Abstract

Lipid productivity is the key factor for selection of any microalgal species for biodiesel production. In the present investigation, four different phosphate application strategies were assessed with five green microalgal species, namely *Tetradesmus obliquus*, *Tetradesmus lagerheimii*, *Chlorella vulgaris*, *Chlorella minutissima*, and *Chlamydomonas* sp. to achieve higher lipid yield under laboratory batch culture mode. Under biphasic phosphate-starved approach (BPSA) the lipid yield was increased significantly, but it consisted of two biomass harvesting phases, which would lead to an increase in the overall cost of biodiesel production. On the other hand, the low-dose sequential phosphate addition (LDSPA) strategy resulted in higher lipid yield, which was comparable with BPSA. Among the test microalgae, the best response in terms of lipid yield was recorded for *C. minutissima*; therefore, was taken further for outdoor study.

Outdoor studies were conducted in mini and raceway pond systems at different culture depth in three major seasons, and the optimal depth was taken for further experimentation. In the mini pond system, under the LDSPA mode of cultivation, the projected annual biomass and lipid productivities were 10.0 and 1.4 ton hectare^{-1} year^{-1}, respectively, considering 11 cultivation cycles per year. On the other hand, the raceway pond cultivation under the LDSPA mode resulted in the projection of 37.6 and 5.8 ton hectare^{-1} year^{-1}, respectively, for biomass and lipid productivities with equal numbers of cultivation cycles. The annual lipid productivity was ~40% higher under the LDSPA mode as compared to their respective batch cultures in mini and raceway pond systems. A profound (~14-fold) reduction in phosphate supplementation under the LDSPA mode was also evident.

Drying of the microalgal slurry was carried out by a single rotary drum dryer with varied drum surface temperature and rotational speed. Based on the drying time, lipid recovery, and energy consumption, drum drying at 80 °C drum surface temperature with 0.3 rpm depicted >90% lipid recovery as compared to the bone-dried biomass, thus could be recommended for drying of the microalgal slurry at industrial scale. Fatty acid methyl ester profiles of the biodiesel obtained from *C. minutissima* biomass grown under control and LDSPA modes in the raceway pond system were characterized. Fuel characteristics viz. viscosity, density, saponification value, acid value, calorific value, cetane index, iodine value, flash point, copper strip corrosion, monoglyceride, diglyceride, triglyceride, free glycerine, sulfur, phosphorus, water, and ash contents were analyzed and found to be within the specified limits of national and international biodiesel standards.

Keywords: Biodiesel; Biomass Productivity; *Chlorella minutissima*; Drum Drying; Fuel Characteristics; Lipid Productivity; Microalgae; Raceway Ponds.