A Review on Mangroves as a Source of Novel Biomolecules

Mohammad Sharifi[1]and Bipinraj N kunchirman[2]

[1,2] Department of Biotechnology, Bharati Vidyapeeth Deemed to be University, Pune, Maharashtra. India

Abstract

Most of the earth's coastline is made up of mangrove habitats. The mangroves are hotspots of microbial diversity for a variety of reasons. Additionally, these communities are crucial to the upkeep of this environment. It is understood that these microorganisms play innumerable functions in this ecosystem, but it is also understood that it is impossible to thoroughly cultivate bacteria in any environmental sample. The potential applications of the biomolecule compounds generated by bacteria associated with mangroves are highlighted in this review paper.

Keywords: Mangroves, Biomolecules

Introduction

Mangroves are halophytic species of trees and shrubs that are diversified botanically and include 12 groups. All of these plants have developed strong resistance to the severe conditions of their habitat and are often buried by tidal water throughout much of the year. These plants often exhibit some viviparity and may grow in challenging conditions (Packialakshmi and Kanimozhi, 2014). About 53 000 square miles of the world's land are covered by the mangrove environment. In India, there are about 4800 square kilometres of mangroves, representing 8% of the country's coastline (Kumari et al., 2013). According to their natural environments, mangroves are often divided into two groups: real mangroves and mangrove allies. Mangroves are highly developed morphological and physiological organisms that have evolved to live in hostile and stressful environments. They have undergone a number of physiological changes that have led to the creation of unique chemical compounds that provide these plants with defence against a range of biotic and abiotic challenges. Many significant bioactive chemicals that are currently utilised commercially as antibacterial, antifungal, inflammatory, and anticancer medicines originate from mangroves (Patra and Thatoi, 2011). Microbes may live in any biological niche, unlike other species. Previously, it was known that terrestrial microorganisms were abundant sources of secondary metabolites with biological activity that were essential for pharmacological or agrochemical uses (Butler, 2005).

There have been several metabolites found with unusual structures and effective bioactivities. These include the clinically-tested antimalarial drug artemisinin, the antibiotic penicillin, and the anticancer drug taxol. A lot of academic and commercial attention is currently being paid to microbes from unusual or specialised ecological niches, such as mangrove habitats, as a result of the increased recognition of the difficulty of finding commercially significant metabolites through traditionally investigated habitats and the frequent rediscovery of previously described components (Faulkner , 2001).

Along tropical and subtropical coasts, mangrove trees flourish in distinctive intertidal wetlands. When natural, industrial, and agricultural wastewater is discharged into offshore marine regions, the mangrove ecosystem plays a significant role in the toxicity and detoxication of the contaminants. In intertidal microenvironments, mangrove microbial communities are resilient to a variety of stressors, including salt, pressure, humidity, temperature, mineral composition, nutrition, and restrictions on light and air. Additionally, they have intricate connections to several creatures (Ananda et al., 2002).

Due to their microbial nature, certain buds have allegedly evolved over millions of years and created distinctive metabolic pathways for predation, ecological adaptation, and defence. As a result, they may produce a staggering amount of metabolites that have never been seen in their terrestrial counterparts (Rothschild and Mancinelli, 2006).

It may be argued that these microorganisms possess a unique ecological status since they are able to create and excrete potent compounds with unpredictable structures or intriguing bioactivities that may serve as new physiological agents for humans. The majority of these research' findings, meanwhile, have been inconsistently distributed.

Bacterial Biomolecules

More research is being done on bacteria as potential medication sources. The recent finding of a number of polyketides from populations of mangrove bacteria that are taxonomically distinct has led some researchers to believe that these microorganisms bring an essential new perspective to the study of marine microbial natural products. Surfactin isomers, which are distinctive cyclic lipopeptide biosurfactants made up of seven amino acid units and one hydroxyl fatty acid side chain having 13–15 carbons, have been shown to be abundant in the bacterial species Bacillus. Surfactin isomers exhibit inhibitory effects on fibrin clots (Arima et al., 1968), platelet cytosolic phospholipase A (Vollenbroich et al., 1997, and lipopolysaccharide (Kim et al., 1998), in addition to having antimycoplasma , antiviral , and anticancer properties (Kameda et al., 1974). A novel surfactin isomer and eight analogues with the same biosynthetic origin but different functional groups have all been isolated as a result of the use of the mangrove plants connected to Bacillus sp. (Tang et al., 2007).

