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Algae Therapy: Highlights on the Pharmaceutical Potentials of Algae

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Research Article

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Abstract

The markets for prescribed drugs are growing quickly worldwide. A developing share of today's promising pharmaceutical research focuses on the manufacturing of effective bioactive compounds from algae. Pharmaceutically treasured products from algae and its industrial commercialization today are still in its infancy and can be considered as a gateway to a multibillion dollar industry. Algae represent a principal untapped useful resource of genetic potential for precious bioactive agents and high-quality biochemical. This tested capability of algae to produce these compounds places these microorganisms in the biotechnological highlight for functions and commercialization as in the pharmaceutical industry. The manufacturing of algal metabolites, which stimulate protection mechanisms in the human body, has spurred extreme find out about of the utility of algal biomass and products thereof in more than food preparations, pharmacological and clinical products. There is, therefore, a massive scope in addition learn about of the identified algal compounds and their activities in the treatment and prevention of various diseases, in addition to an ongoing search for other, as yet undetected, metabolites.

Keywords: Microalgae; Pharmaceutical applications; Biological activities

Introduction

Certainly, "our life depends on microalgae" since they compose 50 percent of overall oxygen production [1]. As autotrophs support aquatic ecosystems, and in general all land plants and animals lean on microalgae directly or indirectly. Firstly, the primary production of marine and freshwater bodies relies on microalgae [2]. Secondly, they are situated in the base of food chains having an essential role in the world's aquaculture industries for their protein needs [3]. Based on the size and morphology, algae may be subdivided into 2 main categories: macroalgae and microalgae. Macroalgae are composed of multiple cells, organized into structures that resemble higher plant roots, stems, and leaves (e.g. kelp). Microalgae are mostly unicellular, a diverse group of primary producers (autotrophs) organisms capable of forming organic compounds from pure inorganic materials like atmospheric or marine carbon dioxide [4]. They are microscopic in comparison to algae which are simpler autotrophic organisms with a large variety [5]. Today's advanced plant life is believed to have been developed from these basic plant-like microscopic organisms.

Around 41,000 species of macroalgae and microalgae were described. The microalgae are categorized according to the quality of photosynthetic pigments, the food reserve for carbohydrates, the cell walls, the structure and orientation of flagella 1 [6]. Furthermore, these microalgae contain proteins, pigments, essential fatty acids, vitamins, polysaccharides and minerals [7]. Such high-value products Furthermore, these microalgae contain proteins, pigments, essential fatty acids, vitamins, polysaccharides and minerals [7]. Such high-value products may be proven particularly important and beneficial to the pharmaceutical industry by giving new choices to treat illnesses like inflammation and immunomodulating actions [8]. Eventually, the microalgae that provide us with oxygen, foods, and car fuel, also provide us with effective medical substances against virus diseases (Herpes simplex and AIDS), cancer and drug-resisting bacterial strains. Pharmaceutical products of quality and their industrial marketing are still developed and can be viewed as a key to a multimillion-dollar industry. Scientists have just begun to explore the huge biological resource and physiological perspective of microalgal species as growing in every environmental niche [9].

Bioactive compounds from algae and their types

Bioactive compounds are physiologically active substances with functional properties in the human body. There is, therefore, a super enthusiasm for the improvement and manufacture of a number of bio-compounds that can probably be used as functional ingredients such as phycocyanins, carotenoids, fatty acids, polyphenols, and polyunsaturated compounds [10]. The manufacturing of bioactive compounds from natural sources has currently emerged, pushed by using a developing wide variety of scientific research that exhibit the advisable consequences of these compounds on health benefits [11]. These natural products are important in the search for new pharmacologically active compounds and play necessary position in new drug discovery for the treatment of human diseases [12].

