

# DEVELOPMENT OF HIGH VALUE PRODUCTS AS DIETARY SUPPLEMENTS AND HEALTH MANAGEMENT

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## ABSTRACT

The ocean's rich biodiversity is not just a source of good food but also holds special compounds that make marine products more than just nourishment – they become functional foods. Bioactive peptides from fish protein and marine polysaccharides like algal fucans offer various health benefits, including preventing blood clots, fighting cancer, and lowering cholesterol. Exploring the relationship between food and health, “nutraceuticals” describes substances in food that bring health benefits. These natural compounds, distinct from synthetic drugs, target specific diseases with improved effectiveness. The nutraceutical market, valued at \$250 billion in 2014, is expected to reach \$18 billion by 2025, influenced by the Covid-19 pandemic's second wave. The growing global demand for nutraceuticals, set to hit \$385 billion by 2020, is driven by competitive pricing and effectiveness compared to traditional therapies. Leading contributors to this market are the USA, Europe, and Japan, with marine-derived nutraceuticals like seaweed-based products, omega-3 fish/algal oil, and fish proteins playing a crucial role. In India, the expanding middle class, dealing with lifestyle-related health concerns, fuels double-digit growth in the nutraceutical market since the early 2000s, contributing to global expansion.

**Keywords:** Marine polysaccharide, Nutraceutical, Pharmacological potential

## INTRODUCTION

The remarkable biodiversity of marine products not only makes them appealing as nutritious food items but also positions them as reservoirs of novel, biologically active compounds. Embracing the concept of functional foods, these marine wonders go beyond basic nutritional value, offering bioactive compounds with the potential to enhance overall health and reduce the risk of illness and disease. Bioactive peptides derived from fish protein hydrolysates, along with algal fucans, galactans, and alginates, have demonstrated compelling properties such as anticoagulant, anticancer, and hypocholesterolemic activities. Over the past two decades, more than 3000 new compounds have been isolated from various marine organisms, including seaweed, corals, and microorganisms. The exploration of marine products has led to the isolation of several nutraceuticals in recent years. Fish oils and marine bacteria emerge as excellent sources of omega-3 fatty acids, while crustaceans and seaweeds boast powerful



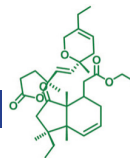
antioxidants like carotenoids and phenolic compounds. Seafood consumption can be stratified into two groups: women, infants, and young children benefiting from omega-3 fatty acids, and adults preventing or delaying chronic diseases through seafood consumption. Recognizing the impact of dietary fat on coronary heart disease and stroke risk, dietary advice from regulatory bodies emphasizes seafood as a component of a healthy diet, particularly for its potential to replace other protein foods high in saturated fat.

## **EXPLORING NUTRACEUTICALS: BRIDGING FOOD AND HEALTH FOR THERAPEUTIC BENEFITS**

The term “nutraceutical” is defined as any substance that is a part of food and provides medical or health benefits, encompassing disease prevention and treatment. Nutraceuticals are distinct from drugs, as they involve concentrated, isolated, or purified pharmacologically bioactive molecules. Unlike synthetic drugs, these potential bioactive substances are sourced from natural origins and concentrated using environmentally friendly extraction and purification techniques. The purification process ensures the removal of unnecessary components, enhancing the quantities of the intended pharmacophores. These pharmacophores specifically target particular diseases, resulting in heightened pharmacological activities of nutraceutical products. Importantly, the safety of these products is maintained, as evidenced by a mean lethal dose ( $LD_{50}$ ) exceeding threshold limits. Bioactive molecules play a pivotal therapeutic role in human health, prompting collaboration between nutritionists and biomedical scientists to uncover new bioactive molecules for therapeutic benefits. The global nutraceutical market, encompassing functional foods, beverages, and dietary supplements, reached a value of approximately \$250 billion in 2014. In response to the challenges posed by the second wave of the Covid-19 pandemic, the nutraceuticals market is anticipated to experience significant growth, with a projected Compound Annual Growth Rate (CAGR) of up to 35%, reaching \$18 billion by 2025, up from the current \$4 billion.

