Marine blue green algae: Microorganism of bioactive potential

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Marine blue green algae are among the most primitive life forms on earth. These simple prokaryotes have not only the ability to perform photosynthesis but also adapted to almost any of the most extreme habitats on earth. They are also known to exist in various marine ecosystems varying from deep-sea hydrothermal vents to Antarctica [1]. These wonderful tiny microbes furthermore contribute to complex microbial food webs playing important ecological and biochemical roles in different marine ecosystems. In recent years blue green algae have been a potential source of bioactive secondary metabolites thereby attracting researchers for their fascinating structures. These metabolites have been exploited for the treatment of some deadly diseases such as cancer and AIDS.

Recent findings have revealed a number of the cytotoxic compounds reported from marine blue green algae to have activity against a variety of cancerous cell lines and in other cytotoxicity models. For instance lipopeptides such as obynamide, palau'imide, lyngbyabellin C-D, ulongamides A, ulongapeptin, apratoxins B-C isolated from *Lyngbya* sp., have been found to be active against KB cells [2]. The cytotoxic lipopeptide compounds such as guamamide, microamide and tasiamide from *Symploca hydroides* and deacetyl-hectochlorin from *Bursatella leachii* were also found to be active against the KB cell lines. The compounds including jamaicamides A-C, lyngbyabellins E, dolabellin, aurilides

B isolated from *Lyngbya majuscula* and wewakpeptins A-B from *Lyngbya semiplena* were found active against H-460 human lung cell line [2, 3]. The lipopeptides showing activity in brine shrimp toxicity assay (a crustacean model to predict cytotoxicity) are malyngamides U, malyngamide T, hermitamides A-B isolated from *Lyngbya majuscula* and semiplenamides A from *L. semiplena* [3]. Besides cytotoxic metabolites marine blue green algae is a prolific source of other bioactive molecules comprising lobocyclamides A-C (antifungal agents) isolated from *Lyngbya confervoides*, carmabin A and B, dragomabin and dragonamide A (a antimalarial activity) from *Lyngbya majuscula*, hectochlorin (a potent stimulator of actin assembly) from *Bursatella leachii*, sulfolipid an anti HIV compound from *Phormidium tenue*, microginin-FR1 (an angiotensin-converting enzyme inhibitor) isolated from *Microcystis aeruginosa*, largamides D-G (a chymotrypsin inhibitor) from *Oscillatoria* sp. and Microcystin-LR (a potent and specific inhibitor of protein phosphatases 1 and 2A) from *Nodularia* sp. showing us new hope to fight with dangerous diseases [3–6].

Interestingly, this group of microorganisms is famous not only for their bioactive secondary metabolites but also for their nutritional values. Marine blue green algae are nutrient-rich energy producing food that increases the body's metabolic rate and appear to possess significant protein and a range of vitamins, minerals and amino acids. Ancient medicinal account also exists for their therapeutic value as a super food. For example, the chromophore phycocyanobilin (PCB) and C-phycocyanin (C-PC), found in marine blue green algae, is often used as a dietary nutritional supplement and these have also been found to have anti-inflammatory activity and versatile potential in therapy of various diseases [7, 8]. Some well-known species of blue-green

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algae used as dietary supplements include *Aphanizomenon flos-aquae*, *Coccolopia*, *Cyanidium caldarium* and *Spirulina platensis*, *Synechococcus elongates*.

In modern era of advance development in molecular biology and recent progress of new technologies have shown us an exceedingly bright future in the discovery of life saving drugs. Phylogeny and genome analysis of blue green algae has revealed the presence of numerous cryptic gene clusters encoding putative natural products. Polyketide synthases (PKSs) and Non-ribosomal peptide synthases (NRPS) are such class of gene clusters involved in the biosynthesis of secondary metabolites; although these gene cluster are found to be inactive in almost all studies but gene knock out experiments may involve these cluster in the synthesis of specific and novel peptides [9]. Different synthesis pathways other than non-ribosomal and polyketide machinery also synthesize large number of valuable secondary metabolites but all these pathways are closely linked to the primary metabolism of the producing organism [10]. Present knowledge of biosynthetic machinery of this microscopic group of photosynthesis performing gram-negative bacteria warrant the exploration for future development of commercial drugs and creates biological space with a rhythm for renewed focus on natural-product resources.

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