Can biorefining of forages make animal production more sustainable?

Seminar in connection with the PhD defense of Vinni Kragbæk Damborg Jensen’s doctoral thesis
Foulim, 31 January 2019

Steffen Adler
NIBIO – Norwegian Institute of Bioeconomy Research
NIBIO – Norwegian Institute of Bioeconomy Research
680 employees in different locations. Annual turnover 77 million Euro. Owned by the Ministry of Agriculture and Food.
NIBIO’S MAIN AREAS

Geography and Statistics

Biotechnology and Plant Health

Food Production and Society

Forest and Forest Resources

Environment and Natural Resources
NIBIO provides knowledge on biological resources from soil, forests and water.
Biorefining of forage crops
Grass juice in the diet of growing pigs
ProRefine – a CORE Organic project
BIOREFINING OF FORAGES

Sustainability
Development that meets the needs of the present without compromising the ability of future generations to meet their own needs.
Bruntland Report (1992)

Three pillars
BIOREFINING OF FORAGES

Biorefining of forages is not new, but it has attained new interest
- Houseman & Connell, 1976
- Wilkins, 1977
- Näsi, 1983
- Soya protein became a cheap alternative
- New interest in biorefining after 2000
  - Kamm et al., 2016
  - Kromus et al., 2004
  - Grass 2004
  - Stødkilde et al., 2017; Damborg et al 2018
  - Franco et al, 2018
BIOREFINING OF FORAGES

• Compared to annual crops, perennial forages can utilise the growing season efficiently and produce high yields of DM and CP

• Why separate protein-rich from fibre-rich fractions?
  • Most monogastrics are not able to digest plant fibres efficiently
  • Alternative use

Lucerne
Industrialisation of biological processes
Harvester

Screw press

Fermentation chamber

Transportation

Wikimedia: Mayer C., 2011, domaine public (décès des auteurs 1917 et 1911)
Forages – a local protein source for growing pigs

Proceedings of the 9th Nordic Feed Science Conference 2018, Uppsala, Sweden
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² Felleskjøpet Agri, Norway
³ Norsvin SA, Norway

Photo: Norsvin
Crop yields in Norway 2017 (Hedmark County)

- Lucerne
- Red clover forage
- Forage intensive
- Soybean seeds (Brazil)
- Rye and triticale
- Faba bean
- Forage average
- Potato
- Wheat
- Rapeseed
- Barley
- Oats

CP yield, tonnes/ha
Non-CP yield, tonnes/ha
FORAGES – A LOCAL PROTEIN SOURCE FOR GROWING PIGS

Aim of the project
Assess the effects of including forage juice preserved with formic acid in the diet of growing pigs on growth rate and meat quality on a commercial farm
Production of forage juice

- Commercial pig farm in Hedmark County, Norway
- Organically managed ley (80% timothy and meadow fescue, 20% red clover)
- Phenological stage of heading (grasses)
- First cut from 2.3 ha
- Harvested and preserved 13-16th June 2016
- Pulp was baled and sold to a nearby dairy farm

https://www.youtube.com/watch?v=38heTQEXCKk
Forages – A Local Protein Source for Growing Pigs

Forage production and processing

- 2.3 ha ley
  - First cut
  - Ca 6800 kg of DM/ha

- Screw press

- Juice
  - 52,000 L
  - (5% DM)
  - Ca 17% of DM
  - Protein 13%

- Pulp
  - 74 roundbales 550 kg
  - (32% DM)
  - Ca 83% of DM
  - Protein 87%
Feeding experiment

• 160 crossbred piglets (43 kg, 83 days)
• 2 test and 2 control groups of 20 animals
• Test diet contained 10% grass juice on DM basis
• Control diet: Vekst 120 (Kambo)
• Liquid-fed according to a feed curve with increasing feed intake
Diets

- 16% crude protein, isoenergetic, 20% DM, similar AA comp.
- Felleskjøpet Agri, Norway

Test diet

- 10% forage juice and 90% adjusted concentrate feed mixture on DM basis
- 4.9% soybean meal

Control diet

- Commercial concentrate feed mixture mixed with water
- 7.6% soybean meal
Results

