Bioactive substances of cyanobacteria (*Nostoc muscorum*): a review

Rizvi Rimsha[1]*, Jain Richa[1], Kumar Sheela[1], Shrivastava P.N.[1] and Jain Manju[2]

[1]S.S.L. Jain P.G. College Vidisha (M.P.) 464001
[2] Govt. Girls College Vidisha (M.P.) 464001
E-mail: risvirimsha22@gmail.com

ABSTRACT:

Cyanobacteria is one of the most important organism (algae) due to its different classical activities like nitrogen fixation, which is most prevailing function of cyanobacteria. But, recent reports are demonstrating their pharmaceutical importance also. *Nostoc muscorum* is a species of cyanobacterium belonging to the family Nostocaceae. Which contains different bioactive components like phenolics, phycocyanin, triterpenoids amino acids, poly-unsaturated fatty acids, sulphates polysaccharides and carotenoids. These components are specific for antimicrobial, antioxidant and antibacterial activity. However, Different chemical compounds make it incredible and highly significant algae.

KEYWORDS: *Nostoc muscorum*, Biochemical, antimicrobial, antioxidant, antibacterial, pharmaceutical.

INTRODUCTION:

Nearly 50,000 natural products have been discovered from microorganisms, 10,000 of these are reported to have biological activity and over 100 products are in use today as antibiotics, anti-tumor agents, and Agrochemicals (1). An antimicrobial or antibiotics are an agent that kills microorganisms or inhibits their growth. A cyanobacterium is one of them important algae that can produce different bioactive substances.

Cyanobacteria, also known as blue-green algae include a highly diverse group of prokaryotic microorganisms and widely distributed in nature and can be found in most terrestrial and freshwater habitat (2). It can able to perform oxygenic photosynthesis and used as an important food for other organisms. The genus Nostoc (cyanobacteria) is one of five genera in the family Nostocaceae of subgroup 4, section A, of the oxygenic phototrophic bacteria. They share characteristics of both gram negative bacteria and photosynthetic eukaryotes (3). Cyanobacteria are ubiquitous in their global distribution. Moreover, it is widely found in various locations such as pond, soil, rock, bark, sea and fresh water (4, 5). Cyanobacteria are also having a wide range of bioactive compounds. Although, antibacterial, antiviral, algaecide, antifungal and cytotoxic activities have been reported in these organisms (6,7,8,9). The properties of the bioactive compounds are still not completely understood (10). Cyanobacteria produce many bioactive compounds, both intra- and extracellular to survive in extreme environmental sources (11,12,13,14). Due to different bioactive compounds cyanobactria is very helpful to produce these compounds at commercial level. Various reports are available to introduce these important biochemical (15,16,17). Screening of cyanobacteria and algae for antibiotics and other pharmacologically active compounds has received considerable attention during the past few decades (14,18,19,20,21). This review article would be helpful in the field of research work, related to the cyanobacteria and production of pharmaceuticals important bio-molecules.

They are an excellent source of fine chemicals, renewable fuel and bioactive compounds. Cyanobacteria is considered to be one of the potential organisms and useful to mankind in various ways. A number of important advances have occurred in cyanobacterial biotechnology in the recent years.

HABITATE:

N. muscorum are tolerant of saline environments, with sugar products providing osmoregulatory activity in salt tolerance (22). So, the ideal environment for *N. muscorum* on the pH in the range of 7.0 to 8.5, with a lower pH limit of 5.7 (23). *N. muscorum* grows best when light intensity is less than that of direct sunlight, but can continue to grow and fix nitrogen in the presence of glucose and absence of sunlight (23).

Most probably 20% of all known cyanobacteria occur in saline conditions and a majority of them are truly marine. However, less work has been done to understand the cyanobacterial biodiversity of marine environments of India (24).

PHOTOSYNTHESIS AND METABOLISM:

Cyanobacteria use phycobiliproteins as accessory pigments. Photosynthetic pigments and electron transport chain components are located in thylakoid membranes lined with particles called phycobilisomes. These contain phycobilin pigments, particularly phycocyanin and transfer energy to photosystem II (25). Carbon dioxide is embezzle through the Calvin cycle, and the store carbohydrate as glycogen. Sometimes they will store extra nitrogen as polymers of arginine or aspartic acid in cyanophycin granules. Since cyanobacteria lack the

enzyme α- ketoglutarate dehydrogenase, they do not have a fully functional citric acid cycle. The pentose phosphate pathway plays a central role in their carbohydrate metabolism (25). Some reports are demonstrating that the cyanobacteria are capable of considerable metabolic flexibility (26).

SCIENTIFIC CLASSIFICATION

Kingdom: Bacteria

Phylum: Cyanobacteria

Order: Nostocales

Family: Nostocaceae

Genus: *Nostoc*

Species: *muscorum*

GENOME STRUCTURE:

The genome of *Nostoc muscorum* has not been sequenced. However, other species of the genus Nostoc have been studied and contain one chromosome. The three species that have been sequenced, *Nostoc punctiforme, Nostoc sp. PCC 7120, and Nostoc azollae,* each contain plasmids. They have between 5.35 and 8.23 million base pairs in their sequences (27).

