World Academy of Science, Engineering and Technology
International Journal of Biological and Ecological Engineering
Vol:12, No:11, 2018

Application of the Carboxylate Platform in the Consolidated Bioconversion of Agricultural Wastes to Biofuel Precursors

Authors : Sesethu G. Njokweni, Marelize Botes, Emile W. H. Van Zyl

Abstract : An alternative strategy to the production of bioethanol is by examining the degradability of biomass in a natural system such as the rumen of mammals. This anaerobic microbial community has higher cellulolytic activities than microbial communities from other habitats and degrades cellulose to produce volatile fatty acids (VFA), methane and CO_2. VFAs have the potential to serve as intermediate products for electrochemical conversion to hydrocarbon fuels. In vitro mimicking of this process would be more cost-effective than bioethanol production as it does not require chemical pre-treatment of biomass, a sterile environment or added enzymes. The strategies of the carboxylate platform and the co-cultures of a bovine ruminal microbiota from cannulated cows were combined in order to investigate and optimize the bioconversion of agricultural biomass (apple and grape pomace, citrus pulp, sugarcane bagasse and triticale straw) to high value VFAs as intermediates for biofuel production in a consolidated bioprocess. Optimisation of reactor conditions was investigated using five different ruminal inoculum concentrations; 5,10,15,20 and 25% with fixed pH at 6.8 and temperature at 39 ˚C. The ANKOM 200/220 fiber analyser was used to analyse in vitro neutral detergent fiber (NDF) disappearance of the feedstuffs. Fresh and cryo-frozen (5% DMSO and 50% glycerol for 3 months) rumen cultures were tested for the retainment of fermentation capacity and durability in 72 h fermentations in 125 ml serum vials using a FURO medical solutions 6-valve gas manifold to induce anaerobic conditions. Fermentation of apple pomace, triticale straw, and grape pomace showed no significant difference ($P > 0.05$) in the effect of 15 and 20 % inoculum concentrations for the total VFA yield. However, high performance liquid chromatographic separation within the two inoculum concentrations showed a significant difference ($P < 0.05$) in acetic acid yield, with 20% inoculum concentration being the optimum at 4.67 g/l. NDF disappearance of 85% in 96 h and total VFA yield of 11.5 g/l in 72 h (A/P ratio = 2.04) for apple pomace entailed that it was the optimal feedstuff for this process. The NDF disappearance and VFA yield of DMSO (82% NDF disappearance and 10.6 g/l VFA) and glycerol (90% NDF disappearance and 11.6 g/l VFA) stored rumen also showed significantly similar degradability of apple pomace with lack of treatment effect differences compared to a fresh rumen control ($P > 0.05$). The lack of treatment effects was a positive sign in indicating that there was no difference between the stored samples and the fresh rumen control. Retaining of the fermentation capacity within the preserved cultures suggests that its metabolic characteristics were preserved due to resilience and redundancy of the rumen culture. The amount of degradability and VFA yield within a short span was similar to other carboxylate platforms that have longer run times. This study shows that by virtue of faster rates and high extent of degradability, small scale alternatives to bioethanol such as rumen microbiomes and other natural fermenting microbiomes can be employed to enhance the feasibility of biofuels large-scale implementation.

Keywords : agricultural wastes, carboxylate platform, rumen microbiome, volatile fatty acids
Conference Title : ICBBB 2018 : International Conference on Bioenergy, Biofuels and Biorefineries
Conference Location : Cape Town, South Africa
Conference Dates : November 15-16, 2018