Producing VFAs On Starch-Waste-Activated Bacterial Fermentation

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Introduction

Globally more than two billion metric tons **Municipal Solid Waste** is generated every year, with an expected increase to 3.8 billion tons by 2050 according to the United Nations [1]. However, there is hope as food waste, being the main type of waste, holds a lot of potential as unused energy source for production processes.

Within the scope of this research **Volatile Fatty Acids** (VFAs) are produced as a precursor to the **bioplastic** Polyhydroxyalkanoate (PHA) from **starch-based waste streams** and a Mixed Microbial Culture (MMC) through anaerobic digestion. The starch-based waste comes from agricultural use and the MMC is housed within sludge from a water-treatment-facility that has been cultured in feed. The main question is thus '**Can the starch-based waste streams produce a reliable and useful level of VFAs under the chosen conditions?' [2].**

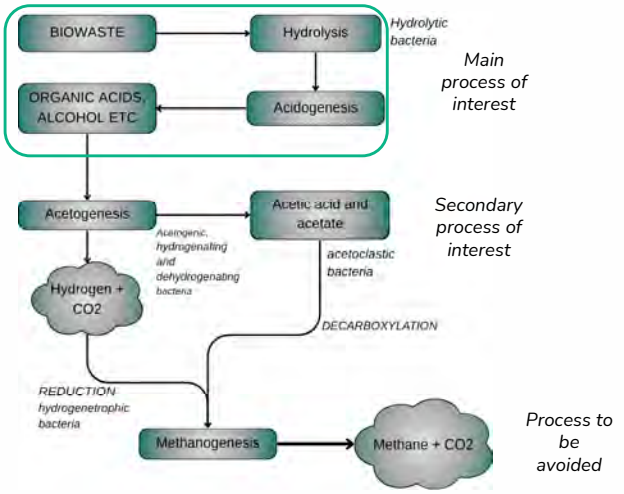

Figure 1: Diagram of anaerobic digestion on biowaste; Aside from acidogenesis it is shows that acetic acid is also converted at a latter stage. Modified from Evans G. [3]

Methods

- Batch bottle fermentations were performed on two different starch-based waste streams with pH 5.5 and incubation at 35°C. A range of HRTs was chosen as design parameter.
- The inoculum and feed volumes within the bottles were based on the same ratio.

Table 1: Design of experiments of batch bottles.

Design	Waste Feed	HRT
1	A	2
2	A	2
3	A	4
4	A	4
5	A	6
6	A	6
7	B	2
8	B	6
9	B	4

Figure 2: Representation of fermentation bottle. Created in Biorendr.

Results

Waste Feed A

At this stage in the research only the chemical oxygen demand (COD) has been analysed, this is a measure of the 'oxygen' necessary for organic reactions, such as the fermentation [4].

Looking at the consumption/decrease in soluble COD between start and end of experiment, this value does become higher relative to the number of days the fermentation ran. When comparing the difference per day this trend is not repeated but all have a similar decrease with stdev=0.14.

This overall similar decrease suggests a steady-state consumption of organic compounds rather than production.

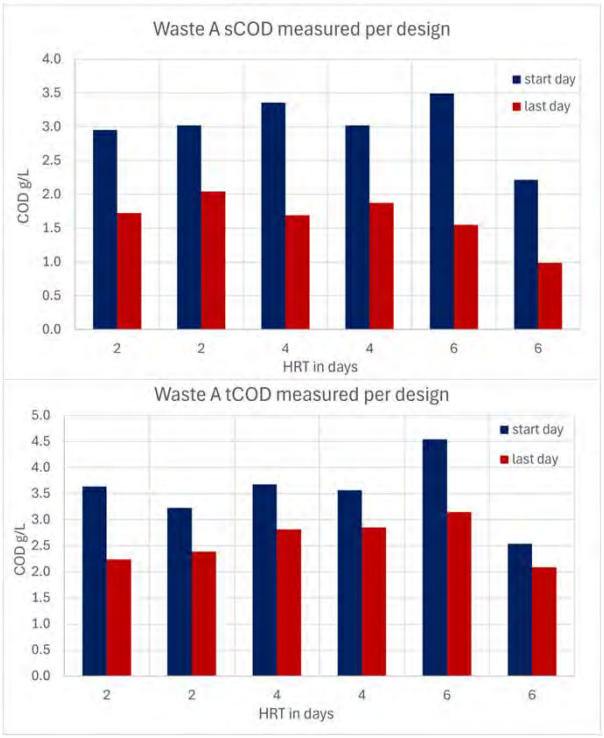

Figure 3: Chemical oxygen demand measurements of waste feed A designs (1-6). Measured value is of first and last day of the experiment, with the top graph showing soluble COD and bottom showing total COD.

Waste Feed B has not produced enough data to compare at this time.

Conclusion - Discussion

The experiments on feed A showed an overall decrease in COD that would suggest that from the start of the batch experiments the inoculum reached a state where VFAs were not produced in higher quantity than they were reduced. This could indicate the inoculum had gone through hydrolysis and acetogenesis already or the feed does not have polymers to digest.

In order to better determine if the waste feeds are efficient fermentation substrates a further characterisation of the feeds and biomass (genomics) should be made as well as more duplo experimentation for feed B. When analysis of VFA concentration is finished more complete conclusions can be drawn, including to what extent sCOD directly correlates with VFA concentrations.

For future it might be of interest to research producing metabolites from methane in case this pattern repeats..

References

[1] Z. Lenkiewicz, Beyond an age of waste. 2024. DOI: https://doi.org/10.59117/20.500.11822/44939.
[2] A. Berenjian, Essentials in Fermentation Technology. (1st ed.) . DOI: https://doi.org/10.1007/978-3-030-16230-6.
[3] Evans G, Biowaste and Biological waste treatment. 200. DOI: https://doi.org/10.4324/9781315074368
[4] X. Cheng *et al.*, Advancement in rapid on-site detection of COD.202. DOI: 10.1016/j.cej.2025.160542.

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