum* derived adsorbents offer scalable and low-cost solutions for the remediation of contaminants in real-world wastewater systems.

IVC 13

DEVELOPMENT OF PLASTICIZER-MODIFIED ALGINATE BIOPLASTIC FILMS FROM *Sargassum siliquosum* FOR SUSTAINABLE PACKAGING APPLICATIONS

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The growing environmental burden associated with petroleum-based plastics has intensified research into biodegradable alternatives derived from renewable resources. Recent studies have shown that seaweed-based biopolymers are particularly attractive due to their abundance, sustainability, and polysaccharide-rich composition. In this study, biodegradable bioplastic films were developed using sodium alginate extracted from the brown seaweed *Sargassum siliquosum*, with commercial sodium alginate used for comparison. A total of twelve film formulations were prepared by incorporating different plasticizers, including polyethylene glycol (PEG), tributyl citrate (TBC), glycerol, and sorbitol, to systematically evaluate their influence on film properties. The extracted alginate-based films exhibited a uniform light-yellow appearance, whereas commercial alginate films were visually transparent. Among all formulations, the E4 film demonstrated superior overall performance, exhibiting enhanced tensile strength (8.52 ± 0.95 MPa), higher elongation at break (65.09 ± 13.97 %), and reduced water vapor permeability (161.74 ± 17.79 g/m^2/day). Consequently, the E4 film was selected for further modification to improve water barrier properties. Crosslinking was carried out using a calcium chloride ($CaCl_2$) dip-coating method, which significantly reduced water solubility (23.30 ± 0.83 %) and enhanced structural integrity under aqueous conditions. Surface morphology analysis using scanning electron microscopy (SEM) revealed smooth and homogeneous film surfaces, indicating good dispersion of plasticizers within the alginate matrix. Attenuated total reflectance-Fourier transform infrared (ATR-FTIR) spectroscopy confirmed the presence of characteristic functional groups and effective interactions between alginate and the plasticizers. Mechanical property evaluation revealed that the type of plasticizer strongly influenced the tensile strength, flexibility, and elongation behaviour. Biodegradability tests conducted in neutral and marine soil environments demonstrated rapid degradation of the alginate-based films, confirming their environmentally friendly nature. Overall, this study highlights the potential of seaweed-derived alginate bioplastics for sustainable packaging applications.

IVC 14

SEAWEED-DERIVED DUAL-RESPONSIVE BIOPOLYMER STRIP FOR SUSTAINABLE AQUACULTURE MONITORING

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Aquaculture production is greatly influenced by abiotic elements, which consist of temperature and pH, which alter the metabolic activity, ammonia toxicity, oxidative stress, and normal fish health. Unexpected fluctuations in these parameters can result in physiological consequences and great economic losses. Despite the fact that electronic sensors and commercial test kits are available, their price, maintenance requirements, and environmental footprint restrict accessibility, especially for small-scale farmers. Therefore, the development of eco-friendly, low-value, and user-friendly monitoring equipment is essential for climate-resilient aquaculture systems. This study proposes the fabrication of a biodegradable dual-responsive indicator strip by using seaweed-derived biopolymers. Agar and/or alginate serve as the primary film-forming matrices due to their incredible mechanical strength, water compatibility, and biodegradability. The strip consists of two functional layers: a pH-sensitive layer incorporating natural seaweed extract that is capable of colour change within pH 6–9, and a temperature-sensitive layer embedded with a reversible thermochromic dye which is designed to respond within aquaculture-relevant thermal stress thresholds (30–34°C). The strips are organised through casting of solution with managed polymer and pigment concentrations, observed by using drying, lamination, and calibration beneath popular buffer solutions and managed temperature conditions. The developed dual indicator gives simultaneous visible detection of two important water quality parameters without the need for electricity or technical knowledge. By using transforming seaweed biomass into a functional environmental monitoring tool, this innovation promotes value chain diversification, reduces plastic dependency, and aligns with blue economy and sustainable aquaculture techniques. The study demonstrates the ability of seaweed-derived biopolymers as eco-responsive structures for realistic abiotic factor detection in aquatic systems.

IVC 15

DEVELOPMENT OF NANO-CELLULOSE–ALGINATE HYDROGEL FROM *Padina pavonica*: A BLUE-ECONOMY APPROACH TO VALUE-ADDED BIOMATERIALS

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This study explores the development of a sustainable sodium alginate–cellulose nanocrystal (CNC) composite hydrogel derived from the brown seaweed *Padina pavonica*, aligning with the principles of the blue economy and marine resource valorization. Sodium alginate extracted from *P. pavonica* exhibited desirable physicochemical characteristics, including a 15.22 ± 0.57% yield, semi-crystalline structure, and suitable viscosity. CNCs recovered from post-extraction residues demonstrated high crystallinity (≈92.7%) and thermally stable rod-like morphology, ensuring efficient utilization of seaweed biomass and reducing processing waste. The resulting alginate–CNC hydrogels, functionalized with varying concentrations of gallic acid (GA), displayed enhanced structural, antioxidant, and antimicrobial properties. Increasing GA concentration decreased porosity while improving swelling capacity, indicating the formation of a denser yet highly hydrophilic network. Bioactivity assays confirmed a strong GA-dependent antioxidant response and notable antibacterial activity, with the 0.4% GA hydrogel achieving the highest inhibition against *E. coli* and *S. aureus*. By converting abundantly available coastal seaweed into high-value biomaterials, this work demonstrates a pathway for ocean-based circular bioeconomy, adding value to marine resources while promoting eco-friendly product development. The GA-functionalized hydrogels show promise for biomedical uses such as wound dressings and controlled drug delivery systems, highlighting their potential contribution to sustainable ocean-derived industries and ecosystem restoration efforts.

IVC 16

TURBINARIA SEAWEED-DERIVED CELLULOSE NANOCRYSTALS AS A NANOFILLER IN FISH COLLAGEN-BASED HYDROGEL: PHYSICOCHEMICAL, AND BIOACTIVE CHARACTERISTICS

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This study investigates a novel hydrogel fabrication composed of fish collagen integrated with cellulose nanocrystals (CNC), eliminating the need for toxic crosslinkers. Designed for potential tissue engineering applications, these hydrogels were fabricated using freeze-drying techniques to create a hydrogel with interconnected macropores, facilitating nutrient transport. Herein, CNCs were extracted from brown seaweed fibers with a yield of 19% and a zeta potential of -40.8±0.3 mV. Considering the morphological features, the isolated CNC possesses a needle-like structure with an average aspect ratio of 21, a length of 364 ± 15nm, and a width of 17± 6 nm, respectively, and possesses non-toxic behaviour in human epithelial cell lines. The incorporation of CNC in the hydrogel matrix significantly ($p < 0.05$) decreases the porosity and enhances the swelling ratio of the hydrogel, attributed to enhanced polymer-nanocrystal interactions that produced denser networks, which aligns with FTIR and XRD findings. Moreover, CNC enhances the tensile strength and bioactive properties of the hydrogel. These findings highlight the potential of seaweed-derived CNC in the reinforcement ability of hydrogel composites in tissue engineering applications.

IVC 17

EVALUATION OF IN-VITRO ANTIBACTERIAL ACTIVITY OF *Gracilaria verrucosa* SEAWEED EXTRACT FROM KINYA, SRI LANKA.

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Gracilaria verrucosa, a red seaweed found along the coast of Kinya, Sri Lanka, is gaining attention as a potential source of natural antibiotics. Its bioactive compounds have demonstrated effective antibacterial properties. With antibiotic resistance becoming a global health issue, there is a growing need for alternative and sustainable treatments. *Escherichia coli* and *Staphylococcus aureus* are among the most common and problematic pathogens responsible for a range of infections, including gastrointestinal disorders and skin diseases. The extract of *Gracilaria verrucosa* was prepared using ethanol as the solvent, with two concentrations: 25 mg/ml and 50 mg/ml. The antibacterial activity of these extracts was tested using the well diffusion method on Muller Hinton Agar (MHA) medium, targeting *Escherichia coli* (ATCC 25922) and *Staphylococcus aureus* (ATCC 25923). The findings, analyzed using IBM SPSS Statistics version 21, revealed significant antibacterial activity, with the largest inhibition zones observed against *Staphylococcus aureus*, measuring 15.28±0.32 mm and 16.52±0.12 mm for the 25 mg/ml and 50 mg/ml concentrations, respectively. In comparison, the inhibition zones against *Escherichia coli* were slightly smaller, measuring 13.00±0.00 mm and 13.48±6.44 mm. The Minimum Inhibitory Concentration and Minimum Bactericidal Concentration for both bacterial strains were 15 mg/ml and 25 mg/ml, respectively. These results suggest that *Gracilaria verrucosa* has considerable potential as a sustainable source of antimicrobial compounds. Given their rapid growth, renewability, and unique biochemical profiles, seaweeds like *Gracilaria verrucosa* could play a pivotal role in the next generation of antimicrobial therapies.

IVC 18

A COMPARATIVE STUDY ON THE MULTI-BIO-FUNCTIONAL PROPERTIES OF POLYSACCHARIDES EXTRACTED FROM THE BROWN SEAWEEDS, *Rosenvingea endiviifolia* AND *Sargassum wightii*: FOCUSING ON THE CYTOTOXIC SAFETY, ANTICANCER ACTIVITY AND PREBIOTIC POTENTIAL

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The marine macroalgae are one of the richest sources of structurally diverse polysaccharides, which often possess unique monosaccharide compositions, sulphate groups, and glycosidic linkages that contribute to their distinctive physicochemical and biological properties. In the present study, polysaccharides (RV, SW) were extracted from two different brown seaweeds, *Rosenvingea endiviifolia* and *Sargassum wightii*, and their various bioactivities were evaluated. SW exhibited lower available carbohydrate (64.38±3.3%) and higher fucose content (31.2± 1.3%) compared to RV. The RV showed higher available carbohydrate (80.95± 8.6) but less fucose content (19.3± 1.3%). Both have very low reducing sugar levels (0.019% - 0.027%). The antioxidant assays DPPH, ABTS and FRAP showed appreciable free radical scavenging and reducing power to both samples, in which SW showed slightly higher than RV. The MTCC assay for both samples demonstrated low cytotoxicity towards normal L929 cells, with SW showing comparatively stronger anti-cancer activity against HCT 116 cells. Both the polysaccharide samples showed an appreciable prebiotic score, indicating their bio-functional carbohydrate polymers.

IVC 19

OPTIMISATION OF PHYSICAL CHARACTERISTICS OF CARRAGEENAN-HPMC BLEND BIODEGRADABLE FILMS USING RESPONSE SURFACE METHODOLOGY

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There has been a strong emphasis on exploration of biodegradable alternatives from renewable resources in response to the growing environmental concerns over synthetic plastics. Because of their natural biodegradability, film-forming characteristics, and abundant availability, seaweeds can be a potential option for bioplastic preparation because of the presence of various polysaccharides like carrageenan. The purpose of this research was to generate biodegradable films by utilizing a mixture of carrageenan and hydroxypropyl methylcellulose (HPMC), which improves the flexibility and mechanical strength of the film. These films are then plasticized with polyethylene glycol 4000 (PEG 4000) and reinforced with citric acid as a cross-linking agent. Several tests were conducted to evaluate their mechanical and physicochemical qualities. These included the measurement of thickness, tensile strength, elongation at break, transparency, moisture content, water solubility, swelling percent, water vapour permeability, water vapour transmission rate, and biodegradability. Response surface methodology (RSM) was utilized to achieve the goal of optimizing the tensile strength of the films. Using a face-centred central composite design (CCD), the impact of the components on the functional parameters was analysed to determine the most effective composition. The analysis of variance (ANOVA) was used to determine the statistical significance of the model. The final optimised bioplastic exhibited excellent functional properties in terms of tensile strength, moisture content, transparency, water vapour permeability, water vapour transmission rate and biodegradability, thereby acting as a sustainable alternative to various petroleum-based plastic for daily use.

IVC 20

EFFECT OF GEOMETRICAL TRANSITION ON CELL-SURFACE STIFFNESS AND CELLULAR AFFINITY OF SEAWEED DERIVED EDIBLE SCAFFOLD FOR MARINE FISH MEAT

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The global demand of marine fish is rising drastically due to population growth and increased consumption, leading to overfishing and ecological instability. Cultivated sustainable marine fish meat offers a transformative solution to fulfill this demand without sacrificing marine life. However limited surface area of the sheet structured scaffold for cell attachment still restricting achievable cell density and volumetric yield for the scalable production. This study explores the development of sustainable seaweed based edible scaffold structure like sheet and tube (using alginate, gelatin, carrageenan) which enhances the cell-surface attachment. We engineered and compared sheet structured scaffold with the tubular structured scaffold. The result shows enhanced surface-area on tubular structure compared to sheet, hypothesizing that this geometry will maximize cell-scaffold affinity, density, and tissue organization. Scanning Electron Microscopy (SEM) results proved that the tubular architecture provides a significantly higher surface area than sheet-like structures. Crucially, force spectroscopic analysis has been performed using Atomic Force Microscope to quantify the adhesion forces between marine faunal cells and the scaffold. This work mainly focuses on the changes in mechanobiological aspects on cell-surface stiffness due to change in structure and shape.

IVC 21

NEXT GENERATION EDIBLE SCAFFOLDS: A NOVEL CO-AXIAL FLOW SYSTEM FOR *IN SITU* BIO-FABRICATION OF SEAWEED-3D CELLULAR ARCHITECTURE

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In the field of cellular agriculture, the development of lab-grown foods has gained significant attention as a sustainable alternative protein to meet the increasing global demand for animal- derived foods. Seaweeds, being rich in bioactive compounds, and proteins, present a promising edible biomaterial for scaffold-based bio fabrication. This study aims to explore seaweed- derived biomaterials as edible scaffolds for the *in-situ* fabrication of 3D cellular architectures. Here, seaweed extracts such as gelatin, alginate, and carrageenan were utilized as microcarriers for mammalian cell growth for their excellent biocompatibility, biodegradability, and intrinsic edibility, reducing downstream processing requirements. Scaffolds were fabricated through a chelation and carbon dioxide release mechanism to achieve controlled porosity and transparency, thereby facilitating necessary gaseous exchange vital for cell viability. A novel coaxial flow- bio fabrication system was employed, enabling the simultaneous extrusion of multiple biomaterials through a core–shell configuration. This approach allows the fabrication of hierarchical tubular scaffolds that more closely mimic native tissue architecture compared to conventional single-nozzle fabrication techniques. The developed prototype consisted of three interconnected nozzles functioning as a junction, wherein the seaweed hydrogel formed the scaffold shell while mammalian cells as the core. The resulting tubular scaffolds demonstrated precise spatial control, and effective cell encapsulation. Subsequent evaluation revealed significant degradability and sustained cell proliferation, confirmed through fluorescence staining. Notably, cells exhibited appreciable adhesion and growth over a 16-day culture period, indicating excellent biocompatibility and structural support. Overall, the study demonstrates the potential of seaweed-based edible scaffolds fabricated via coaxial flow systems as a contamination-free and sustainable platform for 3D cellular bio fabrication.

IVC 22

OCEAN-INSPIRED BIO-CONTROL: TURNING MARINE ALGAE INTO NATURAL WEAPONS AGAINST RECENT INVASIVE SOUTH EAST ASIAN THRIPS, *Thrips parvispinus* IN INDIA

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Chilli is a major spice and vegetable crop growing worldwide for domestic use and export, but its production was severely reduced by a recent invasive South East Asian thrips, *Thrips parvispinus* in India (50–80% yield loss). Frequent pesticide uses increased production costs and contaminates soil and water. Currently, marine habitats remain underexplored for pest management. Seaweed-derived compounds offer broad-spectrum, early-stage protection, yet field application is limited. Therefore, a roving survey was done in East and West coast of southern India to collect marine algae. The collected algae were identified by CSIR-Marine Algal Research Institute, Mandapam, Tamil Nadu. Endophytic fungi were isolated, identified and screened against laboratory reared *Spodoptera litura* Fabricius larvae. Further, the Gas and liquid chromatography and mass spectrometer (GC-MS & LC-MS analysis) was carried out for both marine algae and endophytic fungal microbes to know the metabolomic profile. The insecticidal bio-active compounds were identified based on bio-assay study and the help of existing literature. Two bio-formulations (UHSB-MAM1 and UHSB-MAM2) were developed utilizing metabolites of marine algae and evaluated against second and third instar larvae of *S. litura* based. UHSB-MAM1 @ 2000 ppm showed 60% mortality of *T. parvispinus* after 24 hrs of treatment in flower dip method. Similarly, it was 58% in residue contact method. Another formulation, UHSB-MAM2 @2000 ppm recorded 55% mortality of *T. parvispinus* within one day of treatment whereas it was 50% in residue contact method. The initial study on exploring metabolites of marine algae paves the way to utilize the management of *T. parvispinus* in chilli ecosystem.

IVC 23

SEAWEED-BASED pH-SENSITIVE SMART FILMS FROM *Gracilaria*: VALORIZATION OF AGAR AND EXTRACTION WASTE FOR SEAFOOD FRESHNESS MONITORING

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The growing demand for sustainable and intelligent food packaging has accelerated interest in seaweed-derived biopolymers. In this study, a pH-sensitive active packaging film was developed using agar extracted from *Gracilaria canaliculata* combined with chitosan as a functional biopolymer, agar-extraction-waste-derived nanocellulose as a reinforcing agent, and anthocyanin as a natural pH indicator. Agar was extracted through an optimized alkali-assisted process, while nanocellulose was valorized from agar extraction residues, promoting a circular bioeconomy approach. The resulting composite films were characterized for their physicochemical, mechanical, barrier, optical, and pH-responsive properties. Incorporation of nanocellulose significantly enhanced film strength and structural integrity, while anthocyanin imparted distinct and reversible color changes in response to pH variations associated with seafood spoilage. The developed films were evaluated for their applicability in seafood packaging under ambient and chilled storage conditions, targeting fresh as well as battered and breaded seafood products. The pH-sensitive response enabled real-time visual monitoring of freshness of the respective products, while the biopolymer matrix supported improved preservation performance. Overall, this work demonstrates the potential of seaweed-based smart packaging films as sustainable alternatives for seafood quality monitoring and shelf-life extension.

IVC 24

ULTRASONICATION-ASSISTED HYDROTHERMAL SYNTHESIS OF BIOACTIVE CARBON DOTS FROM RED SEAWEED (*Gracilaria*) FOR ANTIMICROBIAL AND ANTIOXIDANT APPLICATIONS

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Carbon dots (CDs) synthesized from the polysaccharide-rich red seaweed *Gracilaria* represent an emerging and sustainable nanomaterial for active food preservation, owing to their inherent antioxidant and antimicrobial properties. In this study, CDs were produced via a combined hydrothermal carbonization and ultrasonication method. The structural and functional characteristics of CDs were comprehensively evaluated. Spectroscopic analyses, including UV-Vis and FTIR, indicated significant structural transformations, marked by a reduction in carbonyl groups (1750–1450 cm^{-1}) and increased hydroxylation (3400–3200 cm^{-1}), which were directly correlated with enhanced bioactivity. The obtained CDs exhibited a uniform spherical morphology with quantum sized range and displayed excitation-dependent photoluminescence, withssion peaks between 300 and 400 nm. The CDs demonstrated exceptional antioxidant capacity, as assessed by radical scavenging assay and metal chelating ability. Furthermore, they exhibited potent, broad-spectrum antimicrobial activity, including effective inhibition against bacterial pathogens such as *L. monocytogenes* and *S. aureus*. The enhanced bioactivity is primarily attributed to the preserved and newly formed polar functional groups on the CD surface. These findings establish seaweed-derived CDs as sustainable, high-performance biomaterials with significant potential for application in active food packaging and biomedical coatings, addressing critical needs in food preservation technology.

