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MARINE BIOTECHNOLOGY- A REVIEW

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ABSTRACT

Marine biotechnology is a developing field of study that aims to apply biotechnology to the study and application of marine organisms for a variety of purposes. It is an interdisciplinary field that uses the principles and techniques of biology, engineering, and chemistry to develop commercial, environmental, and medical products and processes. Marine biotechnology is being used to create innovative products and processes that benefit the environment, such as bio-remediation technologies that use marine organisms to clean up pollution. Marine biotechnology is also being used to create more sustainable food sources, such as microalgae-based food substitutes and algae-based biofuels. Moreover, marine biotechnology is being used to create new medicines and treatments for diseases such as cancer and diabetes. Marine biotechnology has enormous potential. Scientists are creating new opportunities to address a variety of environmental and medical challenges by understanding and utilising the unique properties of marine organisms. Marine biotechnology has the potential to transform how we perceive and interact with the ocean and its inhabitants.

KEYWORDS: Marine biotechnology, Marine ecosystems, Marine drug discovery, Bioactive marine components.

INTRODUCTION

Biotechnology is defined as the use of a living organism, system, or process to create a commercial service or product. Biotechnology is not a new field, and humans have been aware of it for a long time. Mold-fermented foods in China and beer brewing and bread making in Egypt were the origins of fermentation technology (An earlier form of biotechnology).[1,2] Biotechnology has a wide range of applications, from the development of life-saving drugs to the improvement of food and the conservation of bio-waste. Such vast applications of this particular topic make us believe that civilization has already transitioned from the information age to the biotechnology age. Biotechnology has four major applications: biomedical, agricultural, industrial, and environmental. The biomedical sector is the fastest growing of these.

Some examples of this success include recombinant human insulin, novel pharmaceutical drugs, different vaccines, and so on. The introduction of genetically engineered tomatoes, soybeans, cotton, and other crops into the market demonstrates the impact of biotechnology in agriculture. There has also been tremendous progress on the industrial and environmental fronts.[3]

Marine biotechnology is defined as the application of scientific and engineering principles to the production of materials by marine biological agents in order to provide goods and services.[4] The study of the oceans in order to develop new pharmaceutical medications, chemical products, enzymes, and industrial processes is known as marine biotechnology. It also helps to improve biomaterials, health care diagnostics, aquaculture and seafood safety, bio-remediation, and bio-fouling. Commercial success stories from other fields of biotechnology are well known. Marine biotechnology, on the other hand, is still in its infant stages.

Life began in the sea and has continued to the present day. The oceans cover more than 70% of the earth's surface and are home to the most ancient and diverse life forms. As the world's population and people's needs continue to grow, so will the demand for natural resources. To meet these growing demands, we can look to the marine environment, which covers one-third of our planet.

Marine biotechnology is the invention of products and processes from marine organisms using biotechnology, molecular and cellular biology, and bio-informatics techniques. This is an exciting scientific field that is also growing economically. No ecosystem provides more genetic diversity or opportunities for new processes and products than the world's oceans.

The promise of the blue biotechnology[5]

Marine biotechnology can play an important role in meeting the challenges of the 21st century, contributing significantly to global economic recovery and growth by producing new knowledge (Scientific knowledge of marine life and ecosystems) and enabling access to products and services through cutting-edge technologies.

In 2011, it was estimated that 20,000 marine natural products had been discovered in the past 5 decades, and preclinical and clinical pipelines for new pharmaceutics contained nearly 1500 molecules, many of which were related to anticancer research. However, major contribution for new antibiotics, anticancer, and immune system modulators can be accounted for in the field of marine biotechnology. Because of the widely spread use of known compounds (i.e., antimicrobial resistance), new antibiotics are required, which is one of the areas of global interest in applied marine pharmacology.

