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Review Article

ALGAE AS FUTURE DRUGS

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ABSTRACT

Scientists are looking for biologic drugs which are cheaper than the existing drugs. The biologic drugs manufactured in mammalian cell culture or by bacteria or yeasts for treating diseases like diabetes, multiple sclerosis and cancer cost too much. The alternate is green algae, which is abundant, resilient, cheap to grow, and efficient at folding complex proteins.

Keywords: Algea , chlorophyll, antioxidant, anticoagulant.

INTRODUCTION

Algae, the chlorophyll containing organisms known to have more than 20000 species. The multicellular plants growing in salt or fresh water are known as Macro-algae or "seaweeds". Due to their fast growing nature can size up to 60 m in length [1]. Based on their pigmentation they are classified into three broad groups: i) brown seaweed (Phaeophyceae); ii) red seaweed (Rhodophyceae) and iii) green seaweed (Chlorophyceae). The main utilization of seaweeds are in the production of food and the extraction of hydrocolloids. Microalgae are microscopic organisms that grow in salt or fresh water. In terms of abundance the three most important classes of micro-algae are the diatoms (Bacillariophyceae), the green algae (Chlorophyceae), and the golden algae (Chrysophyceae).

Phytoplankton have diatoms as the dominant life form representing the largest group of biomass producers on earth as more than 100,000 species exist. Silica present in the cell walls of diatoms help it to accumulate oils and chrysolaminarin. Green algae abundant in fresh water possess starch as storage compound. The fresh water green algae Haematococcus pluvialis is commercially important as a source for astaxanthin, Chlorella vulgaris as a supplementary food product, and the halophilic algae Dunaliella species as a source of β-carotene. The golden algae are similar to the diatoms and produce oils and carbohydrates. The blue-green algae (cyanobacteria) are found in a variety of habitats and are often known for their toxic water polluting products. In the recent years Algal biomass has emerged as a sustaibale energy source which is economic and environment friendly too [2]

APPLICATIONS

1. Hydrocolloids

Various industrial products are made up from macro algae [3]. *Alginates* from the cell wall of brown algae are polymers composed of D-mannuronic acid and L-guluronic acid monomers are used in food and pharmaceutical industries in the form of stabilizers for emulsions and suspensions [4]. *Carrageenans* from the cell wall of red algae have application in food, textile and pharmaceutical industries.

2.Pharmaceuticals and cosmetics

The micro-algae can produce bioactive compounds like antibiotics, algicides, toxins. A lot of antibiotics have been isolated from algae and show great chemical diversity (fatty acids, bromophenols, tannins, terpenoids, polysaccharides, alcohols). Most of them produce neurotoxic and hepatotoxic compounds [5]. Chlorella and Arthrospira (Spirulina) are used in skin care, sun protection and hair care products [6]. A lot of investigation for potential pharmaceuticals and nutraceuticals from algae has been done and more is still to come [7]. There is a vast possibility that discovery of new metabolites from micro algae is very likely. There is therefore also potential for the discovery and production of high value compounds. Algae is used as a thickening and water-binding agent as well as an antioxidant. As it is rich in vitamins and minerals, algae conditions and hydrates the skin while it nourishes, rejuvenates, detoxifies and replenishes minerals. The important form like Irish moss and carrageenan contain proteins, vitamin A, sugar, starch, vitamin B_1, iron, sodium, phosphorous, magnesium, copper and calcium. They all have industrial applications [8,9].

As anticoagulants, antibiotics, antihypertensive agents, blood cholesterol reducers, dilatory agents, insecticides, and anti-tumorigenic agents. In cosmetics, algae act as thickening agents, water-binding agents, and antioxidants. Some algae are also potential skin irritants. For example, the phycocyanin present in blue-green algae has been suspected of allergenicity and of causing dermatitis on the basis of patch tests (*Current Issues*). Microalgae Chlorella, Astaxhanthin and Spirulina have been found to possess anti-cancer, immune stimulatory, detoxifying, anti-diabetic, anti-inflammatory, antihypertensive and digestive properties [10]. Caulerpin in Red and Green algae control inflammation while sulphated polysaccharide act as pro-inflammatory. The fucodans, sulphated polysaccharide, of brown algae origin is also anti-inflammatory. The versatility of the green algae *Chlamydomonas reinhardtii* analyzed for the utilization in the drug industry. In the study it was found that it produced proteins at very high levels [11].

4. High value oils

Long-chain poly-unsaturated fatty acids (vlcPUFAs) eicosapentaenoic (EPA), docosahexaenoic acid (DHA) and arachidonic acid (AA) known for their nutritional importance. Interestingly the vlcPUFAs in the oil-rich fish originate from marine micro-algae that are eaten by the fish. Algal genes encoding relevant enzymes have been identified and recently several groups have reported progress on using these genes to produce DHA and ARA in transgenic plants, including crops such as soybean, linseed, tobacco and the model species Arabidopsis [12]. By adding additional genes to the ones that are needed to produce ARA and EPA, production of DHA has been established in soybean, Brassica juncea and Arabidopsis [13]. An alternative approach is to use directly the algae that are the most efficient primary producers of the vlcPUFAs.