IVC 25

BIO-EFFICACY OF *Sargassum wightii* SEAWEED EXTRACT AMENDED WITH *Methylobacterium oryzae* AS A LIQUID BIOFERTILIZER IN TOMATO (*Solanum lycopersicum* L.) PLANT

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Liquid seaweed fertilizers have gained considerable attention as sustainable alternatives for enhancing crop productivity. The present study evaluated the bio-efficacy of *Methylobacterium oryzae*-amended seaweed liquid fertilizer (SLF) on the growth performance of economically important horticultural crops, specifically tomato and chili. Sequential solvent extraction of *Sargassum wightii* revealed that methanol yielded the highest extractive value (137 mg/g), followed by water (94 mg/g), ethanol (80 mg/g), chloroform (20 mg/g), and petroleum ether (10 mg/g). The optimized seaweed-to-methanol ratio of 40:250 (w/v) produced maximum extraction efficiency. Phytochemical profiling of the methanolic extract revealed total phenolic content (0.456 mg/mL), flavonoids (1.587 mg/mL), chlorophyll (0.78 mg/g), carotenoids (5.27 mg/g), protein (0.63 mg/mL), carbohydrates (0.98 mg/mL), lipids (0.285 g/mL), and amino acids (0.546 µg/mL). Viability assessment of *M. oryzae* in 40% SLF demonstrated sustained bacterial survival with a cell density of 750 × 10^6 CFU/mL after six months of storage at 3% (v/v) inoculum concentration. Dual application methods (seed soaking and foliar spray) significantly enhanced *M. oryzae* colonization in both rhizosphere and phyllosphere of tomato and chili plants throughout the 90-day experimental period. Bio-augmentation with *M. oryzae* synergistically amplified the growth-promoting efficacy of SLF, as evidenced by significant improvements in root length, shoot length, fresh biomass, and dry biomass compared to SLF alone. These findings demonstrate that supplementation of seaweed liquid fertilizer with plant growth-promoting rhizobacteria (PGPR) such as *M. oryzae* constitutes a promising integrated biofertilizer strategy for sustainable horticultural production systems.

IVC 26

SEAWEED LIQUID FERTILIZER -SUSTAINABLE AGRICULTURE FOR ECO-FRIENDLY ENVIRONMENT

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Samples of 100% Seaweed Liquid Fertilizers (SLFs) obtained from a brown seaweed *Sargassum wightii* collected along the South East of Tamil Nadu coast of Mandapam during four different seasons viz., pre-monsoon, Monsoon, Post-monsoon and Summer were analyzed for macro elements: Potassium (K), Phosphorus (P), Calcium (Ca) and Sulphur (S) and microelements: Magnesium (Mg), Iron (Fe), Copper (Cu), Zinc (Zn) and Manganese (Mn). The SLFs revealed that the amounts of different macro and micro elements were higher in *S. wightii* during four different seasons. Further, the experiments were conducted to study the effect of SLFs of the brown alga *Sargassum wightii* on the growth of Black gram. The application of SLF increased the growth parameter such as shoot length, root length, fresh weight, dry weight and biochemical parameters viz., chlorophyll a, total carotenoids, protein, amino acids, reducing sugars and total sugar and starch content in the lower concentration. Further 10% of SLF treated *Vigna mungo* of root, shoot and leaf was subjected to Scanning Electron Microscopy with Energy Dispersive Spectroscopic Analysis, it reveals that the root portion contained eight elements in the following order: S>Cu>Na>Mg>Ca>P>Si> and Zn. The contribution of S was maximum (49.82% weight) in root. The shoot portion contained eight chemical elements in the following order Si>Na>Cu>Ca>P>S>Mg> and Zn; the leaf portion contained seven chemical elements of root, shoot and leaf not only by quality but also in quantity. Thus, the present experiment revealed the fact that the seaweed of *Sargassum wightii* could be used as a potential fertilizer to enhance the growth and yield. Amongst these, the use of liquid extracts or enzymatically treated colloids for Oligomers which may have some positive effects for humans. Selected aspects of these trends will be discussed during presentation.

IVC 27

ANALYSIS OF SEAWEED-BASED SNACK PRODUCTS IN THE INDIAN MARKET – A CASE STUDY

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The Indian snack market has experienced robust growth in recent years, driven by urbanisation, changing lifestyles, and an increasing demand for convenient packaged foods, accounting for nearly 32% of the total packaged food market in India in 2024. Within this large and well-established sector, seaweed-based snack products remain a niche segment, contributing approximately 1.8% of the overall snack market value in the same year, yet steadily gaining consumer attention. This study analyses the seaweed-based snack products currently available in the Indian market, focusing on product categories, brand presence, and consumer consumption patterns based on secondary data sources. Following their limited but emerging market share, a variety of seaweed-based products can be observed, including roasted and seasoned seaweed sheets, crispy seaweed snacks, seaweed chips, nori sheets, seaweed flakes and seaweed snack mixes. The findings reveal that the Indian market is largely dominated by imported brands, with most products being sold through e-commerce platforms. Consumption is mainly concentrated among urban, health-conscious consumers and is strongly influenced by Asian food habits and global trends. Although seaweed-based snacks currently occupy a small share of the Indian snack market, their increasing product diversity and visibility indicate strong potential for future research, product innovation, and localisation of seaweed-based snacks using Indian seaweed resources.

IVC 28

ZERO-WASTE BIOREFINERY FRAMEWORK FOR THE SEQUENTIAL EXTRACTION OF VARIOUS BIOPRODUCTS FROM *Sargassum polycystum* AND *Gracilaria edulis*

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Seaweed is a prolific resource containing valuable bioactive compounds like carotenoids, polyphenols, vitamins, nutrients, minerals, fibres, protein, carbohydrates and lipid so on, that effectively impact in the human health, environment and circular bioeconomy. Globally, the seaweed cultivation will be hiked about 44.56 billion USD in 2030 that was relatively lower in 2026 (28.43 billion USD). This paves the way to look for suitable and scalable methodologies to extract various bioproducts from two different seaweeds. In this study, two different seaweeds such as *Sargassum polycystum* and *Gracilaria edulis* were utilised for extraction carotenoids, polysaccharides and biochar conversion of leftover seaweed biomass. These two seaweeds were selected in this study due to its ease cultivation, global availability during commercialization. Initially, carotenoids were extracted using Ultrasound assisted extraction (UAE) followed by alginate, fucoidan, carrageenan polysaccharides were collected using three different methods (UAE, MAE and UMAE). Further, nano cellulose crystal (NCC) polysaccharide was extracted from leftover seaweed and then, the biochar was synthesized from relic seaweed biomass and being utilized for drug development and will examine for its efficacy against anti-microbial resistance (AMR). Hence, this study has majorly focused on biorefinery based approaches to utilize the whole seaweed biomass towards commercialization as a zero-waste concept.

IVC 29

COMPARATIVE STUDY OF BIODIESEL PRODUCTION FROM MICROALGAE AND MACROALGAE

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The need for a sustainable biofuel source has been growing significantly due to the depletion of fossil fuels. Recently, the third-generation algal feedstock has gained attention for biofuel production due to its biochemical composition and availability. Both microalgae and macroalgae possess distinct biochemical compositions that make them suitable for biofuel production. The selection of an optimal algal feedstock requires comparing the lipid content with the feasibility of harvesting and processing. While *Chlorella vulgaris* has a high lipid content, it offers high biodiesel potential; however, its cultivation and harvesting processes are energy-intensive. In contrast, *Gracilaria edulis* leads to easy biomass cultivation but has lower lipid content. This study presents a comparative evaluation of these two algal systems to assess whether high lipid yield or ease of processing represents a more practical pathway for sustainable biodiesel production. The cultivation of *Chlorella vulgaris* was optimized using Response Surface Methodology (RSM). The composition of Bold's Basal Medium (BBM) was modified to enhance biomass and lipid productivity. Biomass from both *Chlorella vulgaris* and *Gracilaria edulis* was dried. Biodiesel yield and fuel properties were analyzed and compared.

IVC 30

FROM MARINE WASTE TO SMART BIOMATERIALS: DESIGNING SEAWEED– CHITIN–COLLAGEN HYDROGELS

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Marine resources provide an abundant and sustainable platform for the development of next- generation biomaterials. Seaweed-derived polysaccharides and chitin-based nanomaterials have recently gained significant attention due to their biocompatibility, biodegradability, and functional versatility. In particular, β-chitin nanofibrils obtained from squid pen waste, seaweed-derived nanocrystals, and collagen represent a promising combination for the design of hydrogels for biomedical applications. Each component serves a complementary function: β-chitin nanofibrils provide structural support, seaweed nanocrystals act as hydrophilic crosslinkers and collagen imparts bioactivity and cell-adhesive properties. This review highlights fabrication strategies based on physical self-assembly and natural crosslinking, and their effects on mechanical strength, swelling, biodegradation, and biological performance. The applications of such composite hydrogels in wound healing, drug delivery, and tissue engineering are also discussed. By focusing on marine waste valorisation and seaweed-based nanomaterials, this perspective emphasizes a sustainable pathway toward high- value biomedical products and supports the growing vision of a circular blue bioeconomy.

IVC 31

EXTRACTION, CHARACTERIZATION AND EVALUATION OF POTENTIAL BIOACTIVE COMPOUNDS FROM *Dictyota dichotoma* (HUDSON.) J.V. LAMOUROUX

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In the present study, the bioactive compounds were obtained by solvent extraction methods and characterised by analytical techniques. *Dictyota dichotoma* showed the presence of important bioactive compounds such as tannin and phenolic compounds. The main structural characterisation and bioactive compounds were quantified by FTIR and HPLC analysis. Both methanolic and ethyl acetate extracts of *D. dichotoma* indicated the presence of gallic acid, catechin and quercetin by HPLC analysis. The other major phytocompounds such as Caryophyllene oxide, and Thunbergol were found in GC-MS analysis which shows the retention time of 20.95 and 21.50 respectively. *D. dichotoma* extracts by GC-MS analysis have shown major active compounds that showed potential antioxidant, antimicrobial and anticancer properties. We evaluated the antioxidant and antimicrobial properties of solvent extracts. The results revealed that ethyl acetate extract of *D. dichotoma* was found to be highly effective to scavenge H_2O_2 with lowest IC50 value of 20.57 ± 13.82 µg/mL as comparable with standard rutin (IC50 value 12.48 ± 10.41 µg/mL). In vitro antibacterial activity of solvent extracts of *D. dichotoma* was investigated against different human pathogens. The results revealed that ethyl acetate extract of *D. dichotoma* showed highest inhibitory activity against *Pseudomonas aeruginosa*. These present findings suggested that the ethyl acetate extract of *D dichotoma* possess higher antioxidant and antimicrobial activity compared to the methanolic extract. Thus, the synergistic effect of ethyl acetate extracted compounds could be used in pharmacology industries to develop novel drugs for antibiotic resistant bacteria.

IVC 32

PREPARATION AND CHARACTERIZATION OF ALGINATE FILM

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The development of biodegradable films from natural polymers is crucial to achieve sustainable packaging. Sodium alginate is an anionic polysaccharide that is predominantly located within the cell walls of marine brown algae, where it comprises 30-60% alginic acid. Sargassum is a major source of sodium alginate. Chitosan is a unique natural polycationic polysaccharide with non-toxic, biodegradable, and biocompatible properties derived from shell waste. Fish Gelatin forms strong, transparent, flexible, and biodegradable films with excellent oxygen barrier properties. Although sodium alginate, chitosan, and gelatin are promising, their combined functionality for real-world use, such as forming biocompatible packages, requires further investigation. Chitosan and gelatin have versatile properties suitable for film formation. The solubility of packing materials developed using these polymers has increased their use in several industries. Hence, this study aimed to investigate the preparation and properties of sodium alginate-based films using seafood processing waste. Sodium alginate at different concentrations (low, medium, and high) was used to produce sodium alginate chitosan gelatin films. Sodium alginate at high concentrations had good film-forming ability in chitosan and gelatin solutions. Sodium alginate has good compatibility with chitosan and gelatin. The film had good thermal stability compared to the chitosan gelatin film alone. The tensile strength of the chitosan gelatin film was found lower. Structural investigations by AFM analysis and SEM images showed the biocompatibility of the alginate chitosan-gelatin film. The FTIR spectra demonstrated good interactions between the polymers. The composite film was also found to have improved mechanical strength. Studies have demonstrated the suitability of alginate with chitosan and gelatin extracted from processing discards for the development of bio-packaging materials.

IVC 33

FROM SEA TO SOIL: SEAWEED FERTILIZER FOR SUSTAINABLE *Triticum aestivum* PRODUCTION IN THE ARID REGION OF KACHCHH, GUJARAT

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The rapid growth of the global population has increased pressure on agricultural systems to ensure food security. However, excessive dependence on synthetic fertilizers and pesticides has led to declining soil fertility and increased greenhouse gas emissions, threatening agricultural sustainability and climate stability. These challenges highlight the need for sustainable crop production strategies, among which seaweed-based fertilizers have gained attention. Seaweeds are marine algae rich in bioactive organic compounds that enhance soil moisture retention, nutrient availability, microbial activity, and soil structure, thereby promoting plant growth. In arid and semi-arid regions, soil salinity remains a major limitation to crop productivity; however, seaweeds contain diverse osmoprotective compounds that help mitigate salt stress and improve plant tolerance under saline conditions. Consequently, seaweed extracts are widely used as bio stimulants to enhance crop resilience and growth. The present study was conducted in the Kachchh district of Gujarat. Seaweed, *Kappaphycus alvarezii*, was collected from the coastal region of Okha, Dwarka district, and subjected to physico-chemical analysis. Seaweed fertilizer formulations (1%, 3%, and 5%) were prepared and evaluated through petri dish germination assays for seven days and pot experiments for thirty days using *Triticum aestivum*. Results showed 100% seed germination in 1,3 and 5% Petri dish and 3% and 5% pot for lab-based fertilizer. On the 30th day, seedling vigor index (3986.67 ± 25.17) and plant length (39.87 ± 0.25 cm) highest were recorded in the 3% lab-based fertilizer pot assay. Cost analysis confirmed feasibility, highlighting its potential to support sustainable agriculture and generate eco-friendly livelihood opportunities for local communities.

IVC 34

Kappaphycus alvarezii ASSOCIATED NITROGEN FIXING BACTERIA: A FUNCTIONAL VALIDATION

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Global research in the past decade signifies the role of heterotrophic diazotrophic bacteria (HDB) in marine nitrogen fixation, shifting the focus from earlier studies that concentrated on cyanobacteria. Marine macroalgae establish stable relationships with endophytic and epiphytic bacteria to support their growth, development, and defence mechanisms. Many of the recent studies point to the significance of seaweed microbiome in managing productivity in culture systems. The red seaweed *Kappaphycus alvarezii*, which is the primary source of kappa carrageenan, exhibits a rapid growth rate in oligotrophic oceanic waters. The present study investigated the presence of *K. alvarezii* associated HDB by cultivation in nitrogen-deficient growth medium. The qualitative estimation of ammonia production as an indirect measure of nitrogen fixation was carried out using Nfb broth assay with and without carrageenan as sole carbon source. The molecular analysis revealed the presence of *NifH gene* in some of the isolates. The isolates such as *Stutzerimonas* sp, *Halomonas* sp and *Salinicola* sp showed the plant growth promoting hormone activity, utilized algal polysaccharides for growth, and on co- cultivation with *K. alvarezii* demonstrated enhanced growth as compared to untreated controls, which needs further validation. This study paves an opportunity to explore the biological basis for seaweed microbe associations and in utilizing these marine nitrogen-fixing bacteria in a consortium for seaweed farming.

IVC 35

IMPACT OF SEAWEED EXTRACT SEED COATING ON THE PHYSIOLOGICAL AND BIOCHEMICAL RESPONSE OF BHENDI (*Abelmoschus esculentus*) (L.) Moench

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Seaweeds are marine macroalgae found in coastal and intertidal regions and are rich sources of bioactive and nutritional compounds. They contain polysaccharides, proteins, amino acids, lipids, essential fatty acids, vitamins and minerals, along with antioxidants that contribute to their agricultural, pharmaceutical and industrial importance. Improving seed quality through post-harvest practices is essential for achieving better germination, seedling establishment and crop productivity. Among the techniques developed, seed coating has emerged as an effective method, as it involves the application of nutrients and bioactive substances onto the seed surface to enhance seed performance under different environmental conditions. The present study aimed to evaluate the influence of water and methanol extracts of *Sargassum myriocystum* and *Kappaphycus alvarezii* as seed coating treatments. Bhendi seeds were coated with seventeen treatments, comprising a control (T□), water and methanol extracts of *Sargassum* (T□–T□) and *Kappaphycus* (T□–T□□) were applied @ concentrations of 20, 25, 30 and 40 g kg^{-1}.The results revealed that, significant variations among treatments, with *Sargassum myriocystum* methanol coating @ 25 g kg^{-1} (T□) recorded the highest germination percentage (94%), shoot length (16.32 cm), root length (12.35 cm), dry matter production (0.390 g), vigour index I (2695), emergence energy value (7.49), germination relative index (98), dehydrogenase activity (0.746 OD value) and catalase activity (0.312 µg g^{-1}). In contrast, control seeds exhibited lower germination (90%), shoot length (11.72 cm), root length (8.76 cm), dry matter production (0.277 g), vigour index I (1638), emergence energy value (5.76), germination relative index (70), dehydrogenase activity (0.688 OD value) and catalase activity (0.287 µg g^{-1}). The findings provide strong scientific evidence that methanol extract of *Sargassum myriocystum* at an optimum concentration of 25 g kg^{-1} is an effective, eco-friendly and sustainable seed coating material for enhancing crop performance.

IVC 36

FROM OCEAN TO CLINIC: ANTIVIRAL POTENTIAL OF SEAWEED-DERIVED BIOACTIVE COMPOUNDS

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This review synthesizes recent advances in seaweed-derived bioactive compounds—particularly sulfated polysaccharides (fucoidans, carrageenans, ulvans) and phlorotannins from red (*Gracilaria*, *Pyropia*) and brown (*Laminaria*, *Undaria*, *Ecklonia*) seaweeds—as natural antiviral agents and immunostimulants. Viral infections remain a significant challenge to human health, aquaculture, and animal populations worldwide. Seaweeds are rich in bioactive compounds, including sulfated polysaccharides, polyphenols, and lectins, which have shown broad-spectrum antiviral properties. In humans, these compounds inhibit key pathogens such as Influenza virus, HIV-1, SARS-CoV-2, Dengue virus, and Herpes simplex virus (HSV). In aquaculture, viral diseases—including Tilapia Lake Virus (TiLV), Viral hemorrhagic septicemia virus (VHSV), Infectious salmon anemia virus (ISAV), White Spot Syndrome Virus (WSSV), and Infectious pancreatic necrosis virus (IPNV)—cause substantial economic losses. Seaweed-derived bioactives can reduce viral replication, enhance host immune responses, and improve survival rates in infected fish and shrimp. Furthermore, seaweed compounds exhibit antiviral activity against other animal viruses, including Avian influenza virus (AIV, H5N1/H9N2), Feline calicivirus (FCV), and other feline viruses. The mechanisms of action include inhibition of viral attachment, entry, and replication (fucoidan), blocking of viral adsorption and penetration (carrageenan) and inactivation of viral proteins (phlorotannins). This underscores the translational potential of seaweed bioactives for therapeutic applications in humans, aquaculture, and veterinary medicine. Continued research into optimized extraction, formulation, and delivery strategies is critical for harnessing seaweed's full antiviral potential.