Another significant challenge is the use of marine biotechnology for algal bio-fuels, as algae biomass is used to produce bio-diesel, bio-ethanol, bio gasoline, bio-methanol, bio-butanol, and other bio-fuels. The absence of lignin, which is present in cellulosic biomass, and cultivation that has little impact on food production are the two major advantages of the marine biofuel revolution. In this context, microalgae cultivation may have a smaller environmental impact than land biomass. Microalgae, macroalgae, and bacteria have demonstrated their utility in microbial fuel cells, which are systems that produce the electricity generated by microbial metabolism. However, most experts believe that marine biorefining is still in its infancy when compared to terrestrial biomass biorefineries.

Main marine resources

The oceans are an origin of organisms with a wide range of characteristics, physiology, and, as a result, potential secondary metabolites. Microorganisms are the most promising natural molecule resource because, unlike macro-organisms, they can be sustainably cultivated on a massive scale at a low cost.[6,7]

Microalgae are among the most widely used organisms in this industry due to the large amount of compounds they can produce—vitamins, proteins containing essential amino acids, polysaccharides, fatty acids, sterols, pigments, fibers, and enzymes[8] whose quality in terms of chemical activity and structure is often superior to that of synthetic counterparts obtained in the laboratory.[9] Furthermore, as photosynthetic organisms, they can be easily cultivated in photobioreactors or open ponds, utilizing solar energy and greenhouse gases present in the air to produce abundant biomasses while assisting in the reduction of air pollutant concentrations.[10]

Two species dominate the microalgae market: Chlorella and Spirulina. The first is a green microalgae from the Chlorophyta phylum, which includes both microalgae and macroalgae. Its anti-inflammatory, antimicrobial, and anticancer properties make it popular in cosmetics, food, and pharmaceuticals.[8] Spirulina, on the other hand, originally belonged to the phylum of Cyanobacteria, photosynthetic microorganisms also known as blue-green algae, and has a high protein content that makes it an excellent addition to foods. These microalgae are highly adaptable to environmental conditions and grow quickly due to their unique cellular mechanisms.[11]

Fungi and bacteria have distinct properties that make them a rich source of bioactive metabolites. They typically coexist with invertebrates whose defence is entirely dependent on the chemical compounds produced by these microorganisms; additionally, in response to the harsh nature of their environments, fungi and bacteria have established specific properties that are reflected in the metabolites they generate.[7] The actinobacteria, a large phylum of gram positives thought to be a gold mine of secondary metabolites, are of particular interest. Approximately one-third of the 3000 compounds with antibiotic activity isolated from microorganisms have been derived from these bacteria, according to estimates. The majority of these bioactive substances were isolated from the genus Streptomyces, which is discovered in both marine and terrestrial environments.[12]

Corals, sponges, and other invertebrates, as well as fish and sharks, are all sources of bioactive substances. However, technical limitations in their exploitation make their manufacturing unsustainable, and it is frequently impossible to achieve the required quantities on an industrial scale.[13] Macroalgae are among the most easily cultivated photosynthetic organisms for use in food production because they contain metabolites with special nutritional properties like furanones, polyunsaturated fatty acids, pigments, phycocolloids, and phlorotannins. Some red algae varieties are also used to produce agarose, which is used as a thickening and stabilizing agent in the food industry.[14,15]

Discovery of new products

Our knowledge of the marine ecosystem is so limited that it is estimated that more than 90% of this biodiversity is unknown.[16] One of the most significant constraints to exploring the marine environment is the technical difficulty of trying to access deep seas, which could be resolve by inventive technology developed outside of the field of biology. Remotely controlled vehicles, for example, could help collect samples from places where humans cannot go; automatic data collection technology could help identify regions with high biodiversity.[17]

Furthermore, while many microbes are isolated from the marine environment, they are difficult to analyse, and thus taxonomic classification is complicated, with potential errors that could compromise the entire drug discovery process due to the inability to replicate the isolation event and subsequent identification of the bioactive compound.[15] Innovative analysis techniques, not only for the exploration and sampling of new organisms, but also for the separation, purification, characterization, and analysis of the compound's bioactivity, would thus allow this limitation to be overcome.[18]