ANTIBACTERIAL ACTIVITY OF *NOSTOC MUSCORUM*:

Production of antimicrobial active substance under various growth conditions from the cyanobacterium *Nostoc muscorum* and the purification of the active components and elucidation of its chemical structure were done by El-sheikh and coworkers (17). Bloor and England (28) also report that the anti-biotic produced by *N. muscorum* that inhibit the growth of bacteria.

ANTIMICROBIAL ACTIVITY OF *NOSTOC MUSCORUM:*

Arun *et al.,* (29) reported that the antimicrobial activity of methanolic extract of *N. muscorum* against different microorganisms. *P. aeruginosa* showed maximum zone of inhibition i.e. (2.0 cm), whereas *B. cereus, M. luteus* and *S.aureus* showed 0.8 cm wide zone of inhibition (0.8 cm). On the other hand, *B. subtilis* and *K. Pneumonia* was found to be resistant to methanolic extract of *N. muscorum*. The antimicrobial index for methanolic extract of *N. muscorum* showed the maximum percentage of inhibition 44.4% against different bacterial strains like *Pseudomonas aeruginosa, Klebsiella pneumoniae, Staphylococcus aureus, Bacillus subtilis, Bacillus cereus, Micrococcus luteus* (29).

K. pneumoniae was relatively more sensitive to acetone extract of *N. muscorum* only (50% inhibition) and Then-hexane extract and aqueous extracts of *N. muscorum* were less effective against microorganisms. A higher antimicrobial activity in the methanolic extract of cyanobactreial strains than the acetone extract may be due to abundance of some lipophilic, but polar compounds (29).

ANTI OXIDANT ACTIVITY OF *NOSTOC MUSCORUM:*

The antioxidant potential in the extract of Nostoc strains might be due to the total phycocyanin, triterpenoids and carotenoids present in the algal extracts. Arun *et al*., (29) determined Antioxidant activity, by free radical scavenging (Nitric oxide radical scavenging activity) in the methanolic extract *C. pyrenoidosa, S. platensis and N. muscorum*. It can be said that a high percentage of Nitric oxide scavenging activity was in *N. muscorum* (23.58%) (29). Cellular presence of phenolic compounds has also been coupled with both antioxidant and antibacterial activities (30).

ANTI FUNGAL ACTIVITY OF *NOSTOC MUSCORUM*:

Anti fungal activity of cyanobacteria has been found less than antibacterial and antimicrobial activity. Moor *et al*., (31) found that among the more than 1000 cyanobacterial strains, only 9% were able to inhibit fungal growth. Kreitlow *et al.,* (13) also found no activity against fungi, but inhibitory activity against gram positive bacteria.

PRODUCTION OF SECONDARY METABOLITES:

Worldwide attention is drawn towards cyanobacteria for their possible use in mariculture, food, fuel, colourant, production of various secondary metabolites including vitamins, toxins, enzymes, pharmaceuticals, pharmacological probes and pollution abatement (24). Secondary metabolties from cyanobacteria are associated with toxic, hormonal, antineoplastic and antimicrobial effects (14,32). Secondary metabolites influence other organisms in the vicinity and are thought to be of phylogenetic importance. Recently, there has been an increasing interest in cyanobacteria as a potential source for new drugs (33). The properties of secondary metabolites in nature are not completely understood (10).

REFRENCES:

