World Academy of Science, Engineering and Technology
International Journal of Biotechnology and Bioengineering
Vol:18, No:12, 2024

Optimization of Biomass Production and Lipid Formation from Chlorococcum sp. Cultivation on Dairy and Paper-Pulp Wastewater

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Abstract : The ever-increasing depletion of the dominant global form of energy (fossil fuels) calls for the development of sustainable and green alternative energy sources such as bioethanol, biohydrogen, and biodiesel. The production of the major biofuels relies on biomass feedstocks that are mainly derived from edible food crops and some inedible plants. One suitable feedstock with great potential as raw material for biofuel production is microalgal biomass. Despite the tremendous attributes of microalgae as a source of biofuel, their cultivation requires huge volumes of freshwater, thus posing a serious threat to commercial-scale production and utilization of algal biomass. In this study, a multi-media wastewater mixture for microalgae growth was formulated and optimized. Moreover, the obtained microalgae biomass was pre-treated to reduce sugar recovery and was compared with previous studies on microalgae biomass pre-treatment. The formulated and optimized mixed wastewater media for biomass and lipid accumulation was established using the simplex lattice mixture design. Based on the superposition approach of the potential results, numerical optimization was conducted, followed by the analysis of biomass concentration and lipid accumulation. The coefficients of regression (R^2) of 0.91 and 0.98 were obtained for biomass concentration and lipid accumulation models, respectively. The developed optimization model predicted optimal biomass concentration and lipid accumulation of 1.17 g/L and 0.39 g/g, respectively. It suggested 64.69% dairy wastewater (DWW) and 35.31% paper and pulp wastewater (PWW) mixture for biomass concentration, 34.21% DWW, and 65.79% PWW for lipid accumulation. Experimental validation generated 0.94 g/L and 0.39 g/g of biomass concentration and lipid accumulation, respectively. The obtained microalgae biomass was pre-treated, enzymatically hydrolysed, and subsequently assessed for reducing sugars. The optimization of microwave pre-treatment of Chlorococcum sp. was achieved using response surface methodology (RSM). Microwave power (100 – 700 W), pre-treatment time (1 – 7 min), and acid-liquid ratio (1 – 5%) were selected as independent variables for RSM optimization. The optimum conditions were achieved at microwave power, pre-treatment time, and acid-liquid ratio of 700 W, 7 min, and 32.33:1, respectively. These conditions provided the highest amount of reducing sugars at 10.73 g/L. Process optimization predicted reducing sugar yields of 11.14 g/L on microwave-assisted pre-treatment of 2.52% HCl for 4.06 min at 700 watts. Experimental validation yielded reducing sugars of 15.67 g/L. These findings demonstrate that dairy wastewater and paper and pulp wastewater that could pose a serious environmental nuisance. They could be blended to form a suitable microalgae growth media, consolidating the potency of microalgae as a viable feedstock for fermentable sugars. Also, the outcome of this study supports the microalgal wastewater biorefinery concept, where wastewater remediation is coupled with bioenergy production.

Keywords : wastewater cultivation, mixture design, lipid, biomass, nutrient removal, microwave, Chlorococcum, raceway pond, fermentable sugar, modelling, optimization
Conference Title : ICBBB 2024 : International Conference on Bioscience, Biotechnology, and Biochemistry
Conference Location : New York, United States
Conference Dates : December 09-10, 2024