DIVERSE APPLICATIONS OF ALGAE

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ABSTRACT

Living system on earth comprises of plants and animals. Plants are everywhere. They are primary producers which is a source of many nutrients. Algae are a very large and diverse group of autotrophic organisms which ranges from unicellular to multicellular forms with high protein content. At the same time, algae are important producers of vitamins, minerals and fatty acids also. Many species of algae find their applications in food, dairy, pharmaceutical, cosmetics and industry. Certain beverages are prepared from sea algae. Mainly marine algae have been used as food and medicine for many centuries. Algae is not only used as food but also used as extracts in food, dairy, cosmetics, and industrial uses. Edible algae are recognized as complete foods which provide correct balance of proteins, carbohydrates, vitamins, and minerals. The importance of investigating new options offered by algae cultivation is motivated by the fact that algae are very efficient at converting light, water and carbon dioxide (CO_2) into biomass in a system that does not necessarily require agricultural land. Therapeutic properties of algae is used for promotion of health .Algae is used as one of important medical source due to its antioxidant, anticancer, antiviral properties. Scientists are looking for biologic drugs which are cheaper than the existing chemical 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. Various industrial products are made up from macro algae also. They can act as antibiotics, antihypertensive agents, and cholesterol reducers in blood, dilatory agents, anticoagulants, insecticides, and anti-tumorigenic agents. In cosmetics, the role of algae is as water-binding agents, thickening agents, and antioxidants. Some algae are also potential skin irritants. Most algae do not have lignin associated to the cellulose of the plant cell wall, so the cellulose extraction is easier, less expensive and produces microcrystalline cellulose with chemical properties that can optimize the use of traditional cellulose in some applications as paper production, cosmetics, medicines and membrane filtration.

Keywords: Algae, Biomass, Cellulose, Food, Medicines, Nutrients.

I INTRODUCTION

With the development of our society, in the entire dimension, there has been an increase in the demand of fuel for fulfilling the energy requirements. To fulfil this need, our dependence on the fossil fuels has increased and this is resulting in a significant decline in the quality of these fossil fuels. The other non-conventional energies like solar-, wind, tide energy etc. require expensive equipment to make them usable. Hence, we have an urgent need to find an

alternative to this problem. One of the substituent to fossil fuel and nonconventional energy resources is "ALGAE". Algae are proving themself to be a potential energy generator, and besides energy production, it can be used in a number of different ways. It can be used as a food product and food additive, animal and fish feed, in cosmetics, medicines etc. Besides thus, algae have many benefits linked to it.

II ADVANTAGES OF USING ALGAE

Algae is proving itself to be one of the most promising and long term source of food, animal feed, medicines, cosmetics other co-products and most importantly oil for fuel. They are found in a large number and have a wide variety of benefits associated with them which makes them so attractive. Algae have evolved over billions of years to produce and store energy in the form of oil. It is done more efficiently than any other process, be it natural or engineered. [1]

a. Growth rate of Algae is high.

Number of algae is doubled every few hours, can be grown daily and the biomass and biofuel produced is many times greater than any of our most productive crop

b. High yields of Biofuel

Energy in algae is stored in Algae in form of oils and carbohydrates which when multiplied with its number give us a very large amount.

c. Consumes CO_2

Since algae are plant, it absorbs CO_2 and releases O_2 as it grows. More the amount of CO_2 , more is its productivity.

d. No competition with Agriculture

Algae can be grown anywhere, i.e. on the land which is not suitable for the production of other crops, water sources such as seawater, waste water etc. which are not suitable for other crops.

e. Wastewater can be purified

Algae can be grown in nutrient-rich waters like municipal waste waters (sewage), animal wastes and some industrial effluents, while purifying these wastes at the same time and producing a biomass suitable for biofuel productions.

f. Biomass used as Energy Source

The biomass which is left after the extraction of oil is pelletized and then used in industrial boilers and power generation houses as a fuel

g. Produces industrially useful products

Plastics, chemicals, feedstock, lubricants, fertilizers, cosmetics, and many other products can also be produced using algae.

h. Biomass used as feed and food also

Algae in addition to fuel can be used as an animal feed and the biomass remaining can be also used as a food supplement.

i. Job creating Industry

Algae can be grown in a variety of ways using a variety of methods, which will create a large number of jobs ranging from research to engineering, construction to farming, from marketing to financial services

III APPLICATIONS

3.1Biofuel

Because of the high oil content and rapid biomass production, Algae has been recognised as a potentially good source of biofuel production. There are a no. of methods for the production of biofuel using algae.

