Bio-refining of proteins from grass clover as innovative solution to a truly sustainable organic production.

Erik Fog, SEGES Organic Innovation, Denmark

Track: Scinetific Animals: Europe

Hall: Hall 2-C2 - Bill Mollison
Bio-refining of proteins from grass clover as innovative solution to a truly sustainable organic production

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SEGES is one of Europe’s leading innovation companies in agriculture. We operate on a professional basis and deliver knowledge and innovation that translate into practice.
The project OrganoFinery - Organic growth with biorefined organic protein feed, fertilizer, and energy.

- Will create new solutions to:
  - Low yields.
  - Supply organic protein feed to monogastric animals.
  - Problematic crop rotations.
  - Climate performance.
- By utilizing grass-clover for bio-refining and producing protein concentrate for pigs and poultry.
Harvest of 3-4 cuts of fresh grass-clover
Plant juice pressed within a few hours
Fermented with lactic acid bacteria
Precipitated proteins are separated from the juice
Dried and used as protein concentrate
## Plant and protein yields (two trials in Denmark)

<table>
<thead>
<tr>
<th>Yield (ton ha⁻¹)</th>
<th>Crop DM</th>
<th>Crop protein</th>
<th>Protein conc.*</th>
</tr>
</thead>
<tbody>
<tr>
<td>White clover / Ryegrass</td>
<td>6.26</td>
<td>0.88</td>
<td>0.31</td>
</tr>
<tr>
<td>Red clover</td>
<td>8.82</td>
<td>1.47</td>
<td>1.47</td>
</tr>
<tr>
<td>Red clover / cock’s foot</td>
<td>9.50</td>
<td>1.36</td>
<td>1.36</td>
</tr>
</tbody>
</table>

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<thead>
<tr>
<th>Yield (ton ha⁻¹)</th>
<th>Crop DM</th>
<th>Crop protein</th>
<th>Protein conc.*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa</td>
<td>13.31</td>
<td>2.53</td>
<td>0.89</td>
</tr>
<tr>
<td>Red clover</td>
<td>16.45</td>
<td>2.86</td>
<td>1.00</td>
</tr>
<tr>
<td>Grass clover mixture</td>
<td>19.23</td>
<td>2.95</td>
<td>1.03</td>
</tr>
</tbody>
</table>

*) The yield of protein concentrate is estimated to 35 % of the crop protein.
Biogas as part of the system

1. From the toolbar, click on "new slide".
2. Select a suitable layout from the "drop down" menu.

1. Click on the winged key.
2. From the toolbar, select "Color Range".
3. Select one of the topic colors to color the key.

Grass harvest

Juice press

Press cake

Cattle feed

Fermentation

Bio gas

Digestate fertilizer

Protein separation

Brown juice

Feed

Biogas

Grass

Harvest

Juice

Press

Press cake

Cattle feed

Fermentation
Biogas yields from residues (press cake and brown juice)

<table>
<thead>
<tr>
<th>Yield (Nm³ ha⁻¹)</th>
<th>Est. methane yield.*</th>
</tr>
</thead>
<tbody>
<tr>
<td>White clover / Ryegrass</td>
<td>3,056</td>
</tr>
<tr>
<td>Red clover</td>
<td>2,392</td>
</tr>
<tr>
<td>Red clover / cock’s foot</td>
<td>3,090</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Yield (Nm³ ha⁻¹)</th>
<th>Est. methane yield.*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa</td>
<td>3,492</td>
</tr>
<tr>
<td>Red clover</td>
<td>4,460</td>
</tr>
<tr>
<td>Grass clover mixture</td>
<td>6,254</td>
</tr>
</tbody>
</table>

*) The methane yield is estimated from methane yields of press cake and brown juice from similar crops.
Grass protein as feed (laying hens)

- Feeding trial with laying hens showed that grass clover protein concentrate (GPC) can substantially substitute organic soybean.

Partial replacement of organic soybean and soya cake with GPC (4, 8, and 12 %) didn’t influence the egg production, compared to the control diet.

Total digestibility of dry matter wasn’t influenced, but the digestibility of methionine and lysine decreased significantly.

The yellowness of the yolk increased significantly with GPC in the diet.

Grass protein as feed (milking cows)

- Silage of press cake from production of grass clover protein concentrate was compared with silage of grass clover from the same field as forage for dairy cows.

<table>
<thead>
<tr>
<th></th>
<th>Press cake silage</th>
<th>Grass clover silage</th>
</tr>
</thead>
<tbody>
<tr>
<td>In vitro digestibility</td>
<td>70.7 %</td>
<td>67.6 %</td>
</tr>
<tr>
<td>Crude protein concentration</td>
<td>16.8 %</td>
<td>13.6 %</td>
</tr>
<tr>
<td>Daily DM intake</td>
<td>23.1 (± 0.3) kg/d</td>
<td>22.6 (± 0.3) kg/d</td>
</tr>
<tr>
<td>Daily milk yield</td>
<td>37.4 (± 0.9) kg/d</td>
<td>34.6 (± 0.9) kg/d</td>
</tr>
</tbody>
</table>

(V.K. Damborg, S.K. Jensen, M.R. Weisbjerg: Value of pulp from green protein extraction of grass clover as forage for dairy cows. 2017 ADSA Annual Meeting.)
Economic calculations

- Production model
# Economic results (model calculation on Danish conditions)

<table>
<thead>
<tr>
<th></th>
<th>Economic result (€ / ha green crop)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard conditions *)</td>
<td>201</td>
</tr>
<tr>
<td>Without drying (wet feed)</td>
<td>540</td>
</tr>
<tr>
<td>20 % lower / higher protein price **)</td>
<td>-94 / 496</td>
</tr>
<tr>
<td>10 % lower / higher biogas price **)</td>
<td>24 / 378</td>
</tr>
<tr>
<td>10 % lower / higher protein yield **)</td>
<td>58 / 343</td>
</tr>
</tbody>
</table>

* Standard conditions: 0.7 ton protein / ha; 2,900 Nm³ methane / ha; 0.8 € / kg dry protein concentrate; 0.6€ / Nm³bio-methane.

**) Dried protein concentrate.
Conclusions

- Protein concentrate can be extracted from fresh grass-clover juice.
- Approximately 700 kg of crude protein / ha is realistic.
- The concentrate can substitute soy protein in the diet.
- Silage of grass press cake is a valuable forage for dairy cows.
- Press cake and residual juice are valuable for biogas production.
- Grass bio-refining must be optimized to get a profitable production / a realistic protein price.
- More nitrogen in the crop rotation is part of the benefits.
Thank you for your attention

• And thank you to the partners in the OrganoFinery project:
  • Aalborg University
  • Biotest Aps.
  • SEGES
  • Copenhagen University
  • Aarhus University
  • IFAU – Institute for Food Studies & Agroindustrial Development ApS
  • Danish Technological Institute

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