## **NUTRACEUTICALS: RIDING THE WAVE OF CONSUMER DEMAND**

The nutraceutical market is experiencing a rapid surge, poised to reach an estimated \$385 billion by 2020. These products, with their competitive pricing compared to conventional therapies, are gaining traction globally. Market share is expanding across various regions, including the United States of America (USA), Europe, Japan, Asia Pacific, the Middle East, and Latin America. The global market is primarily dominated by the USA, Europe, and Japan, contributing over 85% of the market share. Marine nutraceuticals and ingredients play a pivotal role in this landscape, with key sources and products of interest encompassing seaweed-based nutraceuticals, phospholipids (bound omega-3 fatty acids) and omega-3 fish/algal oil, micro/



macro algal nutrition supplements, fish proteins and peptides, shellfish chitin, fish collagen, and mineral supplements.

## INDIAN NUTRACEUTICAL MARKET

India's burgeoning middle class, comprising nearly 400 million people with disposable income, is increasingly investing in nutraceuticals and dietary supplements. This demographic shift is influenced by the undeniable link between affluence and lifestyle diseases, which nutraceuticals and dietary supplements are often designed to address. With a substantial market base and a rising prevalence of lifestyle-related health concerns, the industry is poised for double-digit growth in the coming years. Since the early 2000s, the global nutraceutical industry has witnessed significant expansion, with nutraceuticals becoming a favored product portfolio for leading pharmaceutical companies in India and beyond.



*The nutraceutical products developed by ICAR-CMFRI: A wealth of bioactive compounds and nutraceuticals*

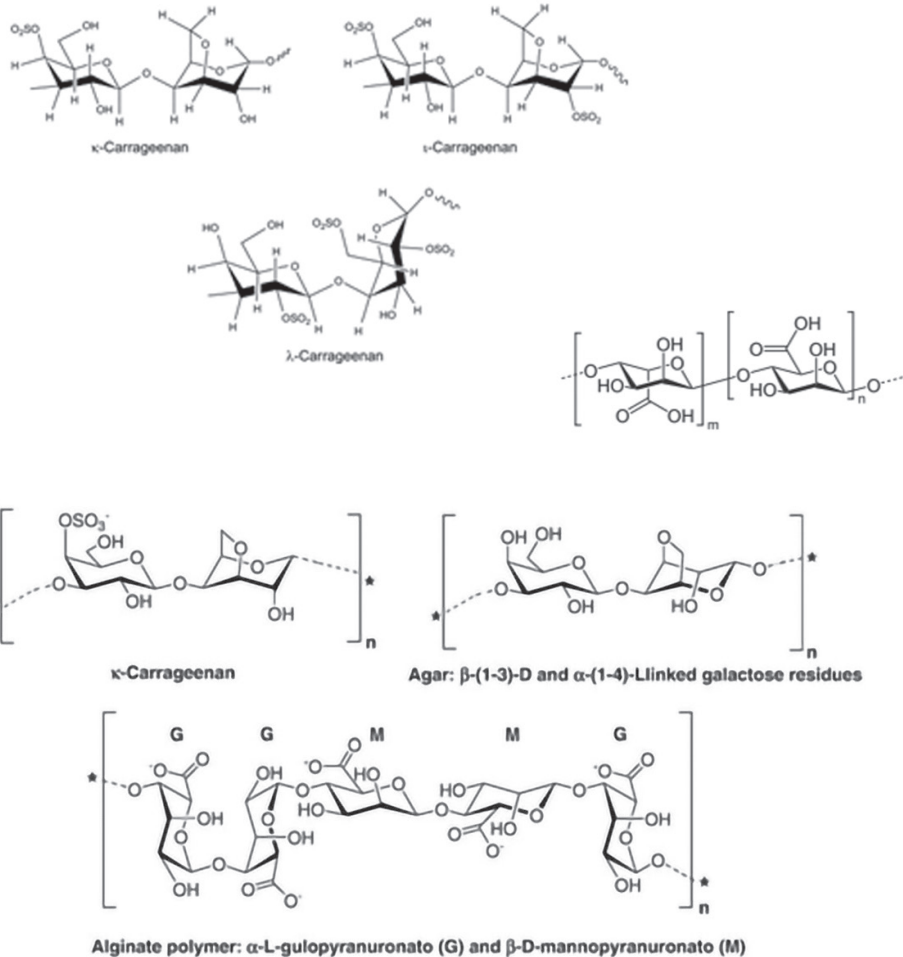
## UNLOCKING THE BIOACTIVE POTENTIAL OF MARINE ALGAE: A HIDDEN TREASURE

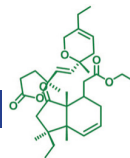
Despite being a multibillion-dollar industry globally, the bioactive potential of marine algae remains largely untapped. For centuries, the medicinal properties of seaweeds were confined to traditional and folk medicines. However, recent years have witnessed a shift in focus, with industries dedicating attention to the discovery and development of compounds from marine