3.1.1 Biodiesel

Algae can potentially contain over 80% total lipids. However, if the production is under normal conditions then the lipid concentration is low (less than 40%) and high oil content is always associated with very low yields. Under stress conditions like insufficient nitrogen availability, the production of various lipids can be stimulated. But due to this the non-lipid part of the biomass is reduced which can be used as a source for other co-products.[2]

3.1.2 Hydrocarbons

Some algae like, *Botryococcus*, does not produce lipids, instead it produces long chained hydrocarbons, unsuitable for diesel production. They can be converted to hydrocarbon chain suitable for diesel production by similar process by which conventional fuels are derived from fossil fuels.

3.1.3 Ethanol

It is generally produced by feedstock containing starch. Polysaccharides present in the algal cell wall could be used as a feedstock in a process similar to cellulosic ethanol production. It has an extra advantage as lignin is rarely found in algae. Also the polysaccharides generally breakdown easily as compared to the woody biomass. [3]

3.1.4 Biogas

When wet biomass undergoes anaerobic digestion than the organic matter is converted to biogas containing 60-70%biomethane and rest CO_2. It has many advantages like, CO_2 produced can be fed back to algae, no need of drying as the process uses wet biomass, nutrients present in digested biomass can be recovered from liquid and solid phase.

3.1.5 Thermochemical Treatment

Under very high pressure and temperature, biomass undergoes a chemical conversion. It ends up in a raw gaseous, liquid or solid phase, depending on the content of water and the extreme conditions applied, which can be upgraded to use as a biofuel. But the energy intake in this process is high in comparison to the production of biogas.[4]

3.1.6 Hydrogen

Hydrogen gas is produced by some algae by manipulating it. But the yield is low as the cells loses energy during formation of hydrogen, due to which less biomass is produced and hence lesser co-production.

3.1.7 Bioelectricity

It can be used for combustion in power plants, but it requires a lot of energy as it needs to be dried before combustion.

3.2 Cosmetics

Algae have natural anti-cellulite and anti-ageing properties. It helps in increasing the elasticity and suppleness of the skins and also stimulates the renewal of damaged skin cells. It can detoxify and cleanse and tone the skin. It increases the lusture of hair, has a moisturizing and softening effect on hair. It forms a gel on reacting with

proteins, which has a moisturizing effect on the skin and softens skin and can produce soothing face packs and masks. It has been known long for its anti-inflammatory and tissue renewal properties which can have a positive effect on problems such as facial wrinkles. It has hydrating properties and forms a protective layer on the skin thus acts as a moisturiser and reduces loss of skin moisture through evaporation.[5]

Algal Specie (Common Name)	Chemical Name	Type	Properties and produc
Bladderwrack	Fucusvesiculosus	Brown algae	Anti-Aging, Anti-inflammatory, Nutritive, Softens Skin, Hair Shine, Skin Firming, Healing, Skin Elasticity, Skin Soothing
Dulse	Palmariapalmata	Red algae	Cleansing, Toning, Skin Soothing, Nutritive, Healing, Anti-Cellulite
Irish Moss	Chondruscrispus	Red algae	Emollient, Moisturizing, Sheaths damaged or dry hair, Nutritive, Skin Soothing, Anti- Inflammatory
Kelp/Kombu	Macrocystispyrifera	Brown algae	Anti-Inflammatory, Nutritive, Skin Elasticity, Healing, Skin Softening, Moisturizing
Laminaria	Porphyraumbilicalis	Brown Algae	De-Toxification, Revitalizing and Firming for Skin, Purifying, Nutritive, Anti-Cellulite
Nori/Laver	Porphyraumbilicalis	Red algae	Stimulates Hair Growth, Strengthens Hair, Nutritive, Moisturizing
Sea Lettuce	Ulvalactuca	Green algae	Antioxidant, Anti-Inflammatory, Skin Elasticity, Collagen Synthesis, Anti-Wrinkle, Emollient, Moisturizing
Sea Palm	Postelsiapalmaeformis	Brown algae	Skin Softening, Anti-Wrinkle, Nourishing, Moisturizing, Anti-Inflammatory, Antiseptic, Hair Shine

Spirulina	Spirulina maxima	Blue algae	Anti aging, Anti-Wrinkle, Collagen Synthesis, Anti-Inflammatory, Nourishing
Wakame	Undariapinnatifida	Brown algae	Antioxidant, Skin revitalizing, Anti Wrinkle, Moisturizing, Skin Smoothing, Sunscreen, Anti-Obesity

3.3 Fertilizers

From ancient time, Algae has been used as a fertilizer in many parts of the world. Algae have a high mineral content and have a property to help increase the water binding capacity of soil. It is capable of fixing atmospheric nitrogen and thus can be used to make bio fertilizers. Algae can be grown simultaneously with the other crops and it will provide the crops with the most basic and important element to grow, that is, nitrogen. Also, plants fertilized with algae resists diseases and attacks by insects. Moreover algae maintain and build up the soil fertility thus increasing the yield. It also improves the physio-chemical properties, helps in gradual build-up of nitrogen and carbon in soil, and improves the pH and the electrical conductivity. There is also an improvement in the grain quality.

