International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 3 Number 7 (2014) pp. 526-532**
http://www.ijcmas.com

Review Article

Antimicrobial compounds of marine algae from Indian coast

Jigna Chauhan and Avani Kasture*

C. G. Bhakta Institute of Biotechnology, Uka Tarsadia University, Maliba Campus, Bardoli-Mahuva Road, Tarsadi, Dist. Surat, Gujarat, India. 394350.
**Corresponding author*

Keywords

Marine environment; antimicrobial; marine algae

A B S T R A C T

Natural products have been known as premier sources that can produce biologically active secondary metabolites which are potential chemotherapeutic agents. Mankind has observed for about thousands of years that marine fauna and flora contain substances with potent antimicrobial activity. Since then, all the life forms from marine environment have been thoroughly investigated for the content of such natural products. In recent years, biological activities, potential health benefits, and nutritional value of marine algae have been intensively investigated. This review, however, focuses specifically on the antimicrobial compounds from marine algae in Indian coast.

Introduction

The marine resources are nowadays widely studied because of numerous reasons such as the oceans cover more than 70% of the world surface and between 36 known living phyla of which 34 are found in marine environments with more than 300000+ known species of fauna and flora. The rationale of searching for drugs from marine environment, stem from the fact that marine plants and animals have adapted to all sorts of marine environments and these creatures are constantly under tremendous selection pressure such as space competition along with predation, surface fouling and reproduction (Jirge and Chaudhari, 2010). Seaweeds have been one of the richest and most promising sources of bioactive primary and secondary metabolites. These compounds have diverse simultaneous functions for the seaweeds and can act as antimicrobial, allelopathic, antifouling, and herbivore deterrents, or as ultraviolet-screening agents. They are also used by the pharmaceutical industry in drug development to treat diseases like cancer, acquired immune-deficiency syndrome (AIDS), infection from virus, bacteria and fungus, inflammation, pain, arthritis etc. Currently, algae represent about 9% of biomedical compounds obtained from the sea.

Marine Organism of Interest

Marine Algae

The seaweed is the largest marine algae

(macro algae) that grow almost exclusively in the shallow waters at the edge of the world's oceans. Seaweeds can be classified into three broad groups based on pigmentation brown, red and green, which are Phaeophyceae, Rhodophyceae and Chlorophyceae respectively. They supply homes and food for many different sea animals fand are also valuable to man as a food and industrial raw material. They use the sun's energy to produce carbohydrates from carbon dioxide and water (Jirge and Chaudhari, 2010). Marine algae produces a wide variety of significant natural compounds, that is the secondary metabolites because they are not involved in the basic machinery of life which often contribute to only a very small fraction of the organism total biomass, the contribution of these compounds to survival may sometimes be comparable to metabolites resulting from the primary metabolism. Secondary metabolite compounds also contribute to growth, reproduction and defense and thus play a primary role in the organism integrity (Maria et al., 2010).

Marine algae in India: Seaweeds found in the intertidal, shallow and deep waters of the sea up, to 180 m depth and in estuaries and backwaters. They grow on rocks, corals, stones, pebbles, other substrates and as epiphytes on seagrasses. Several species of macroalgae with abundant growth occur along the Southern Tamil Nadu Coast from Rameswaram to Kanyakumari covering 21 islands of the Gulf of Mannar. On Gujarat coast, seaweeds occur in abundance in Okha, Dwarka, Porbandar, Veraval, Diu and Gopnath areas. Rich seaweed beds are present in Mumbai, Goa, Karwar, Varkala, Ratnagiri, Vizhinjam, Visakhapatnam and coastal lakes of Pulicat and Chilka. Seaweeds also occur in abundance in Lakshadweep, Andaman and Nicobar Islands. Around more than 10,000 species of marine algae have been reported all over the world. In India, about 740 species of marine algae were recorded, 60 species of them are of economic value. In Mandapam area 180 species of seaweeds are growing, of which about more than 40 species are economically important (Kolanjinathan et al., 2014)