To address the high costs and long lead times of traditional screening programme, the pharmaceutical industry employs modern high-throughput monitoring techniques to identify new drug leads originating from the marine environment, instantaneously testing over 10,000 potential bioactive molecules per week, resulting in a much higher success rate.[19]

When looking for new bioactive substances of marine origin, combining these innovative screening methods with bioinformatics is more effective than simply relying on experimental approaches. Recent advances in information technology have led to development of computational tools that provide more efficient and targeted research than simple genome or compound structure analysis. They enable the optimization of pharmaceutical leads by revealing the mechanism of action without the requirement for experiments.[20]

Recent interest has also been generated by genomics technologies, which are becoming increasingly significant in determining the genetic capabilities of marine organisms. The sequence analysis of different microbial genomes has resulted in the discovery of more proteins per genome than previously known, highlighting the existence of a reserve of bioactive substances that are not demonstrated in the traditional culture conditions utilized in the laboratory.

Furthermore, by applying metagenomic techniques to collected samples and analyzing the biological content of environmental samples, we can identify potential bioactive components produced by microorganisms discovered in the environment that were previously unknown due to their inability to be grown in the laboratory. DNA libraries are created by introducing their isolated DNA from the environment into appropriate hosts; these can then be quickly screened for substances of interest. The major limitations of this promising method are the inability to obtain intact genes from the atmosphere and the incompatibility of the interpretation elements used in libraries, which could be overcome by recent advances in bioengineering. The discovery of bioactive substances with antibiotic activity, such as violaceins, terragins, and turbomycins, using metagenomic methods illustrates their potential for drug discovery from non-cultivable microorganisms.[21,22,23]

Bioactive marine components

Marine ecosystems contain a diverse range of bioactive compounds with potential applications as nutraceuticals in the food and supplement industries. Proteins, peptides, polysaccharides, fatty acids, polyphenols, probiotics, enzymes, vitamins, and minerals are examples of bioactive molecules. The following sections of this review go over the physical and chemical properties of these various molecules, as well as how they contribute biocompatibility in the context of nutraceutical applications.

1) Proteins

Proteins derived from marine sources such as fish (cod, tuna, herring, rout, hake, pollock, and haddock), crustaceans, mussels, extremophiles such as Dunaliella, and seaweeds have distinct properties such as gel formation, film and foaming ability, antioxidant, anticoagulant, and antimicrobial activity. Collagen, gelatin, and albumin are three common marine proteins found in foods that are enzymatically hydrolyzed to produce bioactive peptides that may be used as nutraceuticals. In the food industry, the marine protein protamine is also employed as a natural antibacterial preservative.[14,24,25]

2) Peptides

Bioactive peptides are protein fragments that range in size from 2 to 20 amino acid residues that can be generated during digestion or processing from parent proteins. The primary sequence of the protein substrate and the specificity of the enzyme(s) used to generate such peptides are two factors that can influence the type of bioactive peptides produced. Bioactive peptides can also be synthesized from proteins via hydrolysis (acid or alkaline), cooking, or fermentation. Antimicrobial, immunomodulatory, antithrombotic, and anti hypertensive activity are among the bioactivities of these peptides. They are considered extremely important compounds.

The structure, composition, and sequences of peptides are being studied. Bioactive peptides perform a variety of regulatory functions on various cellular target formulations. Many researchers have concentrated on the development of drugs derived from marine peptides, specifically for ACE inhibition and antihypertensive activity. Marine proteins such as those found in fish, mollusks, and crustaceans are among the richest sources of bioactive compounds.[26,27,28,29,30,31]

