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Sugar Beet Residue Valorization Through Anaerobic Digestion for Hydrogen and Methane Generation

Akerke Toleugazykyzy[1], Ayaulym Daniyarova[2], Kairat Bekbayev[2*], Meicai Xu[3], Yan Liu[3], Wei Liao[3]

[1] Technical Faculty, S.Seifullin Kazakh Agro Technical Research University, Astana, Kazakhstan

[2] Research School of Food Engineering, Shakarim University, Semey, Kazakhstan

[3] Anaerobic Digestion Research and Education Center (ADREC), Department of Biosystems and Agricultural Engineering, Michigan State University, East Lansing, MI 48824, USA

ABSTRACT

Hydrogen production from lignocellulosic biomass using anaerobic digestion/fermentation methods is still in the research stage and, to our knowledge, has not been implemented on a commercial scale. However, co-generation of hydrogen and methane from anaerobic digestion is possible and can have a practical application. Here we used two stage anaerobic digestion to optimize the production of hydrogen and methane from sugar beet residues. The pretreatment of the substrate included mechanical grinding in a ball mill followed by enzymatic hydrolysis with cellulase. The experiments were carried out in two bioreactors (AD1 and AD2) with different hydraulic retention times (HRT): AD1 with HRT of 5 days represented the acidogenesis stage focused on biohydrogen production, while AD2 with HRT of 25 days represented the methanogenesis stage aimed at biomethane production. During enzymatic hydrolysis of beet pulp residues, the concentration of reducing sugars increased significantly, peaking at 43,013 mg/L after 10 hours of fermentation. A notable reduction in dry matter (from 20.16% to 16.33%) and volatile solids (from 17.93% to 12.90%) was also observed during hydrolysis, reflecting the active degradation of organic components. In the acidogenic AD1 stage, cumulative biogas reached approximately 1220 mL with a hydrogen content of 28–41 %, indicating active acidogenesis under short hydraulic retention time (HRT). In the methanogenic AD2 stage, methane concentration increased steadily from 24.1% to 68.4% over 25 days, while carbon dioxide decreased from 32–37% to around 25%, reflecting effective methanogen adaptation and pH stabilization. A steady increase in methane yield demonstrated the success of the two-step process. Thus, the proposed technology shows strong potential for integration into the bioenergy sector. Also, the conducted study confirmed the effectiveness of using sugar beet pulp as a raw material for the purpose of obtaining biohydrogen and biomethane.

Keywords: sugar beet waste, anaerobic digestion, biogas, biohydrogen, biomethane

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***Corresponding Author:**

Kairat Bekbayev, the Department of Technological Equipment, Research School of Food Engineering, Shakarim University, Glinka st. 20a, 071400, Semey, Kazakhstan.
Email: k.bekbayev@shakarim.kz