CHANIA 2023

10th International Conference on Sustainable Solid Waste Management

Room 1 SESSION IX Anaerobic digestion
11.15-11.30, 22 Jun 2023

Synergistic Use of Alkali in Lignin-first Pretreatment and Arrested Anaerobic Digestion for Volatile Fatty Acids from Yard Waste

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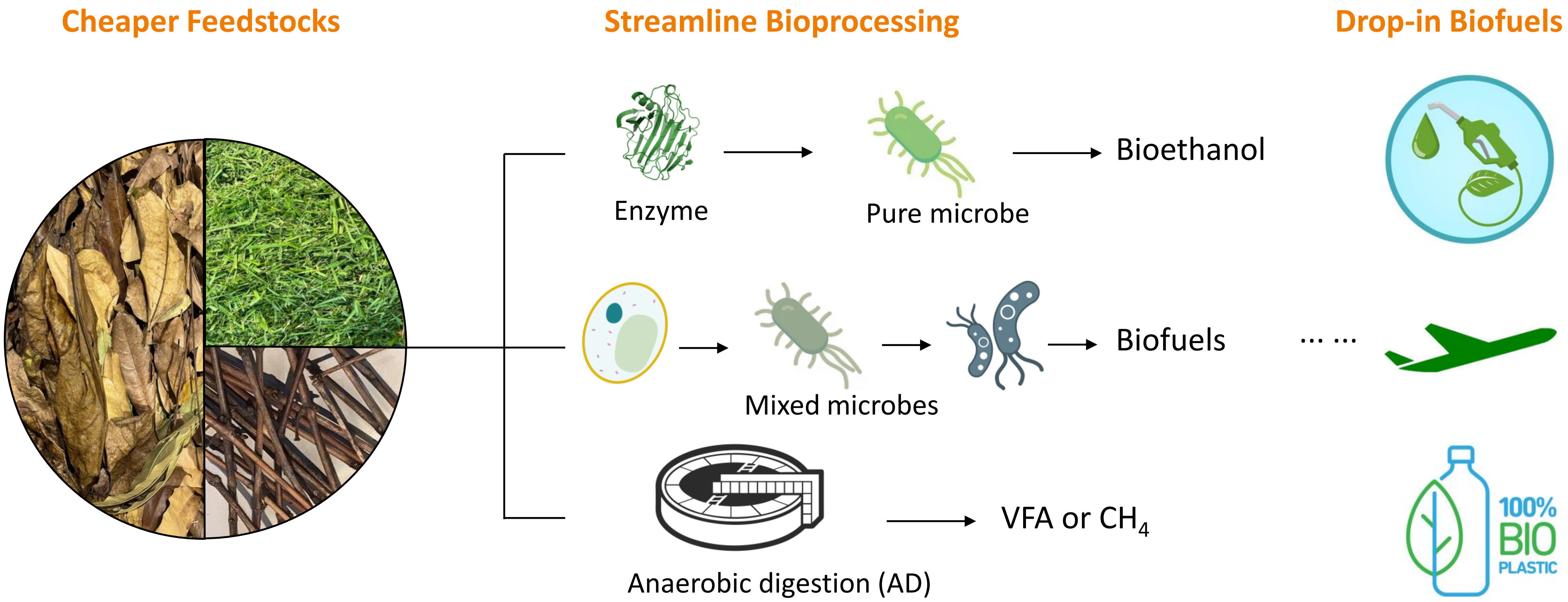
Production of Biofuels vs Petrochemical economy

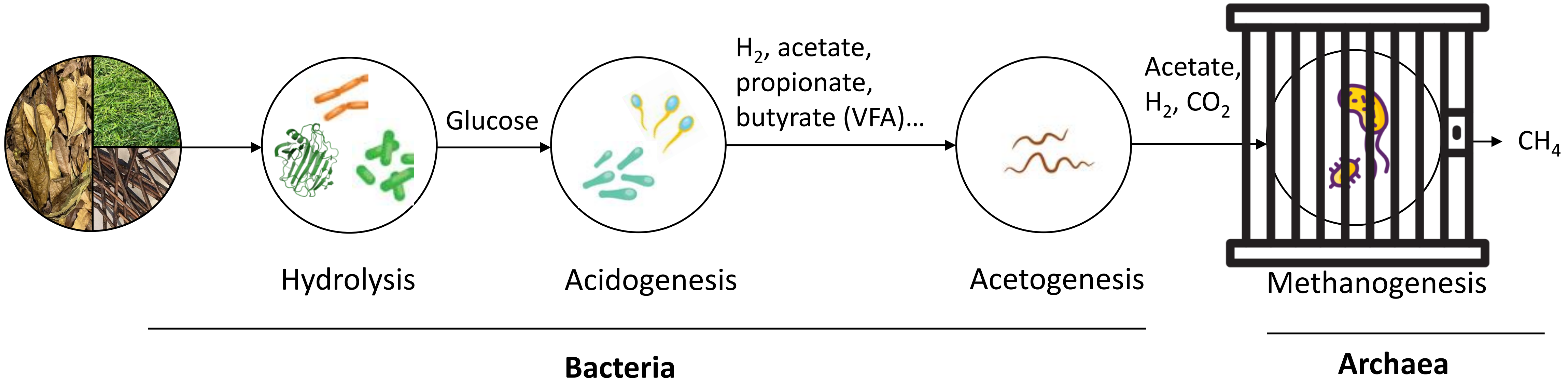


- Yard waste, 0.3 Mt/year in Singapore
- Currently incineration or landfill

- AD: not require added enzyme & nutrition
- Realistic scalability & economic viability

