Steam pretreatment and fermentation scenarios for a sugarcane biorefinery

8th Renewable Energy Postgraduate Symposium – 12 July 2017

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Sugarcane biomass

For every 1,000 kg of millable stalk harvested:
- approx. 300 kg of bagasse produced
- approx. 300 kg of harvest residues discarded
Pre-harvest burning
Current sugar mill operation

Bagasse

Sugar

Molasses
Sugarcane biorefinery

Feedstocks

Bioenergy crop

Plant cells

Plant cell wall

Cellulose microfibril

Lignin

Hemicellulose

Cellulose

Sugar molecules

Glucose

Sugar

Molasses

Ethanol from cellulose

Platform chemicals from hemicellulose

Fuel from lignin rich residues

Fertiliser
Steam pretreatment

Raw biomass

Pretreated biomass

Steam pretreatment process:
- Steam is passed through raw biomass.
- The biomass undergoes pretreatment, converting it into pretreated biomass.

Components involved:
- Bioenergy crop
- Plant cells
- Plant cell wall
- Cellulose microfibril
- Lignin
- Hemicellulose
- Cellulose
- Sugar molecules
- Glucose
Steam pretreatment

Bagasse

Harvest residues
Biorefinery-based pretreatment and fermentation

Conditions as industrial relevant as possible:
• steam pretreatment at 5 – 15 min, 185 - 215°C
• steam pretreatment without catalyst
• preheating of reactor to minimise condensation
• no washing of pretreated solids – only pressed
• no detoxification
• fed-batch SSF up to 15% solids
• low enzyme concentration (10 FPU / g solids)

Not to change pretreatment effects:
• pretreated solids not frozen, but fermented within 24h
• pretreated solids not sterilized – ampicillin
• relative high inoculum of 10% at OD of 1
## Compositional analyses

<table>
<thead>
<tr>
<th>Compound</th>
<th>Sugarcane bagasse</th>
<th>Sugarcane harvest residues</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>g/100 g dry</td>
<td>g/100 g dry</td>
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<tr>
<td>Glucan</td>
<td>33.31 (± 0.37)</td>
<td>29.74 (± 0.03)</td>
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<tr>
<td>Xylan</td>
<td>20.43 (± 0.45)</td>
<td>19.52 (± 0.11)</td>
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<tr>
<td>Arabinan</td>
<td>0.49 (± 0.13)</td>
<td>1.73 (± 0.52)</td>
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<tr>
<td>Total extractives</td>
<td>6.77 (± 0.40)</td>
<td>14.79 (±0.47)</td>
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<tr>
<td>Total lignin</td>
<td>20.85 (± 0.65)</td>
<td>17.44 (± 0.25)</td>
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<tr>
<td>Acetyl groups</td>
<td>4.13 (± 0.15)</td>
<td>2.78 (± 0.05)</td>
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<tr>
<td>Ash</td>
<td>2.19 (± 0.15)</td>
<td>7.03 (±0.06)</td>
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</tbody>
</table>
Digestibility screening

**Bagasse digestibility**
(g glucose / 100 g WIS)

**Harvest residues digestibility**
(g glucose / 100 g WIS)
Hemicellulose recovery screening

Bagasse hemicellulose recovery (g / 100 g feed)

Harvest residues hemicellulose (g / 100 g feed)
CSY screening

Bagasse CSY
(g / 100 g feed)

Harvest residues CSY
(g / 100 g feed)
Areas of >95% responses

Bagasse

Harvest residues
Fed-batch SSF - bagasse
Fed-batch SSF – harvest residues
Conclusions

1) Bagasse and harvest residues have different compositions which have far reaching consequences for a sugarcane biorefinery:
   - Optima pretreatment conditions will have to change to suit feedstock
   - Bagasse seems better suited for electricity/steam generation
   - Harvest residues seems ideal for ethanol and chemicals production over sugar platforms – contain an operating envelope for all studied optima

2) Best digestibility does not always guarantee best fermentability