Individual methane prediction from milk MIR spectra, across multiple breeds, lactation stages, partities and country-specific dairy farming systems

A. Vanlierde, N. Gengler, H. Soyeurt, C. Martin, E. Lewis, F. Grandl, M. Kreuzer, B. Kuhla, P. Lund, C. Ferris, C. Bertozzi, F. Dehareng

Speaker: Frédéric Dehareng
Individual methane prediction from milk MIR spectra, across multiple breeds, lactation stages, parities and country-specific dairy farming systems

Context: Methane produced by ruminants

Greenhouse gas + loss of gross energy intake (6 to 12%)

Sources of mitigation of CH₄ emissions:
- genetics
- diet
- management

Development of a technique that allows large scale studies

FT-IR used in Milk Recording Organisation?
Potential use of Mid infrared spectra of the milk?

- Position of the peaks → **Qualitative** analysis
- Intensity of the peaks → **Quantitative** analysis

Potential use of Mid infrared spectra of the milk?
Potential use of Mid infrared spectra of the milk?

Classical use of MIR spectra

Composition
- Fat
- Proteins
- Urea
- Lactose
- ...
Potential use of Mid infrared spectra of the milk?

Milk control

Indirect trait
ERUCTED METHANE?

Innovative use of MIR spectra

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Individual methane prediction from milk MIR spectra
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Principle to build the equation

\[ CH_4 \]  

MIR milk spectra

Equation

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Principle of prediction

\[ \text{CH}_4 \]

\[ \text{MIR milk spectra} \]

Equation

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First equation of prediction

CH₄ → Equation → MIR milk spectra

Potential use of milk mid-infrared spectra to predict individual methane emission of dairy cows

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¹Valorisation of Agricultural Products Department, Walloon Agricultural Research Centre, B-5030 Gembloux, Belgium; ²Department of Production and Sectors, Walloon Agricultural Research Centre, B-5030 Gembloux, Belgium; ³Animal Science Unit, Gembloux Agro Bio-Tech, University of Liège, B-5030 Gembloux, Belgium; ⁴National Fund for Scientific Research, B-1000 Brussels, Belgium; ⁵UR1213 Herbivores, INRAClermont-Theix Research Centre, F-63122 Saint Genès Champanelle, France
First equation of prediction

![Graph showing predicted vs. measured CH4](image)

**Table: Equation of prediction**

<table>
<thead>
<tr>
<th>Equation</th>
<th>N</th>
<th>SD</th>
<th>R²c</th>
<th>R²cv</th>
<th>SEC</th>
<th>SECV</th>
</tr>
</thead>
<tbody>
<tr>
<td>CH₄ (g of CH₄/Kg of milk)</td>
<td>60</td>
<td>7.3</td>
<td>0.85</td>
<td>0.75</td>
<td>4.25</td>
<td>5.61</td>
</tr>
<tr>
<td>CH₄ (g/day)</td>
<td>60</td>
<td>128</td>
<td>0.77</td>
<td>0.70</td>
<td>87.8</td>
<td>100.6</td>
</tr>
</tbody>
</table>

N = number of observations; SD = standard deviation; R²c = calibration coefficient of determination; R²cv = cross-validation coefficient of determination; SEC = calibration standard error; SECV = cross-validation standard error

*Figure 3: Infrared methane prediction on the basis of milk spectra of the day 1.5 for the different diets: corn silage (●), fresh pasture (○) and grass silage (+). PCA = principal component analysis.*
Merging of reference data sets

More data are needed to - include more variability

- improve performance of the equation
Merging of reference data sets

Use of different instruments

Standardisation step needed

EMR procedure (OptiMIR Project)
Merging of reference data sets

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<tbody>
<tr>
<td>CH₄</td>
<td>446</td>
<td>132.6</td>
<td>0.78</td>
<td>0.74</td>
<td>63</td>
<td>68</td>
</tr>
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</table>
Methane predictions depending on lactation stage

Garnsworthy et al., 2012

→ Reversed curves

→ Need to improve our model
Methane predictions depending on lactation stage

**Hot topic:** Innovative lactation-stage-dependent prediction of methane emissions from milk mid-infrared spectra

A. Vanlierde,* M.-L. Vanrobaey,† F. Deharenge,* E. Froidmont,‡ H. Soyeurt,† S. McParland,§ E. Lewis,§ M. H. Deighton,¶ F. Grandi,‖ M. Kreuzer,‖ B. Gredler,‖ P. Dardenne,* and N. Gengler†

*Walloon Agricultural Research Centre, Valorization of Agricultural Products Department, 5030 Gembloux, Belgium
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‖Itegrasc; Animal and Grassland Research and Innovation Centre, Moonepark, Fermoy, Co. Cork, Ireland
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‖Quantis AG, 6300 Zug, Switzerland

