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Effect of cell rupturing methods on the drying characteristics and lipid compositions of microalgae

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HIGHLIGHTS

- Thin layer drying rate of microalgae is limited by a diffusion mechanism.
- Cell rupturing and drying temperature increased the rate of drying.
- Cell rupturing by French press increased the total lipid yield.
- Developed drying model can be used for designing efficient dryer for microalgae.

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ABSTRACT

This paper investigated the effect of cell rupturing methods on the drying characteristics and the lipid compositions of a green algae consortium grown in an open raceway pond. The ruptured microalgae samples obtained from French press, autoclave and sonication methods were used for conducting thin layer drying experiment at four drying temperatures (30, 50, 70 and 90 °C). The rate of moisture removal at each drying condition was recorded until no change in moisture loss. A typical drying curve for a microalgae consortium indicated that the rate of drying was limited by diffusion. Among three drying models (Newton, Page and Henderson–Pabis) used to fit the drying data, Page model fitted well on the experimental drying data with a coefficient of determination (R^2) of 0.99. Solvent extraction of French press ruptured cells produced the highest total lipid yield with no significant change in lipid compositions.

1. Introduction

Microalgae are novel feedstock for large scale biofuel production in both thermochemical and biochemical platforms (Spolaore et al., 2006; Chisti, 2007; Pienkos and Darzins, 2009). Unlike the terrestrial lignocellulosic biomass, microalgae are cultivated in either open raceway ponds or enclosed photo bioreactors with cell concentrations ranging from 0.5 to 3 g/L and they need to be harvested using various dewatering methods (Benemann et al., 1982; Benemann and Oswald, 1996; Sheehan et al., 1998). Typically, dewatering with flocculation and centrifuge yields an algae paste of about 20% solid content and they required to be further preprocessed for economical downstream processing and preservation (Belarbi et al., 2000).

The general preprocessing steps consisting of cell rupturing, drying and lipid extraction are used for efficiently producing fuels, chemicals and bio-products. Microalgae are usually subjected to cell rupturing to breakdown cell membranes to release lipid globules and bound water molecules (Greenwell et al., 2010). Various cell rupturing methods such as sonication, French press, bead-beating, autoclaving, alkaline treatment and microwave treatment are proposed for microalgae and microbial cells (Lee et al., 1998; Lee et al., 2010). Mechanical disruption of cells was often chosen to minimize chemical contamination of the algae cell (Chisti and Moo-Young, 1986). Cell rupturing has been proven to increase the lipid extraction efficiency, but its impact on drying was not previously investigated. Although drying of microalgae was considered as an energy intensive process, it is important for efficient extraction of lipids, pigments and other high value products with polar solvents, prolonged storage and easy transport (Patil et al., 2008; US DOE, 2010). Drying of microalgae was studied previously and the drying characteristics were explained by simple thin

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