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Microalgal Biomass Production: Lab-to-Land Practices at Bharathidasan University, India

N. Thajuddin*, E. Baldev and D. Mubarak Ali

National Repository for Microalgae and Cyanobacteria- Freshwater (DBT Sponsored), Department of Microbiology, Bharathidasan University, Tiruchirappalli – 620 024, Tamil Nadu, India

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ABSTRACT

Vast expansion in human population and economy had led to continuous demand for more and more energy which threats to exhaust fossil fuels. The extensive use of fossil fuels might cause catastrophic changes in the earth's climate hence; there is an immediate need to develop new renewable energy resource. Microalgae can provide several different types of renewable bio-fuels. There is a strong view among industry professionals that algae represent the most optimal feedstock for biofuel production in the long run. It is also widely accepted that algae alone and no other bio-feedstock have the ability to replace the entire global fossil fuel requirements. Our centre has been engaging in the production of microalgal biomass for biofuel production under the aid of Department of Biotechnology (Govt. of India). In this short communication, it is being elaborated about the lab to land practices followed for biomass production with schematic representation and additional technology is required for the successful production of biomass and biofuel feed stocks.

Introduction

Microalgae are the most primitive members of the plant kingdom existing as single cells in aqueous habitats, but some are organized in the form of simple colonies, filamentous, and several species have developed further and have organized their cells in more complex structures resembling the leaves, stems and roots of higher plants. The majority of the green algae produce carbohydrates in the form of starches as their storage product that could be used in ethanol production. Lipids are a heterogeneous group of organic compounds that includes fatty acids and other vegetable oils. Microalgae are also characterized by higher lipid productivity that could be trans-esterified for biodiesel production. They constitute a vast potential resource in varied areas such as mariculture, food, feed, fuel, fertilizer, medicine, industry and combating pollution. Apart from microalgae the usefulness of cyanobacteria for these purposes has also been established (Thajuddin and Subramanian, 2005).

The application of microalgae are enormous such as, in the removal of CO_2 from the flue gases of coal-fired power stations, the development of green algae as producers of biological hydrogen gas, and the use of diatoms as bio-manufacturers of elaborate three-dimensional structures for the nanotechnology industry (MubarakAli *et al.*, 2011).

*Corresponding author.
E-Mail address: thajuddin@gmail.com

Microalgae share many of the important attributes of higher plants, including similar post-translational processing such as glycosylation, and have a low risk of contamination by human viruses or prions. However, unlike higher plants microalgae have very fast growth rates and transformants can be generated in as little as ten days. Furthermore, cultures can achieve high densities, and can be grown in volumes exceeding 500000 litres. Microalgae are photoautotrophic and therefore do not require a carbon source for energy.

Many microalgae grow in saline or hypersaline waters and thus their large-scale cultures do not compete with conventional agriculture for the limited resources of arable land and fresh water. India is the sixth largest and one of the fastest growing energy consumers in the world. Due to limited crude oil reserves, India meets about 72% of its crude oil and petroleum products requirements through imports, which are expected to expand further in coming years (Baldev *et al.,* 2014). Bio-fuels promise to be an appropriate option to be fixed as a solution to these problems. Algae present multiple possibilities for fuel end-products – biodiesel, ethanol, methane, jet fuel, biocrude and more – via a wide range of process routes. There are several advantages of utilizing microalgae for biodiesel production namely: a) Much greater productivity than their terrestrial cousins, b) Non-food resource, c) Utilize non-productive land and saline water or waste water, d) Can use waste CO_2 streams, e) Can be used to combined with wastewater treatment, f) An algal biorefinery could produce oils, protein, and carbohydrates, g) High oil content in algae species and h) Lower carbon emissions. When biofuels are being burned, they produce less carbon output and fewer toxins. The various metabolic pathways involed in microalgae could be used for different kinds of biofuel production (Fig. 1). The benefits of microalgae in biofuel production are much higher (Table 1) making it as a strong contender among other potential soures.