Bioactive compounds from algae (Figure 1) can be obtained directly from primary metabolisms, such as therapeutic proteins, fatty acids, vitamins, and pigments, or can be synthesized from secondary metabolism. Such compounds can present antivirals, antialgals, antifungals, antienzymatic, or antibiotic actions [13,14]. Many of these compounds (Cyanovirin, linolenic acid, oleic acid, palmitoleic acid, β-carotene, vitamin E, B12, β-carotene, phycocyanins, zeaxanthin and lutein) have antioxidant, antimicrobial and anti-inflammatory properties, with the potential for the reduction and prevention of diseases [15-17]. In most microalgae, the bioactive compounds are accrued in the biomass; however, in some cases, these metabolites are excreted into the medium; these are recognized as exometabolites.

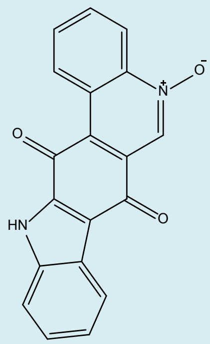
Physiological effects of algal bioactive compounds

Polysaccharides symbolize a type of excessive value-added elements with functions in pharmaceuticals, food, cosmetics, fabrics, stabilizers and emulsifiers [18]. Microalgal polysaccharides incorporate sulfate esters, are referred to as sulfated polysaccharides, and possess special clinical applications. The primary mechanism of therapeutic action is based totally on the stimulation of macrophages and modulation. The biological activity of sulfur polysaccharides is linked to their sugar composition, position, and degree of sulfation [19]. Sulfated polysaccharides derived from algae inhibit some viral infections, such as herpes simplex virus, swine fever virus, varicella virus and salmonid virus [20-22].

The lipid compositions of microalgae are found to be responsible for its antimicrobial activity. This antimicrobial property of microalgae is because of their potential to produce compounds such as β-cyclocitral, α- and β-ionone, neophyte diene, and phytol [20]. Antimicrobial activity against human pathogens, such as *Pseudomonas aeruginosa, E. coli, Pseudomonas aeruginosa, Staphylococcus epidermidis*, and *S. aureus*, has been attributed to eicosapentaenoic acid, docosahexaenoic acid, γ-linolenic acid, hexadecatrienoic acid, palmitoleic acid, lauric acid, oleic acid, lactic acid, and arachidonic acid [23].

Carotenoids have extremely good conceivable advantages to human health, together with the treatment of degenerative diseases, such as macular degeneration and cataract development. These compounds act as antioxidants, lowering oxidative harm by using ROS. Studies indicated that multiplied consumption of phenols diminished the prevalence of degenerative diseases. Phenolic compounds from microalgae with the attainable to fight free radicals have been reported [24]. Oxidative damage through reactive oxygen species (ROS) to proteins, lipids and nucleic acids can cause many continual illnesses such as coronary heart disease, cancer and atherosclerosis. In general, algal strains are regarded a prosperous supply of antioxidants, with viable functions in food, cosmetics, and pharmaceuticals [25]. Antioxidant compounds such as mycosporine amino acids, and dimethylsulfoniopropionate isolated from algae and are amazing chemical blockers of UV radiation [26]. In addition to these compounds, pigments, lipids, and polysaccharides with antioxidant recreation can additionally be discovered in algae.

In humans, the oxidation reactions pushed by using ROS can lead to irreversible harm to cell components, along with proteins, lipids, and DNA mutation or degradation. Consequently, this injury can lead to numerous syndromes such as cardiovascular disease, some cancers, and the degenerative illnesses of getting older [27]. Pigments derived from microalgae have neuroprotective properties, being treasured sources as practical substances in pharmaceutical products that exhibit environment friendly motion in the cure and/or prevention of neurodegenerative diseases. Vitamin E derived from algae has preventive results for many diseases, such as atherosclerosis and coronary heart disease, as nicely as neurodegenerative diseases, such as a couple of sclerosis [28].



