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Review Article

Microalgae and its Potential to Touch Everyone's Life

Ronak Chhaya* and Debabrata Sarkar

Research and Development, Microalgae Solutions India Pvt. Ltd. (Wholly Owned Subsidiary of Alga Energy, Spain), India

***Corresponding Author:** Ronak Chhaya, Research and Development, Microalgae Solutions India Pvt. Ltd. (Wholly Owned Subsidiary of Alga Energy, Spain), India.

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Abstract

Microalgae have in recent times fascinated substantial attention worldwide, due to their massive application potential in the agriculture, animal nutrition, aqua culture, renewable energy, biopharmaceutical, and nutraceutical industries. For growth, microalgae utilize nitrates and phosphates from municipal wastewater and other industries. Microalgae have been consumed by humans since thousands of years. Microalgae are not fully studied crop to produce dietary foods. Microalgae can cultivate easily with limited resources as compared to the traditional crops and produce more yield compared to terrestrial crops. The enervation of renewable source of energy and wastewater treatment are one of the concerning issues for the growing population. Microalgae are wealthy supply of supermolecules called protein and bio-active components, provided one more health benefit. Microalgae has been constructed with an emerging next generation group of unicellular photosynthetic organisms with the ability to handle immediate industrial and agricultural challenges. The tremendous organic variety of microalgae may be leveraged to supply a large quantity of natural or genetically modified precious biomolecules. Microalgae moreover own a fixed of intrinsic advantages, along with low manufacturing costs, very little requirement for arable land, and fast cultivation capacity in both outside structure and with fully controlled photobioreactors. Microalgae have a sizable capacity to transform atmospheric carbon dioxide to valuable commodities such as lipids, carbohydrates, and other biologically active metabolites. The present review describes the potential use of microalgae for agricultural applications, human nutrition, animal nutrition and aqua cultures.

Keywords: Microalgae; Agriculture; Human Nutrition; Animal Nutrition; Aqua Culture

Abbreviations

CO_2: Carbon Dioxide; PUFAs: Polyunsaturated Fatty Acids; Ha: Hectare; %: Percentage; $: US Doller; PBs: Plant Bio Stimulants; N: Nitrogen; P: Phosphorus; K: Potash; Spp: Species

Introduction

Innovative farming has adapted maximum use of chemical fertilizers, which have affected ecological balance and caused environmental pollution due to loss of soil fertility and sustainability. Microalgae as biofertilizer have been identified as great substitutes to pesticides for improving soil fertility. Microalgae produces various plant pathogen inhibitors such as phytohormones, micosporine, antioxidants and carotenoids. The pollutants like nitrates, phosphates, heavy metals from agricultural, industrial, and municipal wastewaters are one of the most critical and common environmental problems in the main developing countries. The excessive presence of pollutants, particularly nitrogen and phosphorus, causes ecosystem problems and subsequent eutrophication of waterbodies, producing alteration of water system health [1]. Due to expensive production process of animal feedstuff, alternative resources for economical high-quality ingredients are desired to meet the growing demands. Usually, microalgae have been used as a sustainable resource for human, animal, and poultry nutritional supplementation due to their various nutritional diversification, i.e., essential fatty acids, carbohydrates, vitamins, carotenoids, and amino acids [2]. So far, microalgae have found various industrial applications: successful examples include food formulation, feed, health products, cosmetics, and fertilizers, as well as tools for wastewater treatment and biofuel production [3]. Nevertheless, most expertise research results have not reached commercial level due to constraints including: (i) production at a non-competitive cost, equated to alternative products obtained both by chemical synthesis, and directly resulting from metabolism by other micro-organisms or even extracts from raw materials fossils; (ii) small market size; and (iii) stricter regulatory constraints in terms of quality specifications, guarantee of safety and minimization of environmental impact [4]. Microalgae can be appeared as a promising meals or feed ingredient, thanks to their dietary characteristics [5]— a trait enormously dependent upon microalga very own composition, and quantity thereof withinside the food intake. Furthermore, said nutritional compounds depend on the species used and the expected growth conditions, in terms of nutritional, luminosity and temperature profile. A varied spectrum of biologically active molecules has been found in microalgae biomass, in the form of proteins, polyunsaturated fatty acids (PUFAs), pigments, vitamins and minerals, or as oligosaccharides [6]. Furthermore, the industrial use of acidic microalgae in food formulation has encountered several challenges and new or improved processing techniques are still needed to reduce production costs [7]. The application of microalgae as feed supplement is presently being accomplished in many Asian nations [8]. With respect to the prospects, microalgal food seems to be the most proficiently available food supplement these days accounting for a huge and hastily increasing market. Indeed, the chemical pattern of microalgae is an intricate combination of minerals and vitamins presenting an immense range of reachable programs uses for dietary residences to antioxidants and anti-aging, in addition think about the preventive effects. In different words, case of microalgae area looks in nutraceuticals. Not long ago, algae have become the latest viable source aimed to produce biofuels as it exhibits several interesting characteristics. Microalgae can produce oil all year round. The productivity of microalgae is higher than that of conventional cultures. The oil content of the microalgae which varied from 20 to 50% is higher than that of other competitors; microalgae produce 15 to 300 times more oil for biodiesel production than traditional crops depending on the area. Creation of biodiesel from non-toxic and highly biodegradable algae lipids. Microalgae can spread at high speeds, which can be fifty times faster than the fastest growing terrestrial culture. They can complete their growth cycle in a few days thanks to the process of photosynthesis, which converts solar energy into chemical energy. Microalgae have the higher photon conversion proficiency against terrestrial plants. Microalgae do not fight for territory in conjunction with food crops [9].