5. Colourants

Micro-algae produce carotenoids. More than 40 carotene and xanthophylls are well characterized [14,15]. Xanthophyll a lutein has a huge application in the colouration of drugs and cosmetics [16]. Phycobillins or phycobiliproteins as are water soluble pigments have their applications in cell biology as fluorescent markers [17], while the Phycobilins are also used in as colorants for food and cosmetic products like a blue phycobilin from *Arthrospira* is used to colour cosmetics and food [5].

6. Waste water treatment

Use of Macro and micro algae in sequester, for the removal or transformation of pollutants is also known. In the treatment processes algal biomass is produced which has a high utility in the production of chemicals, biofuels or biogas as by-products 18 .The micro-algae are applied in the tertiary treatment of domestic wastewater in maturation ponds, or in small-to-middle scale municipal wastewater treatment systems 19 .

7. Removal of heavy metals

Algal biomass as an inexpensive biomaterial for removal of toxic heavy metals. The use of micro algae for removal of heavy metals from waste water have huge application 20

8. Immobilized algae in production of electricity, hydrogen, ammonia, polysaccharides and glycerol

Different algae taxas are used in the produciton of different materials. *Mastigocladus laminosus*, *Phormidium sp.* are used in the produciton of electricity, *Anabaena azollae , A. cylindrica*, *A. sp.* N-7363, *A. variabilis*, *Chamydomonas reinhardtii*, *Chlorogloea fritschii*, *Gleocapsa olpicola*, *Mastigocladus laminosus*, *M. Laminosus*, *Nostoc muscorum*, *N. muscorum*, *Oscillatoria lemnitica*, *Phormidium laminosum*, *Platymonas subcordiformis*, *Porphyridium pupureum*, *Scenedesmus obliquus*, *Synechocytis sp*. PCC 6803 have been used in the produciton of hydrogen. Anabaena azllae, A. cylindrical, A. sp, A.sp ATCC 27893 in the produciton of ammonia while *Aphanocapsa* MN-11, *A.sp*., *Porphyridiumcruentum* in the produciton of polysaccharide 21 .

9. Food Supplement

As microalgae possess high-quality of natural proteins, lipids, carbohydrates, vitamins, pigments and enzymes contents they can be used as food supplement at commercial levels. Omega-3 fatty acid extracted from algae are used as economical food supplement 22 . The edible seaweeds can be used as food supplement due to low calorie, high concentration of minearls, vitamins and proteins and low fat content 23 . Blue green algae *Spirulina* as rich source of vitamin and minerals is used in food industry 24 . Several algae in red algae category like Porphyra and brown algae are directly cosumed by human beings 25 . Moreover the algae use in animals as food supplement is also a achievement 23,26 .

10. Biodiesel Production from Algae oils

Biodiesel can be produced from algae oils from both microalgae and microalgae. In a study it was found that *Chlorella protothecoides*, and *Cladophora fracta* can be used for biodiesel production 27 . The microalgal biodiesel can be used in place of traditional diesel fuel, it can reduce carbon dioxide upto 78% 28 . Algal Biodiesel is easy in transportation, its use can reduce green house gas emission up to 40%.. Through a review it has been concluded that algal biodiesel has the potential to replace petroleum biodiesel fuel 29 .

11. As Human Food

1. Some red algae, brown algae and green algae, are eaten by humans. Approximately 500 species are eaten by humans, and some 160 are commercially important.
2. The red alga Porphyra is the most important commercial food alga 30 .
3. Palmaria palmata, another red alga, is eaten in the North Atlantic region 31 .
4. Laminaria species (brown algae) is eaten with meat or fish and in soups 32 .
5. The green algae Monostroma and Ulva look like lettuce leaves (their common name is sea lettuce), and they are eaten as salads or in soups, relishes, and meat or fish dishes 32 .
6. The microscopic, freshwater green alga Chlorella is cultivated and eaten in Taiwan, Japan, Malaysia, and the Philippines. It has a high protein content (53–65%) and has been considered as a possible food source during extended space Travel 33 .

11. Texturized vegetable protein

The invention of digestible texturized algal protein, TAP, will ignite the use of algae in foods. TAP, Alnuts, Nostoc or other trade names may be used as a meat replacement or supplement. The extrusion technology changes the structure of the protein and yields a fibrous spongy matrix that is similar in texture to meat. TAP may be presented in a wide variety of traditional food forms such as sushi, diced chicken, turkey, tuna or red meats 34 .

