An Overview on Biotechnology of Marine Fungi

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ABSTRACT: In industrial and medicinal applications, filamentous fungus are the most often utilized eukaryotes. Enzymes, pigments, vitamins, polysaccharides, lipids, and other biotechnological applications are among them. In the field of biotechnology, marine fungus are still a relatively unknown category. Exploration of marine fungal biotechnology is based on taxonomic and habitat diversity. This study summarizes what is currently known about the possible uses of obligatory and marine-derived fungi found in coastal, oceanic, and deep-sea environments. Marine fungus have recently been identified as prospective possibilities for new enzymes, bioremediation, biosurfactants, polysaccharides, polyunsaturated fatty acids, and secondary metabolites, according to recent research. Future research into cultivating uncommon and new marine fungus, as well as understanding their physiology or biochemistry, will offer a solid foundation for marine mycotechnology.

KEYWORDS: Filamentous Fungi, Marine Fungus, Marine, Microorganism, Terrestrial Fungus.

1. INTRODUCTION

Filamentous fungi are the most widely used eukaryotes in industrial and pharmaceutical applications. Their biotechnological uses include the production of enzymes, vitamins, polysaccharides, pigments, lipids and others. Marine fungi are a still relatively unexplored group in biotechnology. Taxonomic and habitat diversity form the basis for exploration of marine fungal biotechnology. This review covers what is known of the potential applications of obligate and marine-derived fungi obtained from coastal to the oceanic and shallow water to the deep-sea habitats. Recent studies indicate that marine fungi are potential candidates for novel enzymes, bioremediation, biosurfactants, polysaccharides, polyunsaturated fatty acids and secondary metabolites[1]. Future studies that focus on culturing rare and novel marine fungi, combined with knowledge of their physiology and biochemistry will provide a firm basis for marine mycotechnology.

Diversity or Habitats Organisms' taxonomic as well as evolutionary variety, as well as their occurrence and adaptability to different environments, often offer hints to their potential biotechnological uses. Marine fungus may be classified as either Fungi's "real fungi" or Straminipila's "straminipilan fungi." Direct observations of sporulating structures, culturing, and metagenomics may all be used to evaluate the taxonomic richness of marine fungus. Marine fungi that may be grown and classified are either obligatory or facultative (derived from the sea). The former do not grow or reproduce in freshwater or on land, and they only grow and reproduce in the sea[2]. The majority of them differ morphologically. Among the Ascomycetes, some, such as the Halosphaeriales and Unworthiest, are taxonomically separate orders. These are terrestrial fungi which have colonized maritime environments and adapted to those circumstances, according to current research. So far, around 530 species of obligate marine fungus have been identified, the majority of which are found decomposing lignocellulosic material in the coastal environment, but a few have been found in the deep sea degrading wood.

The majority of them do not seem to match to recognized fungal species, which is why marine biotechnologists are interested in them. The greatest distinguishing characteristic of the marine environment is salinity. The mechanisms of salinity tolerance in fungus. Biotechnology may benefit from fungi's physiological or biochemical tolerance to salt[3].

1.1 In the ocean, there are fungi:

Despite the fact that they aren't on restaurant menus or in the CD, psychedelic rock band covers, Fungi that live in the sea do exist. They, in reality, occur in every kind of marine environment Researchers have taken the time to investigate from subsurface hydrothermal vents arctic ice & deep-sea sediments surface water, salt marshes, or wetlands Low tide on sandy beaches (Figure 1) Marine fungus are very skilled at living on, within, or on top of other living things Algae, corals, sponges, and even sharks various types of fungus Even primary producers are affected. Dinoflagellates and diatoms, for example, are dinoflagellates and diatoms. Infected by marine fungus on a regular basis, a scenario that may have a significant impact carbon cycles on a global scale. Although only a few studies have attempted to quantify this phenomenon. It seems that its actual biomass. This is even more powerful than bacteria. Especially in organically rich environments carbon.

