LIÈGE université
Gembloux
Agro-Bio Tech

Exploiting opportunities in dairy cattle breeding using mid-infrared spectral data associated to novel traits in the Walloon Region of Belgium

Nicolas Gengler

and colleagues from ULiège-GxABT, CRA-W and the whole Futurospectre Consortium:

Soyeurt H., Bastin C., Bertozzi C., Colinet F.G., Froidmont E., Gillon A., Grelet C., Hammami H., Massart X., Mayeres P., Piraux E., Reis Mota R., Vanderick S., Vanlierde A., Vanrobays M.-L., Veselko D., Dehareng F.

The Beginning….

- Very early in 2005….
  - Research started in Gembloux (**Walloon Region of Belgium**) on mid-infrared (MIR) spectral data
    ➔ **MSc then PhD by Dr. Hélène Soyeurt**
  - MRO (DHI) and milk lab joining forces to collect MIR spectra during routine milk performance recording

- In a very short time….
  - From very few herds to all herds in the Walloon Region

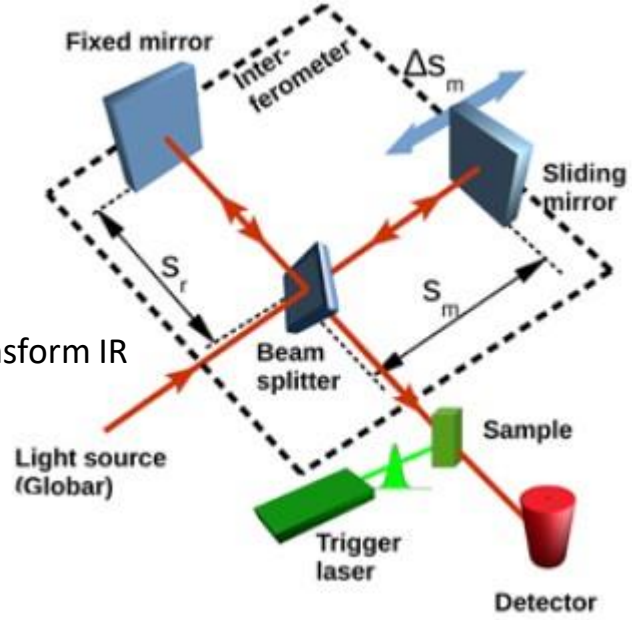
Futurospectre Consortium

- Advantage of our limited size….
  - Very simple and coherent structure with few, already highly interconnected groups:
    - Science and extension (**CRA-W** and **ULiège-GxABT**)
    - DHI (Walloon Breeding Association - **AWE**) and
    - Milk lab (Milk Committee - **CdL**)

- Therefore, already in 2008….
  - Founding of the **Futurospectre** R&D **Consortium**
  - Developed framework to collect, store, research and use the Walloon MIR data ➔ DHI and later milk payment

What is MIR Spectrometry?

Fourier transform IR (FT-IR)



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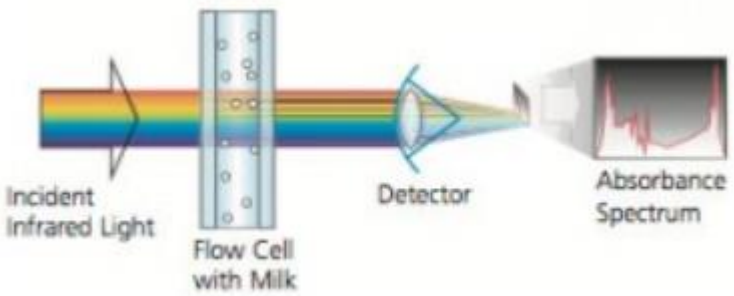

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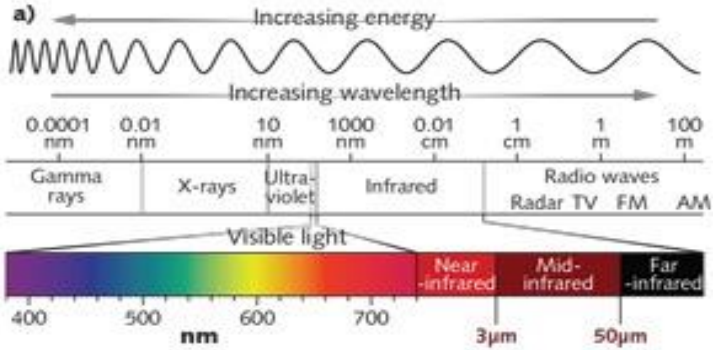

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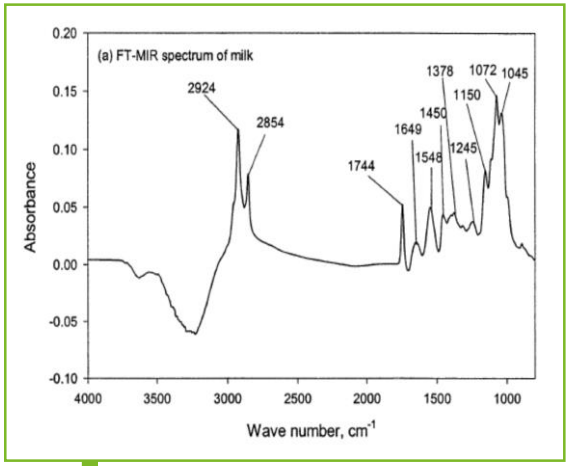
Internationalization….

