The Significance of Algae in The Manufacture of Bioethanol

Raju Potharaju*[1] and M. Aruna [2]
[1] Department of Botany, City Womens Degree college, Hanamkonda, Telangana, India*
[2] Professor Department of Botany, Hydrobiology and Algal Biotechnology Laboratory, Telangana University, Dichpally, Nizamabad, Telangana, India.
Email:rajuvarmabotany@gmail.com

Abstract

Renewable energy sources are in high demand due to concerns about fuel security, the economy, and global warming. The sustainable feedstock and eco-friendliness of bioethanol made from algal biomass are driving its rising popularity worldwide. In this analysis, we look at the environmental impacts of algal bioethanol production from many angles, including farming, harvesting, extraction, and commercialization. The goal of current algal biofuel research is to minimize production costs by creating lucrative secondary by-products. This will ensure the economic sustainability of bioethanol biofuels made from algae. To solve the problem of how to make renewable bioethanol biofuel cheap, we need technology that can maximize extraction capacity with little downstream processing and inexpensive feedstock.

Key words: biofuel, biomass, bioethanol, global warming

1.INTRODUCTION

A major obstacle for the world's expanding population is the availability of sustainable energy. There is little doubt that human population will keep rising for the foreseeable future[1]. There will likely be an equally dramatic increase in the share of fossil fuels used to power vehicles and other industrial processes, driving up the already skyrocketing demand for energy. The daily depletion of fossil fuel reserves has led to a spike in the price of petroleum fuels . In addition, the tremendous consumption of fuel reserves has given rise to other environmental problems, such as global warming. Biofuels have come onto the scene due to heightened awareness in climate change and the need for energy[2]. Timely, affordable, environmentally friendly energy sources that are indestructible, efficient, substitutable, cost-effective, and low-emitting greenhouse gases are essential if we are to fulfill our present and future energy demands[3].

The initial concern in sustainable development should be the utilization of renewable energy sources. Biofuels refer to liquid fuels like bioethanol, biodiesel, and pyrolysis oils, as well as gaseous substances like biogas (methane), and solid fuels such as charcoal and fuel wood pellets that are primarily derived from biomass. Biomass has the potential to yield several fuels, including methanol, ethanol, biodiesel, methane, and hydrogen[4]. Biofuels created from biomass offer numerous environmental advantages at the local level. Biofuels are crucial as they replenish depleted petroleum fuels. Numerous industrialized and developing nations recognize the significance of biofuels in mitigating reliance on imported petroleum, curbing greenhouse gas emissions, and attaining objectives related to rural development[5]. The primary accomplishments of biofuels encompass enhanced energy security, savings in exchange rates, diminished environmental impact, and alleviation of socio-economic challenges. Numerous conventional biofuels are burdened with elevated production expenses, resulting in retail prices that lack competitiveness. Political backing in the form of mergers and tax credit programs has facilitated the entry of some types of fuels into the consumer fuel market, with sugar ethanol in Brazil serving as a notable instance[6].

Global bioethanol production has skyrocketed in the last several years. Actually, output increased from 1 billion liters in 1975 to 86 billion liters in 2010, and it is projected to surpass 160 billion liters by 2020 [7].

Nevertheless, bioethanol's feasibility has been called into question due to the dwindling water supplies and the loss of farmland. A scarcity of staple crops including corn, soybeans, wheat, barley, and sugar cane can result from the excessive utilization of farmland to generate biomass for bioethanol production [8]. Their long-term viability is thus the subject of heated controversy [9]. For the purpose of decreasing these issues have led to an uptick in interest in algae as a potential new renewable biomass source for bioethanol production [10]. The Although the concept of producing energy from algae has been around since the late 1950s, it is only recently that it has gained serious consideration [11].

