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Microalgae as Nanofactory for Production of Antimicrobial Molecules

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Abstract

In recent decades, due to increasing bacterial resistance, have been developed researches to find molecules with antimicrobial activity. The searches for new compounds, especially unexplored sources such as microalgae are a potential alternative. Microalgae are microorganisms extremely diverse and ubiquitous; they have advantages to become a powerful nanofactory due to the variety of metabolic compounds as the ability to form metallic nanoparticles with antimicrobial effect. This mini-review shows the importance of integrating nanotechnology with microalgae and/or their products for the preservation and formation of molecules to be applied in prophylactic therapy and infectious.

Keywords: Nanofactory; Prophylactic therapy; Ubiquitous; Antimicrobial effect

Microalgal Nanofactories

Microbial contamination has caused countless deaths and large public health problems in the world population. The presence of microbial pathogens in foods [1], intensive care unit [2], prosthesis infection [3], among others, has led to the development of methods for the control and prevention of microbial infections. The extensive use of antibiotics has facilitated the continued emergence and spread of resistant organisms, causing global alarm due to the public health threat they represent. Added to this, biofilms formation on biotic and abiotic structures that are difficult to eliminate which causes greater resistance to the removal, generating chronic problems of reinfection [4].

Looking for solutions, some possible strategies have been based on the rotation control of certain antibiotics like employing compounds or complements derived from plants extract, the primary or secondary cell metabolites, that submit multiple mechanisms of action in medical and industrial applications [5,6]. However, the chemical interaction of these biocontrol agents with organic or inorganic elements produces decreased of antimicrobial action.

In this regard, nanotechnology offers a wide range of possibilities as to development of new materials with antimicrobial properties that may affect medical and industrial areas. Despite this, physical and chemical methods for making these nanomaterials cause problems of toxicity limiting their applications in clinical fields. Therefore, for integration of nanotechnology at health systems, it is necessary to use biological routes from microorganisms and plants for the synthesis of nanomaterials [7].

Microalgae offer certain advantages to become a powerful nanofactory. In recent years, the use of microalgae has focused on biofuel production and carbon dioxide fixation [8,9]. However, the diversity of microalgae metabolic compounds has caught the attention due to nutraceutical and pharmacological contribution. Although the antimicrobial activity of microalgae and/or bioproducts have been poorly investigated, there are a great diversity of species and metabolic compounds that recently received important consideration as a new source of novel bactericidal and fungicidal activity (Figure 1).

Microalgae cells can be used for the synthesis of various inorganic nanoparticles, ranging in size from 1-10 nm [10-17]. The microalgae have certain advantages as nanofactories due to fast growth, formation of metabolic compounds and proteins that reduce silver, gold ions and other metals that helps stabilize metallic nanoparticles [18]. Many species of microalgae have the ability to adsorb and entrap heavy metal ions by binding to carboxyl groups of cell biomass [18], meanwhile, polyphosphates and polysaccharides groups, intra- and extracellular, participate in chelation and oxidation of metals [19].

Microalgae can perform extracellular synthesis of metal nanoparticles, besides of eliminate some steps in the process of biorefinery, which it brings greater importance for biomedical and biotechnological applications.

The antimicrobial activity of metal nanoparticles has been demonstrated [20]. The silver nanoparticle acts as a broad-spectrum antibiotic. They produce rapid killing kinetics, even on multidrug-resistant pathogens [21]. The mechanism of action is much debated, but is believed that DNA loses its ability to replicate and membrane proteins are inactivated by interaction of Ag^+ ions [22]. The union of Ag^+ ions causes denaturation of cellular proteins besides the respiratory chain is disengaged causing cellular collapse [23]. Moreover, the metals in the presence of oxygen can induce the generation of reactive oxygen species generating oxidative stress [24].

Many of nanoparticles and bioproducts synthesized by microalgae can be coupled into nanofibers and nanotubes. Thus, this new nanomaterial would enhance the antimicrobial action. These nanofibers can be marketed as prophylactic treatment by incorporation into wound healing bandages, surgical equipment, prosthesis, food packaging, among others.