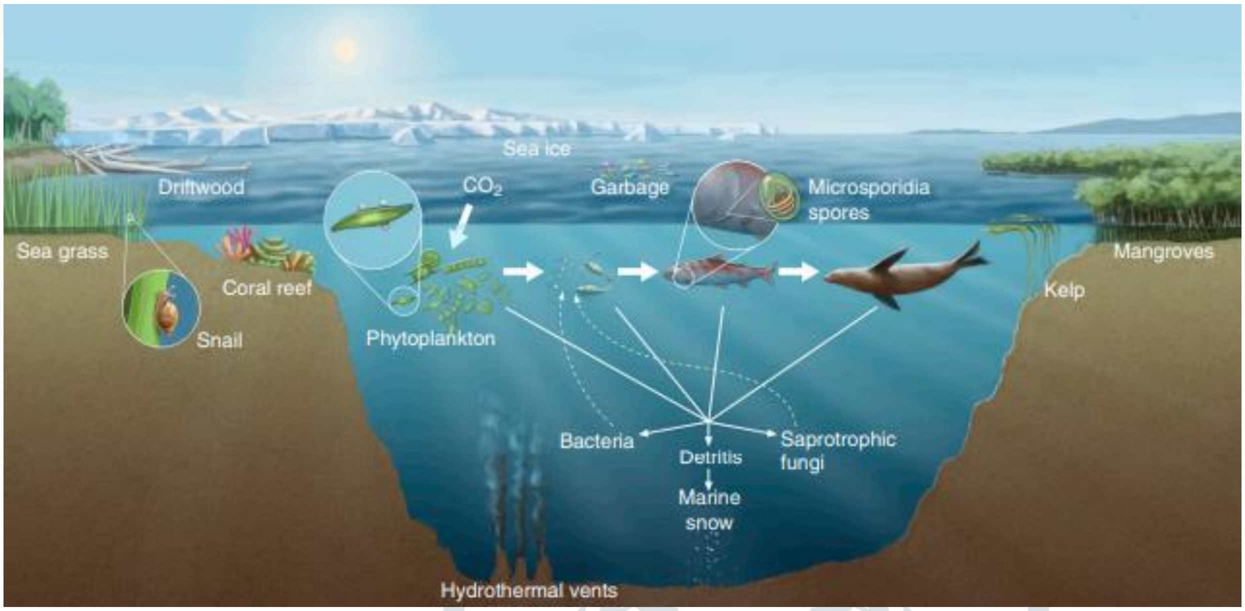

Figure 1: The ecological functions of marine mushrooms and the diversity of marine fungal environments[4]**.**

In the yeast Saccharomyces cerevisiae, the capacity to tolerate salt has been studied from a biotechnological standpoint. During salt stress, overexpression of the HAL1 gene in yeast improves salt tolerance by maintaining a high internal K+ concentration or lowering intracellular Na+. The HAL1 gene from this yeast was successfully transferred into tomato. The offspring of two distinct transgenic plants carrying four copies or one copy of the HAL1 gene showed a higher degree of salt tolerance. This opens up the possibility of developing salt-tolerant crops. For a long time, lignocellulosic substrates from coastal settings have been recognized to harbor a particular variety of obligate marine fungus, the lignicolous fungi, in terms of nutrients in the marine environment. Manglicolous fungus, which grow on rotting woody debris in mangroves, are an important group among them. Coastal ecosystems are detritus-based, with large fungus populations engaged in detritus digestion. The second biggest category of marine fungus is mangrove fungi. Marine endophytic fungus are a fascinating ecological category of fungi that grow within the living tissues of seagrasses and macroalgae. Fungi thrive on coral reefs because they offer an ideal environment for them. Fungi may be found on the surface as well as within scleractinian corals. They may be found in the polyps as well as the calcium carbonate skeleton of these corals.

Fungi linked with living creatures such as coral polyps, sponges, as well as holothurians are found as endobionts in coral mucus, plant detritus, sediments, and the water column, or as saprotrophs in coral mucus, plant detritus, sediments, and the water column[5]. They may have a mutualistic function in healthy corals as well as being accountable for infrequent coral illnesses. The discovery of aspergillosis in the sea fan Gorgonia has sparked a global interest in soft coral mycoflora. Gorgonia ventalina, a soft coral from Puerto Rico, was used to extract 16 fungal genera including 51 species, including two yeasts, from ten species of gorgonian corals in Singapore using a culture-dependent method. Extracellular enzyme produced by marine fungi, such as proteases, laccase, xylanases, as well as cellulases, have found uses in a wide range of areas, including food, drinks, detergents, as well as medicine, (Table 1).

