EXPLORING ALGAE: BIODIESEL PRODUCTION STUDIES

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ABSTRACT

Microalgae have garnered significant global interest due to their vast application potential in the renewable energy, biopharmaceutical, and nutraceutical industries. They serve as renewable, sustainable, and economical sources of biofuels, bioactive medicinal products, and food ingredients. Biodiesel, derived from renewable resources, has become popular for its positive environmental impact. However, the high cost of biodiesel remains a primary obstacle to its commercialization. To reduce this cost, strategies such as utilizing spent cooking oils as raw materials, adopting a continuous transesterification process, and recovering high-grade glycerol from biodiesel by-products are essential. One of the major challenges of the 21st century is to secure an ecological source of transport fuels. Biofuel production based on feedstock obtained from arable land increases food prices and leads to environmental degradation. In contrast, algae present a neutral alternative in many respects, as they can be sourced from polluted water reservoirs. Eutrophication of water bodies, a sign of environmental degradation, results in an increase in algae. Algae accumulating on the shores can be harvested and used as raw material for producing biofuels such as biogas, bioethanol, and biodiesel.

KEY WORDS: Microalgae, renewable energy, biodiesel, bioethanol, Biogas.

INTRODUCTION OF MICROALGAE

Algae encompass a diverse group of unicellular and multicellular organisms, defined by their morphological and ecological characteristics, and play a crucial role as primary producers in aquatic environments[1]. Renewable biofuels are essential to replace petroleum-derived transport fuels, which are limited in availability and contribute to global warming. Among the renewable fuels, biodiesel and bioethanol have attracted significant attention. However, biodiesel and bioethanol produced from agricultural crops using current methods cannot sustainably replace fossil-based transport fuels. An alternative solution lies in biodiesel from microalgae, which has the potential to fully displace petroleum-derived transport fuels without negatively impacting the supply of food and other crop product[2].

Biodiesel, an alternative diesel fuel, is produced from renewable biological sources such as vegetable oils and animal fats. It is biodegradable, non-toxic, and has low emission profiles, making it environmentally beneficial[3]. Biodiesel derived from algal oil possesses physical and chemical properties similar to petroleum diesel and first-generation crop-based biodiesel, and it meets the International Biodiesel Standard for vehicles[4]. The nutrients required for cultivating microalgae, primarily nitrogen and phosphorus, can be sourced from liquid effluent wastewater, offering the dual benefits of providing a growth medium and treating waste effluents[5]

Algae are broadly classified into three main groups: Rhodophyta (red algae), Phaeophyta (brown algae), and Chlorophyta (green algae), and further categorized by size into macroalgae and microalgae. Macroalgae, or seaweed, are large, multicellular algae visible to the naked eye, while microalgae are microscopic single cells. Microalgae can be either prokaryotic, similar to cyanobacteria (Chloroxybacteria), or eukaryotic, akin to green algae (Chlorophyta). They are a rich source of carbon compounds, which can be utilized in the production of biofuels, health supplements, pharmaceuticals, and cosmetics[6].

The mechanism of photosynthesis in microalgae is similar to that of higher plants, but with a generally higher efficiency due to their simplified cellular structure and better access to water, CO2, and other nutrients. Consequently, microalgae can produce 30 times more oil per unit area compared to terrestrial oilseeds[7]. In microalgae cultivation, carbon dioxide is continuously supplied during daylight hours. Algae biodiesel production has the potential to utilize CO2 emissions from power plants that burn fossil fuels. Ideally, microalgal biodiesel production would be carbon neutral, as all the energy required for cultivating and processing the algae would come from the biodiesel itself and methane generated through anaerobic digestion of the biomass residue left after oil extraction[8]. The production of biofuel from microalgae has garnered significant attention because they can be converted into various types of renewable biofuels, including green diesel, jet fuel, methane biogas, ethanol, and butanol[9].

1)BIODIESEL RESOURCES:

Crop	Oil Yield(L/ha)
Corn	172
Soyabean	446
Canola	1190
Jatropha	1892
Coconu	2689
Oil palm	5950
Microalga	136900

Table 1. Comparison Of Some Sources Of Biodiesel

Algae

"Algae" refers to a broad and highly diverse group of eukaryotic, photosynthetic organisms. These lifeforms are polyphyletic, meaning they do not share a common ancestor and are not closely related to each other.

ISSN PRINT 2319 1775 Online 2320 7876
 UGC CARE Listed (Group -I) Journal Volume 12, Iss 1, 2023

FIG 1. ALGAE1

TYPE OF ALGAE.