- Wallonia being small ➔ internationalization
- Participation in **different international projects**, several successful European examples:
  - FP7 ➔ RobustMilk, Greenhousemilk, GplusE
  - INTERREG NWE ➔ OptiMIR (➔ EMR)
  - New: INTERREG NWE ➔ HappyMoo

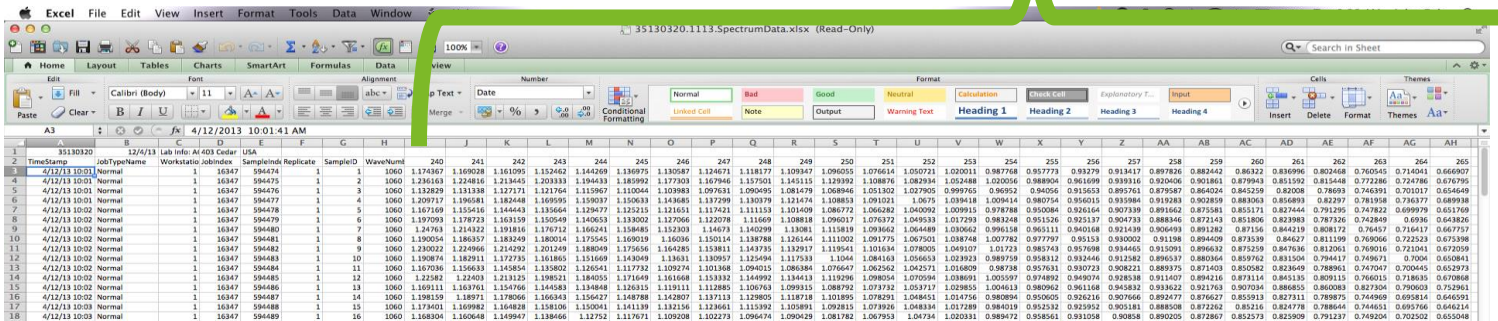
Calibration (Spectra ➔ Prediction)

- Between 850 – 1060 absorbance values (abs)