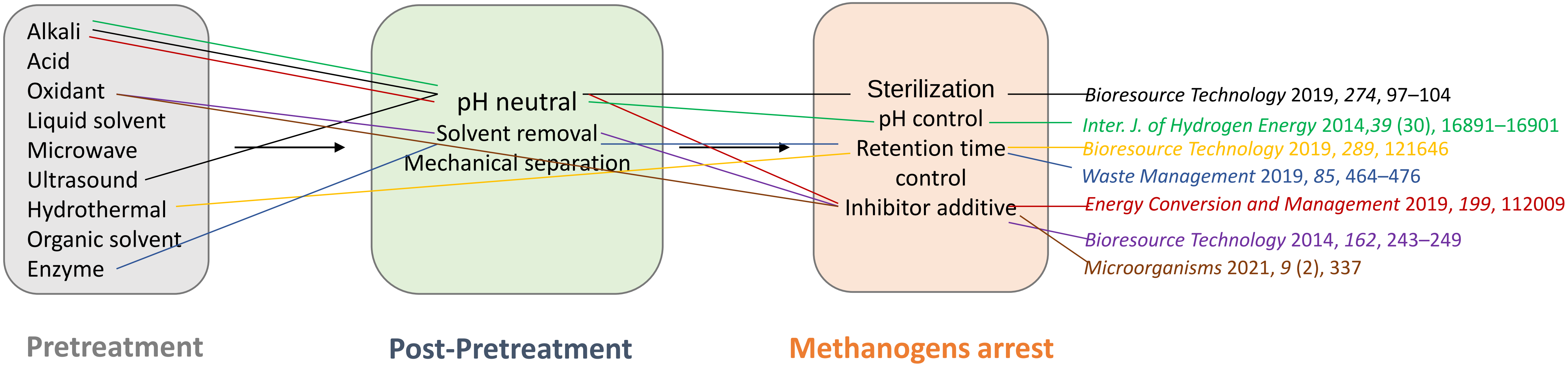
- High yield & quality
- Competitive to petrochemicals

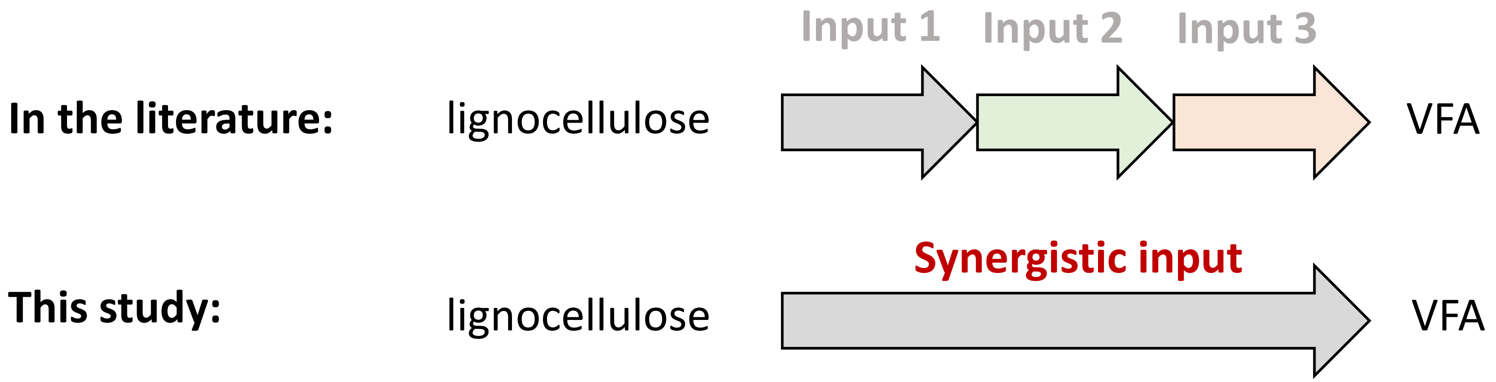
Revisiting anaerobic digestion (AD) for biofuels



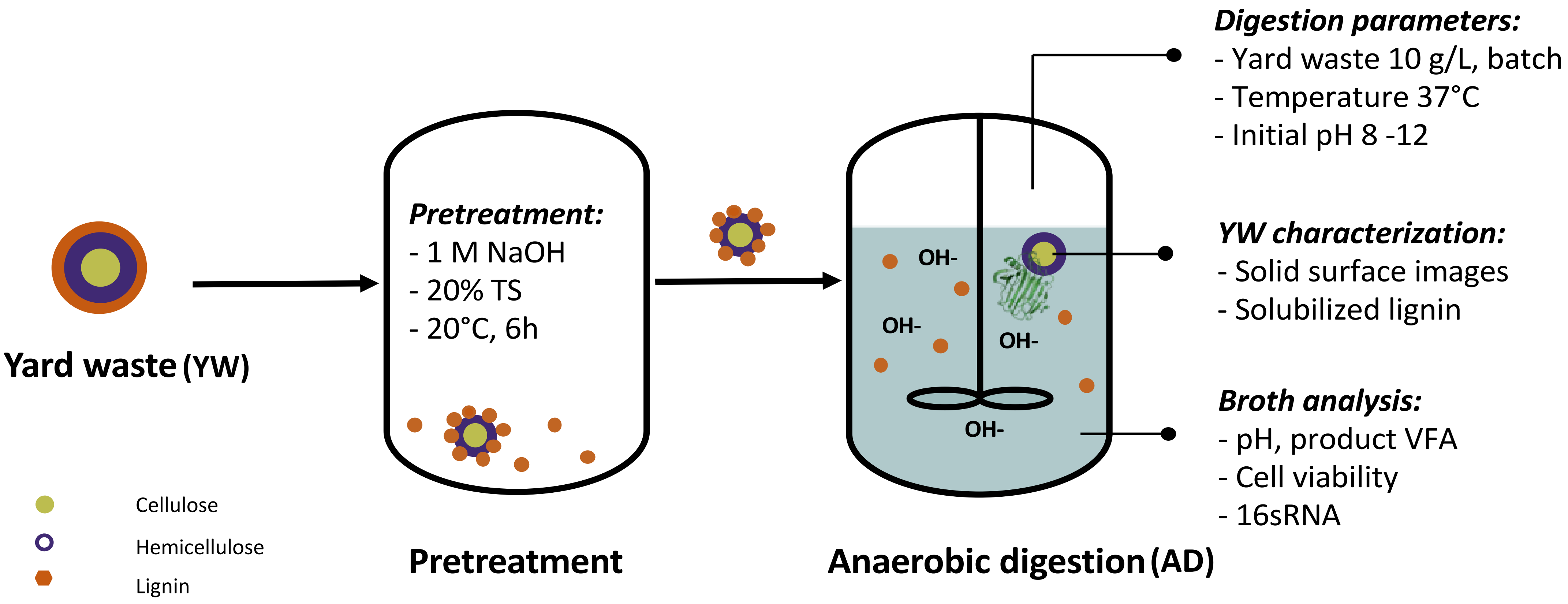
Methanogens-arrested anaerobic digestion (AD) to VFA

