Assessment of the relation between methane concentrations and the methane flux of an artificial reference cow

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Introduction

- Methane emission from dairy cows:
  - 300 g/day
  - 15% global methane budget
  - 90~95% through nose and mouth
  - 6~10% loss of gross energy intake (Blaxter and Clappterton, 1965; Yan et al., 2010)
Introduction

Mitigation strategies

• Nutrition & management

• Genetics

How to assess effects?

Lack of suitable techniques for:

● Individual CH4 measurement
● Large number of cows
● Under representative farm conditions
Introduction

- Methane flux methods - e.g. g/day;
  - Direct: respiration chamber (Blaxter et al., 1972)
  - Indirect: tracer gas technique (SF$_6$) (Grainger et al., 2007)

- Methane concentration method - e.g. ppm:
  - Breath methane measurement method (Garnsworthy et al., 2012; Lassen et al., 2012)
Introduction
Objective

Methane conc. (ppm)

Methane flux (g day$^{-1}$)

Rumen

Breath air

WAGENINGEN UR
For quality of life
Material and methods (1)

- The artificial reference cow (Wu et al., 2014)
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- The artificial reference cow (Wu et al., 2014)
  - Simulate breathing of cows: lungs, resp. track, nose
  - Simulate CH\(_4\) eructation from rumen

- Gives:
  - Controlled methane flux
  - Known methane concentration pattern
  - Concentration pattern evaluation model

- Validation of:
  - CH\(_4\) flux rates
  - CH\(_4\) concentrations patterns
Results and discussion (1)

- Mass balance experiment of the ARC (tidal volume of 4.4 & breath frequency 30 min⁻¹)

\[ y = 0.98x + 4\times10^{-5} \]
\[ R^2 = 0.997, \ P < 0.001 \]
Results and discussion (1)

- Measured methane concentration pattern

![Graph showing measured methane concentration pattern for Cow-A, Cow-B, Cow-C, Cow-D, and Cow-E over time (s). The x-axis represents time in seconds ranging from 0 to 250, and the y-axis represents measured methane concentration in ppm ranging from 0 to 1600. The data shows periodic fluctuations for each cow with differences in peak values and time of occurrence.]
Material and methods (2)

- Five simulated cows (A to E)
  - 200 g day\(^{-1}\) to 400 g day\(^{-1}\)
  - Each performed 216 s
  - Repeated 5 times

- Validate the breath methane measurement method

- Conditions: air quality laboratory & barn

- Data analysis: linear regression \( CH_4 \) concentration vs. flux
Results and discussion (2)

Measured and predicted methane concentrations versus methane production rates; lab conditions

At 5 cm (dashed line):
\[ y = 2.39x + 37.3 \]
\[ R^2 = 0.97, s.e = 36.7, P < 0.001 \]

Predicted:
\[ y = 4.3x + 1.7 \]
\[ R^2 = 0.99, P < 0.001 \]
Results and discussion (2)

Measured and predicted methane concentrations versus methane production rates: **barn conditions**

**Equation 1:**

\[ y = 1.08x + 63.0 \]

\[ R^2 = 0.37, \text{s.e} = 86.2, P < 0.001 \]

**Equation 2:**

\[ y = 4.2x + 0.2 \]

\[ R^2 = 0.99, P < 0.001 \]
Conclusions

- The artificial reference cow properly represented the methane production release, and the system precisely controlled methane concentration and production.

- Breath methane concentration measurements can predict methane production rates of cows under steady laboratory conditions.

- This relation is weaker and shows more variation under disturbed / barn conditions: more research needed.
Thanks!

Now I know how much methane I produce!