Anaerobic digestion as part of the cascade processing of biomass

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Content

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Luke in a nutshell

- Natural Resources Institute Finland (Luke) is a research and expert organization with expertise in renewable natural resources and sustainable food production.
- Luke provides innovative solutions for new business opportunities based on natural resources.
- Our strengths are in sustainable production and use of natural resources and thorough knowledge of bio-based raw materials.
LUKE
Natural Resources Institute Finland

120 M€
Turnover

90 M€
Research & customer portfolio

30 M€
Statutory services

25
Locations in Finland

HQ in Helsinki

Present in 12 campuses with universities, research institutes and polytechnics

1300
Employees

50 research professors
650 researchers

We are one of the four Statistical Authorities in Finland.
Sustainable circular bio-economy: Efficient and sustainable use and valorisation of biomass and side-streams

By-products, side-streams, waste
- Forest
- Agro
- Municipal
- Industrial processes

Bioprocessing
- Microbiological processing
- Anaerobic digestion
- Enzymatic processing

Extraction, fractionation, separation e.g.
- Pressurised hot water/solvent extraction
- Super-critical fluid techniques
- Membrane filtration

Slow pyrolysis

Nutrient concentration technologies
- Pharmaceuticals, cosmetics
- Food, Feed & Ingredients
- Chemicals
- Bioenergy, biofuels
- Nutrient and carbon products
IEA Bioenergy Task 37 Report: Role of anaerobic digestion and biogas in the circular economy
Biogas plant in circular economy

- Quite often biogas plant is the last step in a cascading biomass system where value is created from waste
  - Value from all processing steps
- In the future, biomass will be the source for even a wider array of products e.g. materials, chemicals, fuels and new food and feed products
- Resource efficiency is needed for biomass to meet the needs

Source: Al Seadi et al 2018

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Report includes e.g.

- Biogas as an energy carrier
- Reduction of GHG emissions
- Energy security
- Biogas as raw material – further use of carbon dioxide and methane
- Biogas from AD as a scavenger for organic waste streams
- Biogas treatment for better water quality
- Awareness tool on circular thinking
- Biogas in agriculture
- Balancing income for rural areas
- Challenges in using waste as raw material

- Example case studies from Sweden, Finland, Denmark and Norway
Example projects at Luke

• InnoTrea
  • The aim was to fully utilize bark
    → Create a flexible process concept that can be further optimised
  • Pine and spruce bark

• BIOVFA
  • The aim was to evaluate the VFA production potential of food waste (FW)
Cascade processing of softwood bark

1. Bark
2. Hot water extraction
3. Bark

Hot water flow-through extractions

- Hot water extraction at 75 °C
  - Fatty acids, sugars, phenols etc are removed
  - Hemicellulose, lignin and cellulose contents did not change
  - Some sugars and tannins were extracted

<table>
<thead>
<tr>
<th>Bark HW extract (mg/g)</th>
<th>Man</th>
<th>Glc</th>
<th>Gal</th>
<th>Ara</th>
<th>GaLA</th>
<th>Tannins</th>
</tr>
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<tr>
<td>Spruce</td>
<td>3</td>
<td>18</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>32.2</td>
</tr>
<tr>
<td>Pine</td>
<td>2</td>
<td>15</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>11.8</td>
</tr>
</tbody>
</table>
Pyrolysis of HW extracted bark

Pyrolysis at 443 °C

Char yield 37 – 38 wt %
• Low nutrient and heavy metal content
• Marketable quality for soil amendment and carbon sequestration

Non-condensable gas fraction 21 – 22 wt%
• Spruce bark produced more pyrolysis gas with higher content of H₂, CH₄ and CO than pine bark

Liquid yield 40 – 42 wt%
• Gross heating value of tar
  • Spruce 24.9 MJ kg⁻¹
  • Pine 26.2 MJ kg⁻¹
Anaerobic digestion

- HW extracted pine bark samples produced more methane than untreated samples
- Pyrolysis condensate from pine produced slightly more methane than condensate from spruce
Harnessing biogas plants for the production of value-added products

Anaerobic digestion
- Biogas
- Digestate
Harnessing biogas plants for the production of value-added products

Volatile Fatty Acid fermentation
- VFA's
- Digestate
- H₂, CO₂
Potential of VFA production via anaerobic digestion (BIOVFA project)

• In this study, the aim was to evaluate the VFA production potential of food waste (FW) via AD using a pre-treatment of inoculum to prevent the growth of methanogens.

• The pre-treatment enabled the VFA production and delayed CH₄ production during the tests.

• At the end of the experiment, the cumulative CH₄ production of FW with pre-treated inoculum was 30% higher than in control.
  • likely because of pre-treatment of inoculum solubilized the organic molecules.

Thank you!