Fungal Biomolecules

Particularly endophytic fungi, which make up the second-largest ecological subgroup of marine microorganisms, are abundant in mangrove ecosystems . According to a theory, the endophyte-host connection is a kind of balanced antagonism involving the participants' secondary metabolites (Schulz et al., 1999). Mangrove endophytic fungi have gained attention as possible sources for metabolic products with extremely distinctive chemical structures and potential therapeutic leads as a result. Recently, scientists have started looking into the ingredients that mangrove endophytic funguses are rich in. As a result, several novel compounds with various bioactivities have been isolated.

Coumarins In plants appear relatively often. However, they are only present in a few number of fungi. Five new coumarin pestalasins A–E were isolated in our lab from Pestalotiopsis sp., which was obtained as an endophyte from the leaves of the Chinese mangrove plant Rhizophora mucronata, along with the well-known chemical 3-hydroxymethyl-6,8-dimethoxycoumarin (Xu et al., 2009). Each of the new pestalasins has an oxygenated alkyl side chain substituted at C-3.

Isocoumarin Derived Products Typically, fungi are used to produce isocoumarin-based chemicals for natural goods. Endophytic fungus strain No. 2533, which was discovered on the leaves of Avicennia marina, was the source of the avicennins A and B and two analogues. This is the first study demonstrating the simultaneous isolation of isocoumarins, chlorine-containing isocoumarins, and dihydroisocoumarins, and their coexistence suggests a feature of this endophytic fungus . The ethyl acetate crude of the Paecilomyces sp. tree 1-7 from the China mangrove produced a new dimer paecilin A that included a chromone, a -lactone unit, and a monomer paecilin B.

Quinone derivatives are abundant in nature and have drawn a lot of attention due to the vast range of pharmacological qualities they possess, such as antibacterial, anticancer, and antipathogen activity. The fungi-derived anthracenediones and their synthetic derivatives have received a lot of interest since they have a wide spectrum of powerful anticancer potentials against several malignant cell lines and animal models. Three

anthracenediones, 1403P-2 through 1403P-4 , were found to be present in the mangrove endophytic fungus No. 1403 in early research (Jiang et al., 2000).

Phenol derivatives predominate among fungal metabolites, both from a natural product and pharmaceutical standpoint. Numerous biological properties, such as antibacterial, antifungal, and phytotoxic activities, are present in the majority of them. Enalin A and B were isolated from an ascomycete fungus called Verruculina enalia No. 2606 that was discovered in the rotted wood of a Cassurina tree (Lin et al., 2002).

Meroterpenoids are a collective name for a number of natural compounds. Mangrove fungus have meroterpenoids that have extraordinary scaffolds that typically include two (rarely more) heterologous synthesis pathways (Geris and Simpson, 2009). Meroterpenes of this family have been shown to exhibit a variety of pharmacological actions. They have drawn the attention of several research groups due to their distinctive architectures and bioactivities. The unidentified fungus strain Xylaria sp. No. 2508 that inhabits Avicennia marina produces the meroterpenes from mangrove microbe that are most frequently studied. A series of highly functionalized metabolites, notably xyloketals A–F, H(1), H(2), and J, were discovered after extensive research on this species. Combining single-crystal X-ray diffraction analysis with quantum-mechanical CD spectrum calculations, the configuration of these xyloketals was firmly established and supported by synthetic evidence (Lin et al, 2001).