IVC 37

DEVELOPMENT OF BIODEGRADABLE FILM INCORPORATING ALOE VERA AND SEAWEED FOR FOOD PACKAGING

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Environmental concerns linked to petroleum-based food packaging materials have accelerated the development of sustainable, biodegradable alternatives. Aloe vera possesses antimicrobial, antioxidant, and film-forming properties, while *Kappaphycus alvarezii,* a carrageenan-rich red seaweed, provides good gel strength and mechanical stability. The study aimed to develop biodegradable films incorporating Aloe vera gel and *K. alvarezii* for food packaging applications. Biodegradable films were prepared using Aloe vera gel, seaweed gel, and their composite blends with glycerol as a plasticizer. Three film formulations Aloe vera film (A), seaweed film (K), and composite film (AK) were fabricated by solution casting and dried under ambient conditions. The films were evaluated for physical properties (moisture content, thickness, swelling index, and water solubility), mechanical properties (tensile strength, elongation at break, and water vapor transmission rate), thermal stability using thermogravimetric analysis, and biological properties, including antioxidant and antimicrobial activity. The composite AK film exhibited higher mechanical strength, improved flexibility, and enhanced barrier properties compared to individual films. The composite film showed higher thickness and water vapor permeability, with glycerol contributing to improved elasticity and structural stability. Thermal analysis confirmed the stability of the composite film across a wide temperature range. Aloe vera incorporation imparted notable antioxidant and antimicrobial activity. Biodegradability studies demonstrated natural degradation under environmental conditions. Aloe vera and *Kappaphycus alvarezii*-based composite films show strong potential as biodegradable and functional alternatives to synthetic food packaging materials, with promising applications in sustainable food packaging.

IVC 38

OCEANLUX: *Sargassum wightii* FOR SUSTAINABLE FASHION

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As the global demand for sustainable materials continues to rise, the fashion industry is seeking eco-friendly alternatives to traditional raw materials. With concerns over resource scarcity, environmental impact, and the growing population, renewable materials are becoming a necessity rather than an option. Among these, marine algae stand out as a promising, climate-resilient resource. One such marine algae, *Sargassum wightii*, a brown seaweed abundant in the Gulf of Mannar, is rich in alginate, cellulose, fibers, and polyphenols. Notably, it has excellent film-forming properties, making it a strong candidate for bio-based fashion accessory Leather. This study explores the integration of *Sargassum wightii* (at concentrations of 10–50%) into sheet production and evaluates its mechanical and physical performance against conventional PVA-based Leather. The biochemical analysis of *Sargassum wightii* revealed a high fiber content (33.11%) and significant alginate levels (38.53%), both of which contribute to its durability and flexibility. The leather developed from this seaweed had thicknesses ranging from 0.67 mm to 2.16 mm. Testing results indicated that leather with 20–30% *Sargassum wightii* content exhibited tensile strengths between 15.13 MPa and 26.69 MPa, making them suitable for applications in footwear, leather goods, and saddlery. Additionally, these bio-based leather demonstrated improved fire resistance and reduced water absorption compared to conventional materials. Notably, a *Sargassum wightii* leather with 30% incorporation achieved 55.07% of the tensile strength and 100% of the maximum load-bearing capacity of the control PVA leather, highlighting its potential as a viable sustainable alternative. This research underscores the immense possibilities of marine algae in industrial applications, paving the way for the integration of *Sargassum wightii* into the fashion sector. By leveraging nature's resources, the industry can move towards a more sustainable and environmentally conscious future.

IVC 39

STUDIES ON SHELF-LIFE EXTENSION OF THE MARINE FINFISH *Hemiramphus far* USING THE MACROALGA *Sargassum cinereum* UNDER CHILLED STORAGE CONDITIONS

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Fish and fishery products provide vital high-quality nutrition from marine ecosystems, but in developing countries like India, growing demand for chilled fish is limited by poor cold-chain infrastructure, causing quality deterioration, post-harvest losses, and public health risks. This study evaluated Sargassum cinereum seaweed powder, applied with carboxymethyl cellulose (CMC) as a natural binder, to extend shelf life and maintain quality of chilled marine finfish (*Hemiramphus far*) from harvest to market. Fresh samples were divided into seven groups: control, eviscerated, and eviscerated fish coated with varying *S. cinereum* powder concentrations using CMC. All were stored in ice at a 1:1 fish- to-ice ratio and assessed over 15 days. Organoleptic evaluation showed Group 7 (eviscerated + *S. cinereum* + CMC) with the highest scores chilled (3.6), cooked (4.3) while the control was rejected by days 8–10 due to sour odour and mushy texture. pH increased gradually from near-neutral to alkaline, but Group 7 had the lowest value (7.2 on day 14), indicating delayed spoilage. Biochemical analyses revealed better nutrient retention in treated samples: proteins (16.5–16.7%), carbohydrates (0.91–0.93%), lipids (1.5–2.5%) compared to control. Microbiological counts (log CFU/g) increased progressively, but pathogens (*Salmonella, E. coli, Staphylococcus* spp., *Vibrio* spp.) were absent throughout the experiment. Immediate evisceration with S. cinereum + CMC coating under chilled conditions effectively prolonged H. far shelf life without compromising sensory quality or acceptance. This edible seaweed approach offers a natural, sustainable, consumer friendly solution to enhance chilled fish preservation and strengthen India's marine supply chain.

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MEDICINAL AND PHARMACEUTICAL APPLICATIONS OF SEAWEED

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Seaweeds, a diverse group of marine macroalgae, have emerged as valuable natural sources of bioactive compounds with significant medicinal and pharmaceutical potential. Their rich biochemical composition—including polysaccharides (e.g., alginates, carrageenans, fucoidans), polyphenols, pigments, proteins, vitamins, and minerals—has been shown to exhibit a broad spectrum of pharmacological activities. These compounds demonstrate potent antioxidant, anti-inflammatory, antimicrobial, antiviral, anticoagulant, and anticancer properties, making seaweed extracts promising candidates for drug discovery and therapeutic development. Seaweed-derived polysaccharides are particularly important in pharmaceutical formulations due to their bioactivity and biocompatibility, while other metabolites like polyphenols and carotenoids contribute to protective mechanisms against oxidative stress and disease progression. Research also highlights the role of these natural compounds in supporting immune function and their potential use as nutraceuticals, which bridge nutrition and medicine. Regardless of these beneficial aspects, challenges remain in optimizing the extraction, bioavailability, and large-scale application of seaweed bio actives. Continued investigation into their mechanisms of action and clinical efficacy is essential to fully integrate seaweed-based compounds into modern pharmaceutical and therapeutic practices.

IVC 41

PREPARATION AND CHARACTERIZATION OF FISH GELATIN INCORPORATED BROWN SEAWEED FUCOIDAN AS BIODEGRADABLE PACKAGING FILM

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Fish gelatin extracted from skin wastes of sword fish (*Xiphias gladius*) was evaluated in terms of extraction yield, viscoelastic properties, biochemical composition. The sword fish gelatin yield shows a value of 9.5 %, foaming capacity of 75±0.8% and stability 80±0.7% which was stable up to 10 mins. The FTIR profile of extracted fish gelatin showed the presence of all major peaks and functional groups of gelatins situated in Amide I, II, III, A and B regions. The amino acid profile of sword fish gelatin shown major amino acids such as glycine, proline, alanine and glutamic acid. The composition of extracted sword fish gelatin was well suited to the standard of food industries. Fucoidan was extracted from the brown seaweed *Rosenvingea endiviifolia*) and characterized fucoidan results showed a yield of 2.8% and 43.7% of total fucose, 35.5% of sulfate ,18.1% of uronic acid and 63% of carbohydrates. Further, the structural characterization FT-IR shows major peaks of functional groups of sugar ring, ester, carbonyl group and monosaccharide monomer. ^{1}HNMR results of the extracted fucoidan show peak at its resonance signals at 4 to 5 ppm. The antioxidant result showed maximum activity of 76.8±1.3 % at highest concentration of 100 µg/ml. The antimicrobial activity with 23±0.9mm zone of inhibition area was obtained against *E. coli* with 2% concentration of fucoidan solution. Thus, extracted fucoidan and fish gelatin can be utilized as suitable biopolymers for active biodegradable film.

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INDIAN SEAWEED RESOURCES: COMMERCIAL SPECIES, EXPORT DYNAMICS, AND EVOLUTIONARY TRENDS IN THE GLOBAL MARKET

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Seaweed represents a cornerstone of India's burgeoning blue economy, offering significant potential for sustainable rural development and industrial application. While India hosts over 700 species with an annual harvestable biomass of 0.26 million tonnes, it has historically remained a minor global player, contributing less than 1% to total production. This study examines the strategic shift in India's seaweed sector from the export of raw materials to high-value processed extracts, including phycocolloids, biostimulants, and nutraceuticals. Major commercial species such as *Kappaphycus*, *Gracilaria*, *Sargassum*, and *Gelidiella* are central to this transition. Market analysis indicates that the Indian seaweed market, valued at USD 318.7 million in 2025, is projected to reach USD 625.9 million by 2034, reflecting a CAGR of 7.79%. This growth is propelled by rising global demand for plant-based sustainable ingredients, organic "clean-label" trends, and pharmaceutical innovations. Key export destinations currently include the USA, Brazil, Southeast Asia, and the EU. This paper evaluates the recent policy initiatives and infrastructure developments required to position India as a global seaweed hub, emphasizing the necessity of strengthening supply chains and enhancing processing capacities to capture a larger share of the global market.

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SEAWEED CARTRIDGES

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Innovation in seaweed-based food product development has created opportunities to replace artificial additives with functional, edible, and sustainable alternatives. *'Seaweed cartridges'* represent a novel delivery system designed to carry seasonings and condiments while simultaneously enhancing nutritional value and culinary performance. These cartridges are edible delivery systems filled with seaweed-derived seasonings or condiments, designed to enhance flavor while reducing reliance on synthetic flavor enhancers and excessive sodium. Upon exposure to hot water or cooking conditions, the cartridge shell dissolves, releasing flavors and nutrients while contributing thickening and textural properties to the final dish. In addition to flavor enhancement, seaweed cartridges can be fortified with naturally occurring micronutrients, including iodine-rich bio-salt and calcium, thereby contributing to nutritional adequacy and addressing common mineral deficiencies. For instance, dulse flakes function as a natural monosodium glutamate replacement, delivering Intense umami flavor with significantly lower sodium content than conventional options. Four cartridge formats have been developed to address diverse food applications: (i) Powder Pods – Each cartridge is filled with a specific seaweed flavor profile (e.g., Smoky Dulse, Salty Kelp, Spicy Aonori) (Ii) Flavor Discs – a cartridge is a stack of thin, seaweed discs, each infused with different seasonings. (iii) 3D Hydrogels, based on alginate systems that instantly solidify upon contact with calcium and (iv) Soluble Peptides – a small, squeezable cartridge designed for liquid seasonings like seaweed-infused oils. Overall, seaweed cartridges integrate clean-label seasoning and nutritional fortification into a single platform, demonstrating strong potential for sustainable, additive-free innovation in next-generation food systems.

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SEAWEED AS A SUSTAINABLE SUPERFOOD: NUTRITIONAL POTENTIAL AND ENVIRONMENTAL BENEFITS

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Seaweed is gaining attention as a sustainable superfood because it is highly nutritious and environmentally friendly. It contains important nutrients such as proteins, dietary fiber, vitamins, and minerals like iodine, iron, and calcium, which are essential for good health. Seaweeds also have natural bioactive compounds that act as antioxidants and help reduce inflammation, control blood sugar levels, and support the immune system. Including seaweed in the diet can help prevent nutritional deficiencies and lifestyle-related diseases. One of the major advantages of seaweed is its sustainability. It grows naturally in the ocean without the need for farmland, freshwater, or chemical fertilizers. Seaweed cultivation also helps absorb carbon dioxide and excess nutrients from seawater, improving marine environmental health. In addition, seaweed farming provides income opportunities for coastal communities and supports eco-friendly aquaculture practices. Seaweed can be used as a plant-based food option, reducing dependence on animal products and lowering environmental impact. However, challenges such as taste acceptance, quality control, and safety concerns related to heavy metal content need proper management. Overall, seaweed has great potential as a nutritious, sustainable food that can support human health and global food security.

IVC 45

DEVELOPING EDIBLE SEAWEED VALUE CHAINS THROUGH SUSTAINABLE BIOSECURE PRODUCTION AND INTEGRATED FOOD SAFETY FRAMEWORKS

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The increasing global demand for sustainable and nutrient-dense foods has positioned edible seaweeds as strategic marine bioresources within emerging blue economy frameworks. Global seaweed production reached approximately 37.8 million tonnes (wet weight) in 2022, largely driven by aquaculture. In contrast, India—despite its extensive coastline of nearly 11,000 km, including island territories, and more than 1,150 documented seaweed species—recorded a production of only about 72,385 tonnes in 2023. Current cultivation is predominantly centred on *Kappaphycus alvarezii* and *Gracilaria edulis* for phycocolloid extraction, while direct edible applications and organized value chains remain limited. Edible seaweeds are rich in iodine, iron, calcium, vitamins, dietary fiber, polyunsaturated fatty acids, and diverse bioactive compounds with antioxidant, anti-inflammatory, and metabolic health benefits, highlighting their potential as functional and plant-based food ingredients. However, existing production systems rely largely on open-water cultivation, which is vulnerable to environmental fluctuations, contamination risks, and inconsistent product quality. This ongoing study aims to develop and evaluate a sustainable value-chain framework integrating biosecure production systems with standardized cultivation protocols and comprehensive food safety mechanisms. Controlled cultivation trials of *Ulva spp.*, *Caulerpa spp.*, and *Gracilaria spp.* are being conducted under optimized environmental conditions to improve biomass consistency, nutritional stability, and contaminant mitigation. The framework incorporates heavy metal surveillance, microbial safety assessment, and traceability measures to enhance regulatory compliance and consumer confidence. The anticipated outcomes include strengthened edible seaweed value chains, improved nutritional biosecurity, and enhanced contributions to sustainable blue economy development.

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EXTRACTION AND CHARACTERIZATION OF CARRAGEENAN AND CELLULOSE NANOCRYSTAL FROM RED SEAWEED *Gracilaria verrucosa*

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Red seaweed *Gracilaria verrucosa*, a commercial agar yielding algae species, was used as a potential source for the obtaining of carrageenan. The extraction of carrageenan involves alkali pretreatment followed by aqueous extraction and KCl precipitation. Ash, moisture, gel strength, viscosity and functional groups of carrageenan were determined; these properties were compared with those of commercial carrageenan. The highest yield of crude carrageenan was 10.1%, with a viscosity of 20.33 cP, a moisture content of 0.28%, and a sulfate concentration of 32%. The possibility of the utilization of the carrageenan as a biopolymer and a food additive was also evaluated. The waste of the seaweed left after the extraction of carrageenan was utilized for the isolation of cellulose followed by cellulose nanocrystal. The CNC isolated from *G. verrucosa* waste showed a yield of 14.72±0.1%. The surface functionality of the CNC was evaluated by Fourier Transform Infrared Spectroscopy. X-ray diffraction studies showed that the as-extracted CNC exhibit cellulose I crystalline structure, with a crystallinity index of 65.7%. In Thermogravimetric Analysis (TGA), isolated CNC showed increased thermostability and a lower residual mass. Scanning Electron Microscope (SEM) confirmed the ordinary rod-like shape of the produced CNC with various dimensions.

IVC 47

DUAL-PHASE SEAWEED UTILIZATION: COMBINING BIOCHAR AND LIQUID EXTRACT FOR OPTIMIZED PLANT NUTRITION AND SOIL AMENDMENT

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The present investigation proposes a novel dual-phase seaweed utilization technique, offering a path to a new era in biochar applications for sustainable agriculture. This study introduces a unique methodology where seaweed residue left after the liquid extraction process is pyrolyzed to form biochar, which is subsequently enriched with the same liquid extract, producing a multifunctional soil amendment. Using *Vigna radiata* L. (green gram) as a model crop, evaluated the efficacy of seaweed-derived liquid extract and biochar combinations on morpho-physiological parameters compared with conventional chemical fertilizer. Seaweed liquid-enriched biochar has outperformed all other treatments including control with increased shoot length, root length, dry weight, fresh weight and chlorophyll content. Dual-phase seaweed utilization strategy can be considered as a successful alternative to the harmful chemical-based fertilization techniques, which offers immediate nutrient availability of liquid extract combined with biochar's controlled and sustained delivery of nutrients.

IVC 48

SEAWEED-DERIVED CARRAGEENAN/ALGINATE NANOCOMPOSITE FILM: A PRELIMINARY STEP TOWARDS SUSTAINABLE ANTIMICROBIAL FOOD PACKAGING

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The urgent need to replace petroleum-based plastics in food packaging has accelerated interest in biodegradable materials derived from natural resources. Marine polysaccharides, particularly carrageenan extracted from *Kappaphycus alvarezii*, possess excellent film-forming ability, renewability, and biocompatibility, making them promising candidates for eco-friendly packaging solutions. In the present work, carrageenan was blended with alginate biopolymer to fabricate a biodegradable film incorporated with nanoparticles to enhance its functional performance for antimicrobial food packaging applications. The extracted carrageenan was combined with alginate and fabricated into films using the solvent casting method, resulting in uniform, continuous films that demonstrated good compatibility between the biopolymers. The incorporation of MgO nanoparticles into the polymer matrix was achieved during film preparation, resulting in a stable bionanocomposite structure. The resulting Carrageenan/alginate/MgO NPs nanocomposite film was confirmed with preliminary characterization studies, indicating good compatibility between the biopolymers, nanoparticles their suitability for film fabrication. Notably, the developed film exhibited antimicrobial efficacy, indicating its potential as an active packaging material for enhancing food safety and shelf life. This study highlights the potential of utilizing seaweed-derived polymers in combination with nanotechnology to create sustainable, biodegradable, and active packaging materials. The developed nanocomposite film provides a promising platform for extending food shelf life while reducing environmental plastic waste. Future work will focus on detailed evaluation of mechanical strength, barrier properties and real-time food preservation studies to validate its practical applicability in the food packaging industry.

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ASSESSMENT OF THE NUTRITIONAL BENEFITS AND SENSORY ATTRIBUTES OF DARK CHOCOLATE FORTIFIED WITH *Gracilaria* spp.

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The growing demand for functional foods has encouraged the incorporation of nutrient-rich natural ingredients into widely consumed products such as chocolate. This study aims to assess the nutritional benefits and sensory attributes of dark chocolate fortified with *Gracilaria. Gracilaria* is known for its high content of minerals, dietary fiber, antioxidants, and bioactive compounds, which may enhance the health value of food products. In this research, dark chocolate samples were formulated with varying concentrations of *Gracilaria* and evaluated for their nutritional composition, including mineral content, antioxidant activity, and fiber levels. Sensory evaluation was conducted using a trained or semi-trained panel to assess key attributes such as color, aroma, texture, taste, and overall acceptability. Overall, the findings suggest that *Gracilaria* can be successfully used as a functional ingredient in dark chocolate, providing enhanced nutritional benefits without compromising sensory quality. This study highlights the potential of seaweed-fortified chocolate as a novel functional food product with added health benefits.

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PROXIMATE COMPOSITION AND PHYSICOCHEMICAL CHARACTERISTICS OF SEAWEED-BASED BOBA PEARLS FORMULATED WITH SODIUM ALGINATE AND STRAWBERRY JUICE VIA BASIC SPHERIFICATION METHOD

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The increasing demand for functional and plant-based food products has encouraged the development of innovative alternatives to conventional tapioca boba pearls. This study aimed to evaluate the proximate composition and physicochemical characteristics of seaweed-based boba pearls produced using sodium alginate extracted from seaweed and strawberry juice, employing calcium chloride through the basic spherification method. Sodium alginate extracted from brown seaweed (*Sargassum wightii*) was utilized as a gelling agent, while strawberry juice served as a natural flavoring and coloring component. The boba pearls were prepared by dissolving sodium alginate in strawberry juice, followed by dropwise spherification into a calcium chloride solution to form gelled spheres. Proximate analysis, including moisture, ash, protein, fat, carbohydrate, and dietary fiber contents, was conducted using standard analytical methods. Physicochemical properties such as pH, texture profile, sphericity, color, and water-holding capacity were also evaluated. The incorporation of strawberry juice contributed to favorable color and sensory appeal, while calcium-induced gelation provided structural stability. This study concludes that seaweed-based boba pearls produced via basic spherification possess promising nutritional and functional characteristics and have potential application as a health-oriented ingredient in beverage and dessert products.

