

Review on Nutraceuticals from Algae

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Abstract

Nutraceuticals protect us from many diseases by acting as agents to decrease over-weight, heart disease, cancer, high blood sugar, also acts as immunosuppressants. Nutritionally functional foods have included a numerous nutrients, along with micronutrient supplements, molecules which inhibit oxidation, enzymes, health drinks probiotics and fortified foods. Nutraceuticals are probably getting world-wide recognition as useful compound in the diagnosis of cancer, obesity, osteoporosis, CVD and many degenerative diseases. The microalgae bioactive compounds have significant anti-tumor and anti-inflammatory property. From a biotechnological standpoint, production of such high valued medicinal compounds along with less effort for its development makes it superior. Commercial formulation of functional foods and for nutraceutical applications is due to cultivation of algal biomass.

Keywords: Nutraceuticals • Super foods • Medicine • Therapeutic • Health benefits

Introduction

Increased global interest in the impact of nutrient diets on health sustainability has presumed paramount importance of the nutritional and therapeutic value of foods. Nutraceutical is a substance present in food that offers potential benefits for human health, in the form of tablets, capsules and powders to protect and cure from diseases. The food habits we follow are indeed the reason for any such lifestyle [1]. Excessive workloads, elevated occupational stress, financial status as well as other psychosocial stressors had also compelled people to consume quickly as well as consume too much. Consumption of fast food/junk food has however increased substantially in recent years, leading to a variety of nutritional deficiencies including high blood sugar, over-weight, tumor, heart diseases and other disorders, along with degenerative diseases. Over the time, people had already believed that it's vital to ingest various foods with appropriate and adequate nutrients in order to sustain the normal functioning of human wellbeing. In addition, scientific evidence has also been included and its 96 provides support for nutraceuticals and therapeutic services [2].

Algae

The super foods as nutraceuticals: Biologically active compounds from natural sources with nutritional and medicinal

value like astaxanthin, carotenoids, antioxidants, polysaccharides, long chain PUFA, micro and macronutrients, chlorophyll including several compounds against bacteria and virus are found abundantly in microalgae. *Spirulina*, *Haematococcus*, *Dunaliella* and *Chlorella* are some of the microalgae familiar in biotechnology.

Algae generally produce a wide variety of bioactive compounds, which include astaxanthin, beta-carotene, fucoxanthin, phycocyanin, beta-glucan, essential fatty acids (EPA and DHA) and many others. Microalgae are one of the important microorganisms that are beneficial to society in different ways for the development of new products. Few important organisms like microalgae are important to humans and acts as most promising source for the development of novel products [3]. Many bioactive compounds are used as high-valued compounds like phycobilliproteins, carotenoids, antioxidants, polyols, PUFA and polysaccharides and PUFA. They contain valuable substances which possess many properties like antioxidant, anti-fungal, anti-cancer, anti-viral, anti-microbial activity, anti-inflammatory and immune modulation. In the health food market, microalgae biomass has been used for its valuable. Use of biomass from algae for nutritionally functional purposes is predicted to give a source of income for this type of industry [4].

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Microalgae biotechnology has received increasing attention over the last decade as a result of their significantly higher production compared to conventional crops, which includes their capacity to thrive in regions and weather patterns that are not suitable for farming. Furthermore, the microalgae development acts as a significant biological process of biological fixing for the reduction of CO₂ in the atmosphere [5]. Wide biotechnologically relevant microalgae include *Chlorella vulgaris*, *Haematococcus pluvialis*, *Dunaliellasalina*, *Spirulina platensis* and *Spirulina maxima*. However, microalgae, particularly marine, remain largely unexplored till date and provides a special platform for exploring novel compounds and producing low-cost compounds.

The industrial exploitation from microalgae ranges from basic biomass-based food and nutraceutical feed to valuable pharmaceutical, biomedical, cosmetic, and ecological and their applications. Bio-inspired synthesis of microalgae-based green products and recent advances in algae biotechnology are due to the more knowledge in scientific research, environmental and societal awareness [6].

The biomass of microalgae is remarkably very useful, with health benefits to attract the customers. The most leading area of the food industry is the nutraceuticals/functional food market in the years ahead. The foods with microalgae biomass could have other beneficial effects, such as prebiotic effects or mineral fortification. Marine nutraceutical products constitute a substantial part of the world market and are extracted from several sources giving a variety of biologically active molecules.

