BOOSTING ANAEROBIC LIGNOCELLULOSE UTILIZATION VIA SYNTROPHIC INTERACTIONS

Annabella Juhász-Erdélyi [1], Etelka Kovács [1], Roland Wirth [2], Gergely Maróti [2], Zoltán Bagi [1,2], Kornél L. Kovács [1,2]

[1]*Department of Biotechnology and Microbiology, Faculty of Science and Informatics, University of Szeged;*
[2]*Institute of Plant Biology, HUN-REN Biological Research Centre, Szeged*

Lignocellulose-based biomass represents one of the most abundant renewable resources, holding great promise for sustainable energy generation and as a raw material for the chemical industry.

Our research aims to develop a stable, efficient microbial consortium capable of degrading lignocellulose under artificial conditions, relying on tight syntrophic interactions. To this end, we investigated the degradation efficiency of rumen-derived anaerobic fungi (AGF), methanogenic archaea (MA), and bacteria (BAC), cultivated on straw. Using SEM, HPLC, and metagenomic approaches, we observed intensive microbial proliferation and close cell-to-cell associations among AGF, MA, and BAC. Metagenomic sequencing provided insights into dynamic community shifts, while HPLC analyses revealed the composition of degradation products.

In line with previous findings on biomass pretreatment, we also applied biological pretreatment in our system. Both the anaerobic fungus–methanogen (AGF-MA) and the fungus–methanogen–bacterium (AGF-MA-BAC) consortia generated substantial methane yields when supplied with hydrogen. Notably, the AGF-MA-BAC community produced 27% more methane than AGF-MA alone, and under optimal microbial configurations, methane production increased by 50–60%. Subsequent biogas fermentation trials confirmed that the AGF-MA-BAC consortium consistently achieved the highest methane output. These results support our hypothesis that this minimal microbial community enhances structural breakdown of plant biomass and maximizes methane generation.

Since methane is the primary energy carrier in biogas and directly usable as a renewable fuel, the synergistic action of this microbial system offers a promising route for energy-efficient processing and utilization of lignocellulose-rich biomass and agricultural residues.