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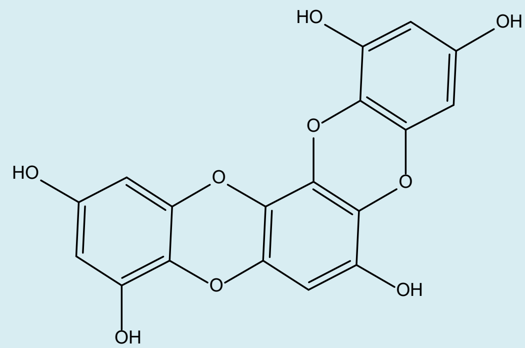

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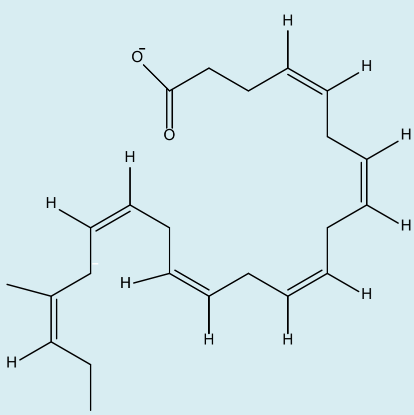

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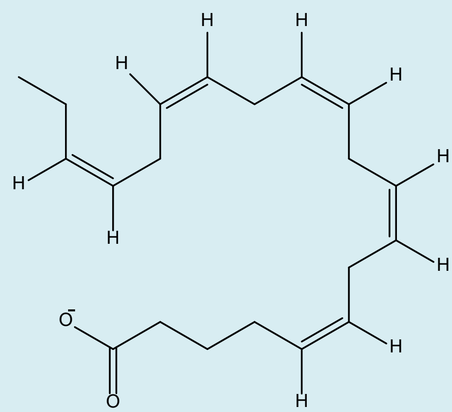

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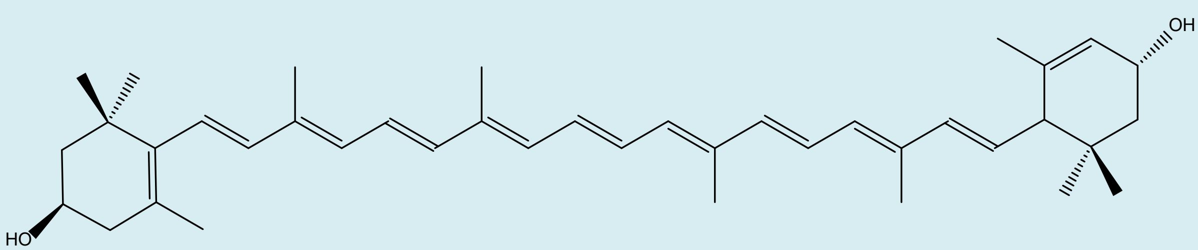

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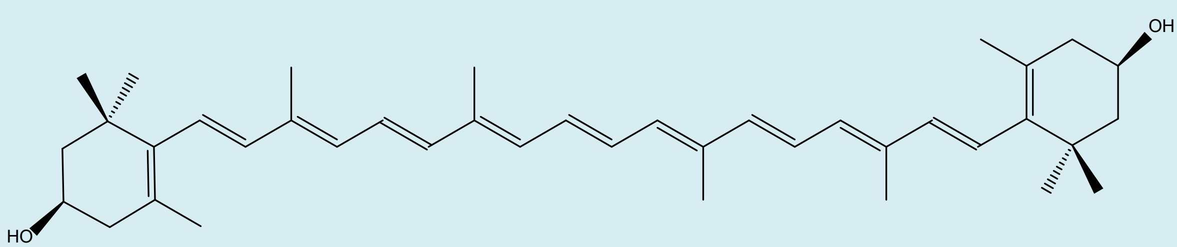
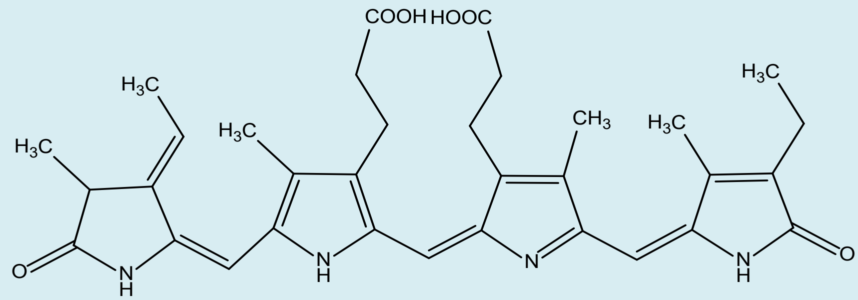
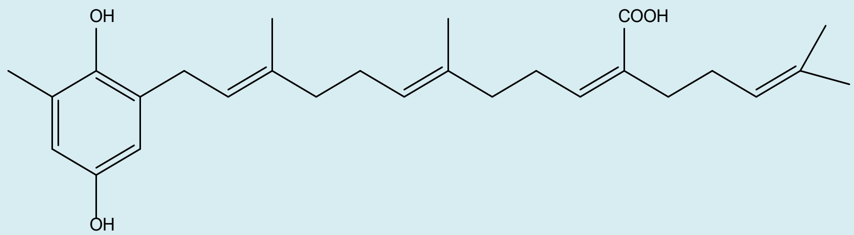