Literature Review

New medicines from old foods

Microalgae were used as a source of human nutrition for years together. Even though nutritional content of microalgae has been very well established, its intestinal absorption and total nutrient content actually rely on not just the genes of the specific strains but also with the production method used in conversion of raw material. Several other researchers emphasize the colour, taste, smell and texture of microalgae biomass as future obstacles, while others signify that microalgae also have expected taste, smell and texture. To produce unique food products using microalgae, such attributes are to be considered. Some disadvantages of using too much of microalgae for humans are the conversion of nucleic acid to uric acid leading to kidney disorders. Cyanobacterial biomass, other than being generated under lab settings, is obtained from natural resources. Though natural habitats are extremely beneficial for the use of nutrients found naturally in the water bodies, the effectiveness of this raw material is not that good when compared to that produced in regulated condition. Some cyanobacteria might produce potent hepato and neuro toxins and therefore, if microalgae were also developed in accessible reservoirs or collected from freshwater bodies, there will be a threat that biomass will become contaminated with biological and non-biological toxins [7].

High valued nutraceuticals from microalgae

Microalgae are found to be an integral raw material for innovative products with numerous human functions. Microalgae should be able to act as a dietary supplement and a natural colorant influenced by the chemical properties [8]. The algal industries are on the verge of obtaining alternative revenue for nutraceutical products found in algal biomass. Microalgae which are prominent are *Chlorella vulgaris*, *Haematococcus pluvialis*, *Dunaliellasalina*, *Spirulina* sp.

Carotenoids

The carotenoids found in algae, play an important role as photoprotective agents. They aids in reducing decay of tissues by reducing deoxyribo nucleic acid, protein and membrane lipid damage. The risk of diseases like arteriosclerosis can be lowered in human beings by consuming carotenoid rich diet. Fucoxanthin, another type of carotenoid and its metabolite exert anti-proliferation and cancer prevention is involved in cell cycle arrest, apoptosis, or metastasis [9]. Also, Fucoxanthin has been shown to have anti-proliferative potential using Human Endothelial Umbilical Vein (HUVEC) cells to prevent cancer. As carotenoids are strong antioxidants, they give photo protection to the cells. Several carotenoids from algae have many protective functions against in the breast and cervix. Carotenoids from *Dunaliella* are capable of reducing lipid peroxidation and enzyme inactivation and therefore restore the activity of enzymes. Beta-carotene has the ability to prevent lung, pancreas, pancreas, colon, breast, and ovary, and rectum, prostate and cervical cancer with the help of its antioxidant property. *Dunaliella* derived carotenoids have hepatoprotective effects and they also decrease the occurrence of liver lesions [10].

Acetylenic carotenoids

Various types of acetylene carotenoids include: *Euglenaviridis*, *Tribonemaequala*, *Gonyostomium semen*, *Vacuolariavirescens*, *Pleurochlorismeingensis* formed by: Diatoxanthin, heteroxanthin, diadinoxanthin with antitumoral properties. *Chlorella pyrenoidosa* contains Lutein, another form of carotenoid pigments said to prevent cancer and retinal diseases [11].

Phycobiliproteins (phycocyanin, phycoerythrin)

Cyanobacteria and Rhodophyta are deep coloured water soluble fluorescent pigments and with phycobiliproteins, they. There are two types of phycobiliproteins namely: Phycocyanin and phycoerythrin. The phycocyanin has its application in chewing gums as a colouring agent; it's also been used in jellies, candies, dairy products and ice creams. This phycocyanin is an antioxidant and it reduces inflammation [12].

Astaxanthin

Astaxanthin is a type of carotenoid microalgae like *Haematococcus pluvialis*. It is a red colour carotenoid from β -carotene, lutein and lycopene. Some microalgae which are from yeast and bacteria are

there in salmon, trout and shrimp. Along with its antioxidant properties, astaxanthin also has therapeutic benefits like anti-aging. Dietary supplements containing *Haematococcus* astaxanthin have been used years together as a nutraceutical supplement is safe for human consumption [13]. *H. pluvialis* has astaxanthin which aids in enhancing eyes, protects the skin from premature ageing, strengthen muscles, prevents colon and oral cancer; protect PUFA from oxidation and decreases LDL oxidation. Astaxanthin is said to have 500 times more effect against free radicals than vitamin E. Oxidation of LDL is decreased with the use of dietary.