Three species of marine algae [*S. wightii Greville* brown algae (Phaeophyceae), *C. linum* green algae (Cladophoraceae) and *P. gymnospora* - light brown algae (Dictyotaceae)] were collected by Xavier et al., during low tide by hand picking from the coast of Tuticorin, Tamil Nadu, India. The collected marine algae was identified and used for antibacterial studies (Xavier et al., 2012). Extract from two species of seaweed samples, *Grateloupia lithophila* and *Caulerpa racemosa* were collected by Srivastava et al., from different locations in the Southeast Coastal Region, Mandapam, Tamil Nadu, India and Gulf of Mannar, have been shown to possess a number of biological activities (Srivastava et al., 2010). Three marine algae (*Chaetomorpha antennina*, *Gracilaria corticata* and *Ulva faciata)* from Visakhapatnam coast, Andhra Pradesh, India were showed good antibacterial activity (Ganga et al., 2011). *Acanthaphora spicifera*, red Algae grows up 8cm in height and is widely distributed in the Mandapam coastal area of Tamilnadu, India showed the antimicrobial activity (Pitchaimuthu et al., 2011).

The red alga *Sphaerococcus coronopifolius* was shown to have antibacterial activity; the green alga *Ulva lactuca* was isolated from *Portieria hornemanii*, *Ulva fasciata* produces a novel sphingosine derivative has been found to have antiviral activity in vivo.

Stypoldione is a cytotoxic metabolite inhibits microtubule polymerization and thereby presents the mitotic spindle formation, has been isolated from tropical brown alga, *Stypodium zonale, P. hornemanii* is found to be a novel source of cytotoxic penta halogenated monoterpen, halomon, which exhibited one of the most extreme of differential cytotoxicity in the screening conducted by the National Cancer Institute (NCI), USA. Haloman has been selected for preclinical drug development since this compound shows toxicity to brain, renal and colon tumor cell liner and preliminary in vivo evaluations have been encouraging. An iodinated novel nucleoside has been isolated from *Hyprea volitiae*, which is a potent and specific inhibitor of Adenosine Kinase (Johnsi et al, 2011)

The Chilika lake is one of the largest brackish water lake in Asia situated in the southern part of Odisha, India and is rich in various types of seaweeds and marine macro algae (Chlorophyceae, Rhodophyceae, Cyanophyceae) etc. Its climatic condition is suitable for the growth and development of different types of economic seaweeds from Rhodophyceae family. *Gracilaria verrucosa* (family Rhodophyceae) is one of the most exploited red seaweed of Chilika, India and is commonly known for its uses in food and phycocollides has a high growth rate and tolerates high temperatures. *Gracilaria verrucosa* are found growing abundantly in many areas on the Indian coast and has been listed as one of the richest sources of bioactive primary and secondary metabolites (Sushanto et al., 2013).

Anti-Microbial Compounds

Alkaloids

Arputha et al., investigated the antimicrobial effect of the organic extracts of the two seaweeds *Sargassum wightii* (Brown algae) and *Kappaphycus alwarezii* (Red algae) might be due to the presence of Phyto components alkaloids, phenols and sugars (Arputha et al., 2012). The isolation of various zoanthamine alkaloids in the Indian, Pacific, and Atlantic Oceans suggests that these widespread metabolites may have an important function such as antibiotic, anti-inflammatory, antiosteoporotic and cytotoxic biological activities. As synthetic targets, the zoanthamine alkaloids are a challenge to current synthetic methods and an inspiration for the creation of new reactions. In the contemporary era, it is common for newly isolated natural products with interesting structures or biological significance to succumb to total synthesis within one to two years of their isolation (Douglas et al., 2008)

Steroids

Cholesterol and clinoasterol are steroids present in *Gracilaria crassa* and *G. coronopifolia* respectively, as well as *G. longa* and *G. dura*. Other steroids such as 3-beta-hydroxy-poriferast-5-en-7-one, 3-beta-7-alpha-diol-poriferast-5-ENE and 5-alpha-poriferast-9 (11) -en-3-beta-ol are isolated from *G. dura*; cholestane-3-β-5-diol,5-α:24(S)-ethyl, poriferastene 8, poriferast-5-ene-3-β-7-β-diol and poriferast-5-ene-3-β-7-α-diol were identified in *G. coronopifolia*; *G. longa* also has a various compounds like alpha linolenic acid, gamma linolenic acid, glycolipids, 5-dehydro avenasterol, fucosterol, myristic acid, desmosterol and 5-alpha-24(S)-ethyl-cholestane-3-beta-6-beta-diol. Phytochemical studies of *G. andersoniana* showed the following

isolates: oleic acid, linoleic acid, cholesterol, prostaglandin A2, prostaglandin E2, leukotriene B4 and phytol (Cynthia et al., 2011)