Table 1: Enzyme from Marine Fungi with potential application.

Enzyme	Source of Isolation	Classification of compound	Substrate
Laccase	Basidiomycetous fungi	Copper containing protein	Phenolic compounds
Manganese peroxidase	Basidiomycetous fungi	Heam protein	Phenolic compounds
L-Glutaminase	Beauveria bassiana		L-Glutamine
Gelatinase	Halosphaeria mediosetigera	Metalloproteinase	Corn meal
Amylase	Aspergillus flaviceps	Glycoside hydrolase	Starch

Because of variations in taxonomic diversity as well as environmental adaptations, enzymes generated by marine fungus are expected to vary from those synthesized by terrestrial fungi. The majority of research on enzymes from marine fungus has concentrated on lignocelluloses derived from fungi found around the shore. Researchers are interested in the fungal removal of lignin because lignocellulose enzyme have uses in the utilization of lignocellulose as a renewable resource for the manufacture of paper, food, chemicals, and fuels. Extracellular enzymes such as lignin peroxidase (LiP), manganese peroxidase (MnP), and laccase help fungi breakdown lignin. These enzymes breakdown or alter lignin as well as a variety of aromatic, refractory environmental pollutant found in crude oil wastes, textile effluents, including organochloride agrochemicals, all of which are major sources of pollution. Marine mangrove fungus have been discovered to be a valuable source of lignocellulose degrading enzymes.

According to Pointing and Hyde, the majority of marine fungal strains capable of decay are soft-rot fungi, with just a few capable of white-rot decay. Several obligatory marine and marine-derived fungi isolated from mangrove were shown to have laccase, xylanase, and cellulase activities. Luo et al. discovered cellulolytic, xylanolytic, and ligninolytic enzymes in tropical as well as sub-tropical mangrove fungus. Except for one basidiomycete, Calathella mangrovei, and a mitosporic fungus, Cirrenalia tropicalis, the majority of the fungi were ascomycetes. When cultivated in sea water medium including sugarcane bagasse fibres, pine as well as poplar wood shaving as carbon and nitrogen sources, a marine-derived fungus known as generated all three lignin degradative enzymes, namely LiP, MnP, and laccase, to different degrees.

Marine fungus enzymes with possible uses Enzyme Isolation origins Compound classification References to Substrate Laccase Fungi that are basidiomycetous Protein that contains copper Compounds containing phenolics Manganese peroxidase is a kind of enzyme that degrades manganese. Fungi that are basidiomycetous Protein derived from heam Compounds containing phenolics Peroxidase of lignin Fungi that are basidiomycetous Protein derived from heam Compounds containing phenolics Alkaline Protease is a kind of protease that breaks down al Aspergillus Serine protease is a kind of protease that breaks down amino Cellulase, Az casein Mangrove fungus that are lignicolous L-Glutamine, L-Glutaminase from Beauveria bassiana Xylanase Niger Aspergillus Hydrolase of glycosides Pulp for paper Gelatinase Halosphaeriales mediosetigera is a species of Halosphaeriales. Amylase Aspergillus flaviceps is a kind of fungal infection. Hydrolase of glycosides[6].

1.2 Utilizing Marine Fungi for Bioremediation:

Microorganisms from the land and waters, especially bacteria, are increasingly widely utilized to clean and remediate a variety of contaminated settings. For such uses, marine microorganisms in general, and fungus in particular, have not been thoroughly investigated. A ligninolytic marine-derived mangrove fungus, identified, is an excellent illustration of the potential of marine-derived fungi for use in bioremediation of industrial pollution. This fungus has been proven to decolorize and detoxify a broad range of textile mill including molasses-based raw industrial effluents, resulting in lower COD and phenolic levels.