The vast category of algae includes thousands of distinct species, some of which are more desirable than others depending on the conditions in which they grow. They inhabit mostly terrestrial, marine, and freshwater ecosystems. Extreme environments, such as hot or cold deserts, brackish habitats, acid waters with high concentrations of heavy metals, deep sea waters, and hydrothermal outputs, are not necessary for the growth of the majority of algae species [12]. This suggests that algae could thrive in a wide variety of habitats. Thus, energy independence and stability can be achieved through the biofuel manufacturing process that utilizes algae as a renewable energy source[13]. Modern, cutting-edge methods for producing bioethanol from algae will be better understood after reading this article, as will the ways in which these eco-friendly technologies could solve future problems with energy and environmental sustainability[14].

2.MATERIALS AND METHODS

Raw materials for the synthesis of bioethanol

The economics of ethanol production and the feasibility of fermentation technology heavily rely on the availability and affordability of raw materials. Presently, there is a significant amount of research being conducted on the several methods that may be used to generate ethanol from diverse raw materials [15]. Terrestrial plants have emerged as a viable alternative for the production of bioethanol, garnering significant global interest. However, due to the conflict between food and fuel and land use, the utilization of plants for biofuel has been a subject of controversy and has sparked disagreements on its long-term viability [16]. Furthermore, it should be noted that the use of plant-based lignocellulosic raw materials is a challenging task that requires significant manpower and substantial capital investment for processing [17]. The issue of ensuring a competitive supply of feedstock to a commercial plant, as well as enhancing the efficiency of the conversion process to save expenses, poses significant challenges [18]. Hence, the present economic feasibility of these operations is limited. Algae have garnered increased attention as a viable option for the manufacture of bioethanol, positioning them as third-generation biofuels.

Algal cultivation

It is easy and inexpensive to grow algae in both natural and artificial open-ponds. The growth of algal biomass may be achieved in either an enclosed laboratory setting or an open pond. Past techniques for growing and collecting algae for use in bioethanol manufacturing[19].

The practice of laboratory cultivation

Preliminary investigations on the manufacture of bioethanol from algae indicate that these organisms may be cultured in controlled laboratory settings using various growth mediums and regulated environmental conditions [20]. Typically, algae are cultivated in beakers, plastic pots, and tubs. The generation of algal biomass under laboratory settings is influenced by many parameters, such as the length and intensity of artificial light, aeration, carbon dioxide concentration, temperature, pH of the growth medium, and nutrient delivery. In order to achieve optimum biomass output, these parameters are carefully regulated.

Open ponds

Algal culture in open ponds, whether natural or artificial, is the most popular method for producing bioethanol and has been extensively studied [21]. In recent years, numerous firms have focused on this growth strategy for biofuel production. Open pond systems employ shallow, one-foot-deep ponds ranging from one to several acres in size to expose algae to natural sun radiation. The most often utilized open pond systems include tanks, shallow large ponds, circular ponds, and raceway ponds [22]. Algae growth and productivity are stabilized by closed loop oval-shaped recirculation tubes that range in depth from 0.2 to 0.5 m and need mixing and spreading. Although open pond cultures are more cost-effective, they present challenges such as land usage, water availability, poor production, and suitable climatic conditions.

Steps in the Production of Bioethanol from Algal Biomass

Pretreatment, hydrolysis, fermentation, and distillation are the four main unit processes involved in the synthesis of bioethanol from algal biomass, much as they are in the production of cellulosic ethanol. The complex carbohydrate molecules in algal cells can be broken down into their component simple sugars by enzyme-catalyzed hydrolysis (water addition), but only after pretreatment is cellulose, hemicellulose, and lignin separated from the biomass [23]. The next step is to collect and purify the ethanol so it meets fuel standards after ethanol-producing microbes convert the fermentable carbohydrates into ethanol. On top of that, alcohol manufacturing facilities may recover part of the separated solids and use them as fuel to generate energy and process heat.

Fermentation

The use of microorganisms in fermentation processes allows for the utilization of all five primary biomass sugars, namely glucose, xylose, mannose, galactose, and arabinose. These sugars are derived from the enzymatic hydrolysis of algal biomass. The yeast *Saccharomyces cerevisiae* and the bacterium *Zymomonas mobilis* are widely recognized as the most prominent microorganisms for the synthesis of ethanol from hexoses [24]. The bioethanol generation by fermentation using *Z. mobilis* and *S. cerevisiae*.