Therefore, the integration of biotechnological processes that solve medical problems in society would make a breakthrough for biomedical market.

The productive development of microalgae cultivation with suitable

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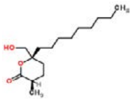
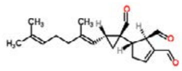
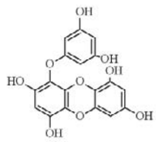
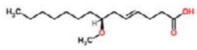
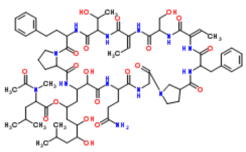
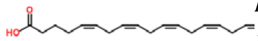
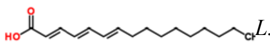
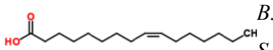
Chemical compound	Chemical structure	Microbial strains targets	Ref.
Malyngolide		*M. smegmatis*, *S. pyogenes*, *S. aureus*, *Pseudomonas* sp.	[10]
Halimedatrial		*S. marinorubra*, *V. splendida*, *V. leiognathi*, *V. harveyi*.	[11]
Phlorotannins		*T. rubrum*, *S. aureus*, MRSA*, *C. jejuni*, *E. coli*, *S. enteritidis*, *S. typhimurium*, *V. parahaemolyticus*, *B. subtilis*, *Acinetobacter* sp., *K. pneumonia*	[12]
(4E,7S)-7 methoxytetradec-4-enoic acid		*S. aureus*, *B. subtilus*	[13]
Pahayokolide A		*B. megaterium*, *B. cereus*, *S. cerevisiae*	[14]
Eicosapentaenoic acid		*Photobacterium* sp., *B. cereus*, *B. weihenstephanensis*, *S. aureus*, *S. epidermidis*, MRSA*	[15]
Hexadecatrienoic acid		*L. anguillarum*, *P. citreus*, *S. aureus*, *S. epidermidis*	[16]
Palmitoleic acid		*B. cereus*, *B. weihenstephanensis*, *S. aureus*, *S. epidermidis*, MRSA*	[16]

Figure 1: Chemical structure of microalgae metabolic compounds with antimicrobial activity. *MRSA: multidrug-resistant *S. aureus*.

photobioreactors [25], could generate high yields in production of metal nanoparticles and/or biomass bioproducts that can be integrated into nanofibers or nanotubes with antimicrobial activity, helping to prevent reinfection by microorganisms, it would be an ideal process.

Microalgae can achieve a promising future as antimicrobials with exploring potential areas for bioprospecting. This coupled with the physiological advantages; it allows incorporation into nanotechnology helping to have antimicrobial molecules capable of solving problems of contamination and infection not solved by common antibiotics.

References

1. Ramírez MLG, Moron SA, Alfieri GAY, Gamboa O (2009) Prevalence of Listeria monocytogenes in fresh tomatoes (Lycopersicum esculentum) and coriander (Coriandrum sativum) in three markets of Valencia, Venezuela. Archivos Latinoamericanos de Nutrición 59: 318-324.
2. Edwards JD, Herzig CT, Liu H, Pogorzelska-Maziarz M, Zachariah P, et al. (2015) Central line-associated blood stream infections in pediatric intensive care units: Longitudinal trends and compliance with bundle strategies. Am J Infect Control 43: 489-493.
3. Dutkiewicz A, Malinowski P (2012) Aortobifemoral prothesis infection. Polish Annals of Medicine 19: 129-133.
4. Burmølle M, Ren D, Bjarnsholt T, Sørensen SJ (2014) Interactions in multispecies biofilms: do they actually matter? Trends Microbiol 22: 84-91.
5. Ramírez Mérida LG, Morón de Salim A, Catinella R, Castillo L (2012) Bacteriostatic and/or bactericidal extract of Aloe vera gel on cultures of Listeria monocytogenes. Arch Latinoam Nutr 62: 73-78.
6. Barra Caracciolo A, Topp E, Grenni P (2015) Pharmaceuticals in the environment: biodegradation and effects on natural microbial communities. A review. J Pharm Biomed Anal 106: 25-36.
7. Narayanan KB, Sakthivel N (2011) Green synthesis of biogenic metal nanoparticles by terrestrial and aquatic phototrophic and heterotrophic eukaryotes and biocompatible agents. Adv Colloid Interface Sci 169: 59-79.