12. HIV Vaccine model

In the recent research it is found that algae-based proteins can inhibit the entry of the HIV virus. HIV vaccine grown in a designer strain of algae may be used with the defective cell wall technique to assure transgenic material does not escape into the environment. The vaccine cost would be lower as the the algal production would be done locally. Instead of extracting the vaccine, people could eat the algae directly and let their bodies metabolize the vaccine. The same process may work for other vaccines such as mumps, measles, malaria, polio, tuberculosis and other preventable illnesses. There are many obstacles to the vaccine scenario, including bioethics, biotechnology and socio-culture issues. However, the simplicity and cost effectiveness of an algae solution would seem to make algae based vaccine model happen sooner rather than later 35 .

13. Personalized Drugs

When markers are developed for personalized diagnosis, scientist will need drugs manufactured specifically to match the genetic needs of each patient and they are likely to need the drugs quickly. Personalized drugs and advanced compounds grown in algae may provide a cost effective solution. Such a production system could produce the designer drugs in days instead of months. While there is a critical global need for micro-algaculture systems, large scale systems are needed too.

14. Food Additives

The cell walls of many types of seaweed contain phycocolloids that have received increasing use in prepared foods. The three major phycocolloids are alginates, agars, and carrageenans. Alginates are extracted primarily from brown seaweeds, and agar and carrageenan are extracted from red seaweeds. Phycocolloids are safely consumed by humans and other animals and are therefore used in a wide variety of prepared foods, such as “ready-mix” cakes, “instant” puddings and pie fillings, and artificial dairy toppings.

1. Alginates, or alginic acids, are commercially extracted from brown seaweeds, especially the kelp Macrocystis, Laminaria, and Ascophyllum. Alginates are used in ice creams to limit ice crystal formation, thereby producing a smooth texture, and are also used as emulsifiers and thickeners in syrups and as fillers in candy bars and salad dressings 36,37 .
2. Agars are extracted primarily from species of the red alga Gelidium, but they are also obtained from other red algae, especially Gracilaria, Pterocladia, Acanthopeltis, and Ahnfeltia. Agars are used in instant pie fillings, canned meats or fish, and bakery icings. Agar is also used as a clarifying agent in beer and wine 38 .
3. Carrageenan, from the Irish word “carraigin” (meaning Irish moss), are extracted from various red algae: Eucheuma in the Philippines, Chondrus crispus in the United States and the Canadian Maritime Provinces, and Iridaea in Chile. Carrageenans are used as thickening and stabilizing agents in dairy products, imitation creams, puddings, syrups, and canned pet foods 39 .

15. Active Additives in Medical Drugs or Insecticides

Phycocolloids have industrial uses in addition to their important roles in food products. Because they are relatively inert and have good gelling properties, they are used as creams and gels for carrying minute amounts of active additives, as in medical drugs or insecticides 40.

1. Agar is used extensively as a bacteriologic culturing substrate in medical and research facilities and is also used as a substrate

for eukaryotic cell and tissue culture, including the culture of algae themselves.

2. Carrageenans are used in the manufacture of shampoos, cosmetics, and Medicines 41.

16. Fertilizer

Seaweeds have been used as agricultural fertilizers for centuries in many parts of the world. Coastal farmers cut seaweeds that were spread over the soil. Kelp is now used to extract macronutrients and micronutrients for specialized plant fertilizers and animal feed supplements. Dried kelp is almost 50% mineral matter; Ascophyllum nodosum, for example, contains 55 trace elements 42 .

17. Industrial Chemicals

Algae are used for production or extraction of some important chemical that have wide industrial values.

1. Iodine can be extracted from brown algae.
2. The green unicellular flagellate Dunaliella is cultivated in saline ponds. The culture conditions are manipulated so that carotene or glycerol is produced in large amounts. These compounds are extracted and sold commercially 43 .

18. Forensic Medicine

Diatoms have been used in forensic medicine. Where death by drowning is suspected, lung tissue is examined. The presence of silica diatom cell walls can verify death by drowning; in mysterious cases, the diatom species can be used to pinpoint the exact location of death because the species are characteristic for a given lake, bog, or bay 44 .

CONCLUSION

The macro and micro algal populations of the aquatic environments provide a vast genetic resource and biodiversity. Scientists are firmed that algae can be utilized in a completely different manner in the drug industry. The therapeutic drugs prepared from algae which subsist on sunlight and carbon dioxide in the air will be manufactured at one-thousandth of today's costs. Hence algae can be an ideal and cost effective substitute. *Chlamydomonas reinhardtii* can be utilized commercially as a robust platform for human therapeutic protein production. The algae based waste water treatment is a powerful tool for sustainable waste water treatment as it can reduce the usage of greater amount of toxic chemicals which are already in use for wastewater treatment. The CO_2 emissions is controlled by the algae bioreactors, the CO_2 emitted can be pumped into an algae feeded tank or pond. Algae in capturing the fertilizers in runoff from farms is also a great area of research. Scientists are working to produce micro algal biodiesel at commercial level.

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