A bioprocess engineering approach to produce renewable protein by nitrogen fixing cyanobacteria

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This project explores the potential of nitrogen-fixing cyanobacteria for sustainable and industrially relevant applications, with a focus on protein production and process optimization. Through an integrated approach combining experimental investigation, process modeling, and techno-economic analysis, this work aims to provide valuable insights into advancing bio-based solutions to global challenges such as food security, environmental sustainability, and resource efficiency. Continuous cultivation in flat panel photobioreactors of diazotrophic cyanobacteria, particularly *Nostoc* sp. PCC 7120, is investigated as a strategy for stable protein production, with the potential of reducing the reliance on nitrogen fertilisers. Key operating variables are analysed to determine their effect on biomass productivity, quality, and nutritional value. Photorespirometry is employed to evaluate the physiological response of nitrogen-fixing cyanobacteria to light and temperature conditions. A Design of Experiments (DoE) framework is applied to systematically investigate and optimize cultivation conditions, focusing on the interplay between light and nutrient inputs to enhance productivity in high-density cultivation systems. Experimental findings contribute to the development of predictive kinetic models, including variables which are often overlooked like gas insufflation efficiency, establishing a basis for process optimization. The potential of *Nostoc* sp. as an iron-rich supplement is also investigated as an alternative application in nutraceuticals and functional foods by evaluating iron dynamics in both batch and continuous systems. Finally, based on the laboratory-scale results projected to a real plant scenario, a techno-economic analysis is performed on a one-hectare basis to assess the economic feasibility of the proposed process and explore alternative downstream possibilities.

Keywords: *microalgae, essential aminoacids, continuous photobioreactor, kinetic modelling, fermentation, technoeconomic analysis*