Terpenoids

More than 600 secondary metabolites were isolated from nearly 3600 seaweeds. Among these, the diterpenoids constitute the most abundant groups with profound ecological and pharmacological significance (Manjusha et al., 2013). Terpenoids are classified according to the number of isoprenoid units (five carbon subunits) incorporated. In Dictyotaceae, the most bioactive products have three or four isoprenoid units, corresponding to the sesquiterpenes and diterpenes, respectively. Diterpenes of the spatane and seco-spatane types are known from *Spatoglossum* (*S. schmittii* and *S. howleii*), Stoechospermum polypodioides and *Rugulopteryx*.

Stoechospermum polypodioides is the only species of the genus known in the Indian Ocean. There are reports of antibiotic, cytotoxic, antiherbivory, cell division inhibition and HSV antiviral activities. The sesquiterpenes are found in *Padina*, *Dictyopteris* and *Taonia*. The genus *Dictyota* contains diterpene as the major metabolite present in all oceans. The terpenoids from Dictyotaceae exhibit bioactivities such as inhibition of herbivores and antifungal, antibiotic, anti-inflammatory, cytotoxic, insecticidal and antiviral activities (Joel et al, 2011).

The halogenated sesterterpenes, neomangicols A–C, isolated from the marine fungus *Fusarium*, offer a striking example of the halogenation effect. Neomangicol A and B show in vitro cytotoxic effect toward the HCT-116 human colon tumor cell line, while their nonhalogenated analog neomangicol C was shown to be inactive. Among all marine macroalgae, red algae are the main producers of halogenated compounds. *Laurencia* (family Rhodomalaceae, order Ceramiales, class Rhodophyceae, phylum Rhodophyta) is considered one of the most prolific genera, being mainly found in tropical, subtropical, and temperate coastal waters. It has been intensively screened over the last fifty years, although a variety of new halogenated molecules are still being reported. Characteristically, the halogenation degree found in compounds from *Laurencia* is relatively high. Diterpenes sesquiterpenes, triterpenes, and C15-acetogenins are the main secondary compounds of this genus with which antimicrobial, antifeedant, antihelmintic and cytotoxic properties are generally associated (Maria et al., 2010).

Phenolic compounds

Recently, much attention has been focused on the micro algae, particularly Blue-green alga (Cyanobacteria) as a source of biologically active, novel compounds such as phycobiline, phenols, (antioxidants) terpenoids, steroids and polysaccharide. However, the occurrence of phenolic compounds in Blue-green alga (Cyanobacteria) is less documented than that in higher plants.

The several epidemiological studies revealed that algal phenolic compounds present in the diet are helpful in treating coronary heart disease concern and osteoporosis stroke and other degenerative diseases. Furthermore, phenols have been reported to exhibit pharmacological properties such as anticarcinogenic, antiviral, antibacterial, antifungal, anti-inflammatory or antitumoral (Munawer

and Mazharuddin, 2011). *Sargassum wightii* have a high amount of phenolic compound. Phenolic compound has the good antimicrobial activity. The results clearly shown that seaweed *S. wightii* is an interesting source for biologically active compounds that may be applied for prophylaxis and therapy of bacterial fish diseases and it should be used for immunestimulation activity in aquaculture (Rajasekar et al., 2013).

Polysaccharides

Seaweeds contain large amounts of polysaccharides, particularly cell wall structural polysaccharides that are extruded by the hydrocolloid industry: alginate from brown seaweeds and agar from red seaweeds. Other polysaccharides are found in the cell wall: fucoidans (from brown seaweeds), xylans (from certain red and green seaweeds) and ulvans in green seaweeds. Seaweeds also contain storage polysaccharides, notably laminarin in brown seaweeds and floridean starch in red seaweeds. When faced with the human intestinal bacteria, most of these polysaccharides (agars, carrageenans, ulvans and fucoidans), are not digested by humans and therefore can be regarded as dietary fibers (Kolanjinathan et al., 2014).

Crude polysaccharide and proteins from *Himanthalia elongate* and *Cedium tomentosum* have shown reduction in blood glucose after intravenous administration by 50% and 30% respectively at 5mg /kg dose (Johnsi et al., 2011). Govindasamy reported that polysaccharides like compounds present in the fraction of seaweed *Gracilaria corticata* play an important role in the defense against the pathogens and proved the antimicrobial activity. Sulfated polysaccharides obtained from G. corticata have proven antiviral activities against many viruses (Govindasamy et al., 2012).