Microalgae in agriculture

Plant bio stimulants (PBs) can play a pivotal role in tackling sustainability disputes because they can decrease addiction on fertilizers, especially on off-farm chemical responses. Furthermore, PBs are also useful to enhance yield and its stability under ecological anxiety [10]. Microalgae are multifunctional. They are efficient of generating biomass that can be exploited for fuel, food, animal feed, and fertilizers. Microalgae own *the* capability *to have* a main have an impact on vital atmosphere *services* seeing that *they (i)* may be *cultivated in wastewater and agricultural runoff,* improving extra vitamins *and reclaiming water for* in addition *use, and (ii) can sequester carbon dioxide and nitrous oxides from* commercial *sources, reducing greenhouse* fuel line *emissions* [11]. Though, the production of microalgae must overcome several obstacles to become economically viable, especially to produce biofuels. The cell extracts and growth medium of several species of microalgae have been shown to contain phytohormones (gibberellins, auxins and cytokinin), which are known to play a crucial role in plant development [12]. Research paper using both the application of the growth medium, and the cell extracts of various algae species have shown a clear effect on plant development with the application of the algae extracts and the algae growth medium [13]. Microalgae biomass appeared to have micro- and macronutrients, especially N, P, and K, and might be deemed as an organic slow-release fertilizer. Assessment of Arthrospira spp. dry biomass exposed that it encompasses 6.70, 2.47 and 1.14% on dry base of N, P and K, individually [14], while, the calcium (Ca) matter in the microalga is relatively lesser than the other mineral deposits [15]. In supplement, some surveys discovered that lead (Pb) is totally lacking in *Arthrospira* spp. biomass, which is a good sign for the safe use of Arthrospira spp. as a plant growth promoter [16]. Still, microalgae are also used in the bioremediation of wastewater due to their ability to concentrate heavy metals. The extracellular and intracellular linked with metal assimilation are difficult, and affected by microalgal species, metal ions and the growing system environments such as pH [17]. Mehta and Gaur [18] reported that complexation and microprecipitation are the most important mechanisms to avoid heavy metal toxicity used by microalgae. Hence, when microalgae are grown in wastewater, an accurate chemical analysis to detect the presence of heavy metal is fundamental in obtaining safe MBS and MBF. Protein hydrolysates are also incorporated as the active elements of PBs [19], and their use in a foliar spray application might improve the biological activity in crops growth. Microalgae comprise several types of amino acids which help mitigate damage caused by abiotic stress and provide positive effects on plant growth and crop yield [20]. Irrevocably, microalgae can encompass polysaccharides (such as β-glucan) that are stated to be involved in the development of plant growth [21].