Amides have been reported to be present in a wide variety of species, from microbes to higher plants (Chen et al., 2002). However, only a small number of these compounds have been identified to have specific pharmacological capabilities, such anticancer, antibiotic, and antiviral activity. Six novel tetramic acids, penicillenols A1, A2, B1, B2, C1, and C2 , found from Aegiceras corniculatum endophytic fungus Penicillium sp. GQ-7, were the first members of this product category to be known (Lin et al., 2008).

Actinobacteria Biomolecules

Actinobacteria, also known as actinomycetes, are a type of Gram-positive bacteria that are abundant in terrestrial habitats. Actinomycetes are abundant providers of a variety of bioactive metabolites, including enzymes, immunosuppressive drugs, anticancer agents, and antibiotics (Lam, 2006). Eighty percent of the natural actinomycete compounds documented to date are produced only by the species Streptomyces, demonstrating the biosynthetic superiority of microbes (Jensen et al., 2005).Most of the bioactive secondary metabolites are now known to be generated by actinomycetes (Berdy, 2005) . Octalactin C , an eight-membered macrolide that was originally discovered, was isolated from the culture broth of Streptomyces sp. V5, which was found in the rhizosphere soil of a mangrove root (Sattler, 2005). Terpenoids: The endophyte Streptomyces griseus subsp. produced two novel germacrane-type sesquiterpene alcohols, 1E,5E germacradiene-3,11 -diol and 1E,5E-germacradiene-2,11-diol. nitrated substances; Three novel p aminoacetophenonic acids were produced by Streptomyces griseus subsp. endophyted in Kandelia candel (Guan et al., 2005).

Streptomyces sp. was found to produce a novel 17-substituted benzoquinoid ansamycin, 17-O demethylgeldanamycin hydroquinone , the well-known antifungal and anticancer drug geldanamycin (DeBoer et al., 1970), and 17-O demethylgeldanamycin . Surprisingly, it has been reported that compound 19 could increase the survival and neurite outgrowth rates of P19-derived neurons and effectively Both the antibiotic rifamycin S and its geometric isomer have been identified as co-isolated from the rare actinomycete Micromonospora rifamycinica strain AM105, which was discovered in mangrove sediment. The complex is being tested for its ability to combat MRSA and several other Gram-positive clinical germs, and it may be effective against Gram-positive pathogens (Huang et al., 2009). The cultivated broth of the endophytic Streptomyces albidoflavus strain I07A 01824 isolated from the leaves of Bruguiera gymnorrhiza contained Antimycin A18 , the first known naturally occurring antimycin having an 8-O-acetyl side chain. The plant pathogenic fungus Colletotrichum lindemuthi-anum, Botrytis cinerea, and Alternaria solani were all effectively

eradicated. Only one-fourth of the corresponding concentration of the common fungicide Blasticidin S was shown to be effective (Yan et al, 2010). On mangrove soil, one team was able to identify Streptomyces sp. 211726 and discover a novel 36-membered macrocyclic lactone called azalomycin F4a 2- ethylpentyl ester as well as three previously identified analogues. All of them displayed widespread antifungal action. Additional, modest inhibitory effects of metabolite were observed in vitro with human colon cancer cell line HCT-116 (Yuan et al., 2010).

Conclusions

Significant advancements in biotechnologically aided chemistry over the last several years have overcome limitations in approach and rekindled the search for intriguing molecules with unique architectures. Many of these substances are created by microorganisms that are linked with mangroves, and they often exhibit distinctive pharmacological effects. The majority of natural compounds found in mangrove ecosystems have their chemistry and biological activity thoroughly summarised in the current study. Deeper research will make new bioactive compounds more available. This will provide further light on how these bacteria may be used to produce valuable goods and medicinal chemicals. They will also provide light on how the mangrove ecosystem interacts with the synthesis of secondary metabolites. The existence of several secondary metabolites with both therapeutic and pathogenic importance produced by mangrove-associated bacteria is yet unknown.

