High rate monitoring of CH4 production dynamics and their link with behavioral phases in cattle

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Methane issue

Feed, grass (polysaccharides)

RUMEN
Polysaccharides
→ Monosaccharides
→ SCFA, energy, CO2, H2
→ CH4

95% CH4 130Kg/y

5% CH4

CH4

CH4

CH4

CH4
Environmental issue of dairy cows

- Livestock: 25% of total anthropogenic CH4 sources
- CH4 production: loss of dietary energy between 6 to 12%

Methane emissions estimates

Emissions in Tg per year

- Wetlands: 217 Tg/year (28.1%)
- Other natural sources (geological, lakes, wildfires, termites, etc.): 123 Tg/year (16%)
- Hydrates and permafrost: 100 Tg/year (13%)
- Ruminants, rice, landfills and waste: 200 Tg/year (25.9%)
- Fossil fuels and biomass burning (incl. biofuels): 131 Tg/year (17%)

Total: 771 Tg/year

Created by Sam Carana for Arctic-news.blogspot.com based on estimates by Sam Carana and on data by IPCC AR5 WG1
Measurement methods on pasture

SF6 method

→ Individual daily production

GreenFeed

→ Individual short-term measurements

What about the CH4 dynamics?
Measurement methods on pasture

Eddy covariance:

→ Herd CH4 daily production
→ GPS
→ Behaviors?

→ AgriGES project

- Measurement of CH₄ and CO₂ fluxes using eddy covariance (Picarro G2311-f)
- Measurement of micro-meteorological variables

P. Dumortier et al., 2015

Each cow was equipped with a GPS (position) and accelerometer (behaviour) device
Questions

✓ What is the link between emission dynamics and feeding behavior?

Rumination

Grazing or eating

Rest
Methane measurement “gas tracker”

- 2 infra-red gas analysers (CH4 and CO2 concentrations)
- Ratio CH4:CO2
- Measurements in barn or on pasture
- Continuous measurements
Methane measurement

CO₂=breathing
CH₄=eructation
Inertial measurement unit of an iPhone to detect behaviors

“Development of an open-source algorithm based on inertial measurement units (IMU) of smartphones to detect cattle grazing and ruminating behaviors”
ALH Andriamandroso, F. Lebeau, Y. Beckers, E. Froidmont, I. Dufrasne, B. Heinesch, P. Dumortier, G. Blanchy, Y. Blaise, J. Bindelle
Submitted to Computers and Electronics in Agriculture.
Inertial measurement unit of an iPhone to detect behaviors

Grazing

Rumination

![Graph showing gravitational acceleration and rotational rate over time](image-url)
Experiment in barn

- 4 cows
- 2 diets: haylage v.s. concentrate diet
- isoenergy and iso-nitrogen diets
- 2 modalities: full diet v.s. 70% DMI
- Latin square

<table>
<thead>
<tr>
<th>Composition</th>
<th>Diet tested</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Haylage</td>
<td>Concentrate</td>
</tr>
<tr>
<td>Haylage</td>
<td>MS (Kg)</td>
<td>6.34</td>
<td>2.05</td>
</tr>
<tr>
<td>Linseed Nutex 68</td>
<td>MS(Kg)</td>
<td>0</td>
<td>1.80</td>
</tr>
<tr>
<td>Cracked wheat</td>
<td>MS(Kg)</td>
<td>0</td>
<td>0.90</td>
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</table>
## Results

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Diet</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Haylage 100%</td>
<td>Haylage 70%</td>
<td>Concentrate 100%</td>
</tr>
<tr>
<td><strong>N</strong></td>
<td>2822</td>
<td>2997</td>
<td>2998</td>
</tr>
<tr>
<td><strong>Ratio CH4:CO2 (Mean±sd)</strong></td>
<td>0.058±0.019 a</td>
<td>0.056±0.020 b</td>
<td>0.036±0.018 c</td>
</tr>
<tr>
<td><strong>Eructations /min (Mean±sd)</strong></td>
<td>0.462±0.221 a</td>
<td>0.391±0.191 b</td>
<td>0.260±0.187 c</td>
</tr>
</tbody>
</table>
Evolution of the acetate and propionate ratio in two fistulated cows eating the haylage or the concentrate diet

![Graph showing the evolution of acetate:propionate ratio over time for two diets: haylage and concentrate. The graph indicates a higher acetate:propionate ratio for haylage compared to concentrate, especially in the initial time points.]
CH₄ dynamics
CH₄ dynamics

Ratio dynamic for cow 3 (04/11/16)

meal
Preliminary results on pasture

- 6 cows
- diets: grass 15 cm high
- 24 hours measurement

<table>
<thead>
<tr>
<th>Measure</th>
<th>Behavior</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grazing</td>
<td>Rumination</td>
</tr>
<tr>
<td>N</td>
<td>693</td>
</tr>
<tr>
<td>Ratio CH4:CO2</td>
<td>0.051±0.039</td>
</tr>
<tr>
<td>Mean±sd</td>
<td></td>
</tr>
</tbody>
</table>
Conclusion

Device “gas tracker”

- All-terrain device
- Continuous measurement system
- No lab analysis
Conclusion

Knowledge enhancement

• In barn: More CH4 after the meal and during rumination
• On pasture: dynamics of the CH4 excreted linked to the post-feeding and less to the animal behavior
  • Effect of the day/night?
  • Effect of supplemented diet?
• For eddy-covariance: geo-localize the animal and the meal period
Acknowledgment

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