Revisiting anaerobic digestion (AD) for biofuels



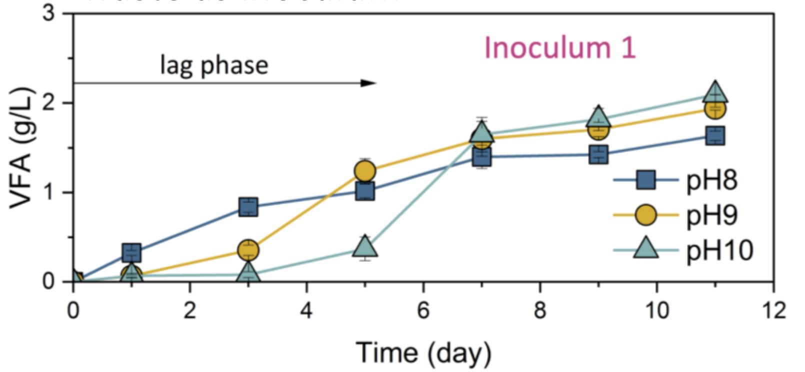


Synergetic alkali in pretreatment, lignin modification & methanogens arrest

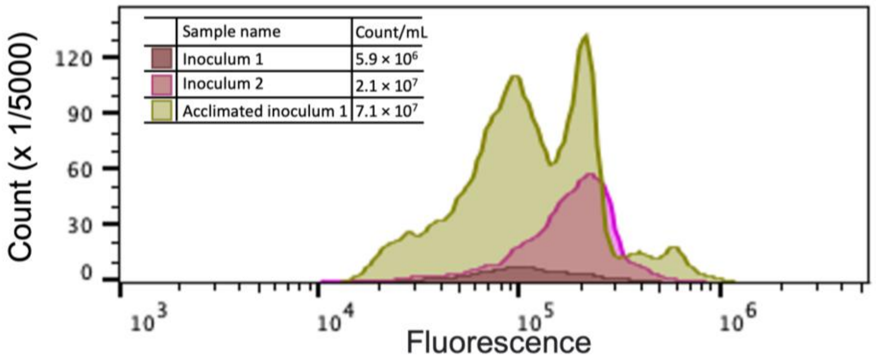


1. Inoculum screen and adaption

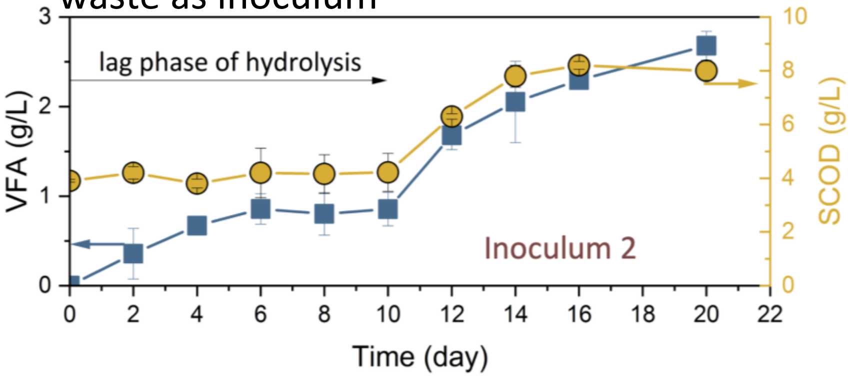
A Using digestate (high biomass) from food waste as inoculum



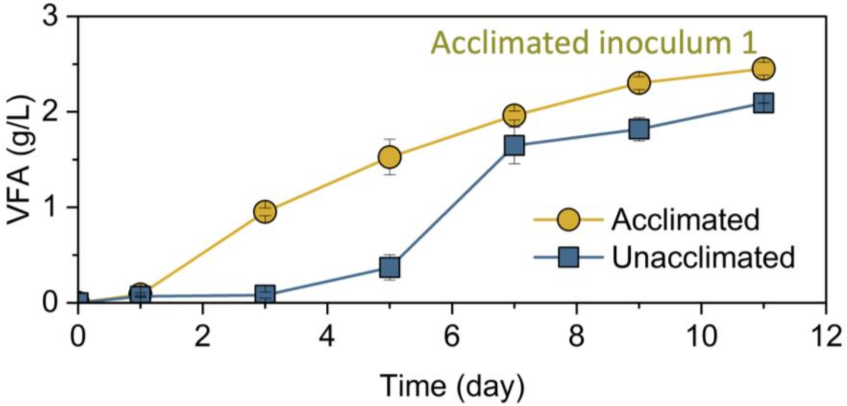
C Biomass count using flow cytometry



B Using digestate (low biomass) from food waste as inoculum



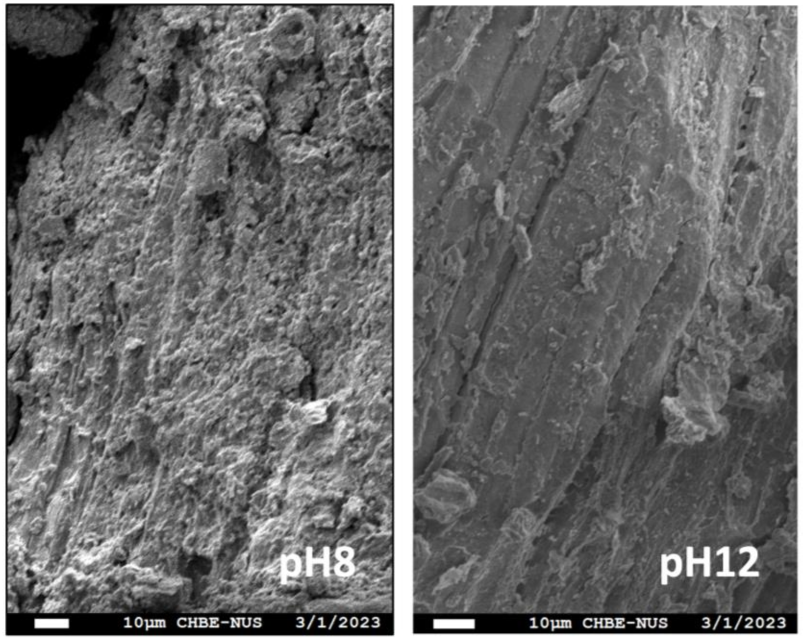
D Using cellulose-acclimated digestate as inoculum