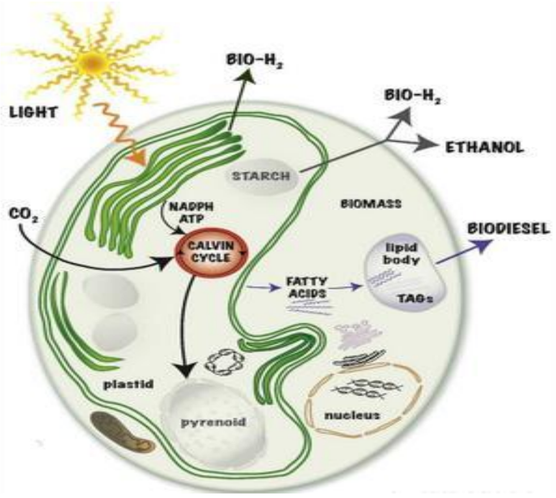

Fig. 1: Metabolic Pathways in Microalgal biofuel Production – Synthesis of Proteins, Carbohydrates, Nucleic acids, Lipids and Hydrogen (Beer *et al.,* 2009).

Table 1: Yield of various plant oils (Demirbas and Demirbas, 2010).

Crop	Oil (Litres/Hectare)
Algae	1,00,000
Castor	1413
Coconut	2689
Palm	5950
Safflower	779
Soy	446
Sunflower	952

Lab to land practices

At the National Centre in Bharathidasan University, various algae which grow at local conditions are cultured. Besides, selected algal species are grown and culture conditions are optimized in the laboratory. These cultures are scaled up gradually with economic feasibility for the production of high value compounds from the algae. The algae is cultivated in traditional "raceway pond" systems, harvested and processed. Figure 2 shows the diagrammatic schematics of microalgal biomass production followed as lab to land practices at Bharathidasan University.

Biodiesel is produced from the algae starting with extraction of Lipids from the dried biomass. Various methods such as Supercritical Fluids Method or Oil press could be used for the extraction. Later transesterification of lipids with methanol and suitable catalyst yield biodiesel (FAME) and glycerol (Fig. 3). In the process methanol could be replaced with ethanol, propanol, butanol, and amyl alcohol. Catalysts could be of alkalis (NaOH & KOH), acids (sulfuric acid, sulfonic acids, & hydrochloric acid) and enzymes (e.g. lipase). Finally Biodiesel/Glycerol mixture is purified by separation through centrifuge and biodiesel (top layer) is removed. Sequentially water washing eliminates contaminants such as methanol, free glycerine and catalyst and dried under vacuum with heat to remove water. The final product obtained is biodiesel.

Fig. 2: Microalgal Biomass Production Process Flow: Collection of Specimens from Aquatic environment (1), Isolation & purification of microalgae using dilution & streak plate method (2), Scaling up the efficient Microalgal strains in terms of high lipid content 250 ml (3), 5 litres (4), 20 litres (5), 500 litres (6), 5000 litres & 35,000 litres

in Raceway Ponds (7), Harvesting of Microalgal Biomass using Plankton net cloth (Filtration) (8), Other methods such as continuous centrifugation, flocculation by chemicals (Alum, Ferric Chloride, Chitosan etc.) and electro-flocculation; Drying the harvested biomass in the form of noodle like flakes (9), Weighing (10) and powdering of dried microalgal biomass (11).

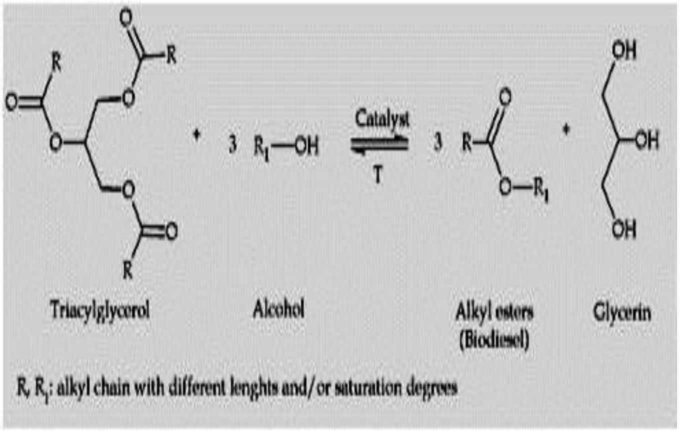

Fig 3: Transesterification of process to develop fatty acid methyl esters (FAME) (Biodiesel)

Conclusion:

The oil-rich, CO_2-utilizing microalgae are technically viable and attractive alternatives for biodiesel production. Even though ethanol derived crops addresses the world gasoline markets, there is a need for biofuels from algal-derived feed stocks to displace our significant petroleum diesel usage. Extensive knowledge on the fundamental algal physiology, genetic manipulation, optimization of mass cultivation, overall system engineering and economic aspects of the microalgal biodiesel production are most warranted.

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