Valorization of green waste as a building block for bioplastics

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Introduction

In 2018, almost 17 million tonnes of plant waste were produced in bordering regions of the Netherlands and Flanders [1]. A way to valorize this waste is through the production of polyhydroxyalkanoate (PHA) bioplastic.

PHAs and its feedstock volatile fatty acids (VFAs) are synthesized from bacteria through fermentation.

This project within ReJuice aims to assess different kinds of green waste streams for their potential to produce VFAs as building blocks for PHAs.

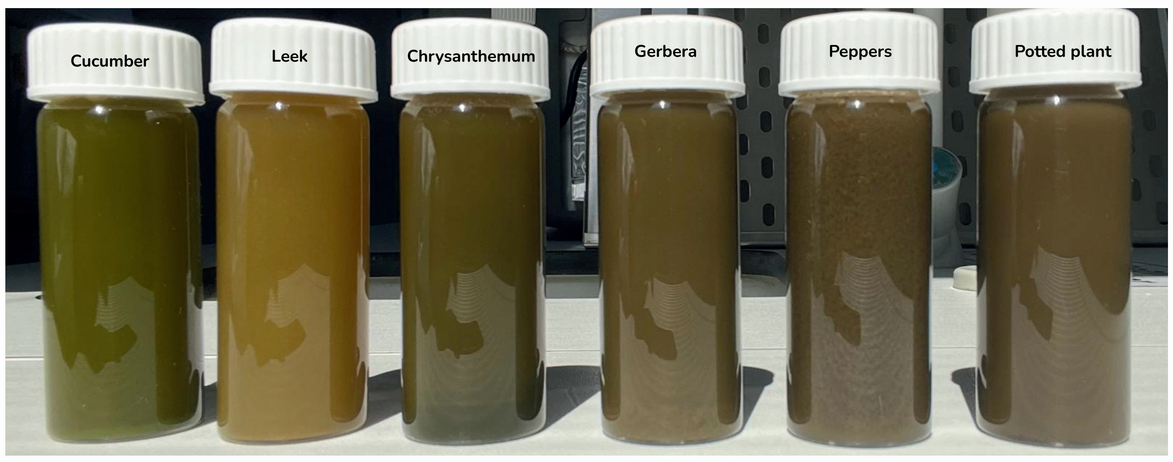

Figure 1: Six different green waste streams used as feedstock in the experiments.

Methodology

- The six feedstocks in Figure 1 were first screened for their components.
- Two inocula were prepared using the feedstocks and sludge from urban WWTP at pH 5 and pH 9.
- A Design of Experiment was utilised for the batch experiments testing only substrate and pH as factors.
- VFA concentration and composition were analysed from the samples of the batch experiments.
- The parameters from the best-performing experiment would then be used as input for VFA production in an anaerobic sequence batch reactor (AnSBR).
- This VFA would be used as feed for producing PHA.

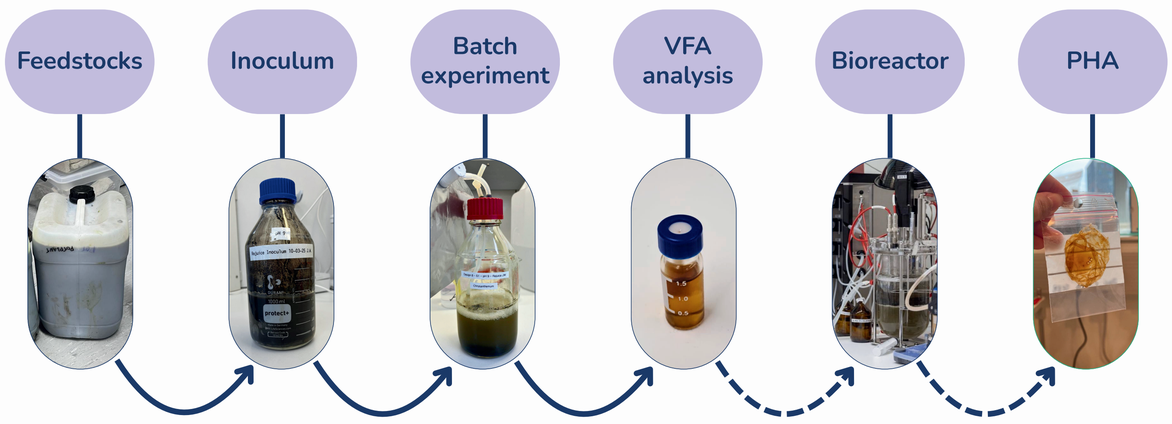

Figure 2: Stepwise approach from feedstock to PHA.

