Abstract

This study investigates the feasibility of producing bioethanol and high-value co-products from a non-nitrogen fixing marine cyanobacterium, *Synechococcus elongatus* BDU 10144, in a low-cost fertilizer-based seawater medium under a sustainable biorefinery perspective. After evaluating three newly formulated agricultural fertilizer-based media, the diammonium phosphate (DAP)-based medium showed comparable growth with the standard Artificial Seawater Nutrient (ASN-III) medium. Further, a multifactor optimization study was conducted using Response Surface Methodology to optimize the macronutrient concentrations of the DAP-based medium. Inclusion of seawater in the DAP-based medium, named as Fertilizer-Seawater (FSW) medium, resulted in a profound cost reduction by 46-fold.

Subsequently, several environmental and nutritional parameters were investigated to maximize the potential of the FSW medium for biomass and carbohydrate production by the test cyanobacterium. The optimal environmental conditions were a light intensity of 50 μmol photon m^{-2} s^{-1} PAR, initial culture pH 10 at temperature of 25°C. Nutritional factors (magnesium, lysine, and calcium) were investigated due to their crucial role in carbon fixation. Among these, lysine supplementation emerged as the most effective in enhancing biomass and carbohydrate productivity.

Thus, consequently, potato peel waste (PPW) was explored as a low-cost lysine supplement. HPLC analysis of PPW extract confirmed the presence of lysine, while microscopic examination revealed an abundance of starch, making PPW a rich nutritional supplement for mixotrophic cultivation. Incorporating 10%-PPW extract into the FSW medium resulted in a 3.8-fold rise in carbohydrate productivity compared to the control ASN-III medium.

Eventually, *S. elongatus* BDU 10144 has demonstrated remarkable potential as a prolific producer of valuable bioproducts, including bioethanol, exopolysaccharides, mycosporine-like amino acids, and sodium copper chlorophyllin. A significant rise in bioproducts productivities ranging from 2.6-3.8-fold was observed in the PPW-FSW medium. Thus, this study establishes a foundation for the prospective large-scale cultivation of the test cyanobacterium in the PPW-FSW medium, enabling cost-efficient and sustainable development of a biorefinery concept. Also, by embracing a ‘waste-to-wealth’ paradigm, this integrated cultivation strategy shows potential for concurrent bioethanol production along with other commercially important bioproducts.

Keywords: Bioethanol; Exopolysaccharides; Mycosporine-like amino acids; Potato peel waste; Seawater; Sodium copper chlorophyllin; *Synechococcus elongatus* BDU 10144