AD and fertilizer of residues from Organofinery

Outline

• **Organofinery** – a green biorefinery concept for organic farming.
• **Biogas production** from residues – press cake and brown juice.
• **Batch tests** of press cake and brown juice.
• **Co-digestion reactor tests** press cake + brown juice.
• **UASB reactor** for mono-digestion of brown juice.
• **Nutrient balance** for mechanical fractionation and biogas process.
• **Conclusions.**
The OrganoFinery - From organic green biomass to protein feed, energy and fertilizer

- **GREEN BIOMASS**
  - Screw press
  - **GREEN JUICE**
    - Fermentation
      - 38°C
      - LAB
    - **ORGANIC PROTEIN CONCENTRATE**
    - **BROWN JUICE**
    - Separation
      - **ORGANIC PROTEIN CONCENTRATE**

- **PRESS CAKE**
- **ORGANIC FERTILIZER**
- **BIOGAS**
- **Biogas plant**
Batch tests of press cake and brown juice

Methane yield in different mixture ratios

- Brown juice
- 15PC:85BJ
- 30PC:70BJ
- 50PC:50BJ
- Press cake

Methane yield (mL-CH4/gVS) vs. Time (days)

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CSTR reactor tests

Press cake and co-digestion of press cake and brown juice

- Co-digestion press cake and brown juice
- Press cake alone

Methane yield (mL-CH4/gVS) vs. Time (days)
UASB reactor – Mono-digestion of brown juice

Brown juice, mesophilic (37°C), pH adjusted, HRT : 1-3 days
Main results for biogas production

**Press cake (PC)**
- Press cake

**Brown juice (BJ)**
- Brown juice

**Co-digestion PC + BJ**
- Brown juice + Press cake

### Batch tests (mesophilic, after 38d)
- Methane yield was $307 \text{ mL-CH}_4/\text{g-VS}$.
- Methane yield was $456 \text{ mL-CH}_4/\text{g-VS}$.
- Methane yield was $426 \text{ mL-CH}_4/\text{g-VS}$ for the 15%PC:85%BJ mix.

### Reactor tests
- CSTR, HRT = 20d, TS-adjusted by H$_2$O
  - Stable process
  - Average methane yield was $202 \text{ mL-CH}_4/\text{g-VS}$.
- UASB, HRT = 3d, pH-adjusted
  - Stable process
  - Average methane yield was $307 \text{ mL-CH}_4/\text{g-VS}$.
- CSTR, HRT = 20d, no adjustment
  - Stable process
  - Average methane yield was $236 \text{ mL-CH}_4/\text{g-VS}$.
Nutrient recovery in press cake and brown juice

After mechanical fractionation
Nutrient conc. x mass of PC/BJ

<table>
<thead>
<tr>
<th></th>
<th>Press cake</th>
<th>Brown juice</th>
</tr>
</thead>
<tbody>
<tr>
<td>% of input</td>
<td>% of input</td>
<td></td>
</tr>
<tr>
<td><strong>Red clover</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>52%</td>
<td>15%</td>
</tr>
<tr>
<td>P</td>
<td>53%</td>
<td>30%</td>
</tr>
<tr>
<td>K</td>
<td>43%</td>
<td>38%</td>
</tr>
<tr>
<td>S</td>
<td>52%</td>
<td>13%</td>
</tr>
<tr>
<td><strong>Clover grass</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>60%</td>
<td>11%</td>
</tr>
<tr>
<td>P</td>
<td>56%</td>
<td>27%</td>
</tr>
<tr>
<td>K</td>
<td>39%</td>
<td>31%</td>
</tr>
<tr>
<td>S</td>
<td>55%</td>
<td>26%</td>
</tr>
</tbody>
</table>
Nutrient recovery in press cake and brown juice

Before and after AD process
Co-digestion PC+BJ, or BJ alone

<table>
<thead>
<tr>
<th></th>
<th>AD digestate</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>g/kg</td>
<td>% of input</td>
</tr>
<tr>
<td>Co-digestion PC+BJ, CSTR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>3.42</td>
<td>94%</td>
</tr>
<tr>
<td>(NH_4^+)</td>
<td>2.11</td>
<td>62% of N</td>
</tr>
<tr>
<td>P</td>
<td>1.35</td>
<td>100%</td>
</tr>
<tr>
<td>K</td>
<td>3.96</td>
<td>99%</td>
</tr>
<tr>
<td>S</td>
<td>0.52</td>
<td>100%</td>
</tr>
<tr>
<td>Mono-digestion BJ, UASB</td>
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<td></td>
</tr>
<tr>
<td>N</td>
<td>0.39</td>
<td>68%</td>
</tr>
<tr>
<td>(NH_4^+)</td>
<td>0.06</td>
<td>16% of N</td>
</tr>
<tr>
<td>P</td>
<td>0.11</td>
<td>59%</td>
</tr>
<tr>
<td>K</td>
<td>2.03</td>
<td>67%</td>
</tr>
<tr>
<td>S</td>
<td>0.06</td>
<td>56%</td>
</tr>
</tbody>
</table>

Red clover
Clover grass

Press cake
Brown juice

Organic Fertilizer

BIOGAS PLANT

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Conclusions

**Biogas production from residues PC and BJ:**

- 42-68% of the biogas potential is recovered in the PC while only 10-15% is recovered in the BJ.

- Both **co-digestion of PC+BJ** and **mono-digestion of BJ** in UASB showed stable process performance.

- Co-digestion of PC+BJ in the ratio coming from the fractionation **does not** need pH, nutrient or TS adjustment.

**Nutrient recovery:**

- 52-60% of N, P, S is recovered in PC and 11-30% in BJ while 39-42% of K is recovered in PC and 31-38% in BJ.

- In the **co-digestion** process a **high share of** total-N is converted into $\text{NH}_4^+$, while this is only limited in the UASB process of BJ.

- Nutrient conc. in digestate from mono-digestion of BJ is **too low** for practical application on the field.
THANKS FOR YOUR ATTENTION