Blue green algae belonging to genera Nostoc, Anabaena, Tolypothrix and Aulosira fix atmospheric nitrogen.[6]

3.4 Health Food and Pharmaceuticals

Medicines, vitamins, vaccines, nutraceuticals, and other nutrients which when made using animals or plants are very expensive. All these can be produced using algae. Many types of algae and the products derived from them have shown medicinal values and nutritional applications.[7,8]

3.4.1 Pigments

There is a variety of pigments present in microalgae which are associated to light incidence. Some of the most important pigments are

3.4.1.1 Chlorophyll

The primary photosynthetic compound

3.4.1.2 Phycobiliproteins

Improves the efficiency of light energy utilization

3.4.1.3 Carotenoids

Protects algae against the solar radiations and their adverse effects

3.4.1.3.1 β-Cartene

Used as a vitamin A precursor

3.4.1.3.2 Lutein, Zexantin and Canthaxantin

Used in Chicken skin coloration and also for other pharmaceutical purposes

3.4.1.3.3 Astaxanthin

Used in aquaculture to provide fishes like salmon its natural red colour.

Natural food colorant in juices, chewing gum, ice sorbets, candies, soft drinks, dairy products etc. also uses pigments from algae.[9]

3.4.2 Polyunsaturated Fatty Acids(PUFAs)

These are important nutrients which cannot be produced by the organisms itself and thus is supplied to the body externally. Omega-3 fatty acids are the well-known PUFAs and are usually obtained from the fish oil. But fishes cannot produce PUFAs, these get accumulated in their body when they eat algae and hence algae are their true sources. In present time, PUFAs are directly being produced by algae with advantages of not having the unpleasant fish odour, is easily purified and in a better way, and the risk of contamination and reaction is also reduced.

PUFAs are important for our body as they help in fighting many diseases like cardiovascular diseases, reduce obesity, regulate membrane fluidity, and also regulate oxygen transport and improve thermal adaption ability.

3.4.3 Other Bioactive Algal Products

3.4.3.1 β-1,3-glucan, an active immune stimulator, is the most important algal compound from a medical point of view. It is a free radical scavenger and also a blood lipid reducer. It can be used against gastric ulcers, wounds and constipation. It prevents action against atherosclerosis, hypercholesterolemia and also shows anti-tumor action. It is very efficient in performing the mentioned.

3.4.3.2 Microalgae is a source which provides almost all essential vitamins,that is, A, B1, B2, B6, B12, C, E, nicotinate, biotin, folic acid and panthothenic acid.

3.4.3.3 Sulfated Polysaccharides of microalgae is effectively used for anti-adhesive therapies against bacterial infections for both warm and cold blooded animals.

3.5 Aquaculture Feed

3.5.1 Bivalves, Shrimps and some finfish cultures has an essential requirement for microalgae in the processes of hatchery and nursery.

3.5.2 Zooplanktons, which are served to freshly hatched carnivorous fish, require microalgae for their production.

3.5.3 The red characteristic color of wild salmon’s and trout’s muscles is acquired by them when they eat green algae, which is not so in cultured fishes, thus reducing market value. Astaxanthin can be added to the feed of cultured fishes which provides them their characteristic red colour.[10]

3.6 Food Additives

There has been an increased use of phycocolloids in prepared foods. The major phycocolloids are

3.6.1 Agar

It is obtained from different species of red algae and usually from algae Gelidium. It has a wide range of applications

3.6.1.1 Food Products

3.6.1.1.1 Frozen foods

3.6.1.1.2 Bakery icings
3.6.1.1.3 Meringues
3.6.1.1.4 Dessert gels
3.6.1.1.5 Candies
3.6.1.1.6 Fruit juices
3.6.1.2 Other Applications
3.6.1.2.1 Industry Uses
3.6.1.2.1.1 Paper sizing/coating
3.6.1.2.1.2 Adhesives
3.6.1.2.1.3 Textile printing
3.6.1.2.1.4 Casting
3.6.1.2.1.5 Impressions
3.6.1.2.2 Biological Culture Media
3.6.1.2.3 Medical/Pharmaceuticals
3.6.1.2.3.1 Bulking agents
3.6.1.2.3.2 Laxatives
3.6.1.2.3.3 Suppositories
3.6.1.2.3.4 Capsules
3.6.1.2.3.5 Tablets
3.6.1.2.3.6 Anticoagulants

3.6.2 Alginates

It is extracted from brown weeds (especially Macrocystis, Laminaria, and Ascophyllum) and is better known as Alginic acids. It has applications in textile industry for cotton yarn sizing. Food and pharmaceutical industry also uses Alginates in ice cream making for smooth texture and prevention of ice formation (because of its chelating ability to form highly viscous solution), as emulsifiersand thickeners in syrups, and in candies and salad dressing as fillers. It is technologically also very important mainly because of its gelling properties.