<table>
<thead>
<tr>
<th></th>
<th>Test</th>
<th>Control</th>
<th>SEM</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feed conversion ratio, MJ/kg LW gain</td>
<td>24.3</td>
<td>23.2</td>
<td>0.97</td>
<td>NS</td>
</tr>
<tr>
<td>Average live weight gain, g/day</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day 1 to 17</td>
<td>808</td>
<td>801</td>
<td>18.7</td>
<td>NS</td>
</tr>
<tr>
<td>Day 1 to 58</td>
<td>892</td>
<td>917</td>
<td>10.9</td>
<td>0.11</td>
</tr>
<tr>
<td>Day 18 to 58</td>
<td><strong>927</strong></td>
<td><strong>965</strong></td>
<td><strong>13.5</strong></td>
<td><strong>0.05</strong></td>
</tr>
<tr>
<td>Day 58 to slaughter³</td>
<td>1090</td>
<td>1148</td>
<td>49.1</td>
<td>NS</td>
</tr>
<tr>
<td>Mortality, %</td>
<td>2.5</td>
<td>2.5</td>
<td>-</td>
<td>NS</td>
</tr>
</tbody>
</table>

- Moderate live weight gain
- Mould developed in the upper layer after 3 month of storage
- Mycotoxin analyses: without risk to animal health
- No signs of appetite loss
- Experiment stopped after 58 days
Feeding experiment

- Test
- Control

Live weight, kg vs. Days after birth

Harvest: 0
Experiment: 17
Post ex: 58
Mould development:
## Results

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<th>P-value</th>
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</thead>
<tbody>
<tr>
<td><strong>Meat and fat quality</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Lean meat, %</td>
<td>60.6</td>
<td>60.5</td>
<td>0.28</td>
<td>NS</td>
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<tr>
<td>Omega-6:omega-3 ratio</td>
<td>8.58</td>
<td>9.69</td>
<td>0.12</td>
<td>&lt;0.001</td>
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<tr>
<td>Stomach ulcer, number</td>
<td>1.53</td>
<td>1.45</td>
<td>0.26</td>
<td>NS</td>
</tr>
<tr>
<td>Intra muscular fat (NIR), %</td>
<td>2.08</td>
<td>1.69</td>
<td>0.16</td>
<td>NS</td>
</tr>
<tr>
<td>Fat colour L (whiteness)</td>
<td>77.1</td>
<td>77.2</td>
<td>0.24</td>
<td>NS</td>
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<tr>
<td>Fat colour a (redness)</td>
<td>3.72</td>
<td>3.35</td>
<td>0.19</td>
<td>NS</td>
</tr>
<tr>
<td>Fat colour b (yellowness)</td>
<td>5.29</td>
<td>5.15</td>
<td>0.13</td>
<td>NS</td>
</tr>
</tbody>
</table>
Pulp silage

- Indicated good feeding value for dairy cows
- 32% DM, 14.6% crude protein, 62.7% NDF, 74.0% OMD, pH 5.2, NEL 6.36 MJ/kg of DM
Conclusions

• Inclusion of 10% forage juice did not affect daily live weight gain in growing pigs, but reduced live weight gain with 38 g/day in finishers

• Forage juice gave a more beneficial omega-3:omega-6 ratio for human nutrition in fat

• Improved preservation methods for forage juice are needed
Sustainability

• In this experiment only a minor part of the diet was replaced with grass juice

• Life Cycle Assessment (Johansen & Hjelkrem, 2018)
  • Production and use of home made grass juice may contribute to reduce global warming, use of fossil fuels and terrestrial pollution
  • Higher land use efficiency
  • Many challenges must be solved
Refined forage legumes as local sources of protein feed for monogastrics and high quality fibre feed for ruminants in organic production
NEW METHODS FOR PRODUCING HIGH QUALITY FEED LOCALLY

Eric Juncker (F), Paolo Bani (I), Søren K. Jensen (DK), Jaakko Nuutila (CORE Organic, FIN), David Parsons (S) Håvard Steinshamn (N), Brit Logstein (N), Lene Stødkilde-Jørgensen (DK), Ülfet Erdal (TUR), Honoré Labanca (F) Divina G. P. Rodriguez (N), Mariem Baccar (F), Steffen Adler (N), David Renaudeau (F) Not present Gunn-Turid Kvam (N)
Objective
To improve local food systems in organic farming based on fractionation of plant parts of forage legumes
NEW METHODS FOR PRODUCING HIGH QUALITY FEED LOCALLY