Its antioxidant activity is greater than lutein, zeaxanthin, canthaxanthin, lycopene, α -carotene, β -carotene and α -tocopherol. Its antioxidant property is because of its unique structure. Astaxanthin's polyene chain traps radicals and the terminal ring of astaxanthin would be used to inhibit oxidation in the cell wall. Due to its distinctive structure, it can be both in and out of the cell membrane. Several mechanisms like quenching of singlet oxygen; protection of membrane by inhibiting lipid peroxidation by protecting membrane phospholipids, preventing oxidation can be done by astaxanthin and, it also improves immune systems function and regulate gene expression [14]. The dysfunction of pancreatic β -cells and tissue damage increases by oxidative stress levels in diabetic patients. Astaxanthin prevents diabetic kidney disorder by reducing the pressure due to oxidation and renal cell damage. By preventing lipid/protein oxidation, astaxanthin inhibits and cytotoxicity.

Astaxanthin is used to treat the ocular inflammation in eyes. It has UV-light protection effect and antioxidant activity. Useage of astaxanthin in the eyes protects it against UV light and oxidation of retina for eye health maintenance. Astaxanthin prevents ulcer due to *Helicobacter pylori* and cure GI infections [15].

UV-induced photooxidation could be prevented by astaxanthin; it also prevents reduction of collage from skin. Astaxanthin also prevents cancer initiation by protecting the body DNA from UV oxidant damage, by promoting early detection and destruction of cells that have undergone malignant transformation by avoiding immune surveillance. Astaxanthin prevents cancer cell development of tissue-melting proteins and inhibits rate of cell multiplication of tumors in development and enhances cell death [16].

Dietary astaxanthin decreases LDL oxidation. Due to its many therapeutic applications, massive international attention in the large-scale production of astaxanthin has emerged.

Chlorophylls

All algae contain the pigment chlorophyll-a. The species of chlorophyta and euglenophyta group contains chlorophyll-b. Chlorophylls contribute their application in pharma, food and traditional medicine because they prevent inflammation. Chlorophyll decreases the risk of colon and rectal cancer [17]. It also increases bile secretion and stimulates liver recovery. It has anticarcinogenic, antioxidant, antimutagenic and antigenotoxic properties. By

supplementing chlorophyllin in diet, cancer progression is prevented as it targets multiple pathways of carcinogens and invades their cell cycle. CHL has helped to prevent the spread of lung tumor growth. Tissue growth is stimulated by chlorophyll and so it elevates healing of wounds [18]. Chlorophyll is in the treatment of ulcers and colon related disorders.

Poly unsaturated fatty acids

They are found abundantly in microalgae. They are necessary for the efficient functioning of the cells. Since people would not be able to generate FA, PUFA daily intake is required to maintain great health. Enhanced deaths due to coronary heart disease are attributable to a lack of long chain PUFA. Different types of PUFA's may be generated using microalgae [19].

Recently, algal-based PUFAs have gained importance as prevent and treat of several diseases like thrombosis, cancer arthritis, rheumatism, diastolic and systolic pressure and heart disease. Important EPA is from nannochloropsis, phaedactylum, nitzschia, isochrysis, diacronema and crypthecodinium and schizochytrium. Omega-6 fatty acids include, gamma linolenic acid, it is an 18-carbon polyunsaturated fatty acid which has 3 double bonds [20]. PUFAs are used to treat/control diseases like cancer, cardiovascular conditions, asthma, inflammatory bowel disorders, and arthritis and kidney disorders.

Spirulina

Spirulina is said to be a wonderful product with 60 to 70%protein. Cyanobacterium 'Spirulina' is full of Gamma Linoleic Acid (GLA), used to treat and prevent a lot of illnesses such as atherosclerosis, cardiac arrhythmia, blood pressure, glioma and autoimmune diseases such as rheumatoid arthritis, skin diseases, acute respiratory distress syndrome, premenstrual syndrome and diabetes. The immune system and the brain function are enhanced by using GLA. GLA may be impaired by mineral deficiency, alcohol/tobacco misuse, infections, aging and other serious health problems. This deficiency can increase arterial thickness, hypertension, and dyslipidemia. Spirulina even contain high levels of vitamin B3, often called niacin that is also proven to enhance dyslipidemia. Spirulina has been used as prevent cancer. Spirulina has adequate amount of vitamins so that it could be consumed regularly. The mechanism of action of spirulina is to decrease macrophage penetration through fat deposits, the reduction of hepatic fat accumulation, the decrease of oxidative stress, the improvement of insulin sensitivity and satiety, diabetes. The effect on fasting serum glucose levels in diabetic animals reduced and suppressed glucose levels because of the water-soluble fraction of spirulina. A substantial drop in fasting blood sugar was reported with spirulina as supplement. Spirulina as a supplement significantly decreased body weight in obese, high blood pressure and hypertension. Spirulina has proven antiviral property. Spirulina can treat depression and attention-deficit hyperactivity disorder by

improving phagocytic activity in macrophages and producing antigen-specific antibodies.