Fatty acids

Venkatesalu et al. investigated fatty acid composition in *Ulva lactuca, Caulerpa chemnitzia, Padina tetrastromatica, Sargassum longifolium, Acanthophora spicifera* and *Gelidium micropterum* collected from Mandapam coast. The green algae shows interesting levels of alpha linolenic acid. The red and brown algae are particularly rich in fatty acids with 20 carbon atoms: eicosapentanoic acid and arachidonic acid. *L. variegata* collected from the Southwest coast of India showed seven fatty acids such as palmitic acid (40%), lauric acid (17%), stearic acid (7%), alpha linolenic acid (6%), oliec acid (6%) and trace amount of myristic acid (5%) and hexadecatrienoic acid (Aseer et al., 2012). The algal species *Chaetoceros* alga is native to Chennai; Tamil Nadu and was found in high concentrations in the Chennai coastal area.

The fatty acid profile of these marine microalgal oil indicated that Pentadecanoic acid (17.56%), 1. Nonadecenoic acid (20.1%), methyl palmitate (2.91%), methyl linoleate (12.07%), palmitic acid (1.97%) as major fatty acids (Ananadhi and Shaleesha, 2012). Microalgae *Skeletonema* is a good source of fatty acid derived antimicrobial substances. In *Chaetoceros* sp. polysaccharides and fatty acids are the major candidate molecules contributing to antibacterial activity (Selvendran M., 2013). These algae also produce important bioactive metabolites like the primary compound with antibiotic activity acrylic acid, and the eicosanoids which are derivatives C20 polyunsaturated fatty acid (PUFA) metabolism through oxidative

pathways that originate mainly from arachidonic acid and eicosapentaenoic acids, the precursors of prostaglandins (PGs). Species such as *G. asiatica* and *G. lichenoids* contain PGE2. PGF2 and 15-keto-PGE2 were respectively isolated from *G. lichenoids* and *G. asiatica*; *G. verrucosa* contains PGA2 that appears to be responsible for a gastrointestinal disorder, known as "ogonori" poisoning in Japan (Cynthia et al., 2011).

The present review showed that seaweeds provide a rich source of structurally diverse secondary metabolites such as terpenes, acetogenins, alkaloids, steroids, polysaccharides, fatty acids and polyphenolics, with many of these compounds being halogenated which having antimicrobial activities. Marine algae collected from Indian coast have been shown to possess a number of antimicrobial activities. This review shows that the Indian coastline is a potential source of a variety of marine algae worthy of further investigation.

Acknowledgement

We wish to thank our institute and department C. G. Bhakta Institute of Biotechnology for providing necessary facilities for the study.

References

Ananadhi Padmanabhan M.R. and Shaleesha A. Stanley, 2012, Microalgae as an Oil Producer for Biofuel Applications, Research Journal of Recent Sciences, 1(3), 57-62

Arputha M. Bibiana, Nithya K., Manikandan MS., Selvamani P. and Latha S., 2012, Antimicrobial evaluation of the organic extracts of *Sargassum wightii* (brown algae) and *Kappaphycus alwarezii* (red algae) collected from the coast of Meemesal, Tamilnadu, International Journal of Pharmaceutical, Chemical and Biological Sciences, 2(4), 439-446

Aseer Manilal, Joseph Selvin, Nooruddin Thajuddin, Sugathan Sujith, Mvn Panikkar, Akbar Idhayadhulla & Radhakrishnan Surendra Kumar, 2012, Biopotentials of marine alga, *Lobophora variegate* collected from the south Indian littoral, An International Journal of Marine Sciences, 28 (1): 47-54

Cynthia Layse F. de Almeida, Heloina de S. Falcao, Gedson R. de M. Lima, Camila de A. Montenegro, Narlize S. Lira, Petronio F. de Athayde-Filho, Luis C. Rodrigues, Maria de Fatima V. de Souza, Jose M. Barbosa-Filho and Leonia M. Batista, 2011, Bioactivities from Marine Algae of the Genus *Gracilaria*, Int. J. Mol. Sci; 12, 4550-4573