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SEAWEED BASED EDIBLE PACKAGING

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Seaweed based edible packaging brings a sustainable alternative to plastics by utilizing marine algae's abundant polysaccharides like alginate, carrageenan and agar which are biocompatible and can be converted into edible films. These films incorporate natural antimicrobials, antioxidants or nanoparticles to enhance functionality. In this way, the seaweed based edible packaging enhances nutritional value (vitamins, minerals, fiber) of food. The seaweed biopolymers form flexible, transparent films that serve as barriers against oxygen, moisture and grease, besides being moisture-sensitive. Applications include single use sachets for seasonings, coffee or instant noodles that dissolve in hot water, edible cups for jello or ice cream, burger wraps, straws and fruit or vegetable coatings, which prolong shelf life by reducing respiration and microbial growth. Companies like Notpla, Evoware have commercialized seaweed sauce packets and cups in flavors like lychee or green tea. Seaweed edible packaging falls in the circular economy landscape and reduces the million tons of oceanic plastics produced every year and promotes zero waste food systems.

IVC 52

ECO-FRIENDLY SYNTHESIS AND BIOEVALUATION OF *Sargassum johnstonii*-MEDIATED GOLD NANOPARTICLES FOR AQUACULTURE AND BIOMEDICAL APPLICATIONS

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Nanotechnology has gained increasing importance due to its broad applications in biomedicine and aquaculture. Green synthesis of nanoparticles using marine seaweeds offers an environmentally sustainable and biologically safe alternative to conventional chemical methods. In the present study, gold nanoparticles (Sj-AuNPs) were biosynthesized using the brown seaweed *Sargassum johnstonii* and evaluated for their antioxidant, antibacterial, and biocompatibility properties. Phytochemical screening confirmed the presence of bioactive compounds, including alkaloids, phenols, tannins, and terpenoids, which facilitated nanoparticle formation and stabilization. The successful synthesis of Sj- AuNPs was evidenced by a characteristic surface plasmon resonance peak at 520 nm in UV–visible spectroscopy. FTIR analysis identified functional groups involved in gold ion reduction and nanopaterial stabilization. X-ray diffraction analysis revealed distinct peaks at 38.22°, 45.41°, and 66.47°, confirming the face-centered cubic crystalline structure of the nanoparticles. Morphological and elemental analyses using FE-SEM, EDAX, and HR-TEM demonstrated predominantly spherical nanoparticles with an average size of approximately 53 nm. The biosynthesized Sj-AuNPs exhibited strong antioxidant activity, with DPPH radical scavenging (78.23 ± 0.19%), reducing power (71.20 ± 0.12%), and total antioxidant capacity (76.15 ± 0.01%). Significant antibacterial activity was observed against *Vibrio harveyi*, showing an inhibition zone of 23 ± 1.35 mm at 150 µg/mL. In vivo toxicity evaluation using Artemia nauplii indicated high survival (97 ± 0.84%) even at 1000 µg/mL, confirming excellent biocompatibility. Additionally, Sj-AuNPs enhanced nauplii survival under hydrogen peroxide-induced oxidative stress. These findings demonstrate the potential of *S. johnstonii*- mediated gold nanoparticles for applications in aquaculture health management and nanomedicine.

IVC 53

BIOREMEDIATION EFFICIENCY OF SEAWEEDS IN FISH RAS EFFLUENT UNDER POLYHOUSE CONDITIONS

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This study assessed the bioremediation capacity of three seaweeds—*Caulerpa taxifolia* (Treatment I), *C. scalpelliformis* (II), and *Dictyota dichotoma* (III)—for treating effluent from a polyhouse-based fish recirculating aquaculture system (RAS). Water quality parameters and nutrients (total ammonia nitrogen [TAN], nitrite-N, nitrate-N, phosphate, silicate) were monitored regularly, remaining stable overall. TAN in the fish unit stayed consistent, but declined sharply in seaweed treatments after 15 days of culture (DOC), falling below optimal levels with rising biomass; similar trends occurred for nitrite-N and nitrate-N, peaking early before normalizing, while phosphate was initially high only in the fish unit and silicate stayed sub-optimal. *C. taxifolia* showed superior nutrient removal, especially nitrogenous compounds, with the highest specific growth rate (SGR: 1.854%) and cumulative biomass gain compared to *D. dichotoma* (1.559%) and *C. scalpelliformis* (1.361%), highlighting its potential for integrated aquaculture.

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ENHANCING PLANT GROWTH-PROMOTING BACTERIAL POPULATIONS IN VERMICOMPOST THROUGH INCORPORATION OF SEAWEED AND BIOCHAR FOR SUSTAINABLE AGRICULTURE PRACTICES

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This study addresses the critical need for sustainable agricultural practices in coastal regions like Kerala, India, by developing seaweed-integrated coconut leaf vermicompost as a viable alternative source to chemical fertilizers, which led degradation, nutrient imbalances, adverse changes in soil microbial communities (including beneficial fungi and bacteria), and cause environmental pollution extending to water bodies and air quality, thus necessitating ecologically sound and resource-efficient alternatives. The research focuses on converting abundant lignocellulosic agricultural waste, specifically coconut leaves, and readily available nutrient-rich *Padina* seaweed (a prevalent brown alga from the Kerala coastline) into a high-quality organic compound through a carefully controlled vermicomposting process utilizing *Eudrilus sp.* earthworms. Selected for their proven efficiency in decomposing organic matter and enhancing nutrient cycling. Furthermore, this research explores the benefits of co-composting with coconut-based biochar, which enhances the physical properties of the compost and soil, improves water retention capacity, increases capacity to cation exchange, improves long-term carbon sequestration potential, and provides a stable, porous habitat conducive for the proliferation of beneficial microbial communities within the resulting organic fertilizer. The primary objective is to quantitatively assess the impact of varying *Padina* seaweed concentrations (ranging from 5% to 100% of the compost mixture by weight, in incremental steps) and the strategic addition of biochar to the vermicompost. The methodology encompasses the collection and specific pre-processing of *Padina* sp. from identified coastal areas (Thikkodi beach) and senesced coconut leaves from established agricultural research centers (e.g., ICAR CPCRI protocols), followed by the establishment of controlled experimental units with combinations of these organic materials maintained under optimized environmental conditions (temperature, moisture, pH) to ensure maximum vermicomposting efficiency and earthworm proliferation. This research is anticipated to yield an optimized, scalable protocol for producing a superior quality vermicompost that not only significantly improves soil fertility, enhances crop nutrition and resilience, and substantially improve environmental footprint of agriculture by reducing the use of chemical fertilizer, but also contributes to effective use of agricultural waste management, promotes circular economy principles, and strengthens the long-term ecological resilience and sustainable productivity of coastal agricultural ecosystems in India.

IVC 55

FUNCTIONAL ENHANCEMENT OF FOXTAIL MILLET PASTA WITH *Padina boergesenii* SEAWEED: PHYSICOCHEMICAL ANALYSIS, SENSORY EVALUATION, AND STORAGE STABILITY

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This study evaluated the incorporation of *P. boergesenii* at 0% (P0), 1% (P1), 3% (P3), 5% (P5), and 7% (P7) levels in foxtail millet pasta and assessed its impact on nutritional composition, textural properties, and sensory quality. Physicochemical and sensory analyses were performed, while storage stability was evaluated through peroxide value (PV), free fatty acids (%FFA), total plate count (TPC), pH, and water activity (a_w). Principal Component Analysis was employed to validate the results. Enrichment with *P. boergesenii* significantly enhanced the nutritional and functional quality of the pasta. The P7 formulation exhibited the highest lipid (1.45%), mineral (1.84%), phenolic (0.448 mg GAE/g), flavonoid, and fatty acid contents, including linoleic (48.97%) and oleic acids (15.46%), along with the highest antioxidant activity (80.65% DPPH RSA), though a decrease in amino acid content was noted. FTIR analysis confirmed characteristic functional group peaks, with $R_{1047/1022}$ and $R_{1022/995}$ ratios indicating increased crystallinity and reduced double-helix order. Cooking time increased from 3 min 30 s (P1) to 5 min 30 s (P7), and cooking loss slightly exceeded 8% in all samples except P1. Texture analysis showed reduced hardness and gumminess and increased springiness ($p < 0.05$), while color shifted toward brownish-green tones. Sensory acceptability followed the order P0 > P1 > P7 > P3 > P5, with P7 preferred for texture. During 60 days of storage, all quality parameters remained within acceptable limits. Overall, 7% *P. boergesenii* incorporation was identified as the most effective formulation.

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NUTRITIONAL FORTIFICATION OF BARNYARD MILLET PASTA USING BROWN SEAWEED *Padina pavonica*: QUALITY CHARACTERISTICS AND SHELF-LIFE EVALUATION

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There is a growing demand for functional foods that combine nutritional benefits with sustainability. This study developed a novel, nutritionally enhanced pasta by combining underutilized barnyard millet (*Echinochloa frumentacea),* a gluten-free nutri-cereal, with calcified brown seaweed *Padina pavonica,* a rich source of minerals and bioactive compounds, aiming to optimize seaweed-fortified barnyard millet pasta and evaluate its nutritional composition, textural characteristics, antioxidant capacity, physicochemical properties, and storage stability. Five pasta formulations were prepared by incorporating seaweed at 0% (P0), 1% (P1), 3% (P3), 5% (P5), and 7% (P7) levels, and analysed for proximate composition, cooking quality, texture profile, and sensory attributes using a 9-point hedonic scale, while bioactive properties were assessed through DPPH radical scavenging activity and Total Phenolic Content (TPC), and physicochemical characteristics including colour, pH, water activity (a_w), and FTIR spectroscopy were measured. Shelf-life studies conducted for 60 days at room temperature using LDPE packaging showed significant improvements in oxidative and microbial stability in fortified samples, with lower Peroxide Value (PV), Free Fatty Acids (FFA), and Total Plate Count (TPC) compared to control. Seaweed incorporation notably enhanced the nutritional and functional profile, with ash content increasing from 0.3% (P0) to 1.53% (P7), protein remaining stable at ~10%, and antioxidant activity showing a more than fivefold increase, as DPPH scavenging improved from 10.82% (P0) to 52.86% (P7), and TPC rose from 0.144 to 0.702 mg GAE/g. Among the fortified samples, the 3% formulation (P3) demonstrated the best performance, with minimal cooking loss (7.0%), optimal sensory acceptance, and favourable textural features. FTIR analysis confirmed successful incorporation of seaweed-derived bioactive polysaccharides and calcium carbonate into the pasta matrix. Based on nutritional enhancement, consumer acceptability, antioxidant potency, and storage stability, the 3% seaweed incorporation level (P3) is recommended as the optimal formulation for developing functional, sustainable barnyard millet pasta.

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EXTRACTION AND CHARACTERIZATION OF ANTIBACTERIAL MARINE POLYSACCHARIDE K-CARRAGEENAN FROM *Kappaphycus alvarezii* AGAINST MULTI DRUG RESISTANT WOUND-ASSOCIATED BACTERIA

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Seaweeds are an abundant and sustainable marine resource, widely recognised for their rich content of structurally diverse bioactive polysaccharides with promising biomedical applications. Among red seaweeds, *Kappaphycus alvarezii* is commercially important due to its high yield of K-carrageenan, a sulfated galactan known for its biocompatibility and biological functionality. With the alarming global rise in antimicrobial resistance (AMR) and the increasing prevalence of multidrug-resistant (MDR) wound-associated pathogens, there is an urgent need to explore alternative, eco-friendly antimicrobial agents derived from marine resources. The focus was shifted to natural resources for the development of antimicrobial compounds in order to overcome this resistance. In this study K-Carrageenan was extracted from *Kappaphycus alvarezii* and characterized by the Fourier transform infrared (FTIR), Gas chromatography mass spectrometry (GC–MS), Liquid chromatography mass spectrum (LC–MS) and Nuclear Magnetic Resonance (H-NMR) analysis. The antibacterial property of carrageenan was tested using the Minimum Inhibitory Concentration and the bacterial cell growth rate. The results showed higher antibacterial activity of K-Carrageenan against *S. aureus*, *E. coli*, *P. aeruginosa*, *P. vulgaris*, and *V. parahaemolyticus.* Well diffusion method, growth curve studies, anti-biofilm studies were done in K-Carrageenan. Intracellular protein molecules and nucleic acid leakage confirmed that 100 µg/mL of K-Carrageenan increase membrane permeability, leading to cell death. At a concentration of 100 µg/ mL of K-Carrageenan was non-cytotoxic to RBCs cells and promoted antibacterial and antibiofilm properties against the wound pathogens. From this study, these results determine the strong potential of K-Carrageenan treating MDR bacteria-infected chronic wounds.

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ISOLATION OF SULFATED POLYSACCHARIDES FROM *Enteromorpha intestinalis* AND THEIR *IN VITRO* BIOLOGICAL EFFECTS ON HEPATOCARCINOMA CELLS: BIOACTIVITY AND ANTIOXIDANT PROPERTIES

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Identification of natural marine bioactive molecules with therapeutic potential is of growing interest due to their efficacy and reduced likelihood of adverse effects. This study aimed to isolate and purify sulfated polysaccharides (sPS) from the green macroalga *Enteromorpha intestinalis* and evaluate their anticancer activity against human hepatocellular carcinoma cells (Hep3B). Polysaccharides were isolated and purified, followed by preliminary characterization using UV–Visible spectroscopy and Fourier Transform Infrared (FTIR) analysis. The total sulfate content was quantified, confirming the sulfated nature of the extract. The antioxidant potential of sPS was assessed using DPPH radical scavenging, ABTS radical cation decolorization, and ferric reducing antioxidant power (FRAP) assays. The cytotoxic effects of sPS on Hep3B cells were evaluated using the MTT assay, while cellular and nuclear alterations were examined using acridine orange/ethidium bromide (AO/EB) and DAPI staining. Mitochondrial membrane potential (ΔΨm) and intracellular reactive oxygen species (ROS) generation were analyzed using Rhodamine 123 and DCFH-DA staining, respectively. Results demonstrated that sPS from *E. intestinalis* were rich in sulfate groups and exhibited significant antioxidant activity in DPPH, ABTS, and FRAP assays. The MTT assay revealed a concentration-dependent reduction in cell viability, with less than 50% viable cells observed at concentrations above 1 mg/mL. Fluorescence microscopy showed compromised membrane integrity, chromatin condensation, and nuclear fragmentation in treated cells. Loss of mitochondrial membrane potential and a marked increase in intracellular ROS levels were also observed following sPS treatment. These findings suggest that sulfated polysaccharides from *E. intestinalis* exert anticancer effects on Hep3B cells through oxidative stress-mediated mitochondrial dysfunction with the potentiality to prevent oxidative damage to normal cells. The study highlights the potential of marine-derived sulfated polysaccharides as promising candidates for further development in hepatocellular carcinoma therapy.

IVC 59

COMPARATIVE STUDY OF R-PHYCOERYTHRIN YIELD FROM MARINE RED ALGAE USING DIFFERENT EXTRACTION METHODS

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R-Phycoerythrin (R-PE) is a natural phycobiliprotein obtained from red algae. High fluorescence efficiency, biocompatibility, and stability make R-PE extensively used in enzyme-linked immunosorbent assays (ELISAs), biotechnology diagnostics, pharmaceutical research, and other fluorescence-based applications. Although R-PE has several applications, its extraction efficiency varies greatly among the red algal species. Hence, standardised protocols for maximising the pigment yield are needed. The extraction of R-PE still remains a challenge due to presence of many polysaccharides and ineffective cell disruption methods. The present study aims to optimise the extraction of R-PE from selected marine red algae by comparing four extraction techniques: aqueous buffer extraction, freeze–thaw extraction, ultrasonic-assisted extraction, and microwave-assisted extraction. Each method is evaluated for its efficiency in terms of pigment yield and extraction effectiveness. By identifying the most suitable extraction technique and algal species, this study seeks to enhance R-PE recovery and reproducibility. The outcomes are expected to facilitate improved extraction strategies and contribute to the sustainable and cost-effective production of R-PE for applications in food industries, cosmetic formulations, biomedical research, and large-scale industrial processes.

IVC 60

FROM GUT TO INDUSTRY: MACROALGAL POLYSACCHARIDE-DEGRADING ENZYMES PRODUCED BY HUMAN COMMENSAL BACTERIA

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Macroalgae are profoundly present in the intertidal regions of oceans and have been consumed as human diet for several decades. Dietary glycans derived from macroalgae have incredible powers to maintain gut microbiome. Human gut bacteria harbor a unique cluster of genes that are dedicated for utilizing a specific type of glycan. Some genes of those clusters consist of endo-acting enzymes that produce a variety of oligosaccharides *in vivo*. Those produced oligosaccharides are often reckoned by immune cell receptors and play outstanding roles in gut homeostasis. Some molecular mechanisms by which human gut bacteria utilize macroalgal glycan have been discovered in the last decade. Several enzymes associated with such locus have tremendous potential for exploitation for food industries and biorefinery. For example, we used glycoside hydrolases, belonging to families 16 and 158 for generation linked oligoacchrides from laminarin and curdlan respectively [2]. Furthermore, our recombinant enzymes are being explored for production of bioethanol using macroalgal biomass.

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INDUSTRIAL APPLICATIONS OF BIOACTIVE COMPOUNDS OF SEAWEEDS IN PHARMACEUTICALS AND COSMECEUTICALS

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Bioactive compounds from seaweeds are of growing importance due to their diverse therapeutic, antioxidant, antimicrobial, anti-inflammatory, and anti-aging properties, offering sustainable and natural alternatives to synthetic chemicals. Seaweeds are rich sources of polysaccharides, phenolics, pigments, proteins, vitamins, minerals, and essential fatty acids, making them highly valuable for industrial applications in pharmaceuticals and cosmeceuticals. In contrast, the extensive and prolonged use of synthetic chemicals in drugs and cosmetic products has raised serious concerns related to toxicity, carcinogenicity, bioaccumulation, allergic reactions, and environmental persistence, emphasizing the urgent need for safer bio-based substitutes. In India, approximately 221 species of seaweeds have been documented for use in pharmaceutical and cosmeceutical industries, while globally more than 300 species are explored for industrial bioactive extraction. Red and brown seaweeds such as *Gracilaria*, *Gelidium*, *Sargassum*, *Laminaria*, and *Padina* are predominantly utilized in pharmaceutical formulations, whereas green seaweeds including *Ulva* and *Caulerpa*, along with brown species like *Turbinaria* and *Ascophyllum*, are widely used in cosmeceutical applications. Major bioactive compounds extracted from seaweeds include alginates, carrageenans, agar, fucoidans, laminarins, phlorotannins, mycosporine-like amino acids, and carotenoids, which play key roles in wound healing, drug delivery, UV protection, skin hydration, anti-aging, and anti-inflammatory therapies. The importance of seaweeds lies in their biodegradability, biocompatibility, renewability, and low environmental footprint, aligning with global sustainable development goals. However, research gaps persist in large-scale cultivation, optimized extraction technologies, identification of novel species, and standardized formulations. In the future, seaweeds are potential to revolutionize pharmaceutical and cosmeceutical industries as eco-friendly, multifunctional resources, greener and more effective industrial innovations.