## High-value Products as Dietary Supplements

algae. Seaweeds, unique sources of industrially important phycocolloids like agar, carrageenan, and alginate, play vital roles as stabilizers, viscosifiers, gelling agents, and emulsifying agents. Agar, a major component of the cell wall of certain red algae, finds applications in various industries. Derived from red algae such as *Gelidiella acerosa*, *Gracilaria edulis*, and species of *Gelidium*, *Pterocladia*, and *Ahenfeltia*, agar is utilized in pharmaceuticals as a laxative for chronic constipation and as a drug vehicle. Algin or alginic acid, a membrane mucilage and a major constituent of all alginates, serves as an emulsifier in pharmaceuticals, contributing to the manufacture of tablets, pills, and ointments. Carrageenan, a sulphated galactan polymer obtained from various red seaweeds, holds a significant market share, with the food sector alone accounting for nearly 70% of its global market.





In 2008, industry analysts estimated the worldwide consumption of marine algal omega-3 ingredients at 71,452 tons, with North America leading at 26,948 tons, followed by Asia-Pacific at 21,145 tons, the European Union (EU) at 13,596 tons, and the rest of the world at 5,762 tons (Real, 2019). The microalgal biomass market, producing 5,000 tons of dry matter annually, generates an approximate turnover of U.S.\$1.25 billion per year (Spolaore et al., 2006). *Chlorella*, encompassing species like *Chlorella vulgaris* and *Chlorella pyrenoidosa*, stands out for its richness in chlorophyll, protein (40–60%), and carotenoids, offering anti-carcinogenic, immunomodulatory, hypolipidemic, gastric mucosal-protective, and detoxification activities. Notable producers of *Chlorella* include Cyanotech in Kailua-Kona, Hawaii, and Earthrise Nutritionals in Ishigaki Island, Japan. *Spirulina* (*Spirulina platensis*) serves as a source of vitamin B12, providing immune enhancement and health benefits such as anemia prevention, hypocholesterolemic effects, and hepatoprotective activities. Producers of *Spirulina* include Cyanotech, Earthrise Nutritionals in Irvine, Calif., and Parry Nutraceuticals. *Dunaliella salina*, renowned for its bioglycerol and  $\beta$ -carotene content, boasts aging retardant and immune enhancement properties. Cognis Nutrition and Health in Tullamarine, Australia (BASF), is a notable producer. *Cryptocodinium cohnii*, a producer of DHA (> 30%), is primarily used in infant formula along with arachidonic acid (ARA). DSM-Martek Biosciences supplies *Cryptocodinium cohnii*. *Schizochytrium* sp. is another microalga producing DHA (> 35%) and 13.5% DPA, serving as a nutritional supplement and active ingredient in poultry feed. *Nitzschia laevis* produces EPA, and Photonz Corp. has developed a pharmaceutical-grade EPA omega-3 manufacturing process from microalgal biomass, utilizing SFE technology from Separex S.A., Champigneulle, France, with an application focused on cardiovascular disease.

### **POLYUNSATURATED FATTY ACID ENRICHED FORMULATIONS FROM LOCALLY AVAILABLE LOW-VALUE FISH AND FISHERY BY-CATCH FOR USE AS NUTRACEUTICALS AND AQUAFEED SUPPLEMENTS**

In the pursuit of utilizing polyunsaturated fatty acids (PUFAs) as key ingredients in nutraceutical formulations, the imperative lies in their isolation at a high level of purity. The global market for consumer products fortified with omega-3 fatty acids is estimated at a staggering \$19 billion (Global Organization for EPA and DHA Omega-3 GOED Omega-3). To harness the potential benefits of PUFAs for aquafeed in mariculture and nutraceutical formulations for human health, their isolation must achieve a level of high purity. These essential fatty acids are abundantly present in various marine fish body oils and fisheries by-products, making them a preferred raw material for the production of concentrated n-3 PUFA supplements. These PUFA-enriched products not only offer a cost-effective alternative to imported PUFA supplements but also serve as valuable resources for nutraceuticals and aquafeed. Utilizing



