Application of novel oil extraction methods for microalgae, *Nannochloropsis spp.*

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Introduction

Non-renewable fuels (fossil fuel) are widely used globally since ancient times. As a result, global oil reserves are rapidly depleting with the growth of population as well as rapid industrialization. Combustion of fossil derived fuels has led increasing emission of greenhouse gasses and it is a major cause for the global warming [1].

Therefore, biofuels are one of the potential solutions for this problem. Biofuels are alternatives, because of several distinct advantages such as reduced emissions of gaseous pollutants such as carbon dioxide, carbon monoxide and sulfur oxides etc., carbon neutrality, availability and their production safety [1].

When compared to petroleum fuel, biodiesel is more expensive. Therefore, biofuels are not readily available for use [2]. To produce biodiesel, the raw materials such as animal fats, short chain alcohol and vegetable oil, soybean, rapeseed, palm, sunflower, coconut, peanut, linseed, safflower, vegetable oils, and also animal fats are used worldwide. However, biofuel production using edible vegetable oils cause to some ethical issues [3]. Algae is another raw material of biodiesel production due to their high lipid level [4]. Microalgae are easy to cultivate without attention. Ability to high per-acre oil productivity, Ability to utilize solar energy and carbon dioxide and minimal land space and environmental requirement those are the reasons for microalgae are promising non-food feed stock for biofuel production [5]. Although, most of the steps of the production process, especially the lipid extraction from algae is expensive and required high energy. Currently research have been conducted to utilize ultrasonic waves and microwave in the oil extraction processes. Using ultrasonic oil extract at low operation temperature and relatively short operational time [6]. Because of applied ultrasonic waves to the microalgae in water, cavitation process is utilized to disrupt the algal cell wall. Microwaves are used to penetrate the algal cell walls so that the lipid pockets are heated and forced to be excreted out of the biological matrix [7].

The objective of this study was to find out better lipid extraction technology from micro algal cell with high-energy efficiency.

Methodology

Filtered sea water and distilled water were used with Guillard and Ryther`s modified F/2 media as growth medium to cultivate *Nannochloropsis* spp which was collected from NAQDA, Sri Lanka (Figure 1). Micro algae samples were harvested after two weeks by flocculation using NaOH as a flocculent agent. The harvested samples were kept in the oven until drying and dried samples were ground using mortar and pestle. Oil was extracted from the grounded samples using different techniques as follows.

One gram of dried algae samples was mixed with 50 ml of petroleum ether and oil was extracted using Soxhlet apparatus (Model Testator) for 2 h duration.

Ultrasonic-Assisted Extraction (UAE) was done with 1.0 g of dried micro algae samples with using hexane as a solvent. Samples were exposed to ultrasonic waves at two different frequencies 28 kHz and 40 kHz for 30 minutes time in ultrasonic bath sonicator followed by Soxhlet oil extraction [8].

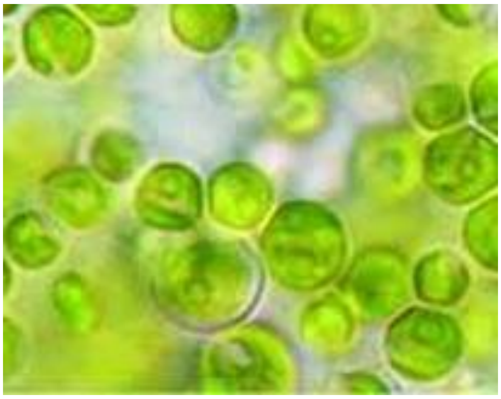

Figure 1. Micro algae *Nannochloropsis spp***.**

Microwave-Assisted Extraction (MAE) was conducted for 1.0 g of dried micro algae powder samples was exposed to microwave irradiation at a frequency of 2.45 GHz (800 W domestic microwave oven) for 10 minutes and 20 minutes time periods followed by Soxhlet oil extraction [8].

Experimental design used in the research is Completely Randomized Design. The data obtained from the experiment were analyzed using the software SAS 9.1.3 version. Percentage of oil content and required power for each extraction was calculated.

Results and Discussion

Extracted oil contents by different extraction technologies were given in the table 1.

According to the results, *Nannochloropsis spp*. in MAE for 20 min showed the highest yield. Ultrasonic -assisted extraction using 28 kHz was significantly lower value compared to other methods.

Table 1. Oil yield of different extraction technologies (Significant level given by superscripts).

Oil extraction technology	Oil Yield (%)
Soxhlet (Conventional)	6.5^{c}
MAE 10 min	9^{b}
MAE 20 min	14.3^{a}
UAE 28 kHz	4.8^{d}
UAE 40 kHz	10.4^{b}

Energy requirement for ultrasonic and microwave assisted oil extraction technologies were given in figure 2.

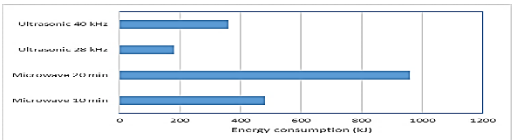

Figure 2. Energy consumption of different treatment.

Conclusion

Highest extracted oil yield showed by Microwave - assisted oil extraction with 20 min time period which was approximately two-fold higher than the Soxhlet - assisted extraction method and three-fold higher than the Ultrasonic - assisted oil extraction method with 28 kHz frequency.

When compare the energy requirements, this study revealed that it was higher in Microwave - assisted oil extraction technology and lowest for Ultrasonic - assisted oil extraction with 28 kHz than the other treatment methods.

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