Trade-offs of N-reducing dietary measures on enteric methane emission and phosphorus excretion in lactating cows

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Wageningen UR
N (& P ?) reducing feeding measures

- On-farm feed production
  - Forages, legumes, cereals
- Purchased feeds
  - Concentrates
  - By-products
- Impact on
  - N excretion
  - P excretion
  - Fermentability / composition / CH₄

Relationships between N/P excretion and enteric CH₄ emission, and any trade-offs?
Enteric fermentation model used

Feed intake

Rumen model fermentation

Methane module

H₂ source

Acetic acid
Butyric acid
Propionic acid
Valeric acid
Microbial growth on aminoacids
Microbial growth on ammonia
FA hydrogenation
Methane

H₂ sink

CO₂ + 4H₂ → CH₄ +2H₂O

H₂ surplus

Methane module

Large intestine model fermentation

Small intestine digestion

Excreta / emissions

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Simulating N reducing measures (Reijs, 2007)

• Feed intake capacity calculations (Zom et al., 2002)

• By grassland management
  – 100 kg available N/ha from animal manure
    150 vs. 350 kg artificial fertilizer N/ha
  – Late cut (4500 kg DS/ha) vs. early cut (3000 kg DS/ha)

• High vs. low feed intake level; 40% vs. 20% concentrates

• N-poor substitutes for grass silage
  maize silage (50%); straw, beet pulp, potatoes (15%)

• FPCM (3.32% milk protein, 4% milk fat); 1 g P/kg milk
Assumptions (Reijs, 2007)

• $\text{NE}_L$ content (MJ/kg DM)
  grass silage HF-EC, HF-LC, LF-EC, LF-LC: 6.3, 5.8, 6.0, 5.7
  straw, beet pulp, maize silage, potatoes: 3.5, 7.3, 6.6, 7.2
  concentrates: 7.2

• N content (g N/kg DM)
  grass silage HF-EC, HF-LC, LF-EC, LF-LC: 35, 26, 23, 18
  straw, beet pulp, maize silage, potatoes: 8, 16, 12, 16
  concentrates: 24

• P content (g P/kg DM: Van Middelkoop, 2012)
  grass silage HF-EC, HF-LC, LF-EC, LF-LC: 4.0, 3.5, 3.6, 3.1
  straw, beet pulp, maize silage, potatoes: 2.5, 0.7, 2.0, 2.4
  concentrates: 4.5
Simulation results: mean & range

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Range</th>
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<tbody>
<tr>
<td>Feed intake (kg DM/d)</td>
<td>19.6</td>
<td>16.0 – 22.4</td>
</tr>
<tr>
<td>Milk production (kg FPCM/d)</td>
<td>27.5</td>
<td>19.1 – 33.8</td>
</tr>
<tr>
<td>N intake (g N/d)</td>
<td>509</td>
<td>311 – 730</td>
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<tr>
<td>P intake (g P/d)</td>
<td>71</td>
<td>53 – 91</td>
</tr>
<tr>
<td>Apparent OM digestion (%)</td>
<td>75</td>
<td>70 – 82</td>
</tr>
<tr>
<td>Apparent N digestion (%)</td>
<td>69</td>
<td>59 – 78</td>
</tr>
<tr>
<td>Apparent P digestion (%)</td>
<td>39</td>
<td>34 – 45</td>
</tr>
<tr>
<td>N excreted (g/d)</td>
<td>365</td>
<td>211 – 558</td>
</tr>
<tr>
<td>P excreted (g/d)</td>
<td>44</td>
<td>30 – 57</td>
</tr>
<tr>
<td>Methane emission (g/d)</td>
<td>407</td>
<td>334 – 441</td>
</tr>
</tbody>
</table>

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Grassland management: N & P

HF, high N fert.
LF, low N fert.
EC, early cut
LC, late cut

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Grassland management: N & CH$_4$

HF, high N fert.
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N excretion & CH$_4$ emission

\[ y = 365.8 + 0.11x \]

\[ r^2 = 0.15 \]

Dijkstra e.a. (2010)

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N excretion & CH$_4$ per kg milk

\[ y = 18.1 - 0.24x \]
\[ r^2 = 0.22 \]
N excretion & CH₄ per kg milk

Mean maize silage
11.1 g N/kg FPCM
14.4 g CH₄/kg FPCM

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N excretion & CH$_4$ per kg milk

Mean HFEC
15.8 g N/kg FPCM
13.4 g CH$_4$/kg FPCM
CH$_4$ & urine N per kg milk

$y = -0.2993x + 17.165$
$R^2 = 0.3504$
CH$_4$ & P per kg milk

\[ y = 0.6819x + 13.829 \]

\[ R^2 = 0.0102 \]
Grassland management: excreta aspects

HF = high N fertilization; LF = low N fertilization
EC = early cutting; LC = late cutting

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Excreta C:N & CH₄ per kg milk

\[ y = 11.6 + 0.44x \]
\[ r^2 = 0.43 \]

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N composition excreta & CH$_4$ per kg milk

Methane emission (g/kg FPCM)

$y = 19.1 - 9.50x$

$r^2 = 0.54$

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Concluding

- As well-known, high potential to reduce N emission
  - Affects DM intake, milk yield
  - Also affects CH$_4$
  - e.g. grassland management

- At least expect lower N excretion may increase CH$_4$ emission

- Dietary N and P content related, but no relationship for P excretion and CH$_4$ emission
  - Variation in P excretion determined by milk yield
  - Variation in N excretion: N digestibility & milk yield

- Relationships manure characteristics and enteric CH$_4$ to be explored further (trade-offs manure CH$_4$, soil emissions)

- Trade-offs cow level might be relevant for those at farm level
  - What would be missing in current farm models?