3.6.3 Carrageenan

It is a group of water soluble polysaccharides and is used as emulsifiers and stabilizers in numerous foods more widely than agar. It is extracted from different red algae found in different places of the world (Eucheuma in the Philippines, Chondruscrispus in the United States and the Canadian Maritime Provinces, and Iridaea in Chile). Chocolate milk, ice cream, evaporated milk, puddings, jellies, jams, salad dressings, dessert gels, meat products and pet foods, especially uses κ - and ι- carrageenans mainly due to their thickening and suspension properties. It can also be used for pharmaceuticals like antitumor, antiviral, anti-coagulant and also for immunomodulation activities.

3.7 Food

For hundreds of years, green micro-algae have been used in Asiatic Countries as nutritional supplement or food product. Algae is a rich source of carbohydrates, protein, enzymes and fiber and many vitamins and minerals like

vitamin A, C, B1, B2, B6, niacin, iodine, potassium, iron, magnesium and calcium. Thus, it is presently used as a major source of food throughout the world and especially in Asian countries like China, Japan and Korea.[11],[12] There are approximately 500 species which are eaten by humans. Laminaria species (brown algae) are eaten with meat or fish and in soups. The green algae Monostroma and Ulva which look like lettuce leaves are eaten as salads or in soups, relishes, and meat or fish dishes.

IV CONCLUSION

With so many advantages linked to it, algae can prove to be one of the most used source for energy generation, and for the production of other products like cosmetics, food additives, nutraceuticals, as a food product itself, fertilizers, purifiers and many more. Use of algae should be encouraged. It will not only help us in making an ecofriendly environment but also will create a lot of jobs in almost all the sectors. Production of Algae is also not a typical task, and while growing, it will solve other environmental problems like purification of water, emission of large amount of CO_2, proper usage of barren land and many more.

REFERENCES

[1] K. Sudhakar, and M. Premalatha, "Micro-algal Technology for Sustainable Energy Production:State of the Art" *Journal of Sustainable Energy & Environment 3 (2012) 59-62*

[2]Melinda J Griffiths, Reay G Dicks, Christine Richardson and Susan TL Harrison, "Advantages and Challenges of Microalgae as a Source of Oil for Biodiesel",*Biodiesel – Feedstocksand ProcessingTechnologies,Pg. 178-200*

[3] N.R. Moheimani , J.P. Webb, M.A. Borowitzka, "Bioremediation and other potential applications of coccolithophorid algae: A review",*Algal Research 1 (2012) 120–133*

[4] Karina H.M. Cardozo, Thais Guaratini, Marcelo P. Barros, Vanessa R. Falcão, Angela P. Tonon, Norberto P. Lopes, Sara Campos, Moacir A. Torres,Anderson O. Souza, PioColepicolo , Ernani Pinto , "Metabolites from algae with economical impact", *Comparative Biochemistry and Physiology, Part C 146 (2007) 60–78*

[5] Yang H, Lee E, et al. *Spirulinaplatensis* inhibits anaphylactic reaction. *Life Sci. 1997;61(13):1237-1244*.

[6] Indira Priyadarshani and BiswajitRath, "Commercial and industrial applications of micro algae – A review", *J. Algal Biomass Utln. 2012, 3 (4): 89–10*

[7]http://aqua.ucdavis.edu/DatabaseRoot/pdf/WRAC104.PDF

[8] http://www.algaeindustrymagazine.com/algae-fertilizer-in-development-by-odu-and-np

[9]http://www.algaeindustrymagazine.com/researchers-examining-fertilizers-for-algae-biofuels

[10] Jin-Ching Lee1 , Ming-Feng Hou2,3,4, Hurng-Wern Huang5 , Fang-Rong Chang6 , Chi-Chen Yeh6 , Jen-Yang Tang4,7,8* and Hsueh-Wei Chang, "Marine algal natural products with anti-oxidative, anti-inflammatory, and anti-cancer properties", Lee et al. Cancer Cell International 2013, 13:55

[11] Michael A. Borowitzka, "Pharmaceuticals from Algae", Encyclopedia of Life Support Systems, BIOTECHNOLOGY- Vol. VII Pg. 1-5

[12]http://files.rushim.ru/books/biochemie/bioactive-marine-natural-products.pdf