Chemical Engineering Journal 215–216 (2013) 929–936

Contents lists available at SciVerse ScienceDirect

Chemical Engineering Journal

journal homepage: www.elsevier.com/locate/cej

Factors affecting cellular lipid extraction from marine microalgae

Rajesh Kumar Balasubramanian [a], Thi Thai Yen Doan [a,b,*], Jeffrey Philip Obbard [a]

[a] Department of Civil and Environmental Engineering, National University of Singapore, Singapore 117576, Singapore
[b] Institute for Environmental Science and Technology, Hanoi University of Science and Technology, Viet Nam

HIGHLIGHTS

- ▸ Investigate key factors affecting extraction efficiency and lipid characteristics.
- ▸ FFA was increased 3 times in extracted lipid for microalgae dried by solar.
- ▸ Chlorinated solvent systems resulted in higher extraction efficiencies than other solvent.
- ▸ Hexane had a poor extraction efficiency, but improved when polar solvents were added.
- ▸ The moisture content affected both lipid extraction efficiency and FFA content.

ARTICLE INFO

Article history:
Received 13 June 2012
Received in revised form 31 October 2012
Accepted 14 November 2012
Available online 29 November 2012

Keywords:
Microalgae
Drying
Lipid classification
Solid phase extraction
Accelerated solvent extraction
Thin layer chromatography

ABSTRACT

Factors affecting intracellular lipid extraction from marine microalgae were investigated using various techniques. The biomass drying method and moisture content, and the solvent extraction system were the factors studied. Lipid was analytically classified into three categories i.e. neutral lipid, free fatty acid (FFA) and polar lipid using solid-phase extraction. Biomass drying methods (freeze-, oven- and solar drying) did not affect lipid yield, but the FFA content of the lipid was three times higher for solar dried biomass. Of the various lipid extraction methods tested, including sonication, homogenization, accelerated solvent extraction (ASE) and Soxhlet extraction, sonication was the least efficient compared to other methods when a partially miscible solvent system i.e. hexane–methanol was used. Chloroform–methanol solvent system had maximum lipid extraction efficiency (33%). A biomass moisture content up to 5% had no impact on lipid extraction efficiency, but higher moisture contents reduced lipid extraction and increased the FFA fraction.

1. Introduction

Microalgae are currently subject to worldwide investigation as a promising sustainable and renewable energy source to meet future energy demand for liquid transportation fuels. Using microalgae to tap solar energy via photosynthesis is not a new concept; where an extensive study was conducted under the United States Aquatic Species Program [1]. Moreover, microalgae production represents a potential solution for the mitigation of climate change since 1 ton of algae results in the fixation of 1.83 tons of atmospheric CO_2 [2]. The yield of lipid–oil feedstock from microalgae has been estimated at 123 m^3/hectare which is up to 20 times higher when compared to palm oil [2]. Chisti [2] estimated that if all US petroleum-based transport fuels were to be replaced by biodiesel, then palm oil plantation would require 61% of the total cultivable land of the continental United States; whereas microalgae would need only 3%, assuming the microalgae contained 15% lipid oil as biomass dry weight.

Processing of harvested microalgal biomass to extract lipid–oil can be an energy intensive process as it requires separation and dewatering of microalgae, biomass drying and the subsequent extraction and purification of lipid–oil. The crude extract contains not only lipid–oils, but also carbohydrates, proteins and pigments. The lipids can be further classified into neutral lipids, free fatty acids, and polar lipids which include galacto- and phospholipids [3]. The lipid composition of various types of microalgae has been studied by several researchers, for example diatoms [3], *Nannochloropsis* [4] and *Phaeodactylum tricornutum* [5]. Lee et al. [6] studied various lipid extraction methods and solvent systems and compared relative extraction efficiencies. It was found that cell disruption with a micro-bead beater followed by extraction with chloroform:methanol (2:1 v/v) was an effective method for lipid extraction [7]. Addition of concentrated hydrochloric acid to a chloroform:methanol solvent system increased the total lipids extracted, especially phospholipids, in microalgae i.e. *Botryococcus*

* Corresponding author. Address: Jalan Tiga, Blk 49, #04-58, Singapore 390049, Singapore. Tel.: +84 913083777.
E-mail address: yenhanhnguyet@yahoo.com (T.T. Yen Doan).

1385-8947/$ - see front matter © 2012 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.cej.2012.11.063