Tryptophan is a natural amino acid precursor (found in spirullin), has an specific role in the regulation of mood and cognition. Spirulina has a beneficial impact on the metabolism of fat by raising HDL levels, which would lead to good heart function. The *Spirulina platensis* concentrate prevented jejunal absorption of cholesterol, indicating that C-phycoyanin is the molecule accountable for this impact.

Phycocyanin often interacts with other pathologically significant oxidants. C-phycoyanin suppresses inflammation by inhibiting the expressions of inducible COX-2 and nitric oxide synthase, and by inhibiting the development of pro-inflammatory cytokines. Phycocyanin also scavenges free radicals, including alkoxyl, hydroxyl and peroxy radicals; inhibits liver microsomal lipid peroxidation; reduces production of prostaglandin E (2); reduces production of myeloperoxidase; reduces production of nitrite; inhibits aggregation of platelets. These all effects lead to anti-inflammatory activity of phycocyanin. Spirulina in diet would enhance digestion, food absorption and activate the immune system.

Discussion

Chlorella

Chlorella is a microscopic unicellular species of green algae, which does detoxification and activation of the immune system. Chlorella is yet another alga which has immense protein (about 60% with most of the amino acids) and has several micronutrients. Chlorella cell wall is rigid and indigestible, so it has to be disrupted to make use of the nutrients present in it.

Chlorella contains significant amounts of folic acid, cyanocobalamin and iron which can help to improve anemia. The incidence of proteinuria and oedema (signs of pregnancy-induced hypertension) by using chlorella reduced in pregnant women. The chlorella supplementation decreases the risk of pregnancy associated effects.

Chlorella contains growth factors to enhance immunity and destroy cancer lesions. The antibody improvement was reported by using chlorella. Since chlorella has immunosuppressive effect, it can be used as a nutritional supplement. Sitting diastolic blood pressure was found to reduce by using chlorella tablets.

Vitamins and minerals

Vitamin A cannot be obtained by algae, but they are capable of producing its precursors, α - and β -carotene (pro-vitamin A). The growth and development of various types of tumors, such as breast, oral cavity, skin, lung, gastrointestinal, hepatic, bladder and prostatic cancers could be prevented by retinoids.

A recent study documented a substantial amount of vitamin C in the coastal diatom (*Skeletonema marinoi*) and their capacity to

change its content with intensity of light and spectrum. Intense infections such as tuberculosis could be prevented by the use of ascorbic acids as an immunomodulatory agent.

It is recognized that microalgae may possess vitamins D₂/D₃ along with provitamin D₃, and so fish possess large amount of Vitamin D. Vitamin D and its derivatives, in addition to their established calcium-related roles, through their antiproliferative and immune modulatory effects on tumor cells perform chemoprevention activities.

Dunaliella tertiolecta, *Tetraselmis suecica*, *Nannochloropsis oculata*, *Chaetoceroscal citrans* and *Porphyridium cruentum* produce Vitamin E, which could be used as food supplements, because, tocopherol was found more in microalgae than in terrestrial plants. Inhibition of low-density lipoprotein oxidation, a mechanism in the development of atherosclerosis could be prevented with the help of tocopherol. Chemoprotection is another property of tocopherol.

Daily requirement of minerals for adults could be satisfied by the consumption of microalgae. Appropriate amount of zinc, phosphorus, sodium, iron, magnesium, and calcium was found in in *D. tertiolecta*, *Isochrisis galbana*, *Tetraselmis suecica*, *C. vulgaris*, *Sochrisis galbana*, *S. platensis*, and *Chlorella stigmatophorai*.