Results & Discussion

The results indicate that both pH and feedstock influence the VFA profile. Two out of six feedstocks showed potential for tailored VFA production for PHA accumulation. Feedstock 1 at pH 9 rapidly produced caproic acid. Feedstock 2 at pH 5 showed a drop in lactic acid due to pH change and a gradual rise in acetic and propionic acids, suggesting an optimal HRT > 4 days.

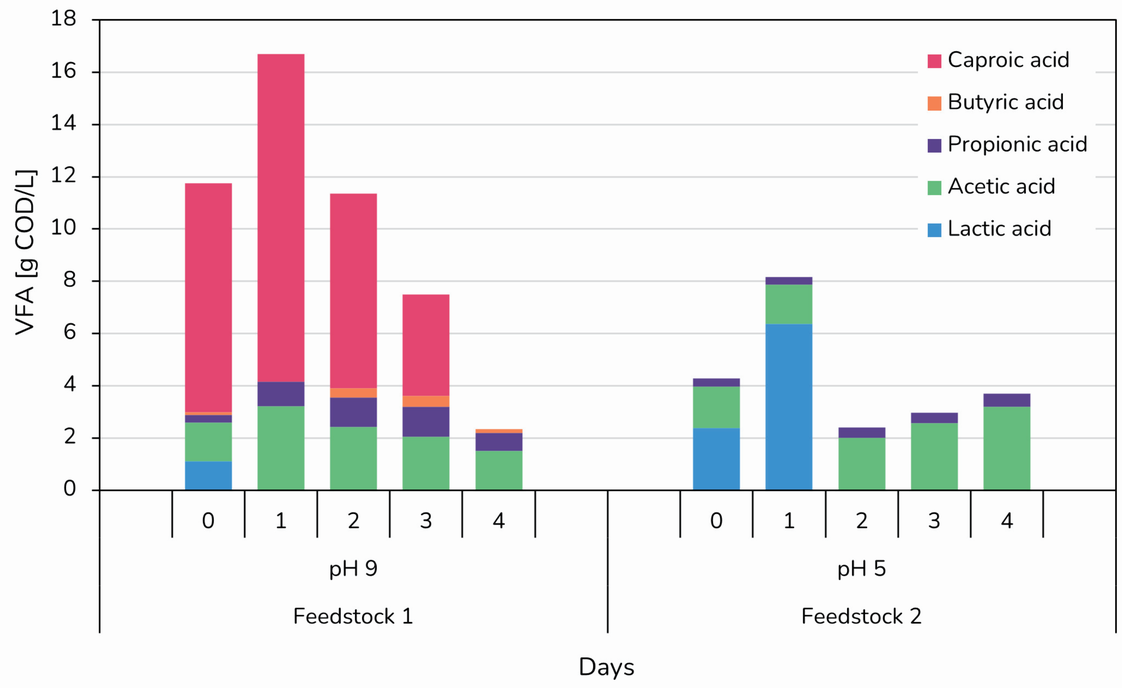

Figure 3: Results of VFA concentration from two batch experiments.

Caproic acid is known to produce PHA with better mechanical properties [2]. By using feedstock 1 as a substrate, a copolymer of PHB, PHV, and PHH can be produced, resulting in improved PHA flexibility [2].

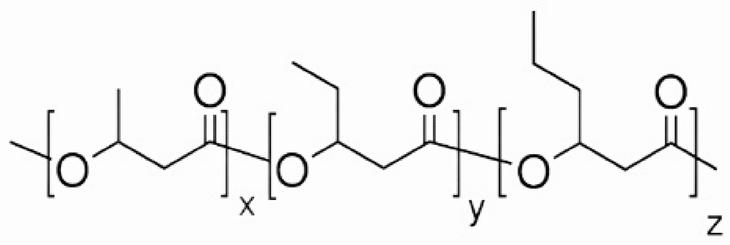

Figure 4: Poly((R)-3-hydroxybutyrate-co-(R)-3-hydroxyvalerate-co-(R)-3-hydroxyhexanoate).

Recommendations

It is recommended to further investigate the use of feedstock 1 for VFA production in an AnSBR with a HRT of 1 day. Additionally, to use feedstock 2 for VFA production in an AnSBR with a HRT > 4 days. This could produce VFAs favorable for PHBV production [3].

References

[1] Interreg Vlaanderen-Nederland. Over ons | ReJuice. Available: https://interregvlaned.eu/rejuice/over-ons.
[2] R. Iglesias-Iglesias et al, "Co-digestion of cheese whey with sewage sludge for caproic acid production: Role of microbiome and polyhydroxyalkanoates potential production," Bioresource Technology, vol. 337, pp. 125388, 2021. DOI: 10.1016/j.biortech.2021.125388.
[3] G. A. de Souza Reis et al, "Optimization of Green Extraction and Purification of PHA Produced by Mixed Microbial Cultures from Sludge," Water, vol. 12, (4), pp. 1185, 2020. DOI: 10.3390/w12041185.

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