These compounds seem to interact with leucine-rich repeat membrane receptors that can activate mechanisms leading to the regulation of several genes involved in the cell expansion [22]. Phytohormones, including auxins, cytokinins, abscisic acid, ethylene and gibberellins, were found in microalgal extracts, which are known to influence plant growth and development [23]. Microalgal extracts, containing phytohormones, might be a new prospect of phytohormone applications in crop productions, increasing opportunities of microalgae valorization [24]. Phytohormones are tiny chemical envoys to regulate cellular activities and can influence metabolic activities like respiration, photosynthesis, nucleic acid synthesis and uptake of nutrient. Both auxins and cytokinin is involved in several aspects of plant growth and development. Auxins are involved in phototropism and gravitropism, root growth and development, cell division, elongation, and turgor pressure. Cytokinin is involved in root and shoot development, leaf senescence, nutrient mobilization, breaking of bud dormancy, seed germination and they also play a fundamental role in cell division [25].

Microalgae for human nutrition

The application of microalgae for food purposes has been well established for hundreds of years. Nevertheless, the business cultivation of microalgae for biomass started solely sixty years ago, e.g., Spirulina was made in early 1960s, additionally the production of *Arthrospira*, *Dunaliella salina*, and the cultivation of *Haematococcus pluvialis was developed within* the Israel, USA, China, Australia and Thailand in the 1980s [26]. Interest in whole-biomass products, commercially called "super foods", are attributed to reports of high macromolecule content, alimentary value, and health advantages [27]. *Arthrospira is* marketed as a supply of high-quality protein, γ-linolenic acid, and pigment content. *Arthrospira is also rumored to exhibit antiviral, anticancer, antioxidant, and anti-inflammatory properties among alternative effects* [28]. chlorophyte within the genus Chlorella have been publicized as providing a "growth factor", that may be a soluble extract composed of a range of substances, as well as nucleic acids, amino acids, vitamins, minerals, polysaccharides, glycoproteins, and β-glucans [29]. Extracts from Chlorella have incontestible several useful properties, cherish lowering steroid alcohol similarly as antioxidant, antibacterial, and antineoplastic activities [30].

Microalgal proteins are studies to have a similar amount of protein compared to the traditional sources like egg, meat, milk and soybean. However, extraction of protein from microalgae has various benefits in terms of nutritional value, efficiency and productivity. The protein harvest from microalgae is testified at 4–15 tons/Ha/year compared to terrestrial crops production of 1.1 tons/Ha/year, 1–2 tons/Ha/year and 0.6–1.2 tons/Ha/year for pulse legumes, wheat, and soybean individually [31]. Animal protein supplies utilize 100 times more water balanced to plant sources for equal protein extraction. Additionally, marine microalgae can be cultivated without freshwater and arable land further maximizing the resources required for additional terrestrial food crops production. Moreover, due to the severe extreme environmental conditions and phototrophic mode of growth, microalgae are exposed to free-radical and high oxidative stresses. This has evolved the microalgae in developing natural protective system such as production of antioxidants and pigments (for example chlorophylls, carotenes *and phycobiliproteins). These components are useful for human supplementation as they are not synthesized internally by individuals.*

Microalgae for animal nutrition

Meat making through livestock conservation is another agriculture field that promotes drastically to universal food creation. Economic development triggered human population to move to metropolitan areas and affected a change in food style that involves more of Non vegetarians. Vegans make only a little percentage of the global human population and hence the meat market is getting higher at a permanent cost [32]. Spirulina has been recurrently used in feed supplements due to its excellent nutrient compounds and digestibility with a very small amount of carbohydrates. Another useful product, livestock feed may be obtained from the biochemically examined algae to evaluate their appropriateness as an alternative or primary livestock feed [33]. Spirulina has an exclusive merger of nutrients covering nutrients that include beta-carotene, vitamin E, trace elements and a quantity of uncharted bioactive compounds [34]. *Spirulina sp. can be cultivated in high saline water, and in alkaline conditions which give an improvement to serve as a feedstock for livestock feed* [35]. Newly, research regarding growth and mass conformation reactions of genetically divergent Australian sheep to Spirulina (*Arthrospira platensis*) supplementation discovered that boost live weight, growth, and physique configuration substantially [36]. Feeding lipid-encapsulated algae additions may increase n-3 content in milk fat without unfavorably affecting milk fat yield [37]. Habitually, microalgae have been used as a natural resource for local livestock, poultry and aquaculture production due to their varied dietary profiles. Research has shown that blending a small portion of traditional feed with microalgae can positively affect the progress, physical condition, overall animal structure and product characteristic and size. Besides, it was quantified that microalgae feed-supplement offerings cholesterol-lowering effect in animals and advances immune response. Also, augments milk superiority and production profit in cows [38], endorses animal growth and rallies egg and meat eminence [39]. Microalgae bargains confrontation to illness concluded antiviral and antibacterial feat [40], recovers gut function [41], deepens the establishment of probiotic flora [42] and upsurges feed exchange [43]. Moreover, it was recently evidenced that algae feed surges reproductive performance and assists in weight control [44]. Therefore, the enriched microalgae can be used as a dietary supplement to improve the quality of their meat, eggs and dairy products which will deliver multiple health gains such as anti-cancer, antioxidant and antivirals for humans while ingested [45].

