Development and evaluation of a thin-layer photobioreactor for optimizing light influence on microalgal cultivation

Serena Lima [a], Arima Marchese [a], Alessandro Cosenza [a], Francesca Scargiali [a]

[a] Department of Engineering, University of Palermo, Viale delle Scienze ed. 6, 90128 Palermo, Italy

E-mail: alessandro.cosenza@unipa.it

Light is one of the key parameters influencing microalgal cultures. This study focuses on the effects of light wavelength and on the optimization of light distribution through the design of an innovative thin-layer photobioreactor (TLPBR). To evaluate the effectiveness of the TLPBR, the growth kinetics of *Nannochloropsis gaditana* and its carotenoid composition (lutein and violaxanthin) were monitored at different light wavelength conditions.

The TLPBR was designed to reduce self-shading, ensuring a homogeneous light distribution and minimizing light gradients within the culture. Furthermore, the system's fluid dynamics was optimized to further mixing and the exchange of CO_2 and O_2. The reactor was developed to provide a wide illuminated surface of the culture, stacking a series of plates in which the liquid film flows downward from one plate to another. The structure of the TLPBR, made of plexiglass for its mechanical strength and chemical resistance, includes a collection basin and four inclined stacked plates, each measuring 34 cm in length, 27 cm in width, and 8.5 cm in height. LED panels placed at the base of the plate above lightens each plate.

An experimental trial lasting 72 days was conducted, during which the microalgal growth and process efficiency were monitored under various wavelength conditions, keeping all other variables constant. An initial batch phase under white light allowed the assessment of growth kinetics and the establishment of a flow rate of 0.4 mL/min, avoiding washout. The system then transitioned to continuous mode, with sequential changes in light wavelength (white, blue, red, green). The culture was inoculated to a constant biomass concentration of 0.045 g/L in F/2 medium with a total volume of 6 L, and the light intensity was maintained at 30 µmol m^{-2} s^{-1}. The wavelength was changed when the culture reached a steady state. At that point, a sample was collected for carotenoid content analysis. Red light was observed to promote growth kinetics, reaching a biomass concentration of 0.3 g/L., while blue light inhibited growth, with a steady-state concentration of only 0.1 g/L. Compared to white light, both green and red light enhanced carotenoid production, while blue light again yielded the lowest results.

This work was carried out under the National Recovery and Resilience Plan (NRRP), Mission 4 Component 2 Investment 1.4 - Call for tender No. 3138 of 16 December 2021, rectified by Decree n.3175 of 18 December 2021 of Italian Ministry of University and Research funded by the European

Union – NextGenerationEU; Award Number: Project code CN_00000033, Concession Decree No. 1034 of 17 June 2022 adopted by the Italian Ministry of University and Research, CUP UNIPA B73C22000790001, Project title “National Biodiversity Future Center - NBFC”.

Keywords: *photobioreactor, light optimization, microalgae, carotenoids*