References

Ananda, K.; Sridhar, K. R. (2002). Diversity of endophytic fungi in the roots of mangrove species on west coast of India. Can. J. Microbiol., 48, 871- 878

Arima, K.; Kakinuma, A.; Tamura, G. Surfactin (1968). A crystalline peptidelipid surfactant produced by Bacillus subtilis: isolation, characterization and its inhibition of fibrin clot formation. Biochem. Biophys. Res. Commun., 31, 488-494

Berdy, J. (2005). Bioactive microbial metabolites. J. Antibiot., 58, 1-26.

Butler, M. S. Natural products to drugs: natural products derived compounds in clinical trials. Nat. Prod. Rep., 2005, 22, 162-195.

Chen, J. J.; Huang, Y. C.; Chen, Y. C.; Huang, Y. T.; Wang, S. W.; Peng, C. Y.; Teng, C. M.; Chen, I. S. (2002). Cytotoxic Amides from Piper sintenense.. Planta Med., 68, 980-985.

DeBoer, C.; Meulman, P. A.; Wnuk, R. J.; Peterson, D. H. (1970). Geldanamycin, a new antibiotic. J. Antibiot., 23, 442-447.

Faulkner, D. J. (2001). Marine natural products. Nat. Prod. Rep., , 18, 1-49.

Fenical, W.; Baden, D.; Burg, M.; Goyet, C. V.; Grimes, J. D.; Katz, M.; Marcus, N. H.; Pomponi, S.; Rhines, P.; Tester, P.; Vena, J. (1999). In: Marine derived pharmaceuticals and related bioactive compounds. Ed.: National Academies Press: Washington, 71-86

Geris, R. ; Simpson, T. J. (2009). Meroterpenoids produced by fungi. Nat. Prod. Rep., , 26, 1063-1094.

Guan, S. H.; Sattler, I.; Lin, W. H.; Guo, D. A.; Grabley, S. (2010). pAminoacetophenonic acids produced by a mangrove endophyte: Streptomyces griseus subsp. J. Nat. Prod., 68, 1198-1200.

Guo, Z. Y.; She, Z. G.; Shao, C. L.; Wen, L.; Liu, F.; Zheng, Z. H.; Lin, Y. C. (2007)1 H and 13C NMR signal assignments of paecilin A and B, two new chromone derivatives from mangrove endophytic fungus Paecilomyces sp. (tree 1–7). Magn. Reson. Chem., 45, 777-780

Huang, H. Q.; Wu, X. P.; S. Yi, Z. W. Zhou, J. Zhu, Z. Fang, J. M. Yue, S. X. Bao. (2009). Rifamycin S and its geometric isomer produced by a newly found actinomycete, Micromonospora rifamycinica.. Antonie van Leeuwenhoek, 95, 143-148.

Jensen, P. R.; Mincer, T. J.; Wiiliams, P. G.; Fenical, W. (2005). Marine actinomycete diversity and natural product discovery. Antonie van Leeuwenhoek, 87, 43-48.

Jiang, G. C.; Lin, Y. C.; Zhou, S. N.; Vrijmoed, L. L. P.; Jones, E. D. G. (2000). Studies on the secondary metabolites of mangrove fungus No1403 from the South China Sea. Acta Sci. Nat. Univ. Sunyatseni, 39, 68-72.

Kameda, Y.; Oira, S.; Matsui, K.; Kanatomo, S.; Hase, T. (1974). Antitumor activity of Bacillus natto. V. Isolation and characterization of surfactin in the culture medium of Bacillus natto KMD 2311. Chem. Pharm. Bull., 22, 938- 944.

Kim, K.; Jung, S. Y.; Lee, D. K.; Jung, J. K.; Park, J. K.; Kim, D. K.; Lee, C. H. (1998). Suppression of inflammatory responses by surfactin, a selective inhibitor of platelet cytosolic phospholipase A2. Biochem. Pharmacol., 55, 975- 985.

Kumari, A., Jain, N. and Devi, C.S. (2013). Novel bioactive compounds from mangrove derived actinomycetes. International Research Journal of Pharmacy, 2(9): 25–29.

