Bioresource Technology 129 (2013) 289–295

Contents lists available at SciVerse ScienceDirect

Bioresource Technology

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

A flexible culture process for production of the green microalga *Scenedesmus dimorphus* rich in protein, carbohydrate or lipid

Liang Wang [a,b,*], Yunguang Li [a,c], Milton Sommerfeld [a], Qiang Hu [a,*]

[a] Laboratory for Algae Research and Biotechnology, Department of Applied Sciences and Mathematics, Arizona State University Polytechnic Campus, Mesa, AZ 85212, United States
[b] Shanghai Advanced Research Institute, the Chinese Academy of Sciences, Shanghai 201203, PR China
[c] College of Life Sciences and Technology, Huazhong Agricultural University, Wuhan, Hubei 430070, PR China

HIGHLIGHTS

- *Scenedesmus dimorphus* was grown to produce protein-, carbohydrate- or lipid-rich biomass.
- The study was performed with combined manipulation of nitrogen deprivation and high light exposure.
- Outdoor yields for protein, carbohydrate and lipid were 0.2, 0.7 and 0.17 g L^{-1} d^{-1}, respectively.
- This research serves as a basis for optimal comprehensive utilization of algal biomass.

ARTICLE INFO

Article history:
Received 29 July 2012
Received in revised form 12 October 2012
Accepted 13 October 2012
Available online 5 November 2012

Keywords:
Scenedesmus dimorphus
Microalgal culture
Protein
Carbohydrate
Lipid

ABSTRACT

Microalgae have the ability to undergo programmatic changes in photosynthetic carbon partitioning and thus cellular biochemical composition, particularly in the relative amounts of crude protein, lipids, and carbohydrate, in response to changes in environmental and culture conditions. In this study, a novel strategy that employs a single microalgal strain *Scenedesmus dimorphus* grown in a single cultivation platform to produce protein-, carbohydrate- or lipid-rich biomass, as so desired, was introduced. With the combined manipulation of nitrogen availability and light intensity and cell inoculation density, it was successfully demonstrated that highest yields for protein and carbohydrate were 0.2 and 0.7 g L^{-1} d^{-1}, respectively, which could be obtained in early stages of cultivation, while the highest yield for lipid, 0.17 g L^{-1} d^{-1}, occured in a late stage of cultivation.

1. Introduction

A common strategy employed for mass culture of microalgae is to select a strain that can grow rapidly and synthesize large amounts of a desirable/target product and to develop a specific process to maximize the yield of the target product. *Nannochloropsis* sp. (Rodolfi et al., 2009), *Isochrysis* galbana (Durmaz et al., 2008), *Scenedesmus* spp. (Ho et al., 2010), and *Chlorella* spp. (Wang et al., 2010) have been evaluated for lipids production for the pharmaceutical and biofuels industries. *Chlorella* spp. (Mahasneh, 1997) and *Spirulina platensis* (Shimamatsu, 2004) are being commercially exploited as a protein source for food and feed. *Eiseniabicyclis* and *Hijikiafusiforme* (Phaeophyceae) (Kuda et al., 1998; Kolb et al., 1999) used for production of carbohydrates can in turn be used as a feedstock for microbial fermentation to produce ethanol (Hirayama et al., 1998; USDOE, 2010). When multiple products (e.g., protein, starch, and lipid) are desired to be produced from an existing industrial setting at a single location, the replication of the same or introduction of different culture systems and associated downstream processing facilities would be required. These common strategies and production practices may impose logistic difficulties and thus financial burden to algal companies, especially for those small biotech startups where any significant capital investment would be a major challenge. Potential cross contamination of algal cultures by another species/strains may affect not only the productivity of cultures, but also the quality of the end products. Many microalgae seem to possess a common default photosynthetic carbon partitioning mechanism which may result in 30–50% protein, 20–40% carbohydrate, and 8–15% lipid on a per total organic matter basis under favorable culture conditions, regardless of species or strains (Hu, 2004). These microalgae may also have the ability to undergo programmatic changes in

* Corresponding authors Addresses: Shanghai Advanced Research Institute, The Chinese Academy of Sciences, Shanghai 201203, PR China (L. Wang), Laboratory for Algae Research and Biotechnology, Arizona State University, Mesa, AZ 85212, USA. Tel.: +86 480 7271485 (Q. Hu).
E-mail addresses: wangliang@sari.ac.cn (L. Wang), huqiang@asu.edu (Q. Hu).

0960-8524/$ - see front matter © 2012 Published by Elsevier Ltd.
http://dx.doi.org/10.1016/j.biortech.2012.10.062