Circular Economy in Food Industry Waste Management (BIVALIA Workshop2 - 2026)

Editors: Elena Diaz Nieto; Francisco Heras Muñoz; Juan Antonio Melero Hernández; Manuel Gertrudix
Madrid, BIVALIA, UAM-URJC, 2026
DOI: 10.5281/zenodo.22206833 · CC BY 4.0
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P.I.2 — From residual municipal waste to high value products: volatile fatty acids and biohydrogen

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Waste management; acidogenic fermentation; biomass

HOW TO CITE THIS CONTRIBUTION

A. Muñoz-Muñoz, J.J. Hernández-García, A. Sarrión, E. Díaz, A.F. Mohedano, M.A. de la Rubia. (2026). P.I.2 — From residual municipal waste to high value products: volatile fatty acids and biohydrogen. In: Diaz Nieto, E., Heras Muñoz, F., Melero Hernández, J. A., Gertrudix, M. (Eds.), Circular Economy in Food Industry Waste Management (BIVALIA Workshop2 - 2026), p. 36. BIVALIA, UAM-URJC. https://doi.org/10.5281/zenodo.22206833

Poster Presentations #19

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Keywords: *Waste management; acidogenic fermentation; biomass*

Acidogenic fermentation (AF) represents a sustainable pathway for biohydrogen generation from the residual fraction of municipal waste (RFMW). This study evaluated the AF of thermo-hydrolyzed RFMW under batch and semicontinuous regimes, analyzing hydrogen yields, fermentation kinetics, volatile fatty acids (VFA) production, and microbial community shifts. Batch assays tested mixed stabilized sludge (MSS) and digested sewage sludge (SSD) as inocula under different substrate-to-inoculum ratios (SIR). MSS was identified as the superior inoculum, achieving maximum hydrogen yields of 19.4 mL H_2/g volatile solids (VS) at an SIR of 1.5. In these assays, kinetics for MSS were best described by a modified logistic model, favoring the enrichment of hydrogen-producing taxa such as Bacillus and Caloramator, while end-point VFAs showed a high correlation with butyrate prevalence. Semicontinuous trials were conducted in continuously stirred tank reactors (CSTR) using MSS at hydraulic retention times (HRT) of 3, 5, and 8 days. Semicontinuous operation initially favored fermentative pathways, reaching a peak hydrogen production rate of 19.6 mL H_2/g VS·d at an HRT of 3 days. However, operating at longer retention times induced a progressive metabolic shift from hydrogenogenesis toward methanogenesis, accompanied by moderate acidification, a substantial accumulation of intermediates (VFAs up to 8.4 g/L), and a decline in stability. Microbial community dynamics reflected these functional changes: hydrogenogenic consortia dominated the initial H_2-producing stages, but extended HRTs caused a transition where *Caproiciproducens* shifted toward *Thermoclostridium* and *Defluviitoga*, allowing low-abundance hydrogenotrophic methanogens to establish. In conclusion, while batch operation optimized hydrogen production via specific inoculum selection, semicontinuous operation revealed that short retention times enhance initial hydrogen yields but compromise system stability. These findings highlight that maintaining long-term acidogenic performance requires strict operational control, particularly pH regulation, to avoid the metabolic diversion of intermediates toward methanogenesis during the valorization of municipal organic waste.

Acknowledgements

The authors greatly appreciate funding from Spanish MCIN/AEI/UE (10.13039/501100011033) through the project PID2022-138632OB-I00 project and Madrid Regional Government through the project TEC-2024/BIO-177. The authors gratefully acknowledge Aqualia for supplying the mixed sewage sludge required for this study, and Econward Tech for providing post-treated thermally hydrolyzed mechanically sorted organic fraction from municipal waste.

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