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MICROALGAL BIOFUEL TOWARDS SUSTAINABLE DEVELOPMENT: PROMISES AND TECHNOLOGIES FOR FUTURE

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ABSTRACT:

Microalgae are regarded as attractive source for biofuel as compared to existing biofuel options including first and second generation biofuels. Many microalgae reported in literature are able to produce hydrogen from light and water. Technologies used for enhanced biofuel production from microalgae includes fermentation optimization, media optimization, genetic engineering tools and improved techniques to catch up more yield in microalgae are in great demand. The present review describes an up to date overview of such high demanding field of research which can provide suitable options to researchers to enhance their learning towards experimenting with biofuel derived from microalgae

Keywords: Microalgae, Biofuel, *Chlamydomonas reinhardti*, Biohydrogen, sustainable development, technologies

[I] INTRODUCTION

The bio-fuel research is demanding these days due to limited supply of fossil fuels. This also provides environmental and economic sustainability as well as helpful in providing eco-friendly substitutes to fuel crisis. It is evident from literature that microalgae are good source for renewable biodiesel and is competent to fulfill the requirement for conventional fuels. It is well known that like plants, microalgae efficiently use sunlight to produce biodiesel and oils [1].

[II] BIOFUEL PRODUCTION OVERVIEW

It was reported that a green colonial microalga *Botryococcus braunii* is a good candidate for bio-fuel production which constitute hydrocarbons equal to 75% of dry weight. The various biotechnological techniques towards enhancing yield of biofuel are summarized in Table 1.

It was reported by Banerjee et al. (2002) that various improved techniques viz. culturing methods; cloning of the algal genes into other microorganisms downstream processing of hydrocarbons play vital role in enhancing the yield of biofuel from this algae[2]. One noteworthy contribution in *Cholrella* spp. describes that thermogravimetric analysis can increase the lipid pyrolysis which can increase the volatile yield up to 80% [3] Alternative power from biological resources for industry gas turbines was elaborately described by Gökalp et al 2003) [4]. Table 2 represents few notable algal species reported as biofuel producers.

2.1 Molecular approaches and transgenic microalgae development

Some molecular biology tools are also reported which reveal an attempt to maneuver lipid buildup through successful transformation by plasmid vector with a regulatory gene i.e. acetyl-CoA carboxylase (ACCase) gene from *Cyclotella cryptic* [5]. Moreover, a gene encoding nitrate reductase and acetolactate synthase was also identified towards developing selective marker for such genetic transformation [6].

One pioneering work on bio-refinery technologies by Fatih Demirbas (2009) describes the usage of biomass upgradation through combining techniques of fractionation, liquefaction, hydrolysis, pyrolysis, fermentation and gasification [7]. Adding to this notable genetic engineering overexpression approach was applied in *Phaeodactylum tricornutum* explaining the increased accumulation fatty acids in comparison to cyanobacteria [8]. There are many interests on creating starchless mutants of *Chlamydomonas reinhardtii* as bioenergy carrier in which it was proved that decline in anabolic processes in the starchless mutants during nitrogen deprivation [9]. A notable report was also evident on genetic engineering approaches for microalgae towards improvement in biofuel production (bio-hydrogen, alcohols, fuel diesel candidates etc.). In recent times, we observed considerable progress in ascertaining bioenergy genes and pathways in microalgae through genetic engineering tools to engineer some of algal strains and it is clear that the advancement in these areas is growing [10,11].

Moreover some studies transgenic microalgae are also attracting the attention of scientists and Katarina et al. (2011) have recently reported various methods for identification of mixed cultures of hydrogen-fermenting microorganisms using PCR based targeting the 16S rRNA gene [12,13].

2.2 Biotransformation and improvement on processing techniques

Dismukes et al. (2008) describes a very interesting report on biofuels productivity in mass culturing derived from aquatic microbial oxygenic photoautotrophs (AMOPs) composed of cyanobacteria, algae and diatoms which has been proved to be very viable option for renewable biofuel applications[14]. Biofuel on the other hand are powerful tools for economic and environmental build up reducing greenhouse gas emissions and various hazardous pollutants [15]. Many microalgae are also reported to produce sizeable amounts (e.g. 20-50% dry cell weight) of triacylglycerols (TAG) [16]. According to Boussiba et al (1978) in *Nanochloropsis salina* cell-lipid content doesn't depend upon starvation of nitrogen, pH value or the source of sea water [17]. Microalgae are regarded as attractive options due to their oil yield output and it was reported that terpenoids hydrocarbon and glycerol containing microalgae viz. *Botrycoccus braunii* and *Dunaliella tertiolecta* are not able to remove nitrogen and phosphorus from secondary treated sewage (STS) [18].

The efforts to produce bio-oil from microalgae for increasing by *Cholella* spp. has been carried out through fast pyrolysis after maneuvering the metabolic pathway through heterotrophic growth and through high density fermentation [19,20].

The microalgae used for various tasks including assimilation and utilization of CO_2 from fossil fuel-fired power plant, study on low-input biomass from microalgae providing greater supplies and environmental benefits than agriculture-based biofuels, microalgae as alternative biofuel as compared to first- and second-generation biofuels are overpowering [21,22,23]. Technologies for production, processing, and extractions of biofuels from microalgae were briefly reviewed along with pioneering work on main reward of second generation microalgae biofuel [24,25]. Furthermore a report on governmental policies by promoting the development of sustainable biofuel programs are also discussed [26].

CONCLUSION

This review gives an insight about various developments in microalgae biofuel discovery and advancements with a major focus on enhancing such strategies for sustainable development.

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[Table-1] Existing biotechnological innovations in biofuel production

Biotechnological approach	**Description**	**Reference**
Enhancing lipid production by improved transformation strategies	ACCase gene insertion into diatoms.	Dunahay et al. (1996)
Markers development	Uses of marker e.g. nitrate reductase and acetolactate synthase	Roessler et al. (1994)
Development of heterologous expression vector	thioesterases in *Phaeodactylum tricornutum*	Radakovits et al. (2011)
Development of mutants	Starchless mutants of *C. reinhardtii*	Work et al. (2010)
Identification of bioenergy genes and metabolic pathways in microalgae,	Genetic engineering of some strains through transgene expression.	Beer et al. (2009)
Molecular tools to characterize different hydrogen producing organism	Targetting to 16srRNA genes ,hydrogenase gene	Tolvanen et al. (2011)

[Table 2] Microalgae used for bio-fuel application

Algae	**Family**	**Reference**
Botryococcus braunii	Dictyosphaeriaceae	Banerjee at al. (2002)
Phaeodactylum tricornutum	Phaeodactylaceae	Radakovits et al. (2011)
Chlamydomonas reinhardtii	Chlamydomonadaceae	Work et al. (2010)
Nannochloropsis salina	Eustigmataceae	Boussiba et al. (1987)
Chlorella protothecoides	Chlorellaceae	Peng et al (2001), Miao et al. (2004), Xiong et al.(2008)