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VALORISATION OF BETA GLUCAN EXTRACTED FROM *Gracilaria corticata* FOR COMMERCIAL ACCOMPLISHMENTS AND ATTAINING SDG 2 AND 3

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In the present research, beta glucan extracted from algae source was explored for its food applications, like as an encapsulating agent for peptides, fibre enrichment in yoghurt and anti-diabetic properties against wistar rats. The β glucan enriched yoghurt was developed by optimizing the concentration of algal β glucan (1-4%) and sodium alginate (0 -0.4%) with incubation time (6-10h) using central composite design, response surface methodology (RSM). The addition of β glucan resulted in improved water holding capacity, firmness, and overall acceptability of the yoghurt. The hypoglycaemic effects of algal beta glucan against Type 2 diabetes in mice was carried out in Animal House Jamia Hamdard, New Delhi. An *in-silico* analysis was conducted using Schrödinger software to evaluate the binding affinity of ABG and metformin (MF) with PPAR-γ protein and TLR4. Mice were administered with ABG (400,700 and 1000 ppm) and MF (500 ppm) p.o., daily for 4 weeks. After 4 weeks STZ was administered at 80 ppm twice, i.p. in 72 hours. *In-silico* study demonstrated significant affinity between ABG and MF for the pocket domain of PPAR-γ protein and TLR4. The *in vitro* studies of α amylase inhibition showed IC_{50} at 2.1µg/ml and α-Glucosidase inhibition at 0.82 µg/ml. The encapsulation efficiency of the beta glucan was evaluated against pumpkin seed protein peptides. The results reported a 71.74% encapsulation efficiency and 69.12% drug delivery. The presence of peptides in the BG matrix was confirmed by SEM along with FTIR.

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SEASONAL VARIABILITY IN YIELD, CHEMICAL COMPOSITION, AND BIOLOGICAL ACTIVITIES OF FUCOIDAN ISOLATED FROM *Sargassum swartzii* ALONG THE SOUTHEAST COAST OF INDIA

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Fucoidan, a sulfated polysaccharide from brown seaweeds, is known for its diverse biological properties influenced by environmental and physiological factors. The present study focused on the isolation and characterization of fucoidan from *Sargassum swartzii* and examined seasonal variations in its yield, biochemical composition, and bioactive potential. Seaweed samples were collected during different seasons along the southeast coast of India, and key environmental parameters such as pH, temperature, and salinity were recorded. Fucoidan was extracted by hot- water extraction followed by ethanol precipitation and analyzed for phytochemical constituents and functional properties. The crude fucoidan yield ranged between 0.93 ± 0.09 % and 2.00 ± 0.15 % (dry weight), with the highest yield during the monsoon season (June–September) under moderate temperature (28 ± 1 °C) and optimal salinity conditions. Phytochemical analysis confirmed the presence of carbohydrates and phenolic groups, whereas biochemical assays revealed higher carbohydrate (50.25 ± 0.18%), protein (1.16 ± 0.04%), and sulfate (36.38 ± 0.04%) contents in monsoon samples. UV–visible analysis showed an absorption peak at 265 nm, and FTIR spectra exhibited bands at 3341 cm−1 (O–H stretch), 672 cm−1 (disulfate group), and 578 cm−1 (S–S stretch) confirming fucoidan structure. Monsoon-derived fucoidan displayed notable antioxidant activity with DPPH scavenging (72.36 ± 2.24%), total antioxidant capacity (69.3 ± 1.16%), and reducing power (83.17 ± 3.33%). Anti-inflammatory assays showed BSA denaturation inhibition (76.2%) and proteinase inhibition (64.1%). Overall, the study demonstrated that monsoon-harvested S. swartzii produces fucoidan with enhanced biochemical quality and strong biological activities, emphasizing the importance of seasonal optimization for maximizing its nutraceutical and therapeutic potential.

IVC 64

ISOLATION AND CHARACTERIZATION OF INDUSTRIALLY RELEVANT AMYLASE FROM EPIPHYTIC *Vibrio* sp. ASSOCIATED WITH MARINE MACROALGAE: A STUDY ON OPTIMIZATION AND TOXICITY

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The demand for robust, marine-derived enzymes is escalating in the food and pharmaceutical sectors. Marine macroalgae serve as a rich ecological niche for epiphytic bacteria with potent enzymatic capabilities. This study aimed to isolate, optimize, and characterize amylase-producing bacteria from three diverse seaweed species and evaluate their safety for industrial application. Thirty-five bacterial isolates were obtained, of which 24 (80%) exhibited amylolytic activity. The three most potent isolates (one from each seaweed) underwent One-Factor-at-a-Time (OFAT) optimization for carbon and nitrogen sources, temperature, time, metal ions and substrate. The overall superior isolate was identified using 16S rRNA sequencing and phylogenetic analysis. The extracellular amylase was partially purified using ammonium sulphate and ethanol precipitation, with molecular weight confirmed via SDS-PAGE. Safety was evaluated through growth on TCBS agar and hemolysis assays (Blood agar and quantitative toxicity). Molecular identification revealed the lead isolate to be a *Vibrio* sp., with an enzyme activity of 110 U/mol after optimization. The isolate is producing yellow colonies on TCBS agar (sucrose-fermenting). SDS-PAGE confirmed the presence of the amylase enzyme. Crucially, the isolate exhibited gamma-hemolysis on blood agar and demonstrated minimal toxicity (<5) in quantitative assays, indicating a safe metabolic profile. The findings suggest that seaweed-associated *Vibrio* sp. is promising, non-pathogenic sources of high-affinity amylase. This study provides a foundational framework for utilizing marine epiphytes as sustainable bio-factories for "green" enzyme production, bypassing the safety concerns typically associated with the *Vibrio* genus.

IVC 65

ISOLATION, PURIFICATION AND CHARACTERIZATION OF R-PHYCOERYTHRIN: *IN SILICO* AND IMMUNOMODULATORY EFFECT OF R-PE ON INFLAMMATORY CYTOKINES AND GENE EXPRESSION ANALYSIS ON MACROPHAGE CELLS

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Marine red algae are recognized for its richness in bioactive compounds. R-PE was extracted and isolated from *G. micropterum*. The pigment was characterized using UV-absorption spectrum, fluorescence spectrophotometer, FTIR, and SDS-PAGE. A gradient elution method of HPLC was employed to purify R-PE and further subjected to LC-ESI-MS analysis. *In silico* molecular docking was performed to analyze the binding affinity of R-PE with key inflammatory markers. *In vitro* anti-inflammatory efficacy of R-PE was evaluated by estimating the levels of TNF-α, COX, LOX, IL-6 and IL-2 using macrophage cells. Further, qRT-PCR was performed to determine the immunomodulatory effect of R-PE to evaluate Nrf2 and NF-κB gene expression. Purified R-PE displayed the expected spectral properties which is again confirmed by absorption, fluorescent spectrum, FTIR and SDS-PAGE analysis. HPLC purified R-PE has confirmed the presence of the chromophore in LC-ESI-MS approving the purity index of the compound. Docking analysis results indicated that R-PE binds preferentially to most of the targeted inflammatory markers like TNF-α, LOX, COX and iNOS suggesting its potential mechanism of action. Additionally, R-PE was further evaluated by quantifying the pro-inflammatory cytokines using RAW 264.7 murine macrophage cell lines. Furthermore, gene expression analysis was performed for evaluating the NF-κB and Nrf2 pathways using qRT-PCR. Integrated approach of *in silico* and *in vitro* findings confirmed the immunomodulatory effect of R-PE in treating various inflammatory disease.

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THERAPEUTIC PROMISE OF *Sargassum wightii* POLYSACCHARIDE AGAINST Aβ42-INDUCED NEURODEGENERATION IN *DROSOPHILA* - A BIOPROSPECTING OF MARINE SEAWEED

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Fucoidan, a sulfated polysaccharide isolated from the brown seaweed *Sargassum wightii*, possesses potent antioxidant, anti-inflammatory, and neuroprotective activities. Alzheimer's disease (AD) is a progressive neurodegenerative disorder characterized by amyloid-β (Aβ) accumulation, oxidative stress, neuroinflammation, and cognitive decline, for which effective disease-modifying therapies remain limited. In the present study, Fucoidan was extracted and characterized using FTIR and GC–MS, and its neuroprotective efficacy, alone and in combination with alkylglycerol (AKG), was evaluated in an Aβ42-expressing *Drosophila melanogaster* model of AD. Aβ42 induction significantly elevated oxidative stress markers including malondialdehyde, hydrogen peroxide, nitric oxide, and reactive oxygen species, accompanied by increased acetylcholinesterase activity, inflammatory mediators (TNFα, *TNFαR*), and apoptotic marker *p53*. Treatment with Fucoidan or AKG individually attenuated these pathological alterations, while their combined administration produced a more pronounced protective effect. Antioxidant enzyme activities (glutathione, catalase, and superoxide dismutase) and the expression of redox-regulatory genes (*SOD, CAT, PHGPx, TRx1*) were significantly enhanced, indicating restoration of redox homeostasis. Furthermore, combination therapy preserved Wnt signaling and stemness-associated genes (*SOX2, Nanog*), which are critical for neurogenesis and synaptic plasticity and were disrupted by Aβ42 toxicity. Overall, the synergistic action of Fucoidan and AKG mitigated oxidative stress, inflammation, cholinergic dysfunction, and apoptosis, while stabilizing key neurogenic pathways. These findings suggest that marine-derived Fucoidan, particularly in combination with AKG, represents a promising multi-target therapeutic strategy for the management of Alzheimer's disease.

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THERAPEUTIC POTENTIAL OF SULPHATED POLYSACCHARIDES: GENE EXPRESSION MODULATION IN BALB/C MICE INFECTED WITH *Mycobacterium tuberculosis*

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Tuberculosis (TB), caused by *Mycobacterium tuberculosis* (MTB), remains a major global health burden despite the availability of conventional drugs such as Isoniazid, Rifampin, Pyrazinamide, and Ethambutol. Natural bioactive compounds from seaweeds offer promising alternatives due to their antimicrobial and immunomodulatory properties. In this study, seaweeds collected from Mandapam and Pudhu Madam (Rameshwaram district, Tamil Nadu) were subjected to acidic water extraction, yielding up to 42 g of sulfated polysaccharides (SPs) per 100 g of dry biomass. In vitro assays (MABA and LRP) demonstrated significant inhibition of MTB (H37Rv) at 250–500 µg/ml concentrations, with *P. tetrastromatica* (79.05%), *G. edulis* (77.17%), and Ulvan (67.4%) showing notable activity. Fucoidan exhibited complete cell viability at 0.25 mg/ml, whereas Carrageenan showed partial toxicity. Animal studies revealed improved WBC counts by the fifth week in SP-treated groups, indicating immunostimulatory effects. Gene expression analysis confirmed Fucoidan's potency, with 10 to 40-fold upregulation across nine immune-related genes. These findings highlight Fucoidan as a safe and effective candidate for adjunct anti-TB therapy.

IVC 68

BIODEGRADABLE AND ECO – FRIENDLY PACKAGING MATERIAL USING CORN HUSK

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Packaging is essential for food protection, yet reliance on synthetic plastics has intensified environmental concerns, driving interest in biodegradable materials from agricultural residues. Corn husk, an abundant maize by-product rich in fibers and polysaccharides, was explored for developing biodegradable films as substitutes for conventional plastic packaging. Corn husk powder prepared using two drying methods was blended with natural additives, including seaweed (*Kappaphycus alvarezii*), glycerol, acetic acid, and corn starch. Four film formulations (C1–C4) were developed using the solution casting method. The films were evaluated for physical, mechanical, thermal, biological, and structural properties using standard analytical techniques, including SEM and FTIR. The moisture content of the films ranged from 7.13 ± 0.1% to 26.46 ± 0.4%, with C4 exhibiting the lowest value. Film thickness ranged from 0.03 to 0.06 mm. C4 showed the highest percentage elongation (24.24%), indicating improved flexibility. Thermogravimetric analysis revealed enhanced thermal stability in C4, with an overall degradation of 98.41%. Antimicrobial activity was observed in all formulations, with C1 showing the highest activity. Soil burial tests confirmed biodegradability, with maximum weight loss observed in C1 (48.43%). SEM analysis revealed smooth and homogeneous film surfaces, while FTIR confirmed functional group interactions among biopolymers. Corn husk-based biodegradable films demonstrate strong potential as sustainable packaging materials, particularly for dry food applications.

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ULTRASONICATION-ASSISTED PRODUCTION OF IMMUNOMODULATORY AND REDOX-ACTIVE PEPTIDES FROM *Kappaphycus alvarezii* FOR NUTRACEUTICAL APPLICATIONS

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Marine macroalgae are increasingly recognized as sustainable sources of bioactive compounds with significant potential in functional foods and nutraceutical development. Among these, seaweed-derived peptides have attracted growing attention due to their multifunctional biological activities, particularly in immune regulation and redox homeostasis. However, efficient processing strategies to enhance peptide release and bioactivity from seaweed proteins remain limited. The present study aimed to develop and characterize an ultrasonication-assisted approach to produce immunomodulatory and redox-active peptides from the red seaweed *Kappaphycus alvarezii*. Ultrasonication was applied as a pretreatment to improve protein accessibility prior to enzymatic hydrolysis. Nutritional evaluation was conducted using standard AOAC methods. Structural modifications induced by ultrasonication were analyzed using Fourier-transform infrared spectroscopy, morpho-structural imaging, and thermal-behaviour profiling. The redox-modulating potential of the generated peptides was evaluated through in vitro antioxidant assays, and immunomodulatory activity was assessed using cell-based immune response markers. Nutritional analysis revealed a protein content (8.68 ± 0.10%), supporting the suitability of *K. alvarezii* as a bio active peptide resource. Ultrasonication significantly enhanced protein hydrolysis efficiency and peptide yield. Structural and thermal analyses confirmed disruption of the protein matrix and improved thermal stability of the peptide fractions. The resulting peptides exhibited pronounced redox modulating activity and significant immunomodulatory effects, including enhanced immune cell activation and cytokine modulation. Ultrasonication-assisted processing effectively valorizes *K. alvarezii* into bioactive peptides with combined immunomodulatory and redox regulating properties, highlighting its potential for sustainable nutraceutical applications.

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FUNCTIONAL FISH SAUSAGE ENRICHED WITH SEAWEED PROTEIN HYDROLYSATES

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Seaweed is increasingly recognized as a sustainable marine superfood due to its rich nutritional composition and abundance of bioactive compounds. With the growing demand for functional foods and alternative protein sources, marine vegan proteins have gained attention for their potential health benefits. Despite their wide availability along the Indian coastline, macroalgae remain underutilized for value-added food applications. In this context, the present study aimed to isolate protein from brown seaweed *Sargassum tenerrimum* using a modified pH-shift technique and to produce protein hydrolysates through enzymatic hydrolysis using bromelain. A food application study was conducted to evaluate the nutritional, bioactive, and sensory attributes of fish sausage enriched with seaweed protein hydrolysates. The hydrolysates contained 5.13% moisture, 65.65% crude protein, 1.72% fat, 26.07% ash, and 2.20% carbohydrate. Functional sausages formulated with seaweed protein hydrolysates showed a significantly higher protein content (16.75 ± 0.36%) compared to the control. Antioxidant activities, including radical scavenging activity, total phenolic content, and reducing power, were significantly higher ($p < 0.05$) in enriched sausages. SDS-PAGE analysis revealed stable actin monomers with enhanced peptide band intensity. The 5 % inclusion of seaweed protein hydrolysates did not adversely affect textural properties while enhancing nutritional value and bioactive potential. Sensory evaluation indicated preferential acceptability, with scores ranging from “liked very much” to “liked moderately”. This study highlights seaweed as a promising source of protein ingredient for developing functional seafood products with health-benefiting potential.

IVC 71

UTILIZATION OF *Kappaphycus alvarezii* FOR DEVELOPING A NUTRIENT-RICH GLUTEN-FREE GRANOLA BAR

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Seaweeds are nutrient-rich marine resources, yet their use in everyday Indian foods remains limited. In this study, a gluten-free granola bar was developed using foxtail millet (*Setaria italica)* and enriched with the edible red seaweed, *Kappaphycus alvarezii,* to improve its nutritional quality. Granola bars were prepared with varying levels of seaweed, and the formulation containing 10 % seaweed showed the highest sensory acceptability. The optimized seaweed-enriched granola bar had a rectangular shape with a length of 7.2 ± 0.1 cm. Incorporation of seaweed significantly reduced the lightness (L) value*, giving the product a darker appearance, and increased the hardness of the granola bar. The combined use of millet and seaweed enhanced the protein and crude fibre content, improving its functional value. Mineral profiling revealed higher levels of calcium, potassium, and sodium in seaweed-incorporated bars. The Na/K ratio of the control granola bar without seaweed was 0.08, which improved to 0.38 in granola bars added with 10 % seaweed. Microbiological analysis showed that hygiene indicator counts were within permissible limits, and none of the major food safety indicator organisms were detected. Overall, the study demonstrates the potential of seaweed incorporation as a practical approach to developing nutritious, gluten-free snack foods with improved functional properties.

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SEAWEED DERIVED POLYSACCHARIDE: A SUSTAINABLE APPROACH TO ENHANCE PLANT GROWTH AND DEVELOPMENT

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The current global scenario shows rapid development in sustainable agricultural practices. With increasing advancement in cropping techniques, fertilization, and harvesting, maintaining soil fertility and crop health is the need of the hour. Seaweed-based bio stimulants are sustainable in nature, thereby enhancing plant growth and development as well as promoting soil health. Polysaccharides derived from seaweeds are biologically active compounds. Agricultural applications of these polysaccharides include foliar spray and seed priming. The present study comprises three parts, the first being the extraction, purification, and characterization of seaweeds collected from the western coast of Maharashtra. The polysaccharides used are alginate derived from *Sargassum tenerrimum*, ulvan from *Ulva fasciata*, and agar derived from *Gracilaria corticata*. Further, the study includes the preparation of a liquid extract from these crude seaweed polysaccharides and its evaluation for plant growth and development. Concentrations of 0.25%, 0.5%, and 1.0% were used for each seaweed polysaccharide, along with distilled water as a control. These polysaccharide extracts (PE) were applied as seed priming agents and foliar sprays to evaluate growth enhancement in various plants. Seed germination, seed vigour, and plant height were studied over a one-month period. Biochemical parameters such as chlorophyll content, protein content, and antioxidant activity of treated plants were analysed. The extracted polysaccharides were also characterized using Fourier Transform Infrared Spectroscopy (FTIR). The results showed enhancement in the overall health and yield of plants.

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CHARACTERISATION AND SHELF-LIFE ASSESSMENT OF INSTANT SEAWEED SOUP MIX

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The present study aimed to develop an instant seaweed soup powder by incorporating varying levels of fish powder and green seaweed (*Ulva* sp.) and to evaluate its nutritional, functional characteristics, antioxidant properties, sensory acceptability and shelf life. Protein content ranged from 3.19% to 15.7% and decreased with increasing seaweed levels. Seaweed addition significantly ($p<0.05$) influenced functional properties, phenolic content, and antioxidant activity. Soup containing 20% seaweed exhibited higher DPPH radical scavenging activity and the highest sensory acceptability. The water absorption index (WAI) and water solubility index (WSI) of soup powders ranged from 4.13 to 6.12 g/g and 12.04% to 22.29%, respectively, indicating rapid reconstitution. Based on the functional and sensory evaluation, instant soup with 20% fish as control and soup with 20% seaweed were selected for storage study at ambient temperature for 6 months. Both samples exhibited lower spoilage indices such as TVB-N, Peroxide Value and TBARS, and higher organoleptic acceptance throughout the storage period. A significant decreasing trend in WAI was observed, while the WSI of both samples increased during ambient storage. The results suggest that seaweed can be used as an ingredient to develop a functional and nutritious instant seaweed soup powder with good storage stability at ambient temperature.

