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Purification of fermentation broths produced from industrial candy waste towards separation and recovery of bio-succinic acid

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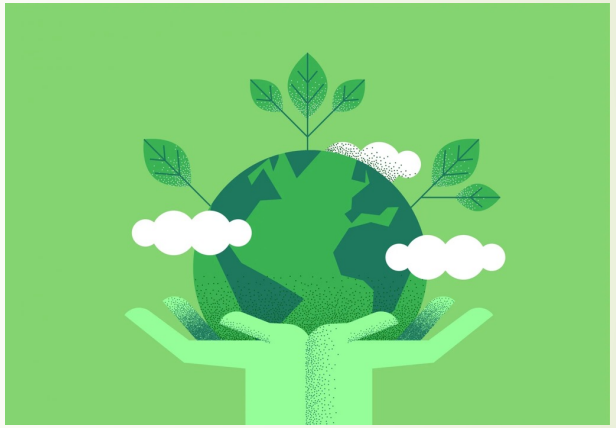
Agenda

- Objectives
- Project's framework
- Succinic acid value and applications
- Work description
- Material and methods
- Results
- Discussion and Conclusions

Objectives

- Utilization of industrial waste through the fermentation process
- Production of bio-succinic acid – Top value-added platform chemical
- Preliminary evaluation of broths purification via separation methods
- Promotion of Circular Economy
- Economic benefits for the industry
- Carbon capture technology
- Environmental protection through proper waste management

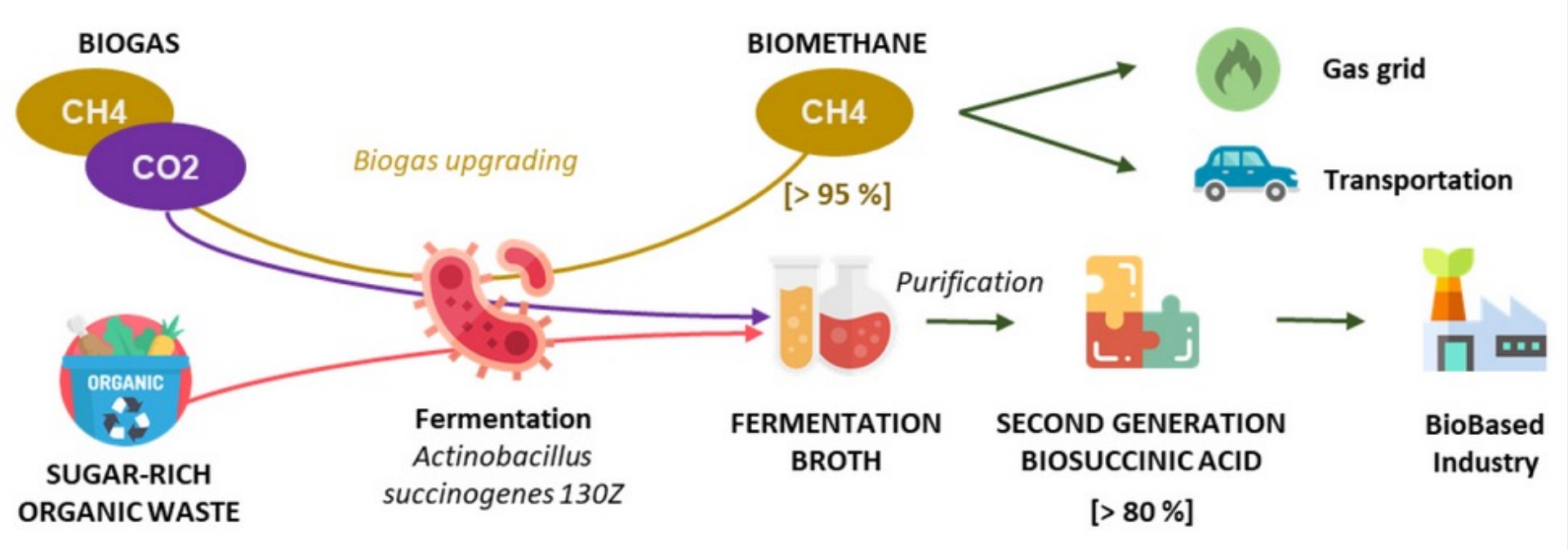


https://blog.siemens.com/2020/12/working-together-for-a-greener-future/

Project

Recycling and use of residual waste streams to simultaneously produce two high-value added products:

- ✓ BioMethane (>95%) from biogas to be used as a biofuel
- ✓ and BioSuccinicAcid (>80%), a second-generation non-fossil alternative to SA



Succinic acid

$C_4H_6O_4$ → four-carbon dicarboxylic acid

- ✓ Essential and high-value chemical platform
- ✓ Identified as one of the most important key chemicals
- ✓ Production of commodity and refined chemicals

(Image credit: Getty Images)

Applications:

- Polymers
- Cosmetics
- Detergents
- Surfactants
- Cement additives
- Food and pharmaceutical industry component

Global Succinic Acid market size

- **2021 → 222.9 million USD**
- **9.7% compound annual growth rate (CAGR)**
- **By 2030 → Projected value - Over 500 million USD**

Succinic Acid Market Size, Share & Trends Analysis Report

- https://www.grandviewresearch.com/industry-analysis/succinic-acid-market

Necessity

Up to now

- Major production of succinic acid derives through petrochemicals → contributes to greenhouse emissions and has multiple implications for the environment

Goal

- fermentation-based succinic acid production with renewable feedstocks → Bio-succinic acid separation

Succinic acid separation and purification process

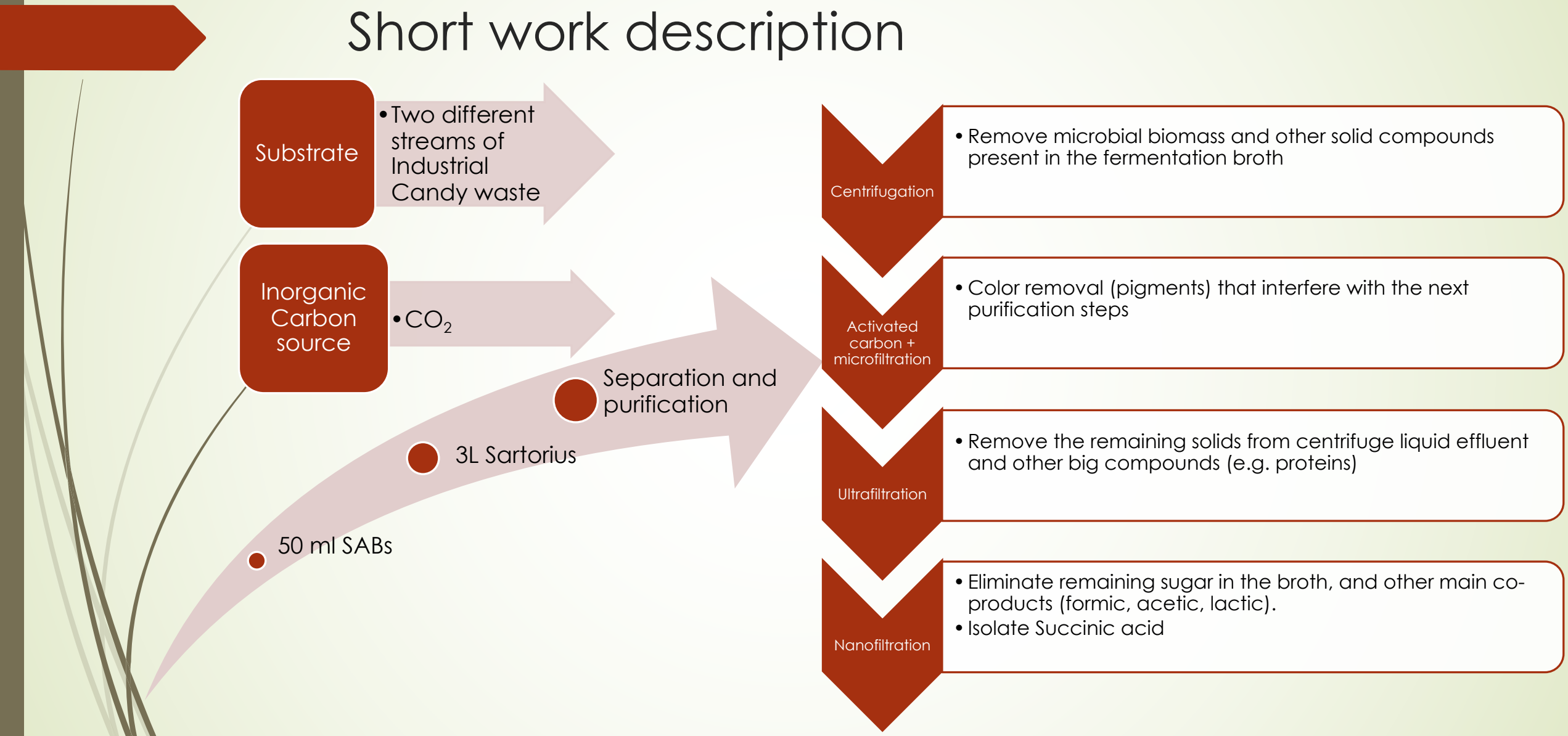
Divided in the following steps:

