



INTISARI

Meningkatnya permintaan energi bersih dan berkelanjutan menuntut inovasi teknologi yang efisien dan ramah lingkungan. Krisis energi global, akibat negatif perubahan iklim, mempercepat transisi menuju sumber energi terbarukan yang berkelanjutan. Urgensi pengembangan hidrogen, khususnya hidrogen hijau, semakin meningkat di Indonesia seiring kebutuhan transisi energi nasional, target *Net Zero Emission 2060*, serta tuntutan pengurangan ketergantungan terhadap energi fosil di sektor industri, transportasi, dan pembangkitan listrik. Penelitian ini bertujuan mengoptimasi sistem kultivasi mikroalga *Chlorella vulgaris* sebagai penghasil biohidrogen melalui pendekatan hibrida yang menggabungkan proses biofotolisis dan elektrolisis. Tiga variabel utama pH medium, lama penyinaran, dan tegangan elektrolisis dioptimasi menggunakan *Response Surface Methodology* (RSM) dengan desain *Face-centered Composite Design* (FCCD) untuk mengetahui pengaruhnya terhadap jumlah sel, biomassa, nilai *optical density* (OD 680 nm), serta produktivitas hidrogen terlarut. Analisis lanjutan menggunakan ANOVA, *paired t-test*, dan korelasi *Pearson* diterapkan untuk menilai signifikansi dan hubungan antar variabel. Hasil penelitian menunjukkan bahwa kondisi optimal dicapai pada pH 10, lama penyinaran 24 jam, dan tegangan 12 V, menghasilkan kepadatan sel $1,47 \times 10^7$ sel/mL, biomassa 523,75 mg/L, nilai OD 0,636, serta produktivitas hidrogen sebesar 227,101 ppb/hari dengan *desirability* 0,955. Model Gompertz terbukti paling sesuai menggambarkan pola pertumbuhan kultur dengan tingkat kecocokan 98,97% untuk OD dan 96,16% untuk jumlah sel. Selain itu, terdapat korelasi positif signifikan dengan peningkatan produktivitas hidrogen oleh mikroalga *C. vulgaris* ($r = 0,724; 0,764$, dan $p\text{-value } 0,027; 0,017 < 0,05$) antara kepadatan sel dan produksi hidrogen, yang menegaskan bahwa peningkatan pertumbuhan mikroalga berkontribusi langsung pada peningkatan produksi biohidrogen.

Kata kunci: Energi terbarukan, hidrogen terlarut, mikroalga *Chlorella vulgaris*, *Response Surface Methodology*



ABSTRACT

*The increasing demand for clean and sustainable energy demands efficient and environmentally friendly technological innovations. The global energy crisis, the negative impact of climate change, accelerates the transition to sustainable renewable energy sources. The urgency of hydrogen development, especially green hydrogen, is increasing in Indonesia in line with the needs of the national energy transition, the 2060 Net Zero Emission target, and the demand to reduce dependence on fossil fuels in the industrial, transportation, and electricity generation sectors. This study aims to optimize the cultivation system of the microalgae *Chlorella vulgaris* as a biohydrogen producer through a hybrid approach that combines biophotolysis and electrolysis processes. Three main variables, medium pH, irradiation duration, and electrolysis voltage, were optimized using Response Surface Methodology (RSM) with a Face-centered Composite Design (FCCD) design to determine their effects on cell number, biomass, optical density (OD 680 nm), and dissolved hydrogen productivity. Further analysis using ANOVA, paired t-test, and Pearson correlation was applied to assess the significance and relationship between variables. The results showed that optimal conditions were achieved at pH 10, 24 hours of irradiation, and 12 V voltage, resulting in a cell density of 1.47×10^7 cells/mL, a biomass of 523.75 mg/L, an OD value of 0.636, and a hydrogen productivity of 227.101 ppb/day with a desirability of 0.955. The Gompertz model proved to best describe the culture growth pattern, with a fit level of 98.97% for OD and 96.16% for cell number. Furthermore, there was a significant positive correlation between cell density and hydrogen production ($r = 0.724$; 0.764 , and p -values 0.027 ; $0.017 < 0.05$), confirming that increased microalgae growth contributes directly to increased biohydrogen production.*

*Keywords: Renewable energy, dissolved hydrogen, microalgae *Chlorella vulgaris*, Response Surface Methodology*