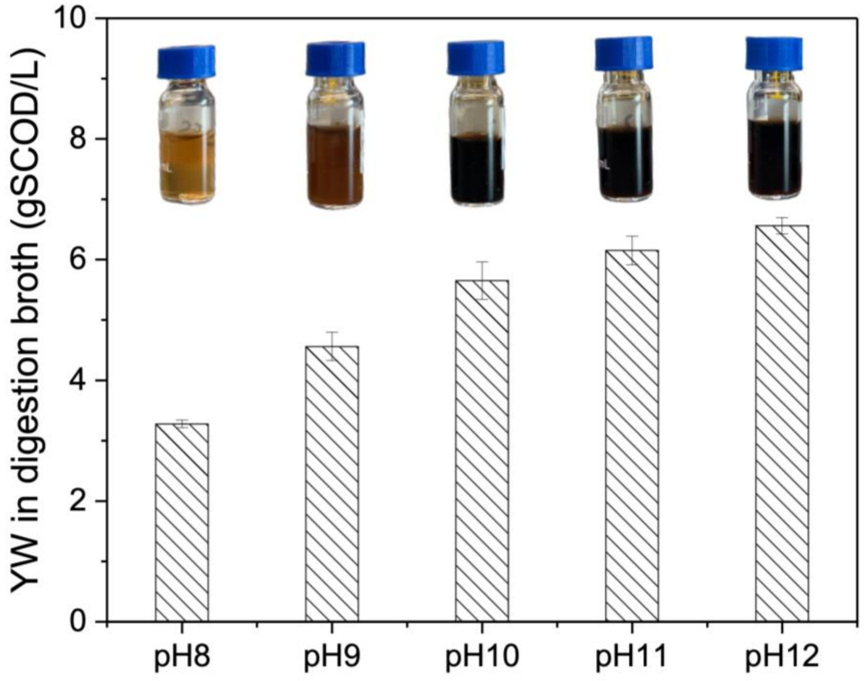
- Microbial catabolism of lignocellulose in alkaline digestion is viable
- Extended lag phase impacted by basicity and biomass
- Acclimation with cellulose feeding eliminated lag phase

2. Lignin dissolution in alkaline digester

A Alkali-pretreated YW slurry diluted to pH 8 and 12 solution



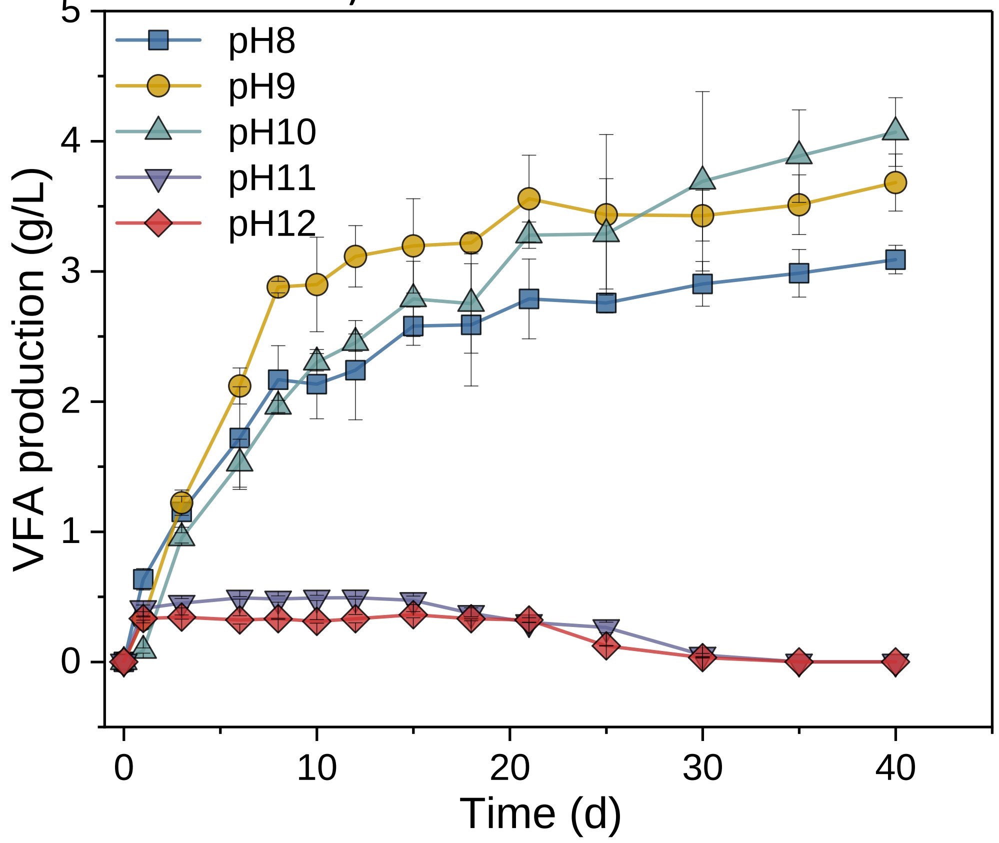
B Alkali-pretreated YW slurry fed into alkaline digesters



- Alkaline digestion kept lignin soluble
- thereby, 1) avoid hydrophobic bind with enzyme
- 2) unlock cellulose exposure

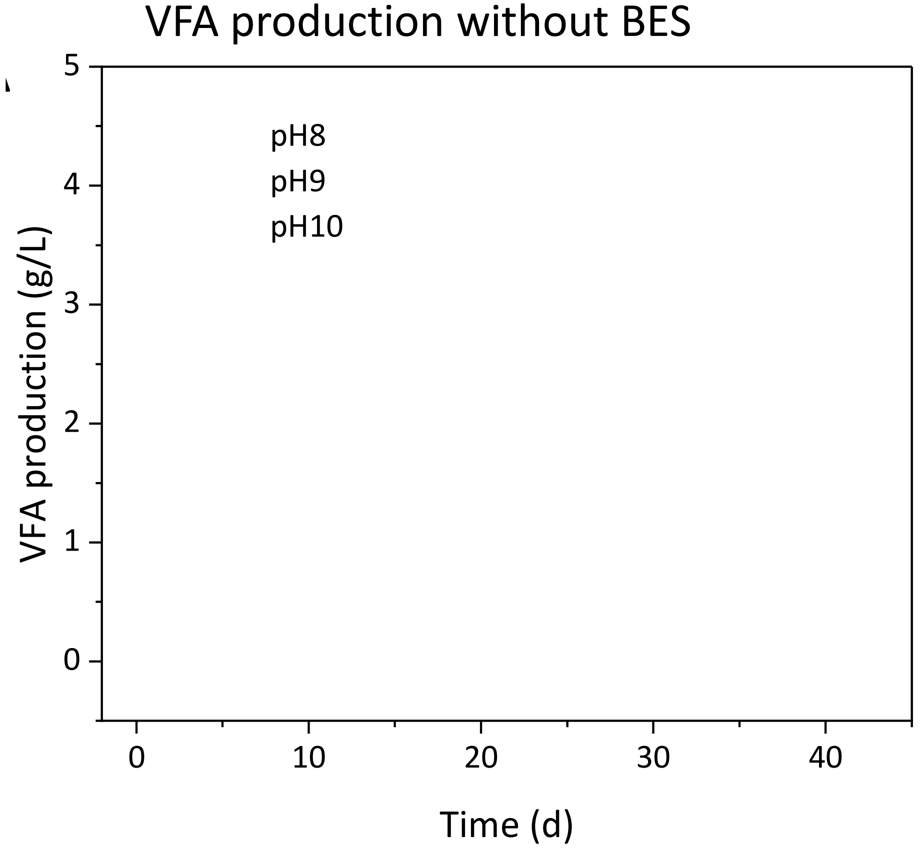
3. YW digestibility with lignin modification