**DIM**

CH₄

Equation

MIR milk spectra

Linear and Quadratic Legendre Polynomials

[Link to the article](http://dx.doi.org/10.3168/jds.2014-8436)
Methane predictions depending on lactation stage

<table>
<thead>
<tr>
<th>Equation (g/day)</th>
<th>N</th>
<th>SD</th>
<th>$R^2_c$</th>
<th>$R^2_{cv}$</th>
<th>SEC</th>
<th>SECV</th>
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<tr>
<td>CH$_4$</td>
<td>446</td>
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<td>68</td>
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<td>CH$_4$ and DIM</td>
<td>446</td>
<td>127.5</td>
<td>0.75</td>
<td>0.67</td>
<td>63</td>
<td>72</td>
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- $N = \text{number of observations}$; $SD = \text{standard deviation}$; $R^2_c = \text{calibration coefficient of determination}$; $R^2_{cv} = \text{cross-validation coefficient of determination}$; $SEC = \text{calibration standard error}$; $SECV = \text{cross-validation standard error}$

→ Statistical parameters are a slightly lower...

...BUT!
Methane predictions depending on lactation stage

Application of CH$_4$ equations on Belgian spectral database

1$^{st}$ lactation Holstein cows

Garnsworthy et al., 2012

→ In accordance with literature

CH$_4$ and DIM

Estimation of methane (g/d)

Week of lactation

0 10 20 30 40 50

300 350 400

0 50 100 150 200 250 300 350

300 350 400 450 500

0 5 10 15 20 25 30 35

300 350 400 450 500

CH$_4$ (g/d)

DIM
Methane predictions depending on lactation stage

Application of CH$_4$ equations on Belgian spectral database

Trends over lactations correspond to what is expected
## Merging of SF6 and respiratory chamber data sets

<table>
<thead>
<tr>
<th>Institution</th>
<th>Reference Method</th>
<th>Number of animals</th>
<th>Number of data</th>
</tr>
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<tbody>
<tr>
<td>CRA-W</td>
<td>SF$_6$</td>
<td>47</td>
<td>265</td>
</tr>
<tr>
<td>Teagasc</td>
<td>SF$_6$</td>
<td>110</td>
<td>262</td>
</tr>
<tr>
<td>AFBI</td>
<td>Chambers</td>
<td>12</td>
<td>24</td>
</tr>
<tr>
<td>Aarhus</td>
<td>Chambers</td>
<td>19</td>
<td>130</td>
</tr>
<tr>
<td>Qualitas/ETH Z</td>
<td>Chambers/SF$_6$</td>
<td>42 + 16</td>
<td>99 + 59</td>
</tr>
<tr>
<td>FBN</td>
<td>Chambers</td>
<td>52</td>
<td>213</td>
</tr>
<tr>
<td>Inra</td>
<td>Chambers</td>
<td>9</td>
<td>82</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>307</strong></td>
<td><strong>1134</strong></td>
</tr>
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Merging of SF6 and respiratory chamber data sets

![Graph showing the merging of SF6 and respiratory chamber data sets.](image)

**Equation (g/day)** | **N** | **SD** | **R²c** | **R²cv** | **SEC** | **SECV**
--- | --- | --- | --- | --- | --- | ---
SF$_6$ + Chambers | 1134 | 106.1 | 0.64 | 0.60 | 64 | 67
Merging of SF6 and respiratory chamber data sets

Equation (g/day) | N  | SD  | R²c | R²cv | SEC | SECV
---              |----|-----|-----|------|-----|------
SF6 + Chambers   | 1134| 106.1| 0.64| 0.60 | 64  | 67   

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Phenotypic and Genetic Large-Scale Studies

Possibility to apply models \textit{a posteriori}

New equation

Walloon Agricultural Research Centre
Individual methane prediction from milk MIR spectra
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Phenotypic and Genetic Large-Scale Studies

Genetic parameters of mid-infrared methane predictions and their relationships with milk production traits in Holstein cattle

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*Department of AGROBIOCHEM and Terra Teaching and Research Centre, Gembloux Agro-Bio Tech, University of Liège, 5030 Gembloux, Belgium
†Department of Valorisation of Agricultural Products, Agricultural Product Technology Unit, and
‡Department of Production and Sectors, Animal Nutrition and Sustainability Unit, Walloon Agricultural Research Centre, 5030 Gembloux, Belgium

Article In Press, Open Access
Conclusions

- It is possible to predict methane from milk MIR spectra

- Important to check if the applications at large scale are logical at a metabolic level

- Integration of DIM information seems to be a good strategy to:
  - take a better account of the metabolic status of cows
  - improve the equation

- Important to include further regions/breeds/regimes to cover the variability

- Merging of data set strategy: analytical standardisation of reference measurements is needed

- Easy and cheap method for large scale utilisation
Thanks to our support and partners!