IVC 74

INFLUENCE OF SODIUM STRESS ON ANAEROBIC DIGESTION AND BIOMETHANE PRODUCTION OF MICROWAVE-ASSISTED ALKALINE PRETREATED BIOMASS

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Marine macroalgae are being explored as a sustainable feedstock for biogas production; however, elevated sodium ion (Na+) release during microwave-assisted alkaline pretreatment can inhibit the anaerobic digestion (AD) process. In this context, the present study explores the combined effect of microwave (MW) and alkaline pretreatment on seaweed cell wall disintegration to enhance hydrolysis and assesses the impact of Na+ ions on anaerobic digestion microbes. Seaweed biomass was pretreated under optimized MW conditions (630 W for 30 min) and Na+ dosage (300 mg g−1 from NaOH) at a biomass loading of 10 g L−1, followed by biomethane potential (BMP) assays. Pretreatment efficacy was evaluated based on soluble organic carbon (SOC), soluble chemical oxygen demand (SCOD), COD solubilization, release of organic biomolecules (proteins and carbohydrates), and biogas production. Due to rapid and localized heating, microwave pretreatment alone achieved significant COD solubilization (10–14%); however, it required high specific energy (SE) consumption (113 MJ kg−1 total solids, TS). To reduce energy demand, alkaline pretreatment was combined with MW, resulting in nearly a 1.8-fold improvement in COD solubilization and a reduction in SE to 75 MJ kg−1 TS. Similar enhancement trends were observed for SOC, SCOD, and biomolecule release (1.5–1.7-fold). BMP results showed the highest cumulative biomethane yield of 238.5 mL g−1 VS at an optimal Na+ concentration of 1.7 g L−1. Further increases in Na+ dosage caused process inhibition, with biomethane yield decreasing to 225.9 mL g−1 VS at 2.8 g L−1. Biogas composition analysis using gas chromatography indicated methane and carbon dioxide contents of 65–70% and 30–35%, respectively. These findings highlight the importance of controlling sodium levels during microwave–alkaline pretreatment to maximize biomethane production from seaweed biomass.

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PHYTO AND PHYCO BASED BIOACTIVES IN ANTI-AGING SKINCARE: COLLAGEN-CENTERED INSIGHTS AND FUTURE PERSPECTIVES

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Skin aging is an inevitable biological process facilitated by both intrinsic and extrinsic factors. A major key molecular contributor to aging of skin is the loss of dermal collagen, caused by reduced fibroblast activity, increased Matrix Metalloproteinases (MMPs) and elevated oxidative stress levels. This progressive loss of dermal collagen leads to visible signs of aged skin such as wrinkles, weakened barrier function and loss of elasticity. Existing methods for addressing skin aging with synthetic retinoids and collagen have limitations, including skin irritation, poor absorption, sustainability and variable efficacy concerns. Consequently, there is an increasing desire to find alternative solutions, such as using naturally available plants and marine-based bioactives to counter the skin aging problem. This paper reviews the emerging role of using plant (Phyto) and marine algae (Phyco) -derived bioactive compounds to restore collagen homeostasis and reduce signs of skin aging. Plant based compounds such as polysaccharides, polyphenols, peptides, pigments and vitamins possess strong antioxidant, anti-inflammatory, and collagen stimulating properties by modulating key cellular pathways, including NF-κB, MAPK/AP-1, and TGF-β/Smad. The marine algae-based compounds such as fucoidan, laminarin, phlorotannins, mycosporine-like amino acids, and carotenoids exhibit remarkable ROS scavenging capabilities, MMP inhibition, photoprotection, and enhancement of procollagen production. Evidence derived from in vitro, in vivo, and emerging human clinical studies demonstrates that these bioactives can improve skin hydration, elasticity and wrinkle appearance. In addition, formulations combining both phyto- and phyco-based bioactives with advanced delivery systems can provide improved stability and bioavailability. This review illustrates that marine and plant bioactives provide sustainable collagen –targeted ingredients that can be developed into the next generation of anti-aging cosmeceuticals and also highlights existing challenges and future perspectives.

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MARINE ALGAE MEDIATED NANOPARTICLES IN COMBATING ANTIMICROBIAL RESISTANCE: A CROSS-DISCIPLINARY REVIEW

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Marine algae have been developed as a bio-nanofactory that is versatile and sustainable producing metal and metal-oxide nanoparticles with strong antimicrobial property. This is a review that systematically reviews the mechanisms of green synthesis, physicochemical properties, antimicrobial mode of action, and cross-disciplinary uses of nanoparticles mediated by marine algae (AMNPs) in solving the global problem of antimicrobial resistance (AMR). The review is based on 80 peer-reviewed studies published in the last 5 years (2015-2024) to conduct a synthesis of evidence on algal metabolites, including polysaccharides, phenolics, proteins, and pigments, in driving nanoparticles bio reduction and capping using a structured search strategy across large scientific databases. The AMNPs exhibit broad-spectrum antimicrobial activity due to membrane disruption, reactive oxygen species formation, metabolic interference as well as biofilm inhibition all of which reduce the chances of development of resistance. They have applications in biomedical therapeutics, drug delivery, wound healing, water disinfection, pollutant degradation, nano-enabled agriculture as well as antimicrobial coatings. Irrespective of their potential, holes exist in mechanistic explanation, standardization, in vivo toxicity testing and scale production. Mechanistic metabolomics, long-term ecotoxicology, bioreactor design that is scaled and regulatory frameworks of biogenic nanomaterials should be the focus of future research. All in all, the AMNPs are an effective and environmental-sensitive future of nanotechnology, which holds a high potential to counteract AMR and develop sustainable antimicrobial technologies.

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FUNCTIONAL CARRAGEENAN COMPOSITE FILMS FOR ACTIVE FOOD PACKAGING APPLICATIONS

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Seaweeds are abundant and renewable marine resources, widely recognised for their rich content of structurally diverse polysaccharides with significant industrial and food-related applications (Holdt and Kraan, 2011). Red seaweeds, in particular, are valued for their high carrageenan content, which exhibits excellent film-forming ability, biodegradability, and biocompatibility (Campo et al., 2009). The extensive use of conventional plastic packaging in the food industry has resulted in severe environmental pollution, creating an urgent demand for sustainable and eco-friendly alternatives. Marine-derived biopolymers have therefore gained attention as promising materials for active food packaging systems. In the present study, carrageenan extracted from red seaweeds, along with chitosan and collagen obtained from marine shellfish by-products, were utilized for the development of carrageenan-based composite films for active food packaging applications. The composite films were prepared using standard chemical extraction and film-forming methods. The characterization studies were performed using Fourier Transform Infrared Spectroscopy (FTIR) and Gas Chromatography–Mass Spectrometry (GC–MS). Functional evaluation of the developed films showed potential physicochemical, barrier properties, antioxidant, antimicrobial, and biofilm inhibition studies against selected food-borne pathogens. The incorporation of collagen and chitosan into the carrageenan matrix significantly enhanced the functional performance of the composite films, improving barrier properties along with antioxidant and antimicrobial activities. The developed films demonstrated effective inhibition of microbial growth and biofilm formation, indicating their potential to enhance food safety and extend shelf life. Overall, this study highlights the potential of seaweed-derived biopolymers for the development of biodegradable and active food packaging materials.

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ANTIOXIDANT POTENTIAL OF SEAWEED AVAILABLE AT OKHA, GUJARAT COAST

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Seaweeds are widely known for their nutritional value and health benefits, especially due to the presence of natural antioxidant compounds. A study was conducted to evaluate the *in vitro* antioxidant potential of seaweed species available along the Okha coast of Gujarat. The seaweed species were collected from intertidal areas during the lowest low tide. Methanolic extracts of the seaweeds were prepared in triplicate, and antioxidant activity was measured using the DPPH (2,2-diphenyl-1-picrylhydrazyl) radical scavenging method. The results showed variation in antioxidant activity among different seaweed. *Sargassum johnstonii* showed the highest antioxidant potential. The lowest antioxidant activity was observed in *Dictyopteris delicatula* and *Erythrocladia irregularis*. Pooled analysis of common species also confirmed *Sargassum johnstonii* as the most effective antioxidant source. The study indicates that seaweeds from the Okha coast have good potential for use as natural antioxidants in food and health-related products.

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THE ALGAL ALTERNATIVE: HARNESSING MICRO AND MACROALGAE BIOACTIVES AS A FUNCTIONAL SUBSTITUTE FOR FETAL BOVINE SERUM

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Fetal bovine serum (FBS) is a cornerstone of animal cell culture, yet its use is limited by ethical concerns and significant batch-to-batch variability. This review examines the potential of aquatic photosynthetic organisms, including freshwater and marine microalgae and seaweed (macroalgae), as high-performance, vegan serum substitutes. Among microalgae, extracts from *Arthrospira platensis*, *Chlorella vulgaris*, and *Dunaliella tertiolecta* have shown exceptional ability to support cell proliferation and myotube differentiation for cultivated meat. Simultaneously, seaweed-derived bioactive polysaccharides from species such as *Ulva lactuca* and *Sargassum* offer a unique capacity to mimic the structural and signalling functions of FBS proteins. These aquatic sources provide essential amino acids, growth factors, and antioxidants that regulate cellular homeostasis in serum-free environments. Recent studies highlight their efficacy in stabilising 3D organoid systems and enhancing extracellular matrix interactions. By leveraging the CO_2-fixing and nutrient-recycling capabilities of these diverse species, these alternatives facilitate a transition toward ethical, reproducible, and scalable bioprocessing paradigms.

IVC 80

COMPUTATIONAL DISCOVERY AND THERAPEUTIC APPLICATIONS OF MACROALGAL PEPTIDES IN WOUND HEALING

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The exploration of natural resources for therapeutic agents has gained increasing attention in wound management. Seaweeds, particularly macroalgae, are rich reservoirs of bioactive compounds, including peptides derived from algal proteins. These peptides exhibit antimicrobial, antioxidant, and tissue-regenerative properties relevant to wound healing. Traditional peptide discovery relies on labor-intensive extraction and screening methods, whereas in silico approaches enable rapid prediction of bioactive sequences. In this study, bioinformatics-based pipelines are employed to virtually digest algal protein sequences and identify peptides with wound-healing potential. Molecular docking and simulation studies are further used to predict peptide interactions with key wound-healing targets involved in inflammation control and tissue repair. Comparative analysis of algal peptide profiles highlights their functional diversity and therapeutic relevance. Beyond antimicrobial activity, these peptides may modulate oxidative stress and inflammatory responses, supporting faster wound closure. Integrating computational predictions with targeted experimental validation offers a sustainable strategy for developing peptide-based wound-care formulations such as hydrogels and dressings. This computational framework supports the potential of macroalgal peptides as eco-friendly candidates for advanced wound-healing applications.

IVC 81

SWISS-ADME-BASED DRUG VALIDATION OF SEAWEEDS DERIVED THERAPEUTIC BIOACTIVES TO TACKLE NEUROLOGICAL AILMENTS

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Seaweeds of diverse types, such as Chlorophyceae, Phaeophyceae, and Rhodophyceae, have been the primary source of notable therapeutic bioactives, employed in tackling metabolic diseases, cancer, neurological ailments, and other health hazards. However, its druggable characteristics, especially the pharmacokinetics determining its absorption, distribution, metabolism, and excretion (ADME), remain poorly understood and studied, especially for tackling neurological ailments, including Alzheimer's, Parkinson's, Amyotrophic Lateral Sclerosis, Cognitive impairments, Huntington's disease, Epilepsy, Depression, Anxiety and Spinal Cord Injury prevalent among the human population. This report scrutinises 60 therapeutic bioactives from seaweeds, determining their ADME characteristics using the SWISS-ADME tool, to tackle neurological ailments. Amid these 60 bioactives, phloroglucinol and pyrogallol exhibited effective ADME characteristics with the consensus lipophilicity score of Log *P*o/w=0.45-0.58; a higher water solubility; and an effective metabolism crossing the blood-brain barrier with a minimal efflux from the neurological system. Concomitantly, these bioactives exhibiting a higher gastrointestinal absorption rate with a bioavailability score of 0.55 buttress their druggable characteristics. We profoundly believe that the therapeutic formulation of seaweed-based pyrogallol/ phloroglucinol could effectively tackle the above-mentioned neurological ailments via targeting these potential targets, such as amyloid and tau protein, cholinergic system, alpha- synuclein, chaperone, Abelson proteins, mitochondrial dysfunction, oxidative stress, N- methyl-D-aspartate receptor, neurofibrillary tangles, angiotensin receptors, and enzymes (monoamine oxidases, secretases, and cyclooxygenases). The report proposes an estimated effective human dose concentration of the therapeutic formulation of phloroglucinol (170-340 mg/70 kg body weight) and pyrogallol (567-1135 mg/70 kg body weight) targeting the above- mentioned clinical variables associated with neurological ailments.

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IN SILICO ANALYSIS OF PARKINSON'S DISEASE: MUTATION PATHOGENICITY AND THERAPEUTIC TARGETING

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Parkinson's disease (PD) is a prevalent neurodegenerative disorder characterised by dopaminergic neuron loss and Lewy body accumulation, with familial forms linked to mutations in genes like SNCA, LRRK2, and PRKN. Marine-derived phycobiliproteins, particularly phycoerythrin from red algae, show promise due to their antioxidant and anti-inflammatory properties. This study aimed to computationally predict the pathogenicity of mutations in critical PD-associated genes (SNCA, LRRK2, PRKN) and evaluate the therapeutic potential of phycoerythrin against mutant PD proteins, comparing it with reference drugs Pramipexole and Resveratrol. A comprehensive *in silico* approach was employed, integrating multiple bioinformatics platforms. Pathogenic mutations were predicted using SIFT and FATHMM. Three-dimensional protein structures were retrieved or modelled, followed by structural validation. Comparative molecular docking (Hex 8.0, ClusPro 2.0, Schrodinger suite -Glide XP) assessed binding interactions, and MM-GBSA calculations determined binding energetics. Long-term binding stability was evaluated through 100 ns molecular dynamics (MD) simulations. Mutation prediction successfully identified pathogenic variants in SNCA (E10K, T46M), LRRK2, and PRKN, revealing significant conformational changes in mutant proteins. Phycoerythrin demonstrated superior MM-GBSA values (e.g., -58.4 to -62.7 kcal/mol for PRKN mutants) compared to reference drugs. Ligand efficiency scores and MD simulations further confirmed phycoerythrin's optimal binding efficiency and exceptional complex stability, with minimal structural drift and sustained interactions. PPI analysis identified AXIN1 and AXIN2 as shared molecular nodes between PD and colorectal cancer. This study provides robust computational evidence identifying phycoerythrin from red algae as a highly promising multi-target therapeutic candidate for familial PD. Its superior thermodynamic stability, ligand efficiency, and MD stability against mutant proteins suggest it could address the root genetic cause of PD, unlike symptomatic treatments. These findings support phycoerythrin as a lead compound for structure-based drug design and warrant further experimental validation through ongoing *in vitro* and *in vivo* studies.

IVC 83

BIODEGRADABLE AND EDIBLE DRINKING STRAWS: CURRENT ADVANCES, MATERIAL INNOVATIONS, AND ENVIRONMENTAL IMPLICATIONS – A REVIEW

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The use of plastics poses major threat worldwide. The utilization of plastic drinking straws causes distress in the ecosystem. That's one of the reasons why the researchers have developed biodegradable, lightweight straws made from biocompatible materials. Edibility is one of the innovations that reduces waste up to 100%. This review discusses the recent developments between 2020 and 2025, it flows from the integration of natural plant-based fibres, polysaccharides, food waste, seaweed (marine biomass), bacterial cellulose, and protein. The wheat and bamboo-based straws showed adsorption of less water while exhibiting greater crystallinity, which acts as a favourable approach for scaling up in industries. The dragon fruit peel straws showed resistance at 65 °C, it displayed great resistance to water and exceptional thermal resistance. The seaweed-CaCO□ mineralized straws exhibited high tensile strength and are capable of adsorbing heavy metals, and by the addition of glycerol, the biodegradability rate increases and is resistant to water at a satisfactory level. The cellulose and composite-enriched straws increased the mechanical strength. Overall, this review emphasizes and focuses on the safety assessments of straws due to the detection of VOCs (volatile organic compounds) in straws made with blends of coffee grounds, thereby enhancing the sensor's quality, producing eco-friendly straws and scaling up to ensure that the straw is highly biodegradable and more compatible than the existing ones.

IVC 84

FROM OCEAN WEALTH TO PLANT HEALTH: SEAWEED BASED SOLUTIONS FOR *Spodoptera litura* MANAGEMENT

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Tobacco leaf eating caterpillar, *Spodoptera litura* Fabricius is reported as an important polyphagous pest due to its severe damage on a wide variety of agricultural crop plants. The farmers are using an insecticide as first line defence against this insect pest. Therefore, it has developed resistance to the commonly available insecticides in the market. Alternatively, marine algae have been considered as important bio-active compounds with eco-friendly pest management activities. Hence, seaweeds were collected from East and West coast of southern India, taxonomically identified them as *Gracilaria corticata* (J. Agardh), *G. follifera* (Forsskal) Borgesen, *G. salicornia* (C. Agardh) E.Y. Dawson., *Halimeda gracilis* (J. Agardh), *Kappaphycus alvarezii* (P. C. Silva), *Padina gymnospora* (Kutzing), *Sargassum lillicifolium* (Turner) C. Agardh, *S. polycystum* (C. Agardh), *S. wightii* (Grev.), *Turbinaria conoides* (J. Agardh) by CSIR-Marine Algal Research Institute, Mandapam, Tamil Nadu. The Gas and liquid chromatography and mass spectrometer (GC-MS & LC-MS analysis) was carried out to know the metabolomics profile. The insecticidal compounds were identified based on bio-assay study and with the help of existing literature. Bio-assay was conducted for individual compounds against *S. litura* under laboratory conditions. Based on the preliminary experiments, two formulations were developed (KP-MAGP1 and KP-MAGP2) and evaluated against second and third instar larvae of *S. litura.* KP-MAGP1 @ 2000 ppm showed 75% (second instar) and 50% (third instar) mortality of *S. litura* after 24 hrs of treatment in leaf dip method. Similarly, KP-MAGP2 accounts 70% (second instar) and 40% (third instar). The study provides a head start for many more researches in plant protection leading to reduced input cost and doubling farmers' income with sustainable crop production.

IVC 85

EVALUATION OF PHLOROGLUCINOL AS AN ANTI-CANCER AND ANTI-METASTATIC COMPOUND IN LUNG ADENOCARCINOMA

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Phloroglucinol (PGL), a bioactive polyphenol found in brown seaweeds with proven antioxidant and immunomodulatory properties. Despite the established properties, the anti-cancer potential of PGL remains less explored. This study utilizes biological approaches to evaluate the potential of PGL in cancer. The results exhibited dose and time-dependent cytotoxicity in A549 cells, with an IC_{50} of 36.04 µM. The flow cytometry analysis showed G□/G□ cell cycle arrest (81.05%) and reduction in S phase and G2 phase (10.62 % & 8.06%). The nuclear condensation and ROS production are confirmed by DAPI and DCF-DA staining. Annexin V-FITC/PI and AO/EtBr staining validated the occurrence of early and late apoptosis (16.21% & 1.68%) and was accompanied by strong fluorescence, indicating apoptotic progression. The anti-metastasis potential was assessed through the scratch assay and inhibited cell migration in A549 cells. Finally, the gene analysis revealed that PGL downregulates inflammatory cytokine expression, thereby inhibiting inflammatory signaling pathways in lung cancer. In conclusion, these findings suggest that PGL exhibits cytotoxic effects, highlighting its potential therapeutic uses in lung cancer.