Field trials and feeding experiments

Sweden
Norway
Denmark
France
Italy
Turkey

Feeding experiments
France: Swine
Italy: Sheep

NEW METHODS FOR PRODUCING FEED LOCALLY

Field trial
Tingvoll,
20.09.2018
NEW METHODS FOR PRODUCING FEED LOCALLY

Field trial
Umeå,
16.08.2018

Photo: David Parsons, SLU
NEW METHODS FOR PRODUCING HIGH QUALITY FEED LOCALLY

Forage legume whole crop (lucerne or red clover)

Leaf stripping (harvester)

Leaf fraction (protein-rich)
Stem fraction (fibre-rich)

Juice production (press screw)

Leaf juice fraction (protein-rich)
Leaf fibre fraction (fibre-rich)
Whole crop juice fraction (protein-rich)
Whole crop fibre fraction (fibre-rich)
Technology

Leaf stripper MRF1 prototype (TRUST’ING – ALF’ING)

Lucerne leaves ensiled with crushed triticale grains

Photos: Eric Juncker
Technology

Press screw (Angel)  

Photo: Erik Fog
NEW METHODS FOR PRODUCING HIGH QUALITY FEED LOCALLY

Organic farming

Forage legumes
- Lucerne
- Red clover

Fractionation
- Leaf stripper
- Press screw

Local feeds
- Protein-rich Juice and leaves
- Fibre-rich Pulp and stems

Sustainability
- Farmer attitudes towards self-sufficiency

Economy
- Monogastrics
- Ruminants

Society

Environment

Foto: Norsvin

Farmer attitudes towards self-sufficiency
NEW METHODS FOR PRODUCING FEED LOCALLY

Social aspects
Stakeholder group meetings
• Focus group interviews

Farmer interviews
• Attitudes towards local food systems, motivation, cooperation, risk management
NEW METHODS FOR PRODUCING FEED LOCALLY

Traditional production of milk and pork

Dairy production
- Herd
- Forage and pasture
- Other feed crops
- Crops for sale

Pork/poultry production
- Herd
- Feed crops and outdoor area
- Crops for sale

Feeds and fertiliser
Milk and meat
Meat
Feeds
NEW METHODS FOR PRODUCING FEED LOCALLY

Concept 1: Cooperation between dairy and pork farm

Dairy production
- Herd
- Pasture

Pork production
- Herd
- Outdoor area

Area
- Forage crops
- Other crops
- Forage legumes

Fractionation and preservation
Forage legumes

Milk and meat

Meat

Feeds

Fibre-rich feeds

Protein-rich feeds
NEW METHODS FOR PRODUCING FEED LOCALLY

Concept 2: Sale of fractionated forage legumes to the feed industry

**Dairy production**
- Herd
- Pasture
- Forages and forage legumes
- Other crops

**Pork production**
- Herd
- Outdoor area
- Forages and forage legumes
- Other crops

**Feed industry**
- Juice and leaves
- Other ingredients

**Fractionation and preservation**
- Forage legumes

**Concentrates**
- Fullfeed

**Milk and meat**
- Feeds

**Juice/leaves/pulp**
- Feeds

**NIBIO**

26.11.2019
## BIOREFINING OF FORAGES

### Strengths

<table>
<thead>
<tr>
<th>Biorefining</th>
<th>Current practice</th>
<th>Grassfed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fractions for monogastrics</td>
<td>Supplements for varying forage qualities</td>
<td>Animal does the «work»</td>
</tr>
<tr>
<td>Lower wilting losses</td>
<td></td>
<td>No arable land outside the farm</td>
</tr>
</tbody>
</table>

### Weaknesses

<table>
<thead>
<tr>
<th>Biorefining</th>
<th>Current practice</th>
<th>Grassfed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fractionation is resource demanding</td>
<td>Inefficient land use?</td>
<td>Low milk yield</td>
</tr>
<tr>
<td>Preservation of protein-rich fractions is challenging</td>
<td>No feeds for monogastrics from grasslands</td>
<td>No feeds for monogastrics</td>
</tr>
<tr>
<td>Preparing protein-rich fractions for monogastrics decreases forage area for ruminants</td>
<td>Import of protein feeds</td>
<td></td>
</tr>
</tbody>
</table>
Summary

Biorefining of forages may contribute to more sustainable animal production, but there are still many challenges to be solved.

- Technical issues and logistics
- Land use
- Processing costs and economy
- Preservation methods
- Attitudes, motivation and cooperation