- i) microbial cell removal,
- ii) concentration and clarification (protein removal),
- iii) succinic acid separation and concentration and,
- iv) purification and final crystal formation.

(Image credit: CanStockPhoto.com)

(Image credit: www.indiamart.com)

Short work description

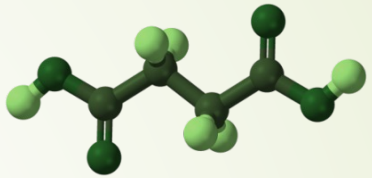


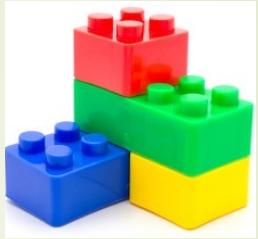
Equipment

- Eppendorf centrifuge 5425
- Amicon cells – Dead end filtration
- Pressure application by N_2 headspace injection
- Activated carbon - Sigma-Aldrich
- Microfiltration 1.2 µm (Whatman Filter pads) and Alfa-Laval 0.2 µm
- Ultrafiltration - Alfa-Laval 1000 and 50000 Da
- Nanofiltration – DK Membrane 150-300 Da
- HPLC Shimadzu Nexera XR with Aminex® HPX-87H Ion Exclusion Column

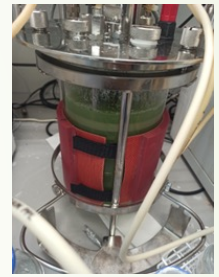
Equipment – Materials used for the experiments

Purification investigation – B1 - Green fermentation broth

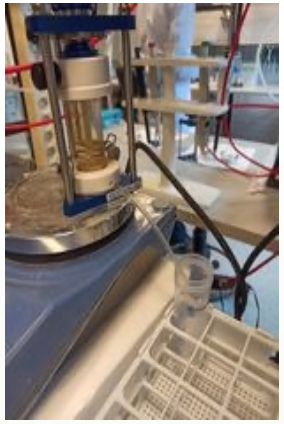


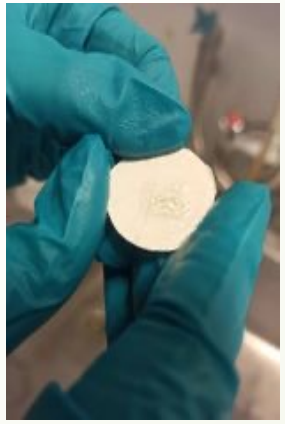


Broth	Trial	Process steps
B1	1	Ultrafiltration (1000 kDa)
B1	2	Centrifugation → Ultrafiltration (1000 Da)
B1	3	Centrifugation → Activated carbon (2.5% w/w) + Microfiltration (1.2 µm)→ Nanofiltration (150-300 Da)
B1	4	Centrifugation → Activated carbon (2.5% w/w) + Microfiltration (1.2 µm)→Ultrafiltration→ Nanofiltration (150-300 Da) 4 bar