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DRYING OF SEAWEEDS (*Gracilaria edulis* AND *Gracilaria salicornia*) IN OPEN SUN, SHADE, SOLAR, INFRARED DRYING: DRYING KINETICS, ENERGY, AND QUALITY CHARACTERISTICS

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Drying of seaweeds *Gracilaria edulis* and *Gracilaria salicornia* was carried out using open sun drying (OSD), shade drying (Shade D), solar drying (SD), and infrared drying (IRD) methods. The effects on drying behaviour, energy efficiency, physical attributes, bioactive components, and antioxidant properties were evaluated. Among the various drying methods, IRD achieved the shortest drying time of 3 h for *G. edulis* and 2 h for *G. salicornia* to reach safe moisture levels (around 15% wb). In contrast, SD and OSD recorded 4 – 5 h for drying. IRD exhibited the highest drying efficiencies (41.45% for *G. edulis* and 45.68% for *G. salicornia*) and the lowest specific energy consumption (SEC) values of 1.67 and 1.53 kWh kg−1 of water, respectively, due to the maximum energy utilization. In contrast, OSD showed the lowest efficiency (18.69%) and the highest SEC (up to 3.95 kWh kg−1) due to the inefficient heat and mass transfer. Drying kinetics modelling indicated that Midilli and Page models best described the drying behaviour of *G. edulis* and *G. salicornia*, respectively (R2 > 0.90). IRD- dried seaweeds exhibited lower shrinkage, higher rehydration capacity, reduced colour change, and better retention of bioactive compounds and antioxidant activity compared to other drying methods. Overall, IRD proved to be the most effective drying technique, while SD offered a viable intermediate alternative. The results highlight the potential of infrared drying, and its possible integration with solar energy, for producing high-quality dried seaweeds with improved energy efficiency for food and nutraceutical applications.

IVC 87

ANTIFOULING POTENTIAL OF DEEP-SEA BACTERIA AGAINST SEAWEED MICROFOULANTS

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Biofouling poses a major constraint in seaweed cultivation leading to reduced growth, compromised biomass quality, and substantial economic losses in aquaculture. Microbial biofilms serve as the primary precursor for biofouling on seaweed surfaces. In the present study, *Bacillus* sp. was identified as the major biofilm forming bacteria associated with cultivated *Gracilaria edulis* collected from Kalpeni island, Lakshadweep. Eight deep – sea bacterial strains (MMRF 3096, MMRF 3095, MMRF 3111, MMRF 3114, MMRF 3084, MMRF 3112, MMRF 3055, MMRF 3057) were screened for their antifouling potential against the test strain *Bacillus* sp. Among them, three deep sea bacterial strains MMRF 3096, MMRF 3057 and MMRF 3055 exhibited strong antibiofilm activity with biofilm inhibition percentage 80%, 89% and 92% respectively with significant reduction in biofilm biomass in vitro. LC-HRMS metabolite profiling of these strains identified key antibiofilm compounds, including 3-(2-methylpropyl)-octahydropyrrolo[1,2-a] pyrazine-1,4-dione; cyclo(phenylalanyl-prolyl) and diselenide, which are associated with quorum-sensing interference and microbial adhesion inhibition. These findings highlight the ecological importance of microbial interactions in seaweed biofouling and underscore the potential of deep-sea bacterial metabolites as environmentally safe antifouling agents. Early biofilm management with probiotic or metabolite therapies promises to enhance seaweed crop health, yield reliability, and sustainable aquaculture expansion.

IVC 88

SEAWEEDS AND MEDICINALLY IMPORTANT COMPOUNDS.

D. Velmurugan

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Seaweeds are considered valuable bioresources due to their abundant and diverse biochemical constituents, including polysaccharides, proteins, essential amino acids, natural pigments, minerals, vitamins, dietary fiber, and phlorotannins. Bioactive peptides exhibiting antioxidant, anti-inflammatory, antimicrobial, antihypertensive, antiviral, and anticancer properties have been reported from various seaweeds. Docking and molecular dynamics simulations were carried out for some peptides KF, KY, KW, FY, GKY, AKY, YRD and LRY reported from selected seaweeds such as *Laminaria japonica, Undaria pinnatifida, Mazzaella japonica and Neopyropia yezoensis* as anti-hypertensives. Several key compounds such as Eckol, Dieckol ,6,6' – Bieckol and Phlorofucofuroeckol –A from *Ecklonia cava and Eisenia bicyclis* linked to neurodegenerative disorders, Alzheimer's and Parkinson's diseases, have also been subjected to molecular docking with the respective macromolecular targets to confirm their binding at the active sites. The presentation will cover the above in detail.

IVC 89

ALTERNATIVES FOR MICROPLASTICS IN RINSE OF COSMETICS USING SEAWEED POLYSACCHARIDES

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The increased usage and mismanagement in the disposal of microplastics have become a visible threat to humans and more specifically to our oceans. Pharmaceutical, cosmetic and personal care product industries are the key players in using microplastics which are materials with a diameter of less than 5000 µm. These microplastics are hydrophobic and heterozygous and are used as exfoliant agents, viscosity enhancers/ bulking agents, and drug delivery systems to deliver lead molecules for maximum utility. Further, many of the commercially available oral healthcare products contain microplastics and have pan India distribution. Likewise, rinse-off cosmetics containing plastic microbeads are banned worldwide owing to its toxic effects on the water bodies. Therefore, novel seaweed polysaccharide-based microbeads are fabricated as an alternative to the plastic microbeads, used in exfoliating cosmetic products. A unique combination of sodium alginate from brown algae, ulvan from green algae in equal ratios are prepared to encapsulate a phyto-molecule for better functionality. The novel microbeads would be a potential substitute for hazardous plastic microbeads used in exfoliating skincare products, with antioxidant and anti-microbial activity and excellent biodegradability. The innovation using seaweed polysaccharides would be discussed which would help in enhancing the Blue Economy using our renewable resources from the bountiful oceans and save waterbodies and the environment for the benefit of mankind.

IVC 90

UNLOCKING THE INDUSTRIAL POTENTIAL OF MARINE ALGAE

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India's 7,500 km-long coastline hosts a rich diversity of marine algae with great potential as sustainable sources of important industrial products. Marine macroalgae and microalgae along India's coasts and islands are sources of high-value biomolecules, including polysaccharides, pigments, proteins, lipids, antioxidants, and bioactive compounds. These algae support various applications in food, nutraceuticals, pharmaceuticals, cosmetics, agriculture, aquaculture, bioenergy, and biomaterials. Recent advances in algal biotechnology, bioprocessing, and integrated biorefinery methods have improved biomass use, product extraction, and economic viability while reducing environmental impact. Beyond industrial uses, marine algae also provide vital ecosystem services, such as carbon sequestration and coastal protection. However, challenges related to cultivation, biomass supply, and commercialization still exist. Strategic research, policy support, and industry–academia collaboration are crucial for unlocking the full potential of India's marine algae, promoting sustainable coastal growth, and strengthening the nation's blue bioeconomy. The poster will mainly focus on work conducted in my lab on marine microalgae and seaweed, including the extraction of valuable products such as nanocellulose, biochar, and secondary metabolites followed by their characterization.

Session 8
Circular Economy Model for Seaweeds
CEM 01 – 05

CEM 01

CIRCULAR ECONOMY APPROACH TO SEAWEED BIOCHAR PRODUCTION FOR SUSTAINABLE WATER REMEDIATION

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The conversion of marine macroalgal biomass into functional carbon-based materials represents an environmentally responsible approach to addressing water pollution while supporting circular bioeconomy objectives. In the present investigation, biomass of *Sargassum wightii* was thermally transformed into biochar at 500**°C**, and the produced material was comprehensively analyzed to assess its applicability for environmental remediation. The resulting biochar demonstrated a satisfactory production yield coupled with consistently high alkalinity, reflecting substantial mineral concentration and effective thermal modification. Spectral analysis indicated a reduction in oxygenated surface functionalities alongside the formation of condensed aromatic carbon structures, enhancing the material's chemical robustness without eliminating its reactive surface sites. Microscopic examination revealed an irregular and porous architecture comprising layered fragments and aggregated particles, which promotes effective interaction with dissolved contaminants. The biochar exhibited a moderate surface area with well-developed pore channels, providing adequate adsorption capacity while maintaining structural integrity. Elemental profiling showed significant accumulation of alkali and alkaline-earth elements, which contribute to elevated alkalinity, improved ion-exchange properties, and possible catalytic activity. Measurements of surface charge confirmed a predominantly negative zeta potential, favouring the sequestration of positively charged pollutants. Crystallographic analysis further identified the prevalence of mineral phases such as carbonates and halides, which enhance buffering behaviour and surface reactivity. Collectively, these characteristics demonstrate that *Sargassum wightii* derived biochar produced at 500**°C** possesses a balanced combination of alkalinity, mineral content, surface charge, and structural features, highlighting its suitability as an economical and sustainable adsorbent for water treatment and contaminant removal within a circular bioeconomy framework.

CEM 02

EXPLORING THE EMPLOYMENT POTENTIALS AND CONSTRAINTS OF WOMEN IN WILD SEAWEED HARVESTING: A STUDY FROM RAMANATHAPURAM DISTRICT, TAMIL NADU

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Seaweed harvesting is an important livelihood activity for coastal communities in Tamil Nadu, particularly in Ramanathapuram district, where women play a dominant yet largely under-recognised role. Women are primarily involved in wild seaweed collection and post-harvest activities, contributing significantly to household income despite facing economic, environmental, and institutional challenges. The present study, entitled “Exploring the Employment Potentials and Constraints of Women in Wild Seaweed Harvesting: A Study from Ramanathapuram District, Tamil Nadu,” was undertaken to analyse the socio-economic profile and participation of women in seaweed harvesting, assess the employment potential in post-harvest operations, and identify the major constraints affecting their livelihoods. An ex-post facto research design was adopted for the study. Primary data were collected from 120 women wild seaweed harvesters selected from coastal villages of Ramanathapuram district using a structured and pre-tested interview schedule. The collected data were analysed using appropriate statistical tools such as percentage analysis, ranking methods, Friedman test, and Kruskal–Wallis test. The results revealed that the majority of respondents belonged to middle-aged groups with low levels of formal education and depended on seaweed harvesting as a primary or supplementary source of income. Women were actively involved in seaweed collection, drying, and preliminary processing, while their participation in value addition, marketing, and decision-making activities remained limited. Post-harvest operations such as drying, sorting, storage, and small-scale processing showed considerable potential for enhancing employment opportunities and income security for women. However, women seaweed harvesters faced several constraints, including occupational health hazards, environmental degradation, seasonal income instability, low market prices, inadequate infrastructure, lack of protective equipment, and limited access to credit, training, and institutional support. The study concludes that strengthening post-harvest employment opportunities, promoting skill development, ensuring access to financial and institutional support, and implementing gender-sensitive policies are essential to enhance the livelihood security and socio-economic empowerment of women engaged in wild seaweed harvesting in Ramanathapuram district.

CEM 03

CULTURAL TABOOS AND MARKET FRICTIONS LIMITING INDIA'S SEAWEED ECONOMY

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Despite strong policy momentum positioning seaweed as a strategic component of India's blue economy, domestic market development remains fundamentally constrained by realities that are rarely addressed in formal discourse. The core challenge in deeply embedded consumption taboos and structural market weaknesses. Sensory aversion linked to marine odor, texture, and colour reinforces rejection even among health-conscious and vegetarian consumers. Concerns over iodine overload, heavy metal accumulation, microbial safety, and the absence of recognizable quality grades further erode international consumer trust. On the supply and value-chain side, the sector is hindered by non-standardized biomass and weak post-harvest infrastructure. Seasonal availability and monsoon-induced supply disruptions discourage long-term contracts, locking producers into low-volume, low-value transactions. These constraints amplify the gap between cultivation targets and actual market absorption. In the present study, insights from a limited stakeholder and consumer survey support these observations, indicating that market resistance is driven more by cultural perception than by lack of awareness alone. Together, these findings suggest that India's seaweed sector operates within a production-heavy, demand-light ecosystem. Addressing its stagnation requires confronting taboo perceptions, enforcing species- and application-specific quality standards, investing in decentralized processing infrastructure, and aligning by-product development with verifiable performance and price competitiveness, rather than relying solely on aspirational narratives of market growth. By linking species-specific quality standards, decentralized processing, and application-focused product design, the work provides an actionable framework to convert policy ambition into market absorption. These insights offer a realistic roadmap for aligning seaweed cultivation with demand, value creation, and long-term sector viability.

CEM 04

GENDER EQUALITY AND YOUTH EMPLOYMENT IN COASTAL COMMUNITIES THROUGH SEAWEED VALUE CHAINS

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Seaweed farming is increasingly recognized as a climate-resilient livelihood that contributes to food security, carbon sequestration, and the restoration of marine ecosystem. Women and youth represent critical but often marginalized groups in coastal communities, this review integrates technological innovations and policy frameworks to explore inclusive strategies that empower these groups across the entire seaweed lifecycle, from cultivation and processing to innovation, entrepreneurship, and marketing. Which includes capacity-building programs tailored to women and youth through women-led cooperatives. Youth engagement in post-harvest technologies enhances product quality and shelf-life through technological interventions, including IoT-enabled monitoring systems, cold chain logistics, and digital traceability platforms, are shown to enhance product quality, reduce post-harvest losses, and expand access to both domestic and international markets and thereby results in increasing competitiveness and diversifying income streams of the coastal communities. Supportive frameworks lead to strengthen cooperative models and microfinance schemes to ensure equitable access and reduce barriers to entry. These frameworks emphasize capacity building, cooperative governance, and equitable resource access as key enablers of empowerment. The review concludes that scaling such inclusive approaches can transform seaweed farming into a driver of resilient marine economies, while simultaneously addressing social inequalities. By integrating technological innovation, supportive policy, and community-led entrepreneurship, seaweed farming can evolve into a model of inclusive, climate-smart development that uplifts marginalized groups and strengthens global sustainability outcomes.

CEM 05

TURNING TRASH INTO TREASURE: INTEGRATING SEAWEED AND LOW VALUE BYCATCH FOR SUSTAINABLE BLUE BIOECONOMY AND LIVELIHOOD SECURITY

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Integrating seaweed biomass into fisheries management systems provides a novel ecosystem-based pathway for nutrient recovery and utilization of unavoidable trawl bycatch. Marine trawl fisheries inevitably generate substantial quantities of low-value bycatch (LVB) due to non-selective gear operations. While bycatch reduction through improved gear selectivity, spatial zoning, and effort control remains the primary conservation objective, a fraction of incidental catch remains operationally unavoidable. Underutilization of this LVB that provides a rich source of proteins, essential fatty acids, collagen, chitin, minerals, and bioactive peptides represents a significant nutritional, economic, and ecological loss. Therefore, promoting its utilization without the risks of increased fishing pressure or juvenile retention, within an ecosystem-based fisheries management (EBFM) framework is an ideal management option. In this regulated context, integrating unavoidable LVB with seaweed biomass such as *Kappaphycus alvarezii*, *Gracilaria edulis*, and *Sargassum wightii*, offers a pathway for nutrient recovery and value addition through low-impact products. Product development pathways include fish protein hydrolysates, collagen–alginate composites, fortified aquafeeds, silage-based livestock feed, biofertilizers, nutraceuticals, and biodegradable packaging materials. This integration demonstrates technical feasibility for nutrient recovery, waste minimization, and multi-sectoral product diversification. Ecologically, it reduces discards, enhances resource-use efficiency, and supports ecosystem-based fisheries management. Socio-economically, it promotes decentralized processing units, value-chain expansion, and livelihood diversification among coastal communities. This integrated valorization framework follows a management hierarchy- avoid, minimize, monitor and only then utilise- that ensures resource conservation and livelihood resilience by embedding discard utilization within an ecosystem-oriented governance.

Session 9
Sustainable Livelihoods
SLI 01 – 08

SLI 01

SEAWEED CULTIVATION FOR CLIMATE RESILIENCE: BUILDING SUSTAINABLE LIVELIHOODS IN LAKSHADWEEP

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The Lakshadweep Archipelago, is highly vulnerable to climate change and anthropogenic pressures, including rising sea surface temperatures, coral bleaching, coastal erosion, and declining fish stocks. These stressors threaten marine ecosystems and the livelihoods of island communities, highlighting the need for sustainable, community-driven interventions that enhance both ecological resilience and socio-economic security. Seaweed cultivation offers a promising nature-based solution within the Blue Economy framework. Cultivation of commercially important species such as *Gracilaria* spp. and *Ulva* spp. contributes to climate mitigation through carbon sequestration and improves coastal water quality by absorbing excess nutrients. Seaweed farming diversifies livelihoods for fisherfolk and women-led self-help groups (SHGs), reducing dependence on vulnerable reef fisheries, while value addition through products such as agar and biofertilizers strengthens the conservation-development linkage. As a pilot intervention, two bamboo rafts (2 × 2 m each) were deployed in the lagoon ecosystem of Kalpeni Island. An initial seeding of 2 kg of seaweed biomass yielded 46 kg within a 40-day cultivation cycle, achieving a daily growth rate (DGR) of 7.72% day^{-1} and a biomass yield of 5.5 kg m^{-2}, demonstrating high productivity under local lagoon conditions. This study identifies seaweed cultivation as a viable climate-resilient livelihood option that integrates ecological performance with community engagement. The cultivation structures also function as microhabitats, supporting juvenile fishes and other marine organisms and enhancing lagoon productivity. Positioning Lakshadweep as a hub for sustainable seaweed cultivation aligns with India's Blue Economy vision and offers a scalable model for small island ecosystems facing similar climate vulnerabilities.

SLI 02

PROMOTING SUSTAINABLE SEAWEED AQUACULTURE IN THE ANDAMAN AND NICOBAR ISLANDS: ENABLING LIVELIHOODS THROUGH LARGE-SCALE SEAWEED FARMING

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Seaweed farming holds significant potential for sustainable livelihood generation, coastal ecosystem conservation, and blue economy development in the Andaman and Nicobar Islands. With approximately 8,249 km² of pristine marine environment, the archipelago offers extensive shallow coastal waters, high water clarity, and favourable temperature and salinity regimes. These conditions are ideal for cultivating commercially important seaweeds native to the region. Key species available include *carrageenophytes* (*Kappaphycus, Sarconema*, and *Acanthophora*), *agarophytes (Gracilaria* and *Gelidiella)*, and edible or feed seaweeds (*Asparagopsis, Ulva*, and *Caulerpa*). Additionally, *Sargassum* species offer potential applications in bioplastics, biofertilizers, and other value-added products. As an eco-friendly, low-input aquaculture practice, seaweed farming can diversify income for island communities particularly women and small-scale fishers while reducing dependence on capture fisheries. Furthermore, farmed seaweeds provide raw materials for the food, hydrocolloid, pharmaceutical, and bioenergy sectors. Despite this promise, large-scale adoption faces challenges regarding seed availability, logistics, market access, and capacity building. To realize the full potential of seaweed farming, strategic interventions are essential. These include site-specific species selection, the development of local shore-based and ocean-based nurseries, the establishment of a laboratory strain bank, and the implementation of supportive policy frameworks for large scale seaweed farming.