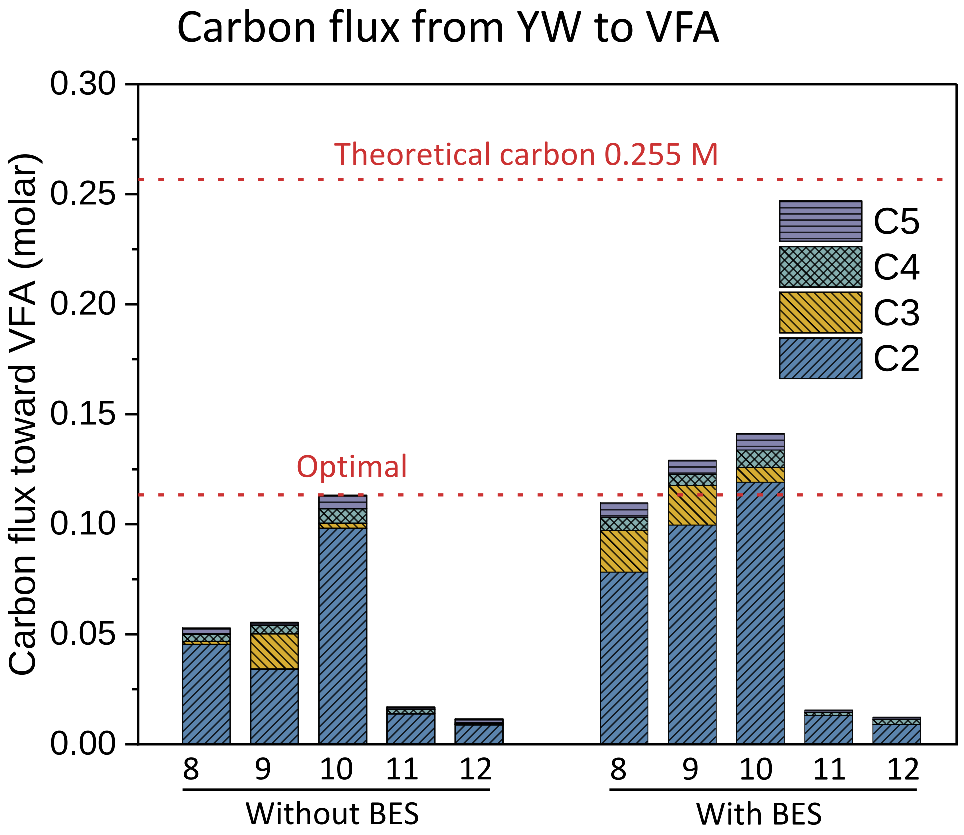
YW digestion at different pH (with methanogens inhibitor BES)



- Lignin modification facilitated YW digestibility (optimal initial pH of 10)
- Reactors failed with initial pH above 11

