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The Effect of Air Injection Rate and Medium Nitrogen Concentration on Cell Biomass and Lipid Content of *Scenedesmus quadricauda* in Flat Plate Photobioreactor

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Abstract

In the present study, the microalgal strain *Scenedesmus quadricauda* was studied in different air injection rates and different medium nitrogen concentrations of Lefebvre-czarda medium by using a flat plate photobioreactor. The result showed that air injection enhanced the biomass concentration, however, high air injection rate did not cause the increasing of growth and biomass concentration. The best air injection rate for saving injection energy among 5 to 65 L/min was 15 L/min. Besides, lipid content was not affected by different air injection rates. Three nitrogen concentrations which are standard, double and triple nitrogen concentrations of Lefebvre-czarda medium were tested. The result of nitrogen effect indicated that the lipid content was enhanced by low medium nitrogen concentration. The highest biomass concentration and lipid content were obtained in standard medium nitrogen concentration of Lefebvre-czarda medium.

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Keywords: Scenedesmus quadricauda, flat plate photobioreactor, Lefebvre-czarda medium, biomass concentration, lipid content;

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1. Introduction

Microalgae are either prokaryotic or eukaryotic photosynthetic microorganisms which can capture carbon dioxide and sunlight to produce the biomass. Besides, they are not only rapid growth but also the ability of living in harsh conditions due to their unicellular or simple multicellular structure [1]. Moreover, biomass growth and lipid accumulation of microalgae are also higher than terrestrial plants and this is an evidence to indicate that microalgae is a potential feedstock for biodiesel [2]. Among them, *Scenedesmus quadricauda* (*S. quadricauda*), a type of fresh water microalgae is a potential lipid producer for biodiesel. Rodolfi et al have investigated lipid production of 30 microalgal strains, and the results showed that the lipid productivity of *S. quadricauda* was relatively high [3]. Additionally, there are few reports about the effect of air injection and medium nitrogen concentration on growth and lipid production of *S. quadricauda*, therefore, *S. quadricauda* was chosen as the subject to investigate the factors that could further increase the growth and lipid production.

Two common systems are used to culture microalgae which include the open system (open raceway pond) and the closed system (photobioreactor). Biomass productivity of photoautotrophic microalgae cultured by photobioreator is higher than raceway pond. The most popular design of photobioreactor are tubular photobioreactor, vertical column and flat plate photobioreactor [4]. Flat plate photobioreactor was used in our study due to their large illumination surface area and smaller light path which could enhance the higher photosynthetic efficiency [5].

The culture mixing and mass transfer in photobioreactor is highly influenced by air injection. Besides, photobioreactor design including geometric design, stirrer, sparger and bubble size also affect the culture mixing and mass transfer [6,7]. Therefore, the optimum air injection rate for sufficient mixing and mass transfer for a flat plate photobioreactor should be determined before the investigation of any other factors.

The biomass and lipid content are the indispensable factors that should be increased in order to satisfy the commercial requirement of biofuel market. On another hand, the biomass and lipid content of microalgae can be easily enhanced by changing the culture medium or cultivation conditions to obtain higher production [8]. The factors which affect the biomass and lipid content of microalgae include: chemical stimulants such as nitrogen and phosphate starvation or salinity stress as well as physical stimulants such as manipulating the pH of medium, temperature, light intensity or photoperiods [2,3,9]. Among these factors, nitrogen starvation is the most suitable technique to enhance the biomass and lipid content [10,11,12].

In this study, *S. quadricauda* was cultured in a flat plate photobioreactor to study the effect of air injection rate and nitrogen concentration. The growth, biomass concentration, and lipid content were used to evaluate the effect of these factors.

2. Methodology

2.1. Strain and starter culture

The *S. quadricauda* strain (50 ml, 7 days old) was purchased from Algaetech International Sdn. Bhd. (Technology Park Malaysia, Kuala Lumpur, Malaysia). The starter culture was conducted in order to increase the microalgal cells and prepare an uniform inoculum for next experiments. The cultivation conditions of starter culture were; 5 L of working volume, Lefebvre-czarda (LC) medium [13], 10000 Lux of light intensity, 25 °C of temperature, 2 L/min of air injection rate, and 10 days of cultivation time. The cells in starter culture were recovered by centrifugation (Hermle Z206A, 41.8 km/s^2 for 5 min), then resuspended into 1.0 L of fresh LC medium. The one liter microalgal suspension was stored under the condition of 5 ^{0}C and darkness as the stock of inoculum for all later experiments.

2.2. Experimental setup

Preculture and experimental culture were conducted consecutively, and microalgal cells in preculture were inoculated for experimental cultures. Preculture and experimental cultures were conducted in the same flat plate photobioreactor as shown in Fig. 1. The cultivation conditions of preculture and main culture which are shown in Table 1 were similar to each others, except for the investigation factors.