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Harnessing the Biotechnological Methods in Marine Product Improvement: Its Innovation in Bioactive Compounds

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ABSTRACT

The application of biotechnology to marine resources offers significant potential for creating valuable products and processes that can enhance human health and well-being. This article explores the diverse biotechnological procedures utilized in the extraction and processing of bioactive compounds derived from marine species, which are rich sources of nutraceuticals, pharmaceuticals, and cosmeceuticals. By employing various extraction methods—ranging from traditional techniques such as solvent extraction and maceration to advanced approaches like subcritical and supercritical fluid extraction—researchers can effectively isolate high-value compounds such as omega-3 fatty acids, collagen, chitin, and carotenoids from marine by-products. Additionally, the integration of molecular biotechnological approaches, including metagenomics and genetic engineering, allows for the discovery of novel bioactive compounds and the enhancement of metabolic pathways in marine organisms to boost the production of beneficial substances. These advancements not only contribute to sustainable utilization of marine resources but also address consumer demands for functional foods and health-promoting products

INTRODUCTION

Any technological application known as "biotechnology" is any use of biological systems, living creatures, or their derivatives to create or alter goods or procedures for particular purposes. Biotechnological methods, which can be broadly divided into three groups—cultivation, bioprocessing, and extraction processes—are used to produce human food sources from marine resources (Freitas *et al*., 2012). More than 60% of the products produced by the seafood processing industry are bycatch and other secondary products that are obtained from the production process. Examples of these products include the heads, gills, skin, trims, fins, frames, bones, viscera, blood, and roes of commercial fish species (Ranadheera & Vidanarachchi, 2014). These by-products can also be processed through different methods, such as biotechnological applications, to create valuable products like fish oils, fish enzymes, collagen, gelatin, carotenoids, chitin, chitosan, and chito oligosaccharide (COS), glucosamine, function foods, nutraceuticals, antifreeze compounds, surimi, and fish protein hydrolysates (Rasika *et al*., 2013; Vidanarachchi *et al*., 2014). The two types of biotechnological methods for creating functional biomolecules from marine resources are those that involve biotechnological procedures and those that involve molecular and genetic alterations.

BIOTECHOLOGICAL PROCEDURES:

BIOPROCESSING:

Marine species have been shown to have a wealth of structurally diverse bioactive chemicals that have potential use in the fields of nutraceuticals, pharmaceuticals, and cosmeceuticals (Ngo *et al*., 2011). Peptides, collagen, chito oligosaccharides, gelatin, sulfated polysaccharides, phloro tannins, sterols, carotenoids, and lectins are among the bioactive functional components derived from marine resources (Zhang *et al*., 2012; Freitas *et al*., 2015). It has been demonstrated that membrane bioreactors with ultrafiltration membranes are useful for bioprocessing and the creation of functional ingredients are thought to be effective when using marine goods

EXTRACTION PROCESSES:

The use of microbes in the laboratory to extract chitin from waste marine shells is becoming more and more common. The biological process can reduce chitin breakdown and produce products with the least amount of waste (Kaur & Dhillon, 2015). Traditional, subcritical, and supercritical fluid extraction methods are available for the extraction process.

a. Traditional extraction method:

1. **Solvent Extraction:** This method involves soaking the raw material in a solvent (such as ethanol, methanol, or a mixture of solvents) to dissolve the desired compounds

2. **Maceration:** The raw material is cut into small pieces and immersed in a solvent for an extended period, allowing the soluble compounds to diffuse into the solvent

3. **Pressing:** The fish or fish by-products are subjected to mechanical pressure to separate oil from solids (press cake). This process may be followed by centrifugation to further refine the extracted oil.

b. Subcritical fluid extraction:

Subcritical fluid extraction (SFE) is an innovative biotechnological approach that utilizes water as a solvent at temperatures and pressures below its critical point to extract valuable compounds from marine products.

Subcritical fluid extraction has been successfully used to isolate bioactive compounds from algae and fish by-products. Subcritical extraction can be used to isolate omega-3 fatty acids from fish oils without degrading them through high-temperature processing. SFE can extract antioxidants and other functional ingredients from algae, which have applications in health supplements and food products (Castro-Puyana *et al*., 2013). SFE can also be employed in the food industry to enhance flavors by extracting essential oils and aromatic compounds from seafood or marine plants, contributing to improved sensory properties in food products.

c. Superficial fluid extraction:

Supercritical fluid extraction involves using supercritical fluids—substances at temperatures and pressures above their critical points. The supercritical fluid is pumped into the extraction vessel containing the sample. The high pressure allows CO_2 to penetrate the sample matrix and dissolve target compounds. **Extraction of Lipids and Oils:** $scCO_2$ effectively extracts omega-3 fatty acids from fish tissues. **Recovery of Bioactive Compounds:** Compounds with health benefits can be isolated from algae and other marine organisms using SFE (Mendiola *et al*., 2013).

MOLECULAR BIOTECHNOLOGICAL APPROACHES:

a. Metagenomic approach with marine organisms:

New enzymes from marine sources have been found using metagenomic-based methods.

Discovery of Novel Bioactive Compounds: The metagenomic approach has led to the identification of novel compounds with antioxidant, antibacterial, antitumoral, and antiviral properties derived from marine fungi, bacteria, and microalgae.

Functional Food Development: Identifying bioactive compounds through metagenomics can lead to the development of functional foods enriched with health-promoting properties derived from marine sources.

b. Genetic engineering approach with marine organisms:

Through the application of genetic engineering, the metabolic pathway of marine algae has been altered to produce more high-value compounds. Certain bacteria and fungi isolated from marine environments have been genetically modified to produce valuable secondary metabolites that have antimicrobial or anticancer properties. Genetic modifications can enhance the nutritional profile of marine products. For instance, enriching fish with omega-3 fatty acids through genetic engineering can provide health benefits and meet consumer demand for functional food (Haard *et al*.,1994). The genetic engineering approach with marine organisms represents a powerful tool for product improvement across multiple sectors.

CONCLUSION:

The concept of a biotechnological approach for the improvement of marine products made a wide utilization of aquatic resources. Integrating bioprocessing techniques and molecular biotechnology offers a promising pathway for the sustainable utilization of marine resources. These methods improve extraction yields and ensure the preservation of sensitive bioactive compounds, thereby enhancing their applicability in health supplements and food products. The ongoing exploration of marine biodiversity will undoubtedly lead to discoveries that can enhance human health and well-being through functional foods and pharmaceuticals derived from marine organisms.

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