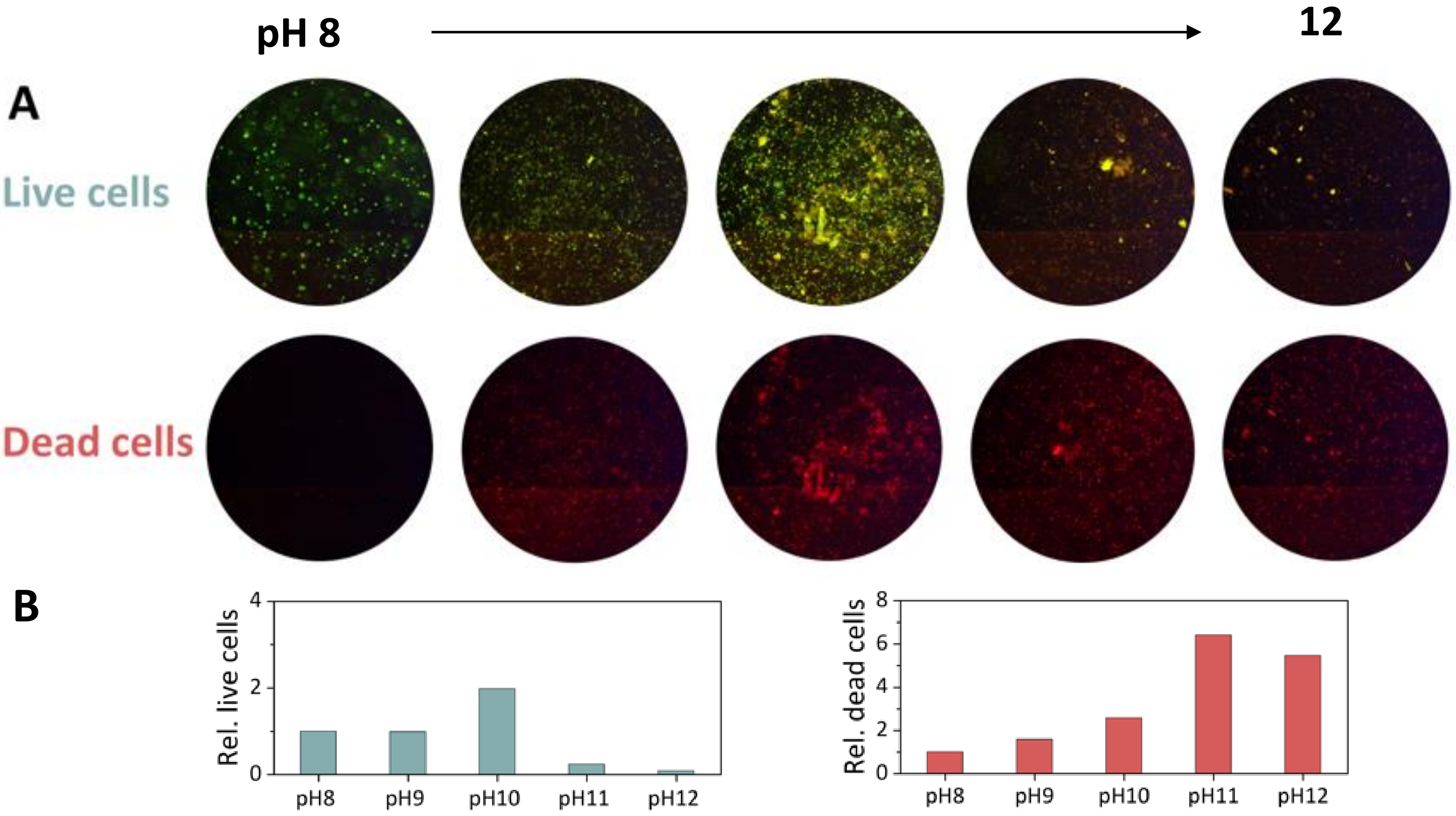
4. Omittance of methanogens inhibitor





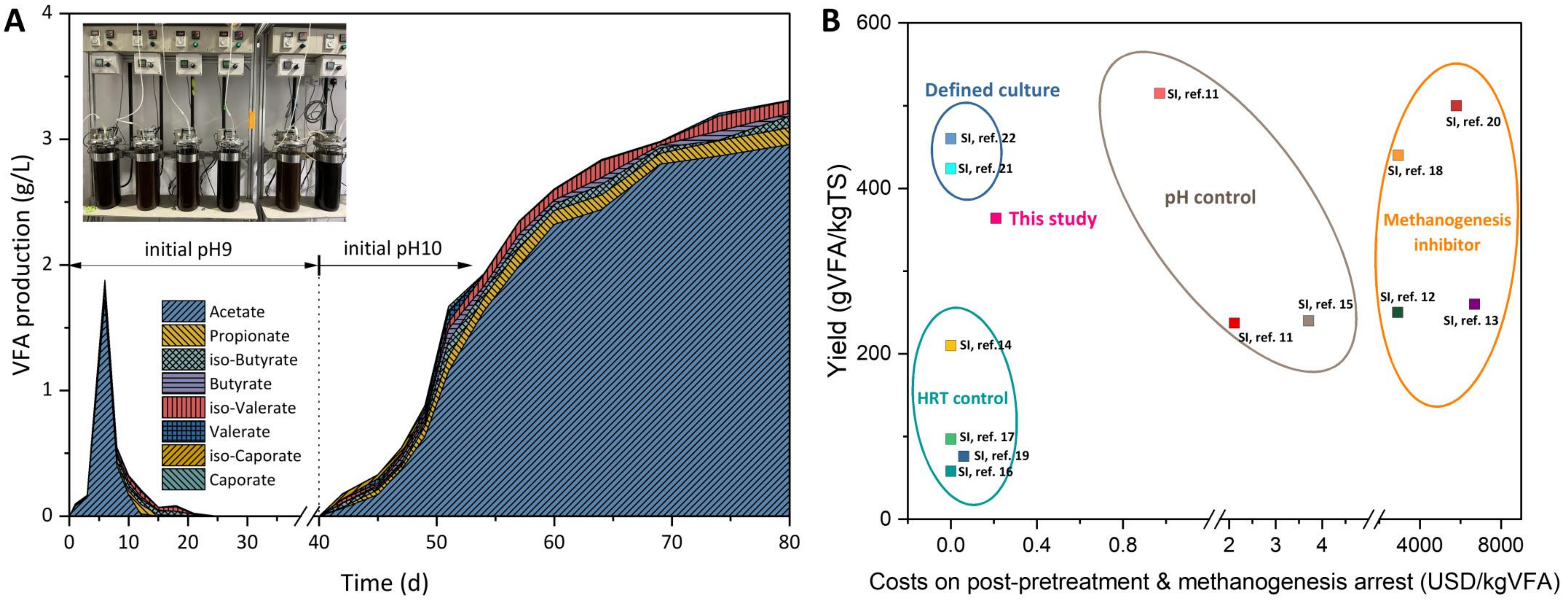
- Maximum carbon flux efficiency of 56 % (pH 10 with BES)
- Carbon flux efficiency of 47 % (pH 10 without BES)

5. Bacterial viability



- Basicity led to increase of dead cells
- Cell viability can recover below pH of 10