Perform distinct enzymatic hydrolysis and fermentation processes.

The aforementioned procedure involves the hydrolysis of pretreatment algal biomass into glucose, followed by the subsequent fermentation of glucose into ethanol in distinct units. The primary benefits of this procedure include the cost-effectiveness of chemicals, brief residence duration, and simple equipment system, all of which facilitate its widespread use. Choi et al. [25] determined that the SHF technique yielded about 235 mg of ethanol from 1.0 g of algal biomass (*C. reinhardtii*). (Fig 1).

Distillation

Various distillation systems have been developed and successfully proved to enable the economic recovery of diluted volatile products from streams that include a diverse range of contaminants. However, the commercial production of algal bioethanol has not been extensively explored, and the specific unit of distillation is seldom addressed.

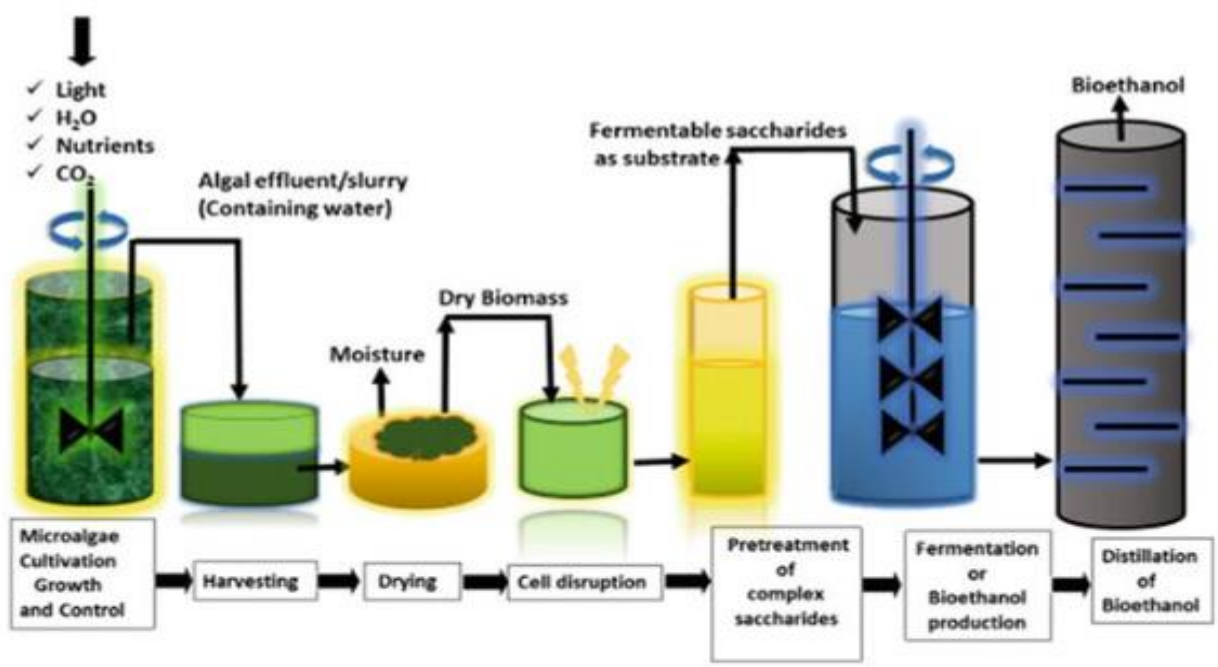

Fig 1 .Schematic representation of bioethanol production from microalgae feedstocks

