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Phaeodactylum tricornutum: A promising algal bio-factory for sustainable pigment production

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Abstract:

Phaeodactylum tricornutum is a single-celled pennate diatom, exhibiting unique silica-based cell wall structures with characteristic golden-brown colour due to a high amount of fucoxanthin. *P. tricornutum* exhibits an innate ability to synthesize bioactive compounds, viz. lipids, and pigments such as Fucoxanthin and β- carotene.

Fucoxanthin is an orange coloured carotenoid, contributing more than 10% of the estimated total production of carotenoids in nature, especially in the marine environment. Fucoxanthin has considerable potential and promising applications due to its antioxidant, anti-inflammatory and anti-cancer activity and is gaining immense popularity as a natural food colorant due to its health benefits, lack of toxicity, and wide availability. Although *P. tricornutum* is recommended as bio factories for pigment production, there are some obstacles to achieving maximum yields and productivities. Therefore, their growth and media engineering provide a promising approach for improving this diatom strain to augment their ability to synthesize and accumulate desired pigments.

The current innovation entailed development of the diatom, *P. tricornutum* as a sustainable platform towards synthesis of the natural colorant, fucoxanthin. Herein, Plackett–Burman design was adopted to select the most important nutrients influencing the pigment content in *P. tricornutum* biomass. This exercise highlighted $NaNO_3$, NaH_2PO_4 and glycerol as positively impacting nutrients significantly affecting the biomass and fucoxanthin content in *P. tricornutum*. After identifying these effective nutrients, Central Composite Design (CCD) was adopted to establish the optimum concentrations of the key nutrients for higher biomass with maximum pigment contents. A maximum of 2.4 g/L biomass, and 623 ug/L pigment was produced using optimum nutrient concentrations representing 100% and 85% validity of the model prediction with respect to biomass and pigment respectively. Cultivation of *P. tricornutum* in this optimized media (Ef/2) enhanced its biomass by 66% and fucoxanthin by 70% as compared to its original media (f/2) composition. The present study further demonstrated the possibility of using variable light intensity (30 μE & 100 μE) and light spectrum (White, Red, and Blue), to modulate *P. tricornutum* growth thereby altering and impacting its pigment content.

Thus, development of an optimum media recipe for *Phaeodactylum tricornutum* cultivation by employing growth and media engineering strategies yielded biomass augmented with higher fucoxanthin content suitable for commercial applications and its effectiveness as a natural colorant.