8. Francisco EC, Balthazar D, Jacob-Lopes E, Franco TT (2010) Microalgae as feedstock for biodiesel production: carbon dioxide sequestration, lipid production and biofuel quality. Journal of Chemical Technolgy and Biotechnology 85: 395-403.

9. Jacob-Lopes E, Franco TT (2013) From oil refinery to microalgal bioreinery. Journal of CO2 Utilization 2: 1-7.

10. Cardllina JH, Moore RE, Arnold E, Clardy J (1979) Structure and absolute configuration of malyngolide, an antibiotic from the marine blue-green alga Lyngbya majuscula Gomont. The Journal of Organic Chemistry 44: 4039-4042.

11. Paul VJ, Fenical W (1983) Isolation of halimedatrial: chemical defense adaptation in the calcareous reef-building alga halimeda. Science 221: 747-749.

12. Eom SH, Kim YM, Kim SK (2012) Antimicrobial effect of phlorotannins from marine brown algae. Food Chem Toxicol 50: 3251-3255.

13. Faulkner DJ1 (1987) Marine natural products. Nat Prod Rep 4: 539-576.

14. Berry JP, Gantar M, Gawley RE, Wang M, Rein KS (2004) Pharmacology and toxicology of pahayokolide A, a bioactive metabolite from a freshwater species of Lyngbya isolated from the Florida Everglades. Comparative Biochemistry and Physiology Part C: Pharmacology, Toxicology and Endocrinology 139: 231-238.

15. Desbois AP, Mearns-Spragg A, Smith VJ (2009) A fatty acid from the diatom Phaeodactylum tricornutum is antibacterial against diverse bacteria including multi-resistant Staphylococcus aureus (MRSA). Mar Biotechnol (NY) 11: 45-52.

16. Desbois AP, Lebl T, Yan L, Smith VJ (2008) Isolation and structural characterisation of two antibacterial free fatty acids from the marine diatom, Phaeodactylum tricornutum. Appl Microbiol Biotechnol 81: 755-764.

17. Govindaraju K, Basha SK, Kumar VG, Singaravelu G (2008) Silver, gold and bimetallic nanoparticles production using single-cell protein (Spirulina platensis) Geitler. Journal of Materials Science 43: 5115-5122.

18. Hameed A, Hasnain S (2005) Cultural characteristics of chromium resistant unicellular cyanobacteria isolated from local environment in Pakistan. Chinese Journal of Oceanology and Limnology 23: 433-441.

19. De Philippis R, Sili C, Paperi R, Vincenzini M (2001) Exopolysaccharide-producing cyanobacteria and their possible exploitation: A review. Journal of Applied Phycology 13: 293-299.

20. Merin DD, Prakash S, Bhimba BV (2010) Antibacterial screening of silver nanoparticles synthesized by marine micro algae. Asian Pacific Journal of Tropical Medicine 3: 797-799.

21. Rai MK, Deshmukh SD, Ingle AP, Gade AK (2012) Silver nanoparticles: the powerful nanoweapon against multidrug-resistant bacteria. J Appl Microbiol 112: 841-852.

22. Feng QL, Wu J, Chen GQ, Cui FZ, Kim TN, et al. (2000) A mechanistic study of the antibacterial effect of silver ions on Escherichia coli and Staphylococcus aureus. J Biomed Mater Res 52: 662-668.

23. Lok CN, Ho CM, Chen R, He QY, Yu WY, et al. (2006) Proteomic analysis of the mode of antibacterial action of silver nanoparticles. J Proteome Res 5: 916-924.

24. Park HJ, Kim JY, Kim J, Lee JH, Hahn JS, et al. (2009) Silver-ion-mediated reactive oxygen species generation affecting bactericidal activity. Water Res 43: 1027-1032.

25. Ramírez-Merida LG, Zepka LQ, Jacob-Lopes E (2015) Why does the Photobioreactors Fail? Journal of Bioprocessing & Biotechniques 5: 7.