[1] B.K. Carte, Biomedical potential of marine natural products. Bioscience, 1996, 46: 271-286.
[2] Potts M,. The ecology of cyanobacteria their diversity time and space. In: Whitton Ba, Poots M. (eds). New York; Kluwer academic publisher, 2002, pp. 465-504.
[3] W.D.P. Stewart, Some aspects of structure and function in N2 –fixing cyanobacteria. Annu. Rev. Microbiol., 1980, 34: 497-536.
[4] N.G. Carr, B.A. Whitton, The biology of cyanobacteria. Oxford; Blackwell Scientific Publications Ltd., 1982.
[5] R.W. Castenholz and J.B. Waterbury, Oxygenic photosynthetic bacteria. Group I. cyanobacteria. Bergey's Manual of Systematic Bacteriology., 1989, 3:1710–1727.
[6] C.S.V.R. Rao, Antimicrobial activity of cyanobacteria. I J Mar Sci., 1994, 23: 55–56.
[7] A.A. Issa, Antibiotic production by the cyanobacteria Oscillatoria angustissima and Calothrix parietina. Environ Toxicol Pharmacol., 1999, 8: 33–37.
[8] B. Pushparaj, Toxicological analysis of the marine cyanobacterium Nodularia harveyana. J Appl Phycol., 1999, 10: 527–530.
[9] I .Schlegel, N.T. Doan, N. de Chazal, G.D. Smith, Antibiotic activity of new cyanobacterial isolates from Australia and Asia against green algae and cyanobacteria. J. Appl. Phycol., 1999, 10: 471–79.
[10] Inderjit and K.M.M. Dakshini, Effect of cultivation on allelopathic interference success of Pluchealance olata. J. Chem. Ecol., 1994, 20: 1179-1188.
[11] V. Dvornyk and E. Nevo, Genetic polymorphism of cyanobacteria under permanent stress: A lesson from the “Evolution Canyons”. Res Microbiol., 2003, 154: 79–84.
[12] M.M. Kulik, The potential for using cyanobacteria (blue green algae) and algae in the biological control of plant pathogenic bacteria and fungi. Eur J Plant Path., 1995, 101 (6): 585-599.
[13] S. Kreitlow, S. Mundt, U. Lindequist, Cyanobacteria- A potential source of new biologically active substances. J Biotech., 1999, 70: 61-63.
[14] G.M.L. Patterson, L.K. Larsen, R.E. Moore, Bioactive natural products from blue-green algae. J Appl Phycol., 1994, 6: 151-157.
[15] Y. Ghasemi, M.T. Yazdi, S.H. Shokravi, N. Soltani, G. Zarrini, Antifungal and antibacterial activity of paddy-fields cyanobacteria from the north of Iran. J Sci I R Iran., 2003, 14: 203-209.
[16] G.V.B. Sethubathi, V.A. Prabu, Antibacterial activity of cyanobacterial species from adirampattinam coast, southeast coast of palk bay. Cur. Res. J. Biol. Sci., 2010, 2: 24-26.
[17] M.M. El-Sheekh, M.E.H. Osmana, M.A. Dyabb, M.S. Amera, Production and characterization of antimicrobial active substance from the cyanobacterium Nostoc muscorum. Environ. Toxicol. Pharm., 2006, 21: 42-50.
[18] R.S. Kumar, N. Thajuddin, C. Venkateswari, Antibacterial activity of cyanolichen and symbiotic cyanobacteria against some selected microorganisms. Afr. J. Microbiol. Res., 2010, 4: 1408-1411.
[19] H.M. Khairy and H.Y. El-Kassas, Active substance from some blue green algal species used as antimicrobial agents. Afr. J. Biotechnol., 2010, 9: 2789-2800.
[20] G.R. Battu, S.P. Ethadi, P.D. Murthy, V.S.T. Praneeth, M. Rao, In-vitro antibacterial activity and preliminary phytochemical screening of three algae from visakhapatnam coast, andhra pradesh, india. Int. J. Pharmacy Pharm. Sci., 2011, 3 (4): 399-401.
[21] L. Mhadhebi, K. Chaieb, A. Bouraoui, Evaluation of antimicrobial activity of organic extracts of six marine algae from tunisian mediterranean coasts. Int. J. Pharmacy Pharm. Sci., 2012, 4 (1): 534-537.
[22] E. Blumwald and E. Tel-Or, Osmoregulation and cell composition in salt- adaptation of Nostoc muscorum. Arch. Microbiol., 1982, 132: 168-172.
[23] F.E. Allison, S.R. Hoover, H.J. Morris, Physiological Studies with the Nitrogen-Fixing Algae, Nostoc muscorum. Botanical Gazette., 1937, 98 (3): 433-463.
[24] N.Thajuddin and G. Subramanian, Cyanobacterial biodiversity and potential applications in biotechnology. Cur Sci., 2005, 89 (1): 47-57.
[25] J. Abraham, R. Chauhan, S. Silambarasan, Biodiversity of Marine Cyanobacteria and its Antibacterial Activity. Journal of Biotechnology and Biotherapeutics., 2011, 1 (4): 15-19.
[26] L.M. Prescott, Microbiology. 6th ed. Mc Graw Hill (NY): Lange MJ., 2005.
[27] National Center for Biotechnology Information. U.S. National Library of Medicine. Web. 15 Apr. 2012.
[28] S. Bloor and R.R. England, Antibiotic production by the cyanobacterim Nostoc muscorum. J. Appl. Phycol., 1989, 1: 367-372.
[29] N. Arun, S. Gupta, D.P. Singh, Antimicrobial and antioxidant property of commonly found microalgae Spirulina platensis, Nostoc muscorum and Chlorella pyrenoidosa against some pathogenic bacteria and fungi. Int. J. Pharma Sci. Res., 2012, 3 (12): 4866-4875.
[30] Y.Q. Yao, X. Ding, Y.C. Jia, C.X. Huang, Y.Z. Wang, Y.H. Xu, Anti-tumor effect of β-element in glioblastoma cells depends on p38 MAPK activation. Cancer Lett., 2008, 264:127-134.
[31] R.E. Moore, G.M.L. Patterson, W.W. Carmicheal, New pharmaceutical from cultured blue green algae in biomedical importance of marine organisms, fautin DG. Ed. Mem. Cel. Acad. Sci., 1988,13: 143-150.
[32] W.W. Carmichael, Cyanobacteria secondary metabolites-the cyanotoxins. J. Appl. Bacteriol., 1992, 72 (6): 445-459.
[33] R.E. Schwartz, Pharmaceuticals from cultured algae. J. Ind. Microb. 1990, 5: 113-124.