Degradation of Hydrocarbons Chronic oil pollution affects the marine ecosystem in many areas of the globe. Catastrophic oil spills, such as the BP catastrophe in the Gulf of Mexico, have wreaked havoc on the ecosystem. Maritime fungus haven't been well investigated as bioremediation options for marine oil spills. Ahearn and Meyers were among the first to describe how marine fungus degrade hydrocarbons. Polycyclic aromatic hydrocarbons are among the most significant and environmentally harmful components of oil pollution (PAHs). From this perspective, ligninolytic fungi are intriguing because they can oxidize PAHs by generating a non-specific enzymatic extracellular complex that is usually utilized for lignin depolymerization. These lignin-degrading enzymes include lignin-peroxidase manganese peroxidase (MnP), and laccase White-rot fungi have strong extracellular lignin-degrading enzyme systems that can digest a wide range of contaminants and have been researched extensively for this purpose. In fungus, a new PAH metabolic route includes hydroxylation by cytochrome P-450 monooxygenase via a series of events that are comparable to those seen in human metabolism. Many non-ligninolytic fungi that might efficiently breakdown PAHs share this mechanism.

Because of their resistance to salty conditions, marine fungus may be used in the bioremediation of contaminated maritime habitats. After eight and sixteen days, a marine Aspergillus sclerotiorum CBMAI 849 (isolated from cnidarians) was able to decrease 99.7% pyrene and 76.6 percent benzo pyrene, respectively. They also discovered that a Mucor racemosus CBMAI 847 depleted significant quantities of benzo pyrene (>50.0 percent). They attributed these reductions to A. sclerotiorum CBMAI 849 or M. racemosus CBMAI 847's ability to metabolize pyrene to pyrenylsulfate but also benzo pyrene to benzo pyrenylsulfate, implying that the hydroxylation mechanism is mediated by a cytochrome P-450 monooxygenase, followed by conjugation with s

Heavy Metals: Both natural and human sources emit a variety of hazardous heavy metals into the environment. Because of their bioaccumulation in the food chain, they have significant environmental and health consequences. The presence of heavy metals in marine sediments has been documented as a consequence of river runoff and human activity. When metal concentrations are greater (1–100 ppm), traditional physicochemical treatment methods become less effective and more costly. Toxic metals are removed from the environment through adsorption as well as metabolic activity in a variety of biological sources, including marine algae, fungus, yeast, and bacteria. The ability of live and dead fungal biomass to remove toxic metals via absorption has been established. The latter appears to be the preferable option owing to the lack of toxicity restrictions, the lack of growth medium and nutrient needs in the treatment, and the fact that the biosorbed metals may be recovered and the biomass reused. There aren't many studies on the use of marine fungus in bioremediation applications for metal biosorption.

1.3 Secondary Metabolites from Marine Fungi:

Microorganisms have long provided a significant supply of drug research leads, especially for antibiotics. Over 20,000 microbial metabolites have been identified, the majority of which were isolated from soil. The trend of reducing drug development from natural sources has prompted researchers to look towards marine species. Marine fungus have become a crucial part of the investigation. In 1968, a marine isolate of the fungus Cephalosporium acremonium was discovered to generate a variety of antibiotics near a sewage outfall off the coast of Sardinia. Endophytic fungi are abundant in metabolites used in the pharmaceutical and agriculture sectors. The manufacturing of L-asparaginase from a Fusarium sp. separated from of the thallus of Sargassum and a sterile mycelial form isolated from the thallus of Catamorphic sp. showed the maximum activity of the enzyme reported recently production of L-asparaginase from a Fusarium sp. isolated from the thallus of Sargassum as well as a sterile mycelial form separated from With more accessibility to the deepest regions of the seas, knowledge of deep-sea fungus is quickly expanding, and the forms discovered may be a rich source of new proteins. Chemical moieties make up the majority of herbicides on the market today. Herbicide resistance is becoming more common as chemical heterogeneity of herbicides targeting fewer modes of action decreases. Researchers tested extracts of 449 marine-derived fungus for inhibition of pyruvate phosphate dikinase (PPDK), which inhibits C4 plant development. With the exception of the protozoan Giardia, this enzyme is found mainly in plants, but it has not been identified in vertebrate or invertebrate animals, possibly lowering the likelihood of PPDK inhibitors having negative toxicological consequences. They identified unguinol, a well-known chemical, and discovered that it inhibits PPDK via a new mechanism that also has a herbicidal impact on entire plants[7].

