Cultivation of *Chlorella vulgaris* on wastewater containing high levels of ammonia for biodiesel production

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HIGHLIGHTS

- Composition of microalgal cells depends on the composition of the wastewater feeds.
- FAME composition of the cultivated *C. vulgaris* is suitable for biodiesel production.
- Increasing NH₄⁺-N yielded additional short-chain and saturated fatty acids.

ABSTRACT

The feasibility of cultivating *Chlorella vulgaris* with wastewater containing high ammonia nitrogen concentrations was examined. The average specific growth rate of *C. vulgaris* was 0.92 d⁻¹ at 17 mg L⁻¹ NH₄⁺-N, but declined to 0.33 d⁻¹ at NH₄⁺-N concentrations of 39–143 mg L⁻¹. At 39 mg L⁻¹ NH₄⁺-N, lipid productivity reached a maximum value (23.3 mg L⁻¹ d⁻¹) and dropped sharply at higher NH₄⁺-N levels, which demonstrated NH₄⁺-N should be controlled for biodiesel production. C₁₆ and C₁₈ fatty acids accounted for 80% of total fatty acids. Increasing NH₄⁺-N from 17 to 207 mg L⁻¹ yielded additional short-chain and saturated fatty acids. Protein content was in positive correlation with NH₄⁺-N content from 17 mg L⁻¹ (12%) to 207 mg L⁻¹ (42%). Carbohydrate in the dried algae cell was in the range of 14–45%, with a peak value occurring at 143 mg L⁻¹ NH₄⁺-N. The results demonstrate that product quality can be manipulated by NH₄⁺-N concentrations of the initial feeds.

1. Introduction

Microalgae are a potential substrate for the production of biofuel, since it grows much faster than other energy crops (Minowa et al., 1995). Their oil contents are in the range of 20–50% of dry weight and the biodiesel can be consumed in a carbon-neutral manner (Chisti, 2007). Microalgae also represent a protein source in quality equal or superior to that of other high-quality plant proteins (Becker, 2004). The present cost of producing biodiesel from microalgae is ten times higher than the cost of crude oil (Chisti, 2008), due in part to the cost of nutrients for microalgal cultivation (Chen et al., 2011).

The use of wastewater to cultivate microalgae provides an effective means of recycling nitrogen and phosphorus and to produce lipids and proteins (Spolaore et al., 2006). For example, microalgae were cultured on livestock fecal effluent following anaerobic digestion and lipid production at a rate of 17 mg L⁻¹ d⁻¹ was observed (Woertz et al., 2009). Feng et al. (2010) set up a semi-continuous process to cultivate *Chlorella vulgaris* on artificial wastewater, yielding a lipid production rate of up to 147 mg L⁻¹ d⁻¹. Wang et al. (2010) cultivated *Chlorella* sp. on anaerobically-digested dairy manure and determined the lipid profiles of the cells. They found that the two most abundant fatty acids were octadecadienoic acid (27.2–33.4%) and hexadecanoic acid (20.6–26.0%) respectively. The potential of protein-rich microalgae residues as a nutrient additive in livestock feeds has also been investigated (Dubinsky et al., 1980) and Ehimen et al. (2011) studied the potential of recovering methane from post-transesterified microalgae residues.

Microalgae, cultivated under various feed conditions, can differ in their intracellular composition (Yeh et al., 2010). Since effluents...