SLI 03

THE POLITICS OF THE LINE: INFORMAL SEA TENURE AND BOUNDARY CONFLICTS IN THE TAWI-TAWI SEAWEED INDUSTRY, PHILIPPINES

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As the global blue economy expands, the transition from informal seaweed farming to regulated value chains often overlooks the complex, pre-existing social structures of coastal communities. This study examines the *de facto* property rights and informal governance mechanisms in the seaweed farming hub of Sibutu, Tawi-Tawi, Philippines, specifically focusing on the tension between customary practices and formal municipal regulation. Utilizing Key Informant Interviews (KIIs) with veteran farmers, traditional leaders, local government unit (LGU) officers, and middlemen, the research reveals a sophisticated system of tenure based on "first-come, first-serve" principles, natural markers, and kinship-based space sharing. Findings indicate that while physical markers—such as poles in shallow areas and floats in deep waters—define boundaries, the stability of these "invisible" grids relies on social capital and "unwritten rules" for handling drifting lines and fallow spaces. A critical discovery of this study is the high reliance on "Customary Law" (*Adat*) and community mediation (barangay/elder level) due to the absence of formal LGU zoning maps and the geographical isolation from state enforcement. The study concludes that for blue economy pathways to be sustainable and inclusive in the Philippines, maritime policy must move beyond top-down zoning. Instead, it must formally recognize the seaweed maritime ancestral domains of the Sibutu farmers and integrate informal conflict resolution protocols into national maritime frameworks to prevent violence and ensure equitable access for smallholder producers.

SLI 04

WOMEN'S PARTICIPATION IN SEAWEED FARMING: SOCIO-ECONOMIC STATUS AND CHALLENGES IN THE MANDAPAM REGION, TAMIL NADU

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Seaweed farming is a climate-resilient aquaculture practice that provides sustainable livelihoods for coastal communities, with women playing a crucial role in the sector. The present study examined the participation of women in seaweed farming in the Mandapam region of Tamil Nadu, with a focus on their socio-economic status and the challenges they face. Primary data were collected purposively from 150 seaweed farmers using a structured interview schedule, of whom 114 (76%) were women. The findings revealed that a majority (61.4%) of the women farmers belonged to the middle age group (31–50 years). Most respondents (95.6%) were married and lived in nuclear families with an average family size of four members. Only 43% of the women had attained secondary-level education, while 71.1% resided in pucca houses, and all respondents had bank accounts. Most women had 16–20 years of experience in seaweed farming, with an average annual income of approximately ₹2,00,000. The majority of households reported a daily expenditure of up to ₹500. Despite their substantial contribution, women farmers faced several challenges, including environmental constraints such as grazing of cultured seaweeds by aquatic organisms and unfavorable weather conditions. Other major issues included the lack of insurance coverage for seaweed farming and occupational health hazards. The study highlights the need for targeted interventions and supportive policy measures to enhance the socio-economic well- being of women engaged in seaweed farming, thereby ensuring the sustainability and equitable growth of the sector.

SLI 05

SEAWEED FARMING IN RAMANATHAPURAM, TAMIL NADU: A PROMISING LIVELIHOOD OR A FADING HOPE?

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Seaweed farming is promoted in India as a low-investment livelihood option for coastal communities, supported by growing global demand. Despite accounting for nearly 97% of global production through aquaculture, India produced only 72,385 tonnes in 2023 against an estimated potential of 9.7 million tonnes. Ramanathapuram district of Tamil Nadu has been prioritized under national seaweed development programmes; however, farmer discontinuation remains a major challenge. This study analyses the socio-economic and institutional determinants of farmer dropout from seaweed farming. Primary data were collected from 90 farmers (55 active and 35 discontinued) using structured interviews and analysed through descriptive statistics, Chi-square tests, and independent sample *t*-tests. Results show that discontinuation is systematic and significantly associated with institutional, experiential, and spatial factors. Gender was significantly associated with dropout ($p = 0.007$), with higher discontinuation among male farmers, while age had no significant effect ($p = 0.292$). Active farmers had significantly greater cultivation experience (19.3 years) than discontinued farmers (13.2 years; $p < 0.001$), indicating experience as a key resilience factor. Cultivation location significantly influenced continuity ($p < 0.001$). Institutional support was critical, as all active farmers received assistance, compared to 37.1% of discontinued farmers who lacked support ($\chi^2 = 23.878$, $p < 0.001$). Although training coverage was high (97%), perceived effectiveness differed significantly ($p = 0.035$), with 68.6% of discontinued farmers reporting training as ineffective. Environmental constraints, poor seed availability, inadequate technical follow-up, and price volatility were the main reasons for dropout. Further, 68.9% of farmers were uncertain about long-term sustainability, and 51.1% were unwilling to recommend seaweed farming. The study underscores the need for strengthened institutional support, improved input supply, continuous capacity building, and market stabilization to enhance farmer retention.

SLI 06

THE *PONDOHAN* SETTLEMENTS AS THE FOUNDATION OF THE SEAWEED PRODUCTION CHAIN IN TAWI-TAWI, THE PHILIPPINES

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As the leading seaweed-producing region in the Philippines, the Sulu Archipelago owes its vast production to the 'pondohan'. These are traditional stilt-house settlements situated right next to the seaweed farms. More than just a unique socio-technical adaptation and a base node in the production chain, 'pondohan' forms a community of indigenous people in its own right. While the sociological dimension of phyconomy has been covered for many years, little is known about the social organization and structure of 'pondohan'. We seek to answer what constitutes a 'pondohan' and how it serves as an important social space for sustainable seaweed production in three major 'pondohan' in Tawi-Tawi. Our findings reveal that 'pondohan' in the province was established prior to 1969 (the year seaweed farming began in the area) and was conceived to maximize production efficiency and convenience. While its overall sustainability is never in question, some challenges were identified. The frail structures of the 'pondohan' indicate that they may not withstand the impacts of a changing climate and that political disagreements occasionally arise both within and between communities. Our study also identifies shifting gender and generational roles, where women and children provide essential labour, while the introduction of 'seaweed fertilizer' has added a physical burden on male farmers. A total lack of government assistance, attributed to their remote location, further complicates these challenges. Our study provides a framework for relief policies aimed at supporting the 'pondohan' as a lasting space towards a more sustainable seaweed farming in the region.

SLI 07

WOMEN-LED SEAWEED FARMING AS A CLIMATE-SMART BLUE ECONOMY MODEL FOR COASTAL INDIA

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Seaweed farming is emerging as a sustainable solution integrating climate action, livelihood enhancement, and blue economy development. In India, coastal women play a crucial role in seaweed cultivation activities including seeding, tying, harvesting, drying, and primary processing. This study examines women-led seaweed farming as a climate-smart model contributing to blue carbon sequestration while strengthening socio-economic resilience in coastal communities. Seaweeds exhibit high growth rates and substantial carbon dioxide uptake capacity, making them promising candidates for nature-based climate mitigation. Expansion of seaweed cultivation enhances carbon capture potential, reduces coastal nutrient loads, and supports marine ecosystem health. When women are organized through Self-Help Groups (SHGs) and cooperatives, seaweed farming generates regular income, promotes financial independence, and encourages entrepreneurship through value-added products such as functional foods, nutraceuticals, and biofertilizers. Despite its potential, challenges persist in market access, price stability, credit availability, and technical training. Strengthening institutional support, improving access to formal financing, and integrating women-led seaweed enterprises into India's Blue Economy framework can enhance both environmental and socio-economic outcomes. Empowering women through climate-smart seaweed value chains offers a triple-win pathway climate mitigation, livelihood security, and sustainable coastal development while accelerating progress toward the Sustainable Development Goals and building resilient coastal communities.

SLI 08

SEAWEED FARMING: BOOSTING COASTAL LIVELIHOODS AND WOMEN'S EMPOWERMENT IN INDIA

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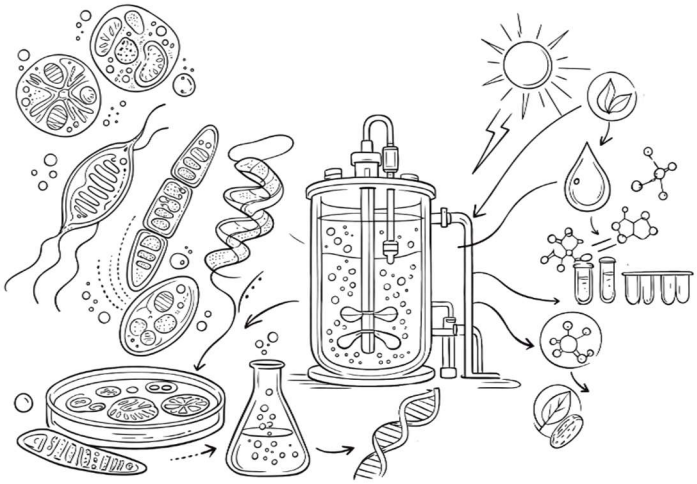
Seaweed farming is emerging as a sustainable marine resource with high potential for improving livelihoods, nutritional security, and environmental sustainability. In India, coastal communities, particularly women, are increasingly engaged in seaweed cultivation, processing, and value addition, generating income and promoting household welfare. India's seaweed production is concentrated in Tamil Nadu, Gujarat, and Lakshadweep, contributing significantly to the local economy and food security. Globally, about 40% of seaweed start-ups are women-led, highlighting the sector's potential for gender empowerment. Despite these opportunities, production faces constraints such as limited technical knowledge, inadequate access to quality planting material, weak market linkages, and insufficient institutional support. Fisheries extension plays a key role in overcoming these challenges through training programs, demonstrations, advisory services, and formation of self-help groups. Extension interventions also enhance women's participation in post-harvest handling, value addition, and market access. Seaweed farming offers additional benefits, including carbon sequestration, habitat for marine biodiversity, mitigation of eutrophication, and potential use in bioplastics and animal feed. Addressing production constraints through women-focused extension strategies, locally appropriate technologies, and strengthened policy support can enhance adoption, sustainability, and scalability of seaweed enterprises. Integrating these approaches will not only improve household incomes and women's empowerment but also contribute to environmentally sustainable coastal development in India.



Session 10
Microalgae: Bioprospecting, Commercial Production and Value Addition
MAL 01 – 06

MAL 01

MECHANISTIC ASSESSMENT OF QUATERNARY HEAVY METAL TOXICITY AND PHYCOREMEDIATION POTENTIAL OF AN INDIGENOUS *Chlorella* sp. ISOLATED FROM INDUSTRIAL POLLUTED SITE

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Heavy metal contamination in aquatic ecosystems typically occurs as complex mixtures, yet most toxicological studies focus on single-metal effects. This study investigated the synergistic toxicity and phycoremediation potential of a heavy-metal tolerant microalga belonging to the Chlorellaceae family, isolated from an industrial effluent-impacted site, was evaluated for its phycoremediation potential. Microalgal cultures were treated with varying concentrations (5, 10, 25, and 50 ppm) of a multi-metal (Cr, Pb, Cu, Zn) master mix over a 72-hour period. Toxicity was quantified by determining the Median Effective Concentration Ec50 through growth inhibition analysis, while physiological stress was monitored via spectrophotometric determination of chlorophyll a and b content. Metal removal efficiency was evaluated at 0, 24, 48 and 72 hours using Atomic Absorption Spectroscopy (AAS) to capture the kinetics of the remediation process. Mechanistic insights into the interaction between the metal ions and the algal cell wall were obtained using Fourier Transform Infrared Spectroscopy (FTIR) and Scanning Electron Microscopy with Energy Dispersive X-ray analysis. (SEM-EDX). Significant degradation of photosynthetic pigments was observed at higher concentrations, correlating strongly with growth inhibition. FTIR spectra confirmed that carboxyl and hydroxyl functional groups were primary binding sites, while SEM-EDX mapping highlighted significant surface morphological damage and metal deposition.

MAL 02

RED MICROALGAL BIOMASS: A SUSTAINABLE SOURCE FOR FOOD ENRICHMENT

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Porphyridium cruentum, a red microalga, is a rich source of bioactive compounds with nutritional and therapeutic relevance. The present study evaluated the proximate composition, pigment profile, and anti-inflammatory potential of *P. cruentum* biomass cultivated under standardized laboratory conditions. Biomass was grown in Guillard's F/2 medium, harvested at the exponential phase, and freeze-dried for analysis. Anti-inflammatory activity was assessed in lipopolysaccharide (LPS)-stimulated RAW 264.7 macrophages by measuring inhibition of cyclooxygenase (COX), lipoxygenase (LOX), inducible nitric oxide synthase (iNOS), myeloperoxidase (MPO), and nitrite accumulation. On a dry-weight basis, the biomass showed low moisture content (4.0 ± 0.01%), moderate protein (23.7 ± 0.004%), carbohydrates (36.5 ± 0.001%), lipids (8.0 ± 0.007%), and ash (28.0 ± 0.01%), indicating good nutritional quality and mineral richness. *P. cruentum* biomass stands out as a nutritionally efficient alternative, delivering a carbohydrate-rich macronutrient profile with markedly lower lipid content. Pigment analysis revealed high concentrations of B-phycoerythrin (15 ± 1.52 mg/g), followed by R-phycocyanin, allophycocyanin, chlorophyll and carotenoid, supporting the antioxidant potential of the biomass. The extract exhibited strong dose-dependent anti-inflammatory effects, with COX inhibition increasing from 14.94% to 36.26%, LOX inhibition reaching 45.24% at 100 µg/mL, and significant reductions in nitrite levels, along with notable iNOS (39.70%) and MPO suppression. *P. cruentum* can provide functional health benefits at relatively low intake levels due to the synergistic action of its proteins and bioactive pigments. Additionally, its microalgal origin supports sustainable biomass production with minimal land and freshwater requirements, making it suitable source for food enrichment.

MAL 03

EFFECTS OF DIETARY MICROALGAE (*Nannochloropsis oceanica*) SUPPLEMENTATION ON GROWTH, ANTIOXIDANT ENZYME ACTIVITY AND IMMUNE RESPONSES OF *Pangasianodon hypophthalmus* Juveniles

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Nannochloropsis oceanica possesses probiotic, prebiotic, immunostimulant, antiviral, and antibacterial properties and is a rich source of eicosapentaenoic acid (EPA) and high-quality protein. A 60-day feeding trial evaluated its effects on growth, digestive enzyme activity, antioxidant status, and non-specific immunity in *Pangasianodon hypophthalmus*. Six iso-nitrogenous diets (T1–T6) were prepared with 0% (control), 0.25%, 0.5%, 1.0%, 1.5%, and 2.0% *N. oceanica* biomass. A total of 180 uniform fingerlings (37.95 ± 1.8 g) were randomly stocked into 18 FRP tanks (200 L) and fed twice daily at 3% of biomass. Growth performance indicators—percentage weight gain (PWG), specific growth rate (SGR), and protein efficiency ratio (PER)—improved significantly with algal inclusion up to 1.0%, with optimal results at 0.25%. Feed conversion ratio (FCR) differed significantly ($p < 0.05$) among treatments, with the lowest FCR observed at 0.25% inclusion. Amylase activity peaked in T3 (0.5%), while the highest protease activity occurred at 0.25% inclusion; lipase activity increased progressively with higher inclusion levels. Hepatic antioxidant enzymes, including superoxide dismutase (SOD) and catalase, were significantly elevated in all algal-supplemented groups. Non-specific immune responses—lysozyme, myeloperoxidase, bacterial agglutination, and haemolytic activity—improved significantly up to 1.0% inclusion, with maximal effects at 0.25%. Survival rates were unaffected by dietary treatments. Overall, dietary *N. oceanica*, particularly at 0.25%, enhanced growth, digestive enzyme activity, antioxidant capacity, and immune responses in *P. hypophthalmus* juvenile.

MAL 04

ISOLATION, CULTIVATION AND CHARACTERIZATION OF MICROALGAL SPECIES FROM WETLAND SOURCES VIA BIOPROSPECTING

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Microalgae are crucial organisms with diverse applications in the fields of biofuels, wastewater treatment, and the production of various bioactive compounds. Among the various microalgal species, *Chlorococcum* sp. has attracted significant attention due to its potential in biotechnological applications. This study aimed to isolate *Chlorococcum* from wetland ecosystems, characterize its growth patterns, and explore its potential applications in biotechnology. The process of isolation was conducted through the serial dilution and plating technique, which effectively isolated individual colonies of *Chlorococcum* from the collected samples. The isolated microalgae were subjected to microscopic and morphological analyses to confirm their identity. The distinct unicellular structure, along with the characteristic green pigmentation and the formation of colonies, confirmed the identification of the microalga as *Chlorococcum*. A detailed study was conducted on the growth parameters of *Chlorococcum*, including the effect of different light intensities, temperature ranges, and nutrient concentrations on its growth rate. The algae demonstrated optimal growth under specific conditions, which were identified during the experiment. The study also involved an analysis of the biochemical composition of *Chlorococcum* to evaluate its potential for biotechnological applications, such as the production of biofuels and other value-added products. Preliminary findings suggest that *Chlorococcum* exhibits promising traits for biofuel production due to its high lipid content, which is a critical factor in biodiesel synthesis. Additionally, its ability to thrive in diverse environmental conditions makes it a potential candidate for large-scale cultivation in different industrial applications. The results of this study contribute to the growing body of knowledge regarding the biodiversity of wetlands and the potential of *Chlorococcum* in sustainable biotechnology. Further research on optimizing cultivation methods and exploring the genetic and biochemical properties of *Chlorococcum* could pave the way for its use in industrial applications, including biofuel production, carbon sequestration, and environmental remediation.

MAL 05

FLUORESCENT CARBON QUANTUM DOTS FROM MARINE CYANOBACTERIA *Leptolyngbya* sp. NOV. KMBMA-1 FOR BIOIMAGING APPLICATIONS

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Carbon quantum dots (CQDs) are emerging nanomaterials with excellent photoluminescence, aqueous solubility, and biocompatibility, making them attractive for biomedical applications. In this study, CQDs were synthesized from the marine cyanobacterium *Leptolyngbya* sp. nov. KMBMA-1 using a simple and eco-friendly hydrothermal method, employing cyanobacteria as the sole carbon source. The synthesized CQDs were systematically characterized by transmission electron microscopy (TEM), X-ray diffraction (XRD), and UV–Visible spectroscopy. TEM analysis revealed uniformly distributed spherical nanoparticles with sizes ranging from 2 to 8 nm, while XRD patterns confirmed the presence of graphitic crystalline domains. UV–Vis spectra exhibited characteristic absorption features associated with electronic transitions and surface functional groups, indicating good stability and functionalization. The bioimaging potential of the cyanobacteria-derived CQDs was evaluated in cancerous (MCF) and non-cancerous (HEK) cell lines. Fluorescence microscopy demonstrated a distinct cell-type–dependent interaction. HEK cells exhibited no detectable fluorescence, indicating the absence of CQD uptake and confirming their biocompatibility with normal kidney cells. In contrast, MCF cancer cells displayed strong intracellular green fluorescence with both punctate and diffuse distribution, indicating efficient cellular uptake and accumulation after 24 h of incubation. Importantly, CQD treatment did not induce morphological alterations or compromise cell viability. These findings highlight the potential of cyanobacteria-derived CQDs as sustainable, biocompatible fluorescent probes for selective cancer cell bioimaging.

MAL 06

COMBINED FREEZE-THAW-ULTRASOUND ASSISTED METHOD FOR THE EXTRACTION OF CRUDE PHYCOERYTHRIN FROM *Porphyridium cruentum*

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Phycoerythrin, a phycobiliprotein from the microalga, *Porphyridium cruentum,* is a fluorescent pink pigment with growing demand in various industries. A wide range of extraction methods like solvent extraction, maceration, microwave and pulsed electric-field assisted extraction methods have been investigated for the extraction of phycoerythrin. Nevertheless, using just one technique alone can account for reduced yield and difficulty in scalability. Hence, this study was an attempt to maximize the yield of phycoerythrin using combination methods of freeze-thaw and ultrasonication, which can be adapted by the industry. It was found that both yield and concentration of phycoerythrin varied with variation in the sequence of freeze-thaw and ultrasonication methods. Though the purity ratio increased with concentration and yield, it did not show significant differences within the treatments. According to the study, freeze-thaw combined with ultrasonication assistance may increase the yield and concentration of crude phycoerythrin. The process needs to be optimized for the highest yield in the shortest amount of time for industrial scale-up.

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