2. LITERATURE REVIEW

Girish Mahajan et al. investigated Microbes continue to play a significant part in the drug development and discovery process. Nonetheless, the number of microbial-derived new chemical entities (NCEs) authorized by the Food and Drug Administration (FDA) has decreased over the last decade. This shortage may be explained in part by the redundancy of molecules found in microbial isolates derived from common terrestrial ecological units. This problem may be somewhat alleviated by looking for microorganisms in under-exploited ecological niches, which lowers the odds of isolating chemicals that are identical to those already on the market. These compounds are representative of a wide range of chemical classes. As a result, microbially derived compounds and analogues in clinical trials continue to show the significance of microbially derived compounds in contemporary drug development[8].

Faraza Javed et al. investigated Marine microorganisms have gotten a lot of attention lately because of their bioactive metabolites, and they provide a unique opportunity to increase the quantity of aquatic natural consumables in clinical studies while also speeding up their development. The emphasis of this study is on compounds derived from marine microorganisms that are now in the medical pipeline and have been discovered or are very likely to be found based on increasing incidental data. The karlotoxin family of chemicals discovered from the dinoflagellate Karlodinium veneficum provides opportunities to develop novel medicines for cancer and high blood cholesterol management[9].

D. B. Strongman et al .studied an index of antagonisra was generated for each of the 27 marine fungi that were tested for indications of interference competition. The antifungal activity of extracts from all of these fungi was evaluated after they were cultivated in liquid culture. Antifungal activity was found in extracts from four fungi: Leptosphaeria oraemaris, Arenariomyces trifurcatus, Monodictys pelagica, and Remispora species. The biochemical basis for this action was explored, and an antifungal sesquiterpene from L. oraemaris, culmorin, was discovered. Both L. oraemaris and A. trifurcatus showed antifungal activity in their triglyceride fractions[10].

3. DISCUSSION

Filamentous fungi possess the metabolic capacity to degrade environment organic matter, much of which is the plant and algae material enriched with the cell wall carbohydrates and polyphenol complexes that frequently can be assimilated by only marine fungi. As the most renewable energy feedstock on the Earth, the plant or algae polymeric substrates induce an expression of microbial extracellular enzymes that catalyze their cleaving up to the component sugars. However, the question of what the marine fungi contributes to the plant and algae material biotransformation processes has yet to be highlighted sufficiently. In this review, we summarized the potential of marine fungi alternatively to terrestrial fungi to produce the biotechnologically valuable extracellular enzymes in response to the plant and macroalgae polymeric substrates as sources of carbon for their bioconversion used for industries and bioremediation.

Previously neglected ecological niches and habitats in marine systems are now used to increase fungal diversity for biorefinery and fossil-free production of organic compounds. Research on marine fungi has long been impeded by the fact that the majority of marine specimens were homologous to terrestrial species. Thus, the pure existence of marine fungi as well as their ecological role had long been disputed. However, distantly related sequences found in oceanic samples and isolation of obligate marine strains have now proven the existence of marine fungi as a separate fungal ecotype. They show unique cultivation properties and features, applicable in biotechnology for new products but also for the redesign of existing biotechnological processes with more robust or challenging culture conditions.

4. CONCLUSION

The potential of marine mycotechnology has already been shown. Obligate and marine-derived fungus from a range of marine environments, spanning from coastal to oceanic and shallow water to the deep sea, have been found to contain interesting enzymes, new metabolic characteristics, and secondary metabolites. Many additional important chemicals, such as extracellular polysaccharides, may be found in them. For marine fungus, the hypothesis that genetic variety based on taxonomy and adaptations to environmental circumstances is the source of new uses has to be investigated more in the future. Further research into the biology of marine fungus may uncover intriguing physiological or biochemical properties that could be helpful in new biotechnology applications. Culturing of hitherto uncultured marine fungus, as well as further in-depth research into the physiology as well as biochemistry of uncommon and fascinating ones, will really set the groundwork for marine fungus technology.

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