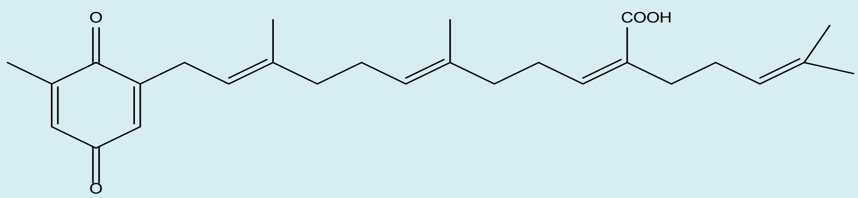
Zeaxanthin



Phycocyanin



Sargahydroquinoic acid



Sargaquinoic acid

Figure 1: Chemical structure of some bioactive compounds originated from algae.

Pharmaceutical uses of algae/algal drugs

Macroalgae contain high valuable bio-products used in cosmetics, food supplements; some drugs used in treatments from different diseases (Table, 1). Whereas, microalgae play a big role in development of anti-cancer drugs [29]. A huge volume of research on bioactive compounds from well-studied algal forms such as *Arthrospira* (*Spirulina*), *Chlorella vulgaris, Dunaliella salina,* and *Nostoc* has led to the identification of antimicrobial, antiviral, anticoagulant antienzymatic, antioxidant, antifungal, anti-inflammatory, and anticancer activity (Figure 2, Table 2). These studies have been based on the extraction of bioactive compounds from these microalgae.

The polyunsaturated fatty acid, eicosapentaenoic acid, obtained from *Phaeodactylum tricornutum* showed antibacterial activities [30,31]. The Cyclic depsipeptides, apratoxin A, originated from *Lyngbya* spp. exhibited promising anticancer activity [32,33]. Similarly, the polyketide, trichophycin A, from *Trichodesmium thiebautii* showed anticancer activity against neuroblastoma cell line [34]. The alkaloids Calothrixin A obtained from *Calothrix* sp., and Haplindole H from *Fischerella muscicola exerted potent* Antiproliferative action against Jurkat cancer cells, and against PC-3 prostate cancer cell line respectively [35,36]. On the other hand, many carotenoids such as astaxanthin was reported to inhibit breast cancer cell migration, inhibited growth of xenografted sarcoma (S180) mice [37]. Similarly, Fucoxanthin suppressed expression of bcl-2 and enhanced expression of cleaved caspase-3 [38]. One of the potent antiviral compounds secreted by algae is the sulphated polysaccharide, calcium spirulan, that was isolated from *Spirulina platensis*. Calcium spirulan showed activity against both herpes simplex virus type 1 (HSV-1) and HIV-1 [39]. Moreover some spirulan-like compounds from *Spirulina* inhibited human cytomegalovirus, HIV-1, HSV-1, human herpes virus type 6 [40].

The carotenoid, lycopene showed various biological activities including its ability to inhibit the growth and colony formation of prostate cancer cell lines PC-3 and DU-145 [41].