Green Algae

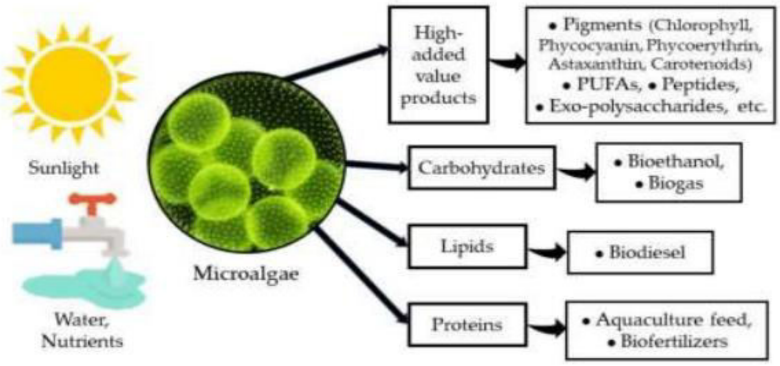
One lineage, the chlorophyte algae, or Chlorophyta sensu stricto, encompasses the majority of organisms commonly known as green algae. This group includes most members of the ancestral scaly flagellates in Prasinophyceae, as well as members of Ulvophyceae, Trebouxiophyceae, and Chlorophyceae.

Figure No 2 . Green Algae

Red Algae

The Rhodophyta, one of the largest phyla of algae, includes over 7,000 currently recognized species, with ongoing taxonomic revisions. Red algae are predominantly found in marine habitats and are relatively rare in freshwater environments. They form a distinct group characterized by eukaryotic cells that lack flagella and centrioles, chloroplasts without external endoplasmic reticulum and containing unstacked (stroma) thylakoids, and the use of phycobiliproteins as accessory pigments, which give them their red color.

Figure No 3. Red Algae



Factors Involved in the Growth of Microalgae

Microalgae require several conditions for growth, with the most crucial physical factors being a source of energy, typically light, and an optimal temperature. Additionally, chemical factors such as the available concentration of carbon dioxide and the presence of macronutrients and trace elements play significant roles. Several parameters, including mixture and oxygen concentration, also affect algal growth.

Light

Light is the primary factor for the photosynthetic growth of algae, impacting the cellular composition of microalgae through photoadaptation or photoacclimatation.

- **Compensation Intensity (Ic):** This is the light intensity below which no photosynthesis occurs, and only cellular respiration is active. At the compensation intensity, photosynthesis just balances respiration.
- **Saturation Intensity (Is):** This is the light intensity at which the photosynthesis rate is at its maximum (photolimitation).
- **Inhibition Intensity (Ipi):** This is the light intensity at which photosynthesis activity is inhibited by light. According to Barbosa et al., photoinhibition becomes significant at light intensities greater than 1200 μmol · m−2 · s−1.
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Temperature

Temperature is another vital physical factor influencing microalgae growth. Each temperature has a specific light intensity that achieves the maximum photosynthesis rate. The optimal temperature increases with rising light intensity. There is an optimal temperature for maximum biomass production, but temperature variations also affect cell composition. Lower temperatures increase the degree of lipid unsaturation, while higher temperatures increase pigment concentrations and oxygen radicals. If microalgae do not grow at the optimal temperature, they require more carbon and nutrients to maintain the same growth rate.

pH

The pH of the culture medium is a critical factor in algal cultivation. The optimal pH for algae growth is usually neutral or slightly acidic to prevent the precipitation of several essential elements. Algae show a clear dependency on the pH of the growth medium, and different species vary significantly in their response to pH.

ISSN PRINT 2319 1775 Online 2320 7876
 UGC CARE Listed (Group -I) Journal Volume 12, Iss 1, 2023

Nutrients

Nutrients, which are inorganic or organic compounds other than carbon dioxide and water, are essential for growth and necessary for cellular function. Some algae require specific organic compounds synthesized by other organisms. However, many algae only need inorganic nutrients, making them suitable as feedstock for biomass fuel production. Limiting nutrients for algae include nitrogen, phosphorus, silica (for diatoms), and iron.

Mixing

Mixing and aerating ensure the uniform distribution of nutrients, air, and CO2 in microalgae culture. They also enable light penetration and distribution inside the culture, preventing biomass from settling and aggregating Without proper mixing, biomass productivity decreases significantly. Continuous mixing in microalgae cultures is essential to keep all cells suspended with free access to light. A proper mixing system in a photobioreactor not only facilitates nutrient dissolution and light penetration but also ensures efficient gaseous exchange.

Table NO 2. Lipid Content Of Different Microalgae

Microalgae	Oil content(%dry weight)
Botryococcusbraunii.	25-28
Chorellaprotothecoides.	23-30
Chlorella vulgaris.	14-40
Crpythecodiniumcohnii.	20
Cylinderdrotheca sp.	16-37
Nitzschia.	45-47
Phaeodactylumtricornutum.	20-30
Schizochytrium sp.	50-77
Spirulina maxima.	4-9
Neochlorisoleoabunndans.	35-65
Crpythecodiniumcohnii.	20

Algae:

Figure No 3. Grinding Algae

Figure No 4: Pure Biodiseal after Purification

CONCLUSION

Many companies and researchers have developed systems to convert microalgae into biofuels, but none have achieved commercial success so far. The primary limitations stem from technological challenges in cultivation and harvesting, as well as determining the optimal growth conditions for microalgae. According to the U.S. Department of Energy, current research on efficient algal oil production is being conducted in the private sector. If predictions from small-scale production experiments are promising, using algae to produce biodiesel might be the only feasible way to generate enough automotive fuel to replace the current global gasoline usage.

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