Lam, K. S. (2006). Discovery of novel metabolites from marine actinomycetes. Current Opin. Microbiol., 9, 245-251

Lin, Y. C.; Wu, X. Y.; Deng, Z. J.; Wang, J.; Zhou, S. N.; Vrijmoed, L. L. P.; Jones, E. B. G. (2002). The metabolites of the mangrove fungus Verruculina enalia No. 2606 from a salt lake in the Bahamas. Phytochemistry, 59, 469- 471.

Lin, Y. C.; Wu, X. Y.; Feng, S.; Jiang, G. C.; Luo, J. H.; Zhou, S. N.; Vrijmoed, L. L. P.; Jones, E. B. G.; Krohn, K.; Steingröver, K.; Zsila, F. (2001). Five unique compounds: Xyloketals from mangrove fungus Xylaria sp. from the South China Sea coast. J. Org. Chem., 66, 6252-6256

Lin, Z. J.; Lu, Z. Y.; Zhu, T. J.; Fang, Y. C.; Gu, Q. Q.; Zhu, W. M. (2008).Penicillenols from Penicillium sp. GQ-7, an endophytic fungus associated with Aegiceras corniculatum.. Chem. Pharm. Bull., 56, 217-221.

Padmakumar, K. and Ayyakkannu, K. (1997). Antiviral activity of marine plants. Indian Journal of Virology, 13: 33–36.

Patra, J.K. and Thatoi, H.N. (2011). Metabolic diversity and bioactivity screening of mangrove plants: A review. Acta Physiologiae Plantarum, 33: 1051–1061.

Rothschild, L. J.; Mancinelli, R. L. (2001). Life in extreme environments. Nature, 409, 1092-1101.

Sattler, I. (2005). Structure determination of germacrane-type sesquiterpene alcohols from an endophyte Streptomyces griseus subsp. Magn. Reson. Chem., 43, 1028-1031.

Schulz, B.; Rommert, A. K.; Dammann, U.; Aust, H. J.; Strack, D. (1999). The endophyte-host interaction: a balanced antagonism?. Mycol. Res.,, 103, 1275-1283.

Tang, J. S.; Gao, H.; Hong, K.; Yu, Y.; Jiang, M. M.; Lin, H. P.; Ye, W. C.; Yao, X. S. (2007). Complete assignments of 1 H and 13C NMR spectral data of nine surfactin isomers. Magn. Reson. Chem., 45, 792-796.

Vollenbroich, D.; Ozel, M.; Vater, J.; Kamp, R. M.; Pauli, G. (1997). Mechanism of inactivation of enveloped viruses by the biosurfactant surfactin from Bacillus subtilis.. Biologicals, 25, 289-297.

Xu, J.; Kjer, J.; Sendker, J.; Wray, V.; Guan, H. S.; Edrada, R. A.; Müller, W. E. G.; Bayer, M.; Lin, W. H.; Wu, J.; Proksch, P. (2009). Cytosporones, coumarins, and an alkaloid from the endophytic fungus Pestalotiopsis sp. isolated from the Chinese mangrove plant Rhizophora mucronata.. Bioorg. Med. Chem., 17, 7362-7367.

Yan, L. L.; Han, N. N.; Zhang, Y. Q.; L. Y. Yu, Chen, J.; Wei, Y. Z.; Li, Q. P.; Tao, L.; Zheng, G. H.; Yang, S. E.; Jiang, C. X.; Zhang, X. D.; Huang, Q.; Habdin, X.; Hu, Q. B.; Li, Z.; Liu, S. W.; Zhang, Z. Z.; He, Q. Y.; Si, S. Y.; Sun, C. H. (2010). Antimycin A18 produced by an endophytic Streptomyces albidoflavus isolated from a mangrove plant. J. Antibiot., 63, 259-261.

Yuan, G. J.; Hong, K.; Lin,H. P.; Li, J. (2010). Azalomycin F4a 2-ethylpentyl ester, a new macrocyclic lactone, from mangrove actinomycete Streptomyces sp. 211726. Chin. Chem. Lett., 21, 947-950.