Furthermore, *in vivo* studies it showed the antiinflammatory effects of lycopene on decreasing the inflammatory marker enzymes lipoxygenase, cyclooxygenase, and myeloperoxidase in an arthritis rat model, compared to tomato lycopene and the anti-inflammatory drug indomethacin [42]. In another study, the pigment C-phycocyanin, showed immunomodulatory effect against many allergic responses in a rat model [43].

Algal species	Uses	References
Acetabularia	Treatment from edema and urinary diseases.	Amer, et al. [44]; Cemile and Çigdem, [45]; Kulikova, et al. [46]; Shanab, et al. [29]; Zhang, et al. [47].
Enteromorpha	Treatment from hemorrhoids, parasitic disease, goiter, coughing and bronchitis; fever reducyion capacity and ease pain	
Grateloupia	Treatment from tonsils, goitre	
Gelidium	Produce agar used in cosmetics.	
Laminaria	Treatment from thyroid problems and urinary diseases.	
Grateloupia	Blood sugar lowing capability	
Sargassum	Treatment from edema; cervical lymphadenitis; diminishes inflammation.	

Table 1: Medicinal uses of some macroalgae.

Algal species	Uses	References
Chlorella	Food supplement; formation and regeneration of blood cells; anticoagulant, antitumor, antioxidant and antibacterial effects	Beheshtipour, et al. [48]; Chang, et al. [49]; Costa and Morais, [50]; Costa, et al. [51]; Falquet, [52]; Henrikson, [53]; Lee, et al. [54]; Lorenz, [55]; Madkour and Abdel-Daim, [56]; Plaza, et al. [57]; Temina, et al. [58]; Zhao and Sweet, [59]. Lee, et al. [60].
Dunaliella	Antioxidant, bronchodilatory, antihypertensive, muscle relaxant, analgesic, hepatoprotective and antiedemal properties. *Dunaliella* cells contained antibiotic substances.	
Nostoc	Used as dietary supplement, treatment of fistula, anti-inflammatory, and anticancer	
Spirulina	Used in food industry, medicine, health beneficial properties, antioxidant, anticancer, antiviral and antibacterial activities. Have positive effects against obesity, diabetes, malnutrition, hyperlipidemia, anti-inflammatory and anemia.	

Table 2: Medicinal uses of some microalgae.

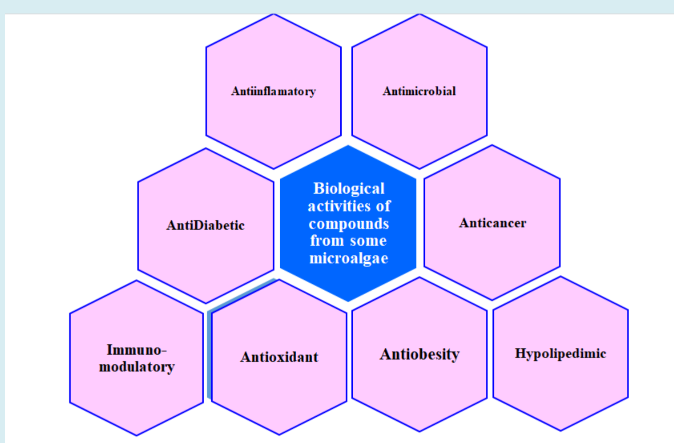


Figure 2: Some bioactivities exerted by microalgae

Conclusion

In recent years, innovative processes and products have been introduced in both macro- and microalgal biotechnology. Bioactive metabolites of algal origin are of special interest in the development of new products for pharmaceutical, cosmetic, and food industries. Further research should be conducted with these bioactive compounds to verify their beneficial effects for humans, their degradability when released into the environment, and their effects when used in animals. These will be adapted to the au ecological demands of strains and to application aims for biomass, valuable substances, and ecology. The therapeutic drugs prepared from algae which exist on both sunlight and carbon dioxide in the air will be manufactured at one-thousandth of today's costs, which makes it cheaper. The use of algae established of scientists in the direction of algal products has multiplied its sustainability in drug improvement field. Yet the improvement of these drugs has few drawbacks which are developing hindrance. Many strains are clearly commercially useful.

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