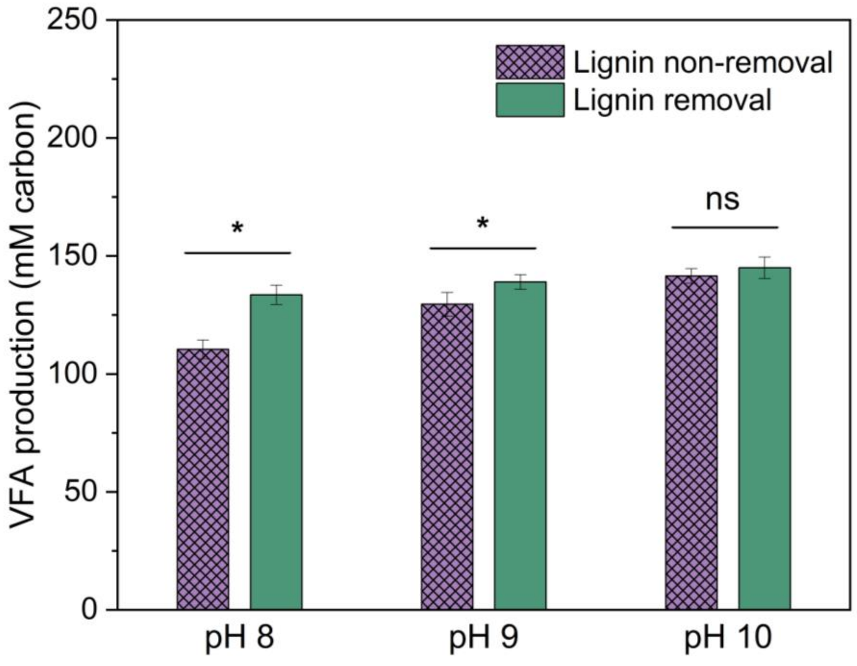
7. Scale-up & economic assessment



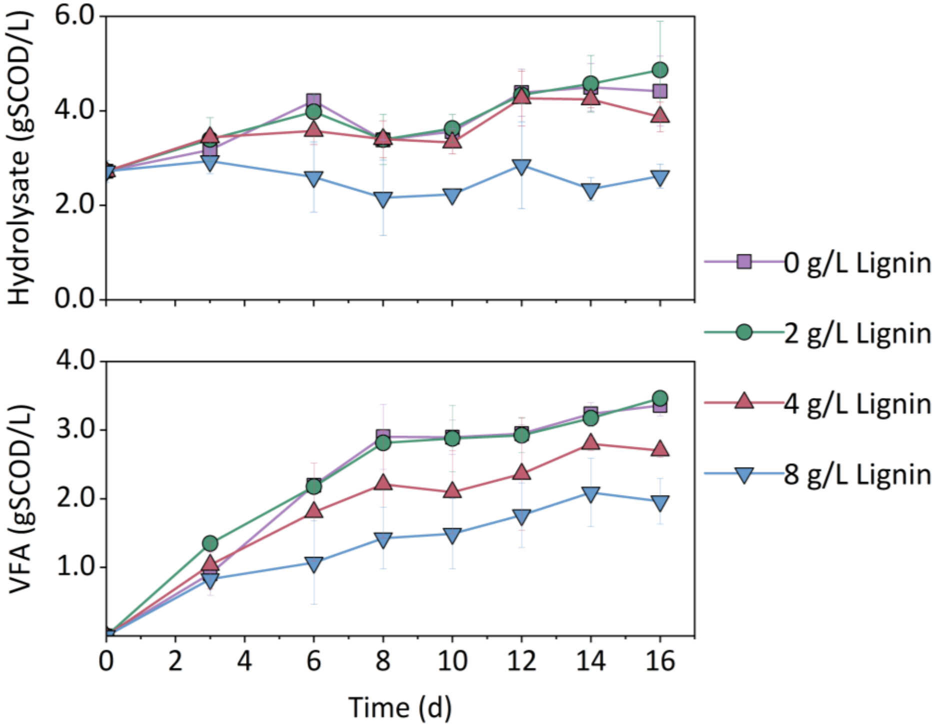
- Low VFA yield with HRT control
- pH control is promised and should integrated with pretreatment
- Comparable yield of 364 $gVFA/kgTS_{substrate}$ at USD 0.21/kgVFA

8. Effect of lignin on AD of carbohydrate fraction

A Effect of re-precipitated lignin on VFA (AD at pH 8, 9, and 10)

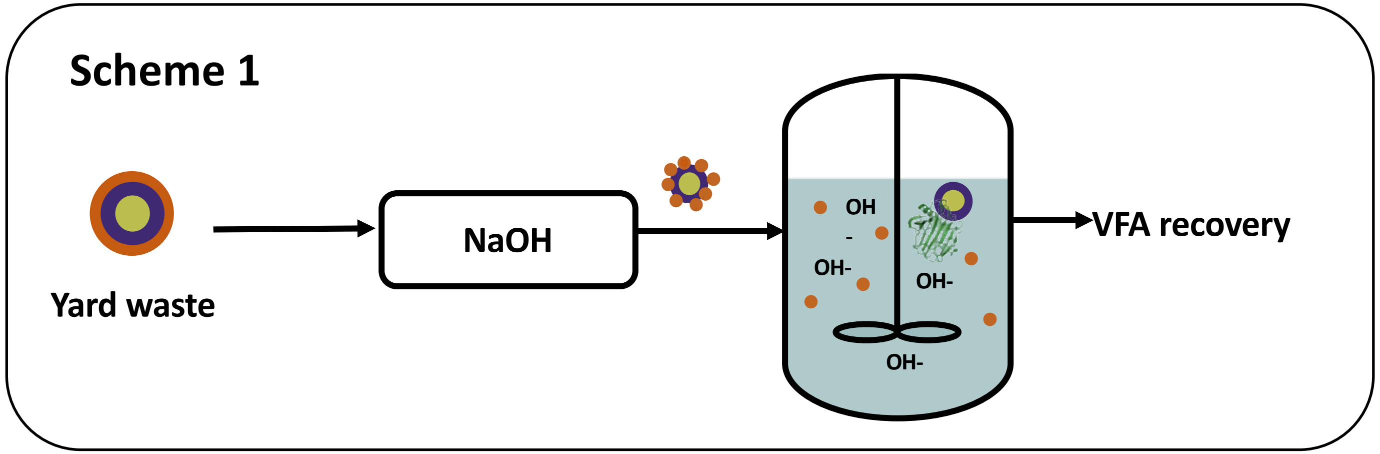


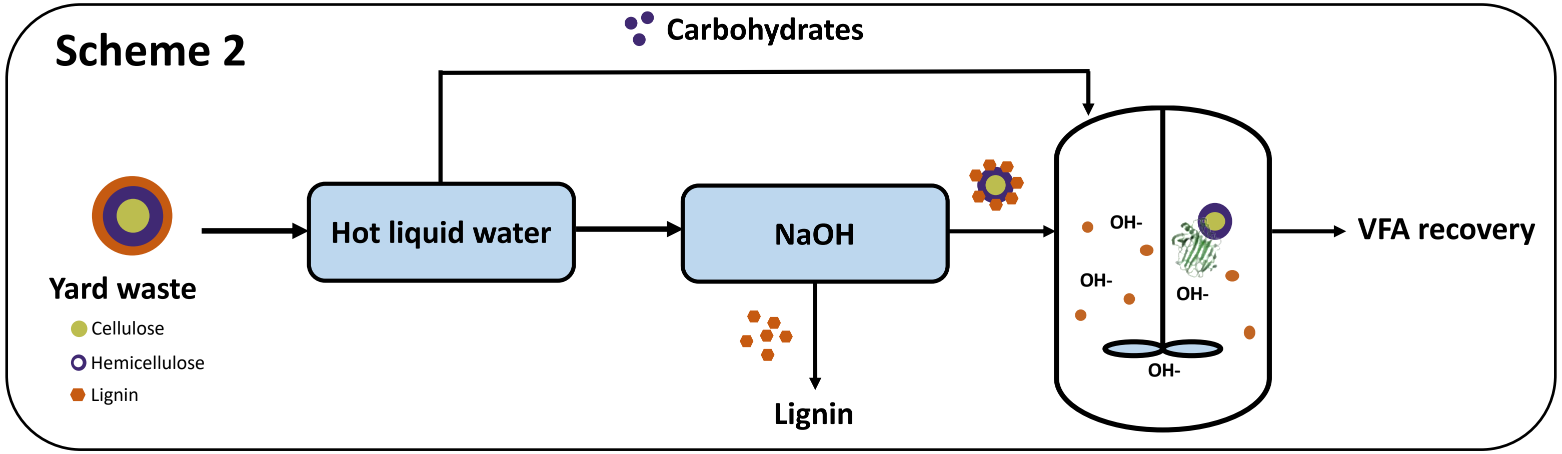
B Effect of soluble lignin on VFA (AD at pH 10)