Douglas C. Behenna, Jennifer L. Stockdill, and Brian M. Stoltz, 2008, The Biology and Chemistry of the Zoanthamine Alkaloids, Angew. Chem. Int. Ed., 47, 2–24

Ganga Rao Battu. Sambasivarao Ethadi, Prayaga Murthy. P, V. S. Paneeth. D. Mallikarjuna Rao. T, 2011, In-vitro antibacterial activity and Preliminary phytochemical screening of three algae from Visakhapatnam coast, Andhra Pradesh, India, Int J Pharm Pharm Sci, 3 (4), 399-401

Govindasamy C, M. Arulpriya, P. Ruban, 2012, Nuclear magnetic resonance analysis for antimicrobial compounds from the red seaweed *Gracilaria corticata*, Asian Pacific Journal of Tropical Biomedicine, S329-S333

Jirge Supriya S and Chaudhari Yogesh S, Sep-Oct 2010, Marine: The Ultimate

Source of Bioactives and drug Metabolites, International Journal of Research in Ayurveda & Pharmacy, 1(1), 55-62

Joel Campos De Paula, Magui A. Vallim, Valeria Laneuville Teixeira, 2011, What are and where are the bioactive terpenoids metabolites from Dictyotaceae (Phaeophyceae), Revista Brasileira de Farmacognosia Brazilian Journal of Pharmacognosy, 21(2): 216-228

Johnsi. Christobel, A.P. Lipton, M.S. Aishwarya, A.R. Sarika and A. Udayakumar, 2011 Antibacterial activity of aqueous extract from selected macroalgae of southwest coast of India, Seaweed Res. Utiln., 33 (1&2): 67-75

Kolanjinathan K., Ganesh P. and Saranraj P., 2014, Pharmacological Importance of Seaweeds: A Review, World Journal of Fish and Marine Sciences, 6(1): 01-15

Manjusha W. A., Anusha W. A., Amritha Krishna B. V., Lavanya L., Rejin Prasad J. J., Remya R. A., and Vijaya surya, 2013, Molecular bioprospecting of *Streptomyces sp*. (ES5) from marine alga *Hypnea musiformis*, Indian Journal of Biotechnology, 12, 218-224

Maria Teresa Cabrita, Carlos Vale and Amelia Pilar Rauter, 2010, Halogenated Compounds from Marine Algae, Mar. Drugs, 8, 2301-2317

Munawer Khan Mohammed and Mazharuddin Khan Mohd., Apr 2011, "Enhancement in Production of Phenolic Compounds (AntiOxidants) in Spirulina Plantensis under Different IAA Regimes " International Journal of Engineering Science and Technology, 3(4): 3004-3009

Pitchaimuthu Pandian, Subramanian Selvamuthukumar, Rajappan Manavalan, and Varadarajan Parthasarathy, 2011, Screening of antibacterial and antifungal activities of red marine algae *Acanthaphora spicifera* (Rhodophyceae*)*, J Biomed Sci and Res., 3(3): 444-448

Rajasekar Thirunavukkarasu, Priyadharshini Pandiyan, Deivasigamani Balaraman, Kumaran Subaramaniyan, George Edward Gnana Jothi, Sakthivel Manikkam, Balamurugan Sadaiyappan, 2013, Isolation of bioactive compound from marine seaweeds against fish pathogenic bacteria Vibrio alginolyticus (VA09) and characterisation by FTIR, Journal of Coastal Life Medicine, 1(1): 26-33

Selvendran M., Apr 2013, Studies on antimicrobial compounds from selected marine phytoplanktons, Int J Pharm Bio Sci., 4(2): 876 – 888

Srivastava N., Saurav K., Mohanasrinivasan V., Kannabiran K. and Singh M., 2010 Antibacterial Potential of Macroalgae Collected from the Madappam Coast, India, British Journal of Pharmacology and Toxicology 1(2): 72-76

Sushanto Gouda, Reliance Rosalin Moharana, Gitishree Das, Jayanta Kumar Patra, 2013, Free radical scavenging potential of extracts of *Gracilaria verrucosa* (L) (Harvey): An economically important seaweed from Chilika lake, India, Int J Pharm Pharm Sci, 6(1): 707-710

Xavier Devanya Rosaline et al, 2012, Screening of selected marine algae from the coastal Tamil Nadu, South India for antibacterial activity, Asian Pacific Journal of Tropical Biomedicine, S140-S146