PUFA-enriched nutraceuticals derived from low-value “fish body oils” helps mitigate the associated risks of hypervitaminosis (A, D) and exposure to environmental toxins like mercury, PCBs, dioxins, etc., commonly found in liver oils. The benefits of omega-3 polyunsaturated oils span cardiovascular disease risk reduction, improved immune function, brain health, and inflammation reduction in conditions like rheumatoid arthritis. Diverse sources of these essential fatty acids include fish, algae, krill, seal, and squid, with Antarctic krill and squid oils standing out for their predominantly phospholipid-bound omega-3 fatty acids, along with the added advantage of krill oil containing the potent antioxidant astaxanthin.

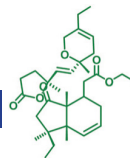
## **MICROORGANISMS: UNLEASHING THE BIOFACTORY POTENTIAL FOR HIGH-VALUE COMPOUNDS**

Stressful ecosystems span a diverse array of habitats and environmental conditions, harboring an immense microbial biodiversity. Within this realm, free-living/heterotrophic bacteria, fungi, and fungi-like protists (thraustochytrids) stand out as microorganisms with unparalleled potential to produce bioactive compounds applicable for various commercial purposes, including pharmaceutical/nutraceutical and cosmeceutical applications. Extensive studies on microbial symbiosis have shed light on the profound impact of these microorganisms (Lemose et al. 1985; Zeng et al. 2005; Penesyan et al. 2009). The metabolites derived from symbiotic relationships with macroalgae have been recognized for their antimicrobial, antifouling, and anticancer properties since as early as 1875 (Graham and Wilcox, 1999; Timmermans et al. 2017).

## **FUTURE PROSPECTS**

In recent years, there has been a notable surge in the exploration of naturally derived bioactives for the development of novel products and as a source for obtaining high-value compounds, capturing the keen interest of both the food and pharmaceutical industries. Groundbreaking research conducted at ICAR-CMFRI has successfully curated a comprehensive database of bioactive molecules sourced from marine organisms, demonstrating significant efficacy against various life-threatening diseases. This breakthrough has paved the way for the creation of several nutraceutical products designed to combat conditions such as arthritis, type-2 diabetes, dyslipidemia, hypothyroidism, osteoporosis, and hypertension, while also serving as immunoboost agents. The Indian nutraceuticals market has experienced robust growth, boasting a compound annual growth rate of 20 percent over the past three years, particularly within the functional food, antioxidants, and immunity booster segments. Projections indicate that India’s nutraceutical industry is poised to claim at least 3.5 percent of the global market share by 2023. Anticipated growth suggests that the nutraceuticals market in India will expand from an estimated \$4 billion to a substantial \$18 billion by the end of 2025. Nutraceuticals occupy





a unique intersection between pharmaceutical and food products, garnering significant appeal due to their naturally derived, concentrated pharmacologically active compounds. Positioned as 'Natural Drugs,' these compounds are gaining recognition for their potential therapeutic applications. As these specific segments of nutraceuticals proliferate in India, widespread acceptance by both consumers and healthcare providers becomes evident. The primary challenge lies in formulating regulatory guidelines that empower physicians to prescribe this specialized category of medicines, fostering continued research and development in this field.

## CONCLUSION

The marine ecosystem, rich in biodiversity, presents a promising source of functional foods and nutraceuticals. Bioactive compounds from marine products, such as fish peptides and algal polysaccharides, exhibit diverse health benefits, from anticancer properties to hypocholesterolemic activities. The global nutraceutical market, valued at \$250 billion in 2014, is expected to reach \$18 billion by 2025, reflecting the growing demand for natural health solutions. Marine-derived ingredients, including seaweed-based formulations and omega-3-rich extracts, play a pivotal role in meeting consumer preferences for wellness. As we navigate this intersection of marine science and nutrition, it becomes clear that harnessing the potential of marine biodiversity holds significant promise for advancing health and well-being in our global community.



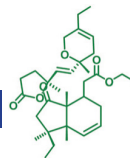
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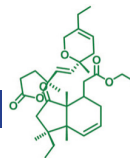




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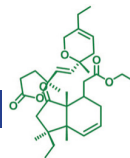
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