3. CONCLUSION

The world's energy consumption has been steadily increasing due to advanced industrialization and motorization, and numerous environmental concerns have resulted from the over usage of fossil fuels. In light of the current climate crisis and the depletion of fossil fuels, biofuels such as bioethanol are undeniably an excellent option. An environmentally beneficial and long-term solution for producing renewable biofuels is using algae biomass as a starting material. By providing an affordable, ecologically friendly, or alternative to traditional, energy-intensive wastewater treatment methods, algae cultivation in wastewater may significantly improve water ecosystem management. Solving issues like the energy crisis and environmental degradation is crucial for the development of a sustainable contemporary civilization. The business of commercial algae culture is thriving. Modern farming practices are mostly based on basic, open-air techniques. Alternatively, our understanding of algal biology and the technical requirements for large-scale algae cultivation systems have both advanced significantly throughout the last half-century. As a result, many kinds of closed photo bioreactors have been refined, which should pave the way for the next decade to see the commercialization of novel algae and algal products. Because biofuels aren't without their environmental impacts, pro-biofuel legislation should include extensive recommendations for improving feedstock production and refining methods. Sustainable, biodiversity-friendly farming techniques are essential for the production of biofuels. Biofuels seem to have promising future growth prospects, but the rapid and consistent global development and use of biofuels sustainability standards is of the utmost importance.

Despite the abundance, cheapness, and sustainability of lignocellulosic bioethanol's raw materials, the high recalcitrance of these materials makes second-generation bioethanol production expensive. With the energy crisis and pollution posing severe obstacles to contemporary society's sustainable growth, using algal biomass to produce bioethanol is undeniably a sustainable and environmentally beneficial way to make renewable biofuels.

Even though there has been a proliferation of algae-to-fuel startups in recent years, none of them have actually constructed a commercial plant. Thus, the commercialization of algal bioethanol is similarly influenced by the method's economics, just like any other industrial process. Prior to its successful large-scale and commercialization, the technology of algal bioethanol production faces a number of obstacles.

In the manufacture of algal bioethanol, the most expensive phase is pretreatment, which is expected to comprise about 33% of the entire cost. A simple pretreatment approach is required, one that does not need a lot of energy or costly chemicals. Hydrolysis of the polysaccharides in the algal biomass should take place immediately, without the need for sugar degradation, which might lead to the formation of fermentation inhibitors. One of the most promising technologies for industrial applications is the use of dilute sulfuric acid, which is also one of the most effective ways now available. Reduce sugar losses, maximize solids concentration, and maintain low reactor and equipment expenses to further reduce the cost of the pretreatment stage in converting algal feedstocks to ethanol. Additionally, one method that is gaining traction in fundamental research is the examination of the consequences of preliminary processing on a deeper level. Algal cell wall composition is very intricate, and studies at the cellular. The many catalytic events affecting biomass and the effects of pretreatments should be better understood at the ultrastructural and even molecular levels. Applying this understanding will lead to an efficient and integrated method for converting biomass into ethanol. Finally, a technological breakthrough that would hasten the commercial development of algal bioethanol would be to identify certain marine bacteria to each variety of algae; this would be an economically efficient technique of biological treatment.

The efficiency with which microalgae and macroalgae produce bioethanol is also distinct. Up until now, the optimum output from microalgae production would have been biodiesel, due to the large capacity of vegetable oils they contain. If we want to enhance the energy balance overall, however, we need to diversify the biofuels output from microalgae. One example of a successful application is producing bioethanol from microalgae biomass, which still contains significant quantities of carbs after lipid extraction. This technique maximizes the sustainability of microalgae biofuels by reusing the waste to generate more energy. It's a win-win situation. Macroalgae, like microalgae, may develop rapidly and produce enormous quantities of biomass. The capacity to absorb nutrients throughout their whole surface and the fact that macroalgae need less energy to produce supporting tissue compared to terrestrial plants are the reasons for the high yields. So, bioethanol produced by macroalgae is going to be a hot commodity soon.

The price of enzymes is the second major technical obstacle. Enzyme specificity and efficacy enhancement, new degrading technology development, and more funding should all be top priorities. algal biomass, and enzyme recovery to cut enzyme costs in half or more. In the process of making algal bioethanol, a biorefinery method may be devised.

We can draw out valuable chemicals from the algae, and the leftovers are full of cellulose, which can be used to make bioethanol. The byproducts of ethanol production still include valuable minerals and organic matter; they might be used into biofertilizer in the future.

Compliance with ethical standards:

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Disclosure of conflict of interest

The authors declare no conflict of interest

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