3) Fatty acid

Marine fish and algae have been discovered to be sources of polyunsaturated fatty acids, particularly omega-3 and omega-6 fatty acids. The inclusion of these unsaturated fatty acids in marine-derived food items boosts their usefulness as nutraceuticals in the food business. Marine-based nutraceuticals have several distinct characteristics not found in nutraceuticals derived from terrestrial resources, which is one of the reasons they are gaining popularity. Fungi (Phycomycetes), fish (salmon, tuna, sardines, and herring), microalgae, extremophiles, macroalgae (Bryophyta, Rhodophyta), and krill are the most common sources of marine oils. Consumption of marine oils has numerous health benefits, including improved vision and neurodevelopment, relief from diseases like hypertension and arthritis, and a lower risk of cardiovascular difficulties.[32,33]

4) Polysaccharides

Marine polysaccharides have numerous commercial applications in food, beverages, and supplements. Fucans/fucanoids, carrageenans, hydrocolloids, and glycosaminoglycans are examples of marine polysaccharides extracted from algae, crustaceans, and other marine organisms. These molecules perform a variety of biological functions such as antiviral, anticoagulant, antiproliferative, antithrombotic, and anti-inflammatory activity. Carrageenans and alginates are sequential biopolymers found in red and brown algae that have been recognised as the most abundant polysaccharides. Brown algae, in addition to alginate, contain highly complex, sulfated matrix polysaccharides known as fucoidans. The saccharide composition, sulphate content, and positions of sulphate groups, molecular weight, linkage mode, and sequence of saccharide residues of fucoidans derived from different marine species vary. Fucoidans' biological properties are improved by structural sulphate groups, allowing them to be used as nutraceuticals in the dairy industry. These secondary metabolites derived from the sea have numerous human health benefits, allowing them to be used as nutraceuticals.[34,35,36,37]

5) Enzymes, Vitamins and Minerals

Enzymes can convert other molecules into useful modern biotechnology that can be used in the food and nutraceutical industries. Enzymes, as food ingredients, can have an impact on spoilage, storage, processing, and safety. Lipase, chitinolytic enzymes, polyphenol oxidase (Catecholase, tyrosinase, cresolase, polyphenolase, catechol oxidase, phendase), transglutamase, and red algal enzymes involved in a starch degradation pathway (for example, α-1, 4-glucanase) are all derived from marine sources. When compared to their terrestrial counterparts, they have superior chemical, physical, and/or catalytic properties. They can also be inhibited at moderate temperatures while still exhibiting high catalytic activity at low temperatures. These enzymes are also used as food products. Because of their salt tolerance, specificity, diverse properties, and high activity at mild pH, they are used in food processing. Due to its unique actions under abnormal conditions, biomolecules including enzymes isolated from extremophiles can be extremely valuable in the food industry, and it is widely accepted that extremophiles have a significant potential to be important resource for use in biotechnology.[38,39,40]

Minerals and vitamins serve many important functions in the body, such as providing transport within cells and acting as cofactors during metabolic pathways. Seaweeds are high in vitamins and minerals such as iron, iodine, manganese, and zinc. Some seaweeds may be used as natural iodine sources.[41,42]

CONCLUSION

The marine environment is a relatively unexplored source of biologically active molecules that can be used in industries such as pharmaceuticals and cosmetics. Recent advances in natural product knowledge, underwater exploration, and bioassays, as well as advancements in technology for isolating and cultivating marine microorganisms, have all greatly contributed to rekindling attention in exploiting the biodiversity locked in the ocean. When embarking on a new seafaring venture, those challenges must be carefully considered, especially if the goal is to commercialise a compound. One of the keys to increasing success rates in this field is a market orientation and an industrial mindset. Identifying specific slowdowns associated with each programme and incorporating viable alternatives is a strategy that can successfully lead to the discovery of novel ocean solutions to today's societal challenges.

India has over 8000 kilometers of coastline and over 2 million square kilometers of exclusive economic zone (EEZ). However, this domain's potential as a foundation for new biotechnologies is largely untapped. International research organizations have recognized the significance of establishing interdisciplinary marine biotechnology research centres. Similar efforts should be made in India to investigate the biotechnological potential of the country's untapped marine biodiversity.

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