Microalgae for aqua culture

Claim for fish for human intake has soared due to the ecological concerns over Open Ocean fishing [46]. The global market for fish and aquatic edible plants was valued in 2008 at US$106 billion. Manufactured goods from fisheries and aquaculture united are supplying the world with 142 million tonnes of protein each time. Bestowing to additional statement by United Nations Food and Agriculture Organization, in the last three periods, world food fish production of aquaculture has augmented by nearly twelve times, at an typical annual rate of 8.8% and the world aquaculture production attained another all-time high in 2010 at 60 million tonnes (excluding aquatic plants and non-food products), with an estimated total value of US$119 billion. Non-toxic marine microalgae as well as various diatoms, correspond to the primary food source at some phases in the life cycle of highly cultured marine animals [47]. Consequently, algal biomass will be in high demand for the fish-food and aquaculture markets in the future and provide plentiful returns for the algae business [46]. One of the challenges in fish nutrition is to generate end products high in long-chain omega-3 fatty acids that are healthy for the consumer, while reducing the use of oils of fish. Omega-3 oils have a strong market demand in the human nutraceutical and animal feed sectors. This growing trend is an additional driver for the commercialization of non-marine omega-3 oils and alternative nutritional ingredients. Seaweed is a rich source of high-quality protein, vitamins, micronutrients (trace elements) and carotenoids, long-chain PUFAs, especially the n-3 and n-6 series such as eicosapentaenoic acid (EPA), docosahexaenoic acid (DHA) and arachidonic acid (AA) are considered pharmacologically important for dietetics and therapy [48]. Seaweed meal is a rich source of high-quality protein, vitamins, micronutrients (trace elements) and carotenoids, which can be used directly in aquatic foods. Furthermore, better weight to growth ratio and protein efficiency of tilapia were observed when fed with seaweed as a nutrient source in the diet. Furthermore, *Phorphidium valderianum has been successfully used as a feed for aquaculture (based on its nutritional performance and non-toxic properties)* [49]. The diatom *Thalassiosira pseudonana is widely cultured to feed a variety of mollusks, including the Pacific oyster Crassostrea gigas and scallops* [47]. Long-chain PUFAs are very susceptible to oxidation due to their unsaturated nature; adding natural antioxidants to extremely unsaturated fish oil can protect it from oxidation [50].

Conclusion

The universal demand for food, combined with the need to develop biotechnology that respects the environment, calls for the implementation of sustainable production models that consider social, environmental, and economic factors, which allow Fighting hunger and poverty, in the context of climate change, is a present and future challenge for the world. In this regard, research and production projects carried out in several countries have shown that the use of microalgae in human and animal nutrition, as well as in plant fertilization, offers multiple nutritional, economic and environmental advantages. Most of those biomolecules don't seem to be made in the animal/human body however termed as essential; therefore, it's extremely suggested to form these biomolecules obtainable for food and feed purposes. though the assembly of biomolecules from alga needs some awareness concerning technology and market price at the economic and farmer level, it's been evidenced that these biomolecules may be produced mistreatment algae as a possible supply at small or massive scale. The challenging market of those biomolecules is sort of convincing to stimulate analysis interests resulting in production programs by the connected organizations. Microalga culturing got attention owing to its biofuel manufacturing characteristics however the notice concerning cultivation technologies may cause set trends for biomolecule production as a pharmaceutical or organic process product. the assembly of biomolecules from algae and their consequent utilization in animal and cultivation feed may support the objectives to ascertain business from microalgae at national or modern scale. Several biomolecules may be made as a derivative whereas producing biofuel from algae as a key directed produce. 82% of the globe fish stocks are overexploited, depleted or endangered, whereas demand for fish macromolecule is exploding. As the world's population is expected to reach nine billion by 2050, demand for important sources of protein continues to outstrip supply.

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