Polysaccharides

Polysaccharides have had important impacts for the food industry as a thickener. Agar, alginate, carrageenan from *Laminaria*, *Gracilaria*, *Macrocystis* are polysaccharides which are found naturally. In contrast to glycoproteins and inorganic sulphate, the sulphate polysaccharides of *Porphyridium* species contain 10 sugars which help to decrease the progression of inflammatory recruitment of immune cells. Polysaccharide improves the immune system of the human being and inhibits the autoxidation of linoleic acid as well as other types of dose-dependent oxidative damage. Exopolysaccharides (EPS) are commonly used as thickening and gelling agents in the food industry. EPS can be said to have numerous pharmaceutical activities (e.g. anti-hyperlipidemia, antioxidant, antibacterial, anticoagulant and antitumor activity). EPS has become well-known for their ability to reduce LDL cholesterol and protect the heart. Its biological effects are very complex, demonstrating antimicrobial, antioxidant, anti-inflammatory activity and preventing the development of certain cancers and the risk of diabetes, neurological disorders and heart disease.

Polysaccharide from *Chlorella* and *Phaeodactylum* protects against. Also, certain raw polysaccharide compounds from *Chlorella pyrenoidosa* prevent tumor. The polysaccharides might have several other health-promoting effects like ulcers, heal wounds and prevent constipation.

The compounds from *Ulva lactuca* have vital applications for treating different illness. *Ulva armoricana* and algae with sulfated polysaccharide compounds has been said to elevate the production of cytokines in intestinal epithelial cells and has immunomodulatory and antimicrobial activity. *Sargassum horneri* with a polysaccharide

named fucoidan, has anti-inflammatory property. *Ulva* have capacity to retain water that makes them useful dietary fibers as they have cell wall polysaccharides which cannot be digested by human beings. *Ulva* have the property of immunostimulator as they improve the host defense against pathogenic fungus *Colletotrichum trifolii* in *Medicago truncatula*. *Ulva* exhibits antiproliferative activity and fight against cancer. *Ulva pertusa* was said to be effective against superoxide radicals than certain vitamins.

Radical scavenging behavior of polysaccharides which are soluble in water of *M. pirifera* and *U. pinnatifida* in midgut has been recommended as functional feed for the improvement of average weight and basic growth. The red algae *Laurencia papillosa* contains a sulphate polysaccharide, is has κ - and λ -carrageenans, depends on antitumor activity towards the breast carcinoma. This property made it possible for it to be used as low cost dietary supplement for daily food intake. A decline in blood toxicity because of the antioxidant activity of polysaccharide had an advantageous effect on vital organs. *Caulerpa cupressoides* has sulfated polysaccharide is used for immunomodulation and thrombosis, with no evidences of mortality Rodrigues et al. Antidepressant and anxiolytic-like effects have been identified in hydrophilic polysaccharides of *Ulva* sp. The genus *Sargassum* has sulphate polysaccharides which has biological properties like anticancer, anticoagulant, antioxidant, antimicrobial, antiviral effects and anti-inflammatory. The polysaccharide acquired from *Sargassum longifolium* brown algae was used for encapsulation with nano-emulsion lipid carrier. This polysaccharide prevented colon cancer. It was reported that ingestion of algae and their polysaccharides regularly will improve health of humans and decrease multiple diseases.

Anti-viral and antimicrobial compounds

Currently, a number of infectious diseases have cropped up which call for experimentation of novel antiviral compounds. Even though several antiviral drugs have been developed, drug-resistance mutations take place, which increases major concerns about the identification of new antiviral molecules with the required properties. Since Microalgae are available abundantly, they have attracted global perspective as source antiviral compounds. *Dunaliella primolecta* with the bioactive compound, pheophorbide exhibits antiviral activity by suppressing the cytopathic effect. Cryptomonad algae with allophycocyanin compounds have significant antiviral activity against Enterovirus. They prevent cytopathogenic effect and slow down viral RNA synthesis. *Gyrodinium impudicum* strain with a homopolysaccharide of galactose with uronic acid and sulphate groups exhibit an impressive activity.

Conclusion

Marine and freshwater ecosystem algae have their ability to generate food ingredients and biologically active compounds since long time Algae contain many exclusive elements, including omega-3 fatty acids, vitamins and minerals. The market for

microalgae nutraceuticals have many roles to play like providing health benefits, they are used in pharmaceutical and cosmetic industries. Their impact for the treatment and protection several diseases should elevate the interest and create research interest that is of particular value to human health. More extensive work into the innovation of new nutritionally functional compounds from microalgae will provide many positive health effects to mankind.

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