Advances in
Biotechnology & Microbiology
ISSN 2474-7637

Juniper Publishers
key to the Researchers

Mini Review
Volume 4 Issue 1 – June 2017
DOI: 10.19080/AIBM.2017.04.555627

Adv Biotech & Micro

Cyanobacterial Diversity: A Potential Source of Bioactive Compounds

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Submission: May 26, 2017; **Published:** June 28, 2017

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Abstract

Cyanobacteria grow and multiply in various aquatic ecosystems with varying environmental conditions. As they vary in their habitats they do produce a variety of bioactive compounds. The bioactive compounds produced by different species of cyanobacteria are commercially important and used as antibacterial, antiviral, antifungal, enzyme inhibitors, immunostimulants, cytotoxic and antiplasmodium activities. In addition, they are a good source of other important compounds such as vitamins, amino acids, sideophores, simple hydrates etc. The complete genome sequence and molecular biology techniques would be used explore cyanobacteria diversity for the modern civilization and industry.

Keywords: Bioactive compounds; Cyanobacteria

Introduction

Cyanobacteria are a group of oxygenic photosynthetic prokaryotes that grow and multiply at the simple expense of light, H_2O, CO and inorganic nutrients [1]. They are widely distributed in nature, ranging from the Antarctic regions to hot springs, deserts to usar soils and to salt lakes and brine water [2]. Their ability to grow over a wide range of ecological situations such as light, temperature, salinity, alkalinity and pollution makes them model photosynthetic prokaryotes, for the study of various metabolites synthesized by these organisms under such situations [3-5].

The application potential of cyanobacteria in biotechnology is enormous [6] and includes photo-production of NH4+ and hydrogen [7], reclamation of deserts [8], waste water treatment [9], biofertilization of rice agriculture [10], functioning as a bioinsecticide for grazing mosquito larvae [11], and providing a rich source of important pharmaceuticals [12]. The full realization of cyanobacterial potential would possible only when their total knowledge at the molecular level is made available to the industry and modern civilization. Chemoheterotrophic microorganisms namely bacteria and fungi are the traditional source of antibiotics and bioactive compounds. In the late 20th century microalgae have been exploited as a source of biologically active compounds [12]. The biologically active compounds isolated from microalgae are known to show antibacterial, antiviral, antifungal, enzyme inhibitors, immunostimulants, cytotoxic and anti-plasmodium activities [13,14]. The antimicrobial compounds isolated from microalgae are chemically characterized as polyketides, amides, alkaloids, and peptides [13]. In addition, microalgae are also a good source of other important compounds such as vitamins, amino acids, fatty acids, siderophores, simple hydrates and other compounds that are essential to support the growth of other microorganisms [15].

Bioactive compounds from cyanobacteria

Cyanobacteria such as *Microcystis, Anabaena, Nostoc* and *Oscillatoria* synthesized varieties of compounds that are biochemically active [16]. Some cyanobacterial species are also known to produce toxic metabolites [17]. The secondary metabolites produced by cyanobacteria are rich sources of novel bioactive compounds applied to the production of medicines and agriculturally important chemicals. Some extracellular metabolites secreted by the cyanobacteria act as toxins or allelochemicals in the natural environment [18]. Cyanobacterial lipopeptides have been identified as interesting biochemically active compounds. Approximately 85% of them are bioactive, including cytotoxic (41%), antitumor (13%), antibiotic (12%), enzyme inhibitor (8%), antiviral (4%) and antifungal activities (4%) [19]. The remaining activity (18%) covers tumor promoting, herbicide, antimycotic, antimitotic, antimalarial, antimicroalgal, cell-differentiation promoting activity, cardio activity and UV absorbing activity useable as sunscreens [19].

Cyanobacterial alkaloids isolated from a variety of species show structural diversity and variety of biological actions such as antifungal activity, cytotoxicity, sodium channel modulation, and inhibition of proteases [20,21]. The major sources of these alkaloids are the filamentous genera such as *Lyngbya, Oscillatoria,* and *Symploca* [22,23]. Moreover, cyanobacteria are known for the production of toxins associated with water blooms. About 40 genera of cyanobacterial species that are responsible for the production of freshwater and marine cyanobacterial toxins have been reported [23]. These toxins, namely cyanotoxins, can be grouped according to their toxicity in vertebrates as hepatotoxins, neurotoxins, irritants and dermatotoxins, and general cytotoxins [24]. They fall into three broad groups of chemical structures: cyclic peptides, alkaloids and lipopolysaccharides [25,26]. The best known cyanotoxins are microcystins and nodularins, which are potent inhibitors of protein phosphatases.

Together with those toxins, during the last few decades, hundreds of cyanobacterial secondary metabolites were reported [17,27,28,29]. These metabolites possess different chemical structures such as fatty acids, phenolics, terpenoids, N-glycosides, lipopeptides, linear and cyclic peptides and alkaloids. In addition, they exhibit a diverse spectrum of biological activities including antibacterial algicidal, antifungal, antiviral, anticancer, cytotoxic, and enzyme inhibiting activities. Most of the potential bioactive compounds are synthesized from the machinery of non-ribosomal peptide synthetase or mixed with polyketide synthase [30]. Apart from the above bio-synthetic pathway some bioactive compounds such as microviridins and cyanobactins used ribosomal pathways [31]. Therefore, cyanobacteria are considered as a source of potential pharmaceutical substances including antifungal compounds.

Conclusion

Multidrug resistant phenomenon is widespread among the human pathogens. So, it is a demand of the hour to search and develop new drugs from the new source. Now a day cyanobacteria are considered as good candidates to find novel bioactive compounds/drugs. However, all the experiments were performed in vitro; so the in vivo activities of such compounds are questionable. Secondly, the natural products isolated from cyanobacteria are relatively large and not each functional subunit plays vital role in showing the bioactivity, so their commercial production could be possible only after optimizing their chemical structure with organic synthesis methods. In addition, most of the studies confined to characterize the effects of the individual bioactive compound, rather than the effect of various compounds in different combination. This idea will provide a new insight into the synthetic biology.

Acknowledgement

SB thankful to the head department of Botany for providing necessary facilities. SB also thankful to the various staff members for their constant support and encouragement.

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How to cite this article: Sunil K D, Sarita D, Santosh B. Cyanobacterial Diversity: A Potential Source of Bioactive Compounds. Adv Biotech & Micro. 2017; 4(1): 555627. DOI: 10.19080/AIBM.2017.03.555627.

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