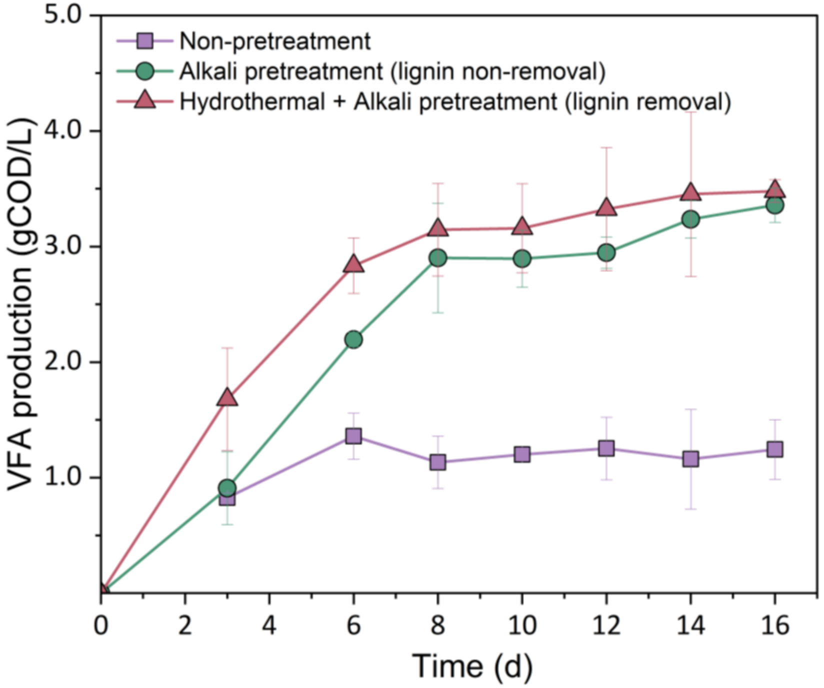


- Re-precipitated lignin inhibited carbohydrates fermentation
- Soluble lignin also inhibited AD with inhibition intensity:
  Acetogenesis > acidogenesis > hydrolysis

9. Separate-out lignin in pretreatment step







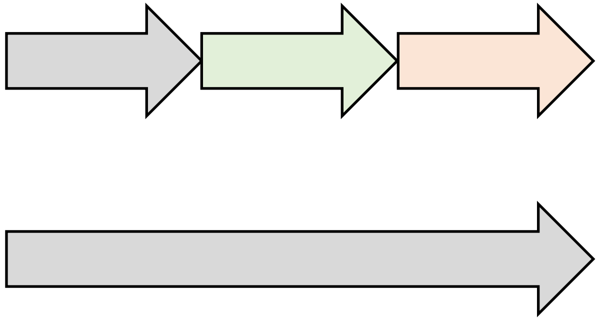
- Removal lignin didn't impact VFA yield from sugar (AD at initial pH 10)
- Lignin recovery of 21 % of YW by weight

Take-home message

1. Improving economic viability of lignocellulose-derived biofuels production in arrested anaerobic digestion: Synergetic use of alkali as an example

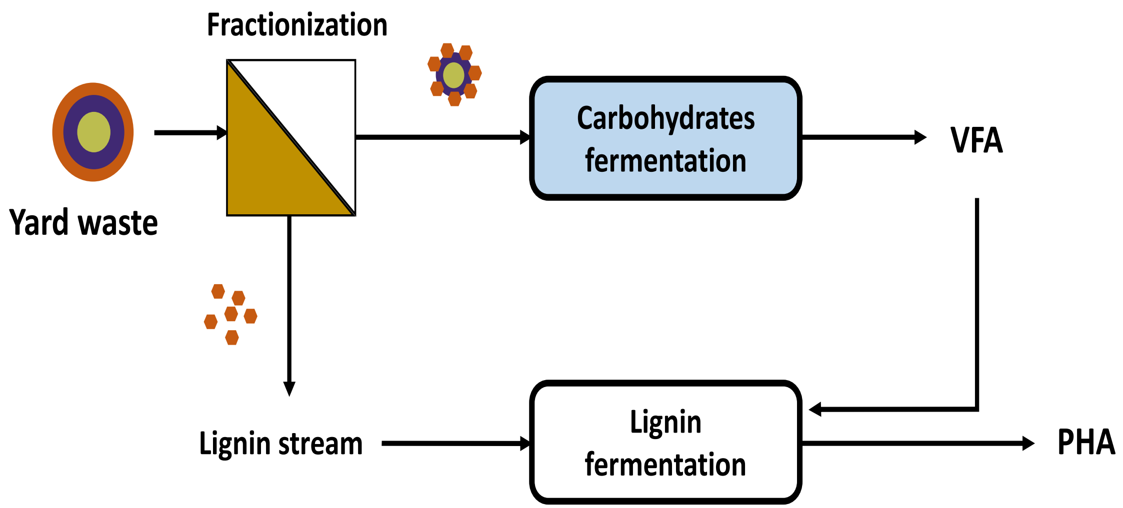
In the literature: lignocellulose → VFA

This study: lignocellulose → VFA



2. Lignin adversely impacted carbohydrate fermentation. Removal lignin in pretreatment facilitated VFA yield and lignin recovery.

Perspectives



Room 3 SESSION XV Waste Valorization II
15.30-15.45, 22 Jun 2023

Lignin valorization to polyhydroxyalkanoates (PHA) assisted by adding volatile fatty acids

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Acknowledgement

A/P Kai-Chee LOH

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Dr. Le ZHANG

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Thank You!

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