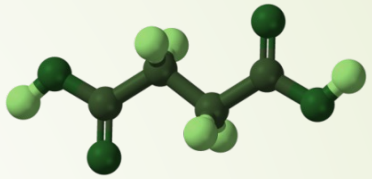


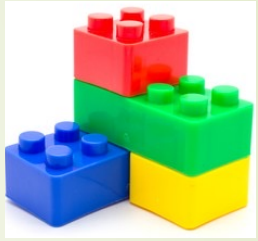
- Retrieval of clarified broth
- High fouling
- Low permeate flow
- Low rejection (13.8 %)
- Low NF pressure



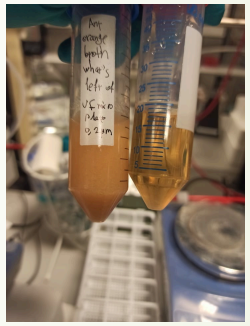


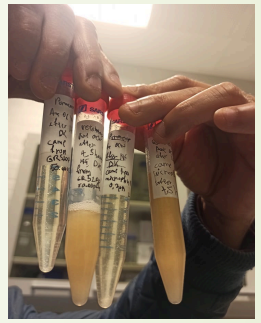
Purification investigation – B2- Orange fermentation broth



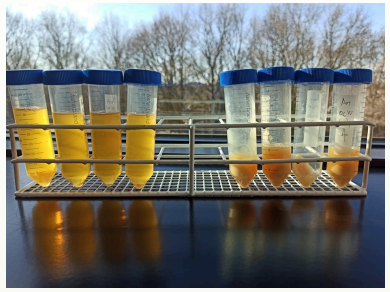


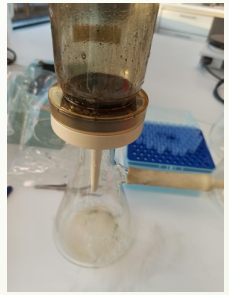
Broth	Trial	Process steps
B2	1	Microfiltration (0.2) → Nanofiltration (150-300 Da)
B2	2	Ultrafiltration (50k Da) → Nanofiltration (150-300 Da)
B2	3	Centrifugation → Microfiltration (0.2 µm)→ Ultrafiltration (50 kDa) → Nanofiltration (150-300 Da)
B2	4	Centrifugation → Activated carbon (2.5%) + Microfiltration (1.2 µm)→ Microfiltration (0.2)→Ultrafiltration (50 kDa) → Nanofiltration (150-300 Da) 4 bar

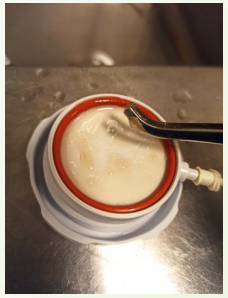




- Retrieval of clarified broth
- Fouling
- Low permeate flow
- Low rejection (17.52 %)
- Low NF pressure







Discussion and Conclusions

- Taking into account the complexity (color, microbial cells, proteins and pigments) of the two real broths' composition, the trials seemed to be successful regarding their clarification and purification
- Established an initial downstream sequence (removing color, rejecting pigments, proteins)
- Low succinic acid rejection values suggested that different operational strategies are required.
- In further research, the use of crossflow filtration, recirculation during filtration, vacuum distillation and high operating NF pressures (8-60 bar) is required.

Thank you for your attention!

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