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Biohydrogen Production Using Fermented Acidic Cheese Whey

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Abstract

Hydrogen production through dark fermentation (DF) is an environmental process with the dual advantages of energy production and waste treatment (Kim et al., 2022). DF is still challenging, requiring further research to make the process more stable regarding productivity. In recent years, redirecting DF towards using lactate-acetate as a new hydrogen-producing pathway has been proposed, which addresses the proliferation of lactic acid bacteria and stability, both of which are bottlenecks in DF (García-Depraect et al., 2021). Besides, the performance of the reactor is influenced by operational parameters such as the organic loading rate (OLR), pH, hydraulic retention time (HRT), and temperature. The range of OLR applied to the process is operationally relevant to obtain suitable microbial growth and hydrogen production rate (HPR). Nevertheless, higher OLR does not necessarily lead to higher hydrogen production. Thus, optimization of OLR is essential to obtain higher productivity (Mohammadi et al., 2012). On the other hand, Fe^{2+} could improve HPR by promoting cell growth because it is a fundamental component of the hydrogenases and could serve as an electron carrier (Ren et al., 2022). This study evaluated the influence of OLR and iron supplementation on the biohydrogen production rate from the lactate-acetate pathway using fermented acidic cheese whey (FCW) in an expanded granular sludge bed reactor. The FCW was collected from a cheese factory in Mexico. Hydrogenogenic granular sludge adapted to FCW was used as inoculum (Ordoñez-Frías et al., 2023). Biohydrogen production was evaluated using three different OLR of 82 g/L·d, 165 g/L·d, and 213 g/L·d corresponding to lactate concentrations of 15.5 g/L, 31 g/L, and 40 g/L, respectively, and at a constant HRT of 4.5 h. The lactate-acetate fermentative pathway was evaluated using an FCW and acetic acid (HAc) with an optimal ratio (8.25) previously found (Ordoñez-Frías et al., 2023). FCW with Fe^{2+} (50 mg Fe^{2+}/L) was added to the optimal OLR condition. The increase in the OLR from 82 to 165 g lactate/L·d positively affected HPR. The highest HPR was observed at 165 g lactate/L·d, and the maximum HPR obtained was 5.8 L H_2/L·d. However, a further increase in OLR to 213 g lactate/L·d decreased the HPR value at 3 LH_2/L·d, 48%

lower than the HPR showed at 165 g lactate/L·d. Butyrate (3.7 g/L) was the primary metabolite in the reactor (at an OLR of 82 g lactate/L·d). Conversely, lactate (9.9 g/L) and caproate (1.6 g/L) were the primary metabolites using an OLR of 165 g lactate/L·d. For the OLR of 213 g lactate/L·d, lactate (25.5 g/L), caproate (1.3 g/L), and propionate (1.1 g/L) were the primary metabolites. So far, no significant improvement in HPR (2.4 L H_2/L·d) was achieved with iron dosing. The results showed that high OLR favored high HPR under the lactate-acetate pathway.

Keywords: Biohydrogen, iron supply, lactate-acetate pathway, organic loading rate

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