PROTEIN-ENRICHED *PORPHYRIDIUM PURPUREUM* BIOMASS VIA NITROGEN AND LIGHT MODULATION FOR BIOTECHNOLOGICAL APPLICATIONS

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Background: *Porphyridium purpureum* is a red microalga with significant biotechnological potential, whose biomass composition can be modulated under controlled culture conditions. Increased nitrogen availability and optimized light intensity stimulate protein accumulation, reflecting adaptive metabolic responses to environmental variations. This metabolic plasticity enables the redirection of biosynthetic pathways toward target compounds. Moreover, the resulting biomass can serve as a biological matrix for generating reducing biomolecules applicable in the functionalization of silver nanoparticles and the development of stable, biocompatible nanobiomaterials.

Aim of the study: To identify optimal nutritional and illumination conditions for maximizing protein accumulation in *Porphyridium purpureum* and to validate the obtained biomass as a source of targeted proteins for subsequent use in the biofunctionalization of silver nanoparticles.

Materials and methods: *Porphyridium purpureum* was cultivated in three nutrient media under controlled temperature, pH, and continuous illumination to determine the optimal growth conditions. Nitrogen source optimization was performed using a single-factor experimental design followed by the Box-Wilson method. The illumination regime was adjusted stepwise according to the growth phases (adaptation and exponential). Biomass productivity and protein accumulation were assessed by protein quantification, MDA content evaluation, and antioxidant activity assays (DPPH and FRAP) using specific spectrophotometric methods.

Results: Optimization of cultivation conditions—by increasing nitrogen from 5.5 to 6.5 g/L and applying phased illumination (56 µmol photons·m^{-2}·s^{-1} for 6 days, then 72 µmol photons·m^{-2}·s^{-1} during the exponential phase)—significantly enhanced protein content compared to standard conditions, while maintaining low oxidative stress (reduced MDA). The optimized biomass reached ~45% protein versus ~33% under conventional conditions.

Proteins were extracted via alkaline solubilization, followed by centrifugation and pH adjustment, yielding a soluble fraction of ~16 g/100 g extract. The extract showed antioxidant and reducing activity (DPPH inhibition ~20%; FRAP ~27 mg ascorbic acid equivalents/g extract), confirming its suitability as a biological matrix.

Conclusions: Optimization of nutritional and illumination conditions significantly enhances protein accumulation in *Porphyridium purpureum* without inducing substantial oxidative stress. The resulting protein extract exhibits antioxidant and reducing capacity, supporting its applicability as a functional biological matrix for the biofunctionalization of silver nanoparticles.

Keywords: *Porphyridium purpureum*, targeted proteins, optimization, biofunctionalization, silver nanoparticles.

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