- “Calibration“
  - ➔ Obtaining **b coefficients**

    e.g., **Fatty acid = $b_0 + \sum b_i\,(abs)_i$**



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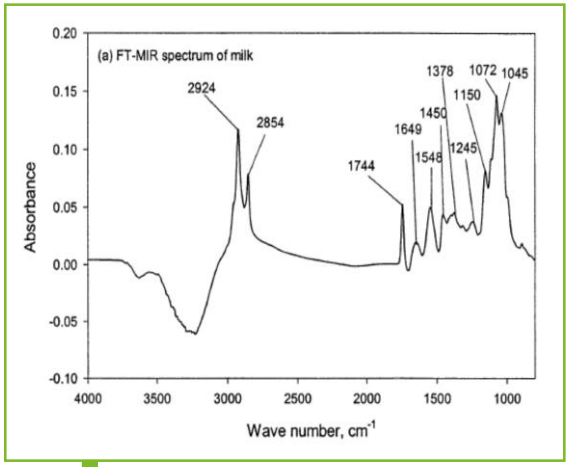
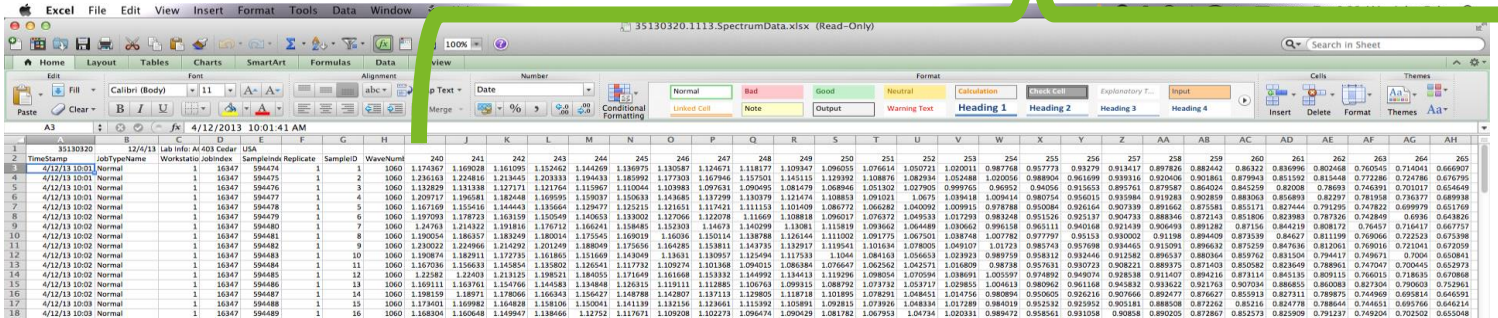
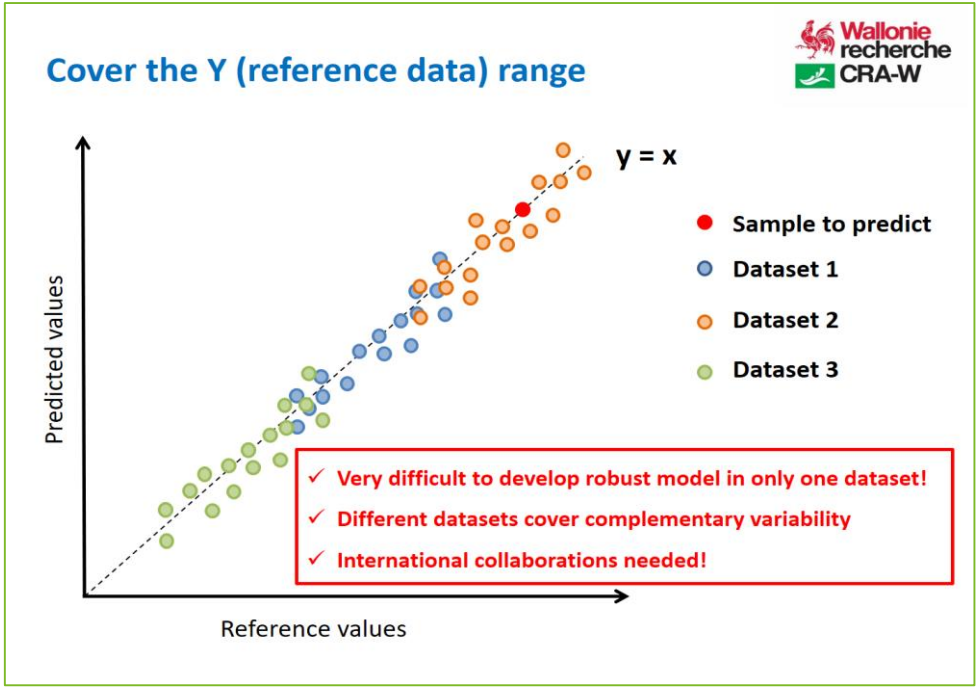


different between brands and models ➔ additional step necessary before calibration across data sets



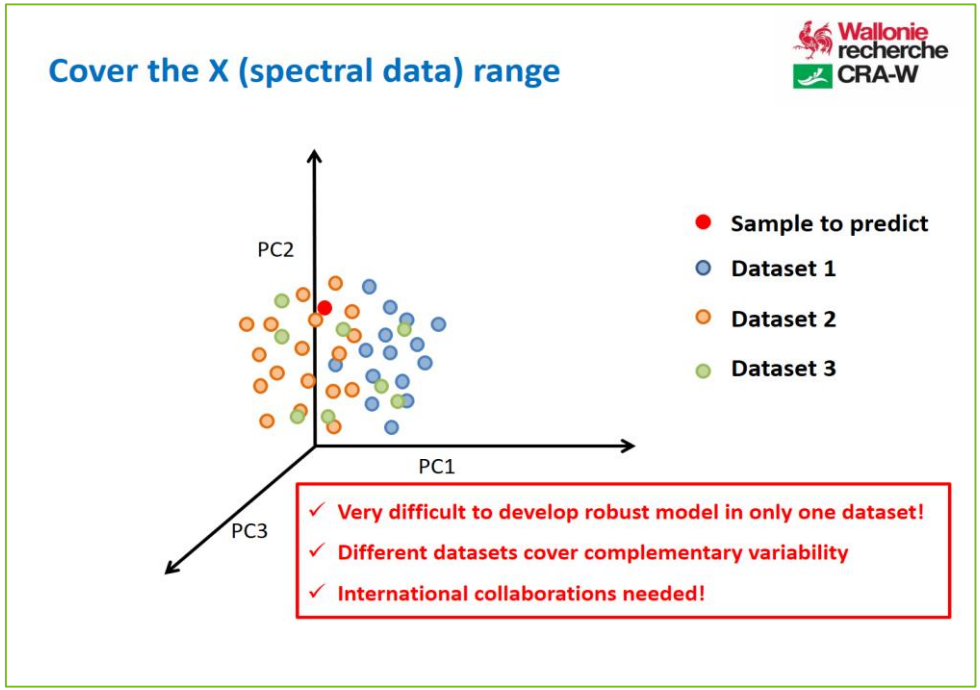
Calibration Needs….

- Largest possible (and expected) variability
  - In **reference phenotypes**
    - E.g., if values between 1 and 10 are expected, reference data from 1 to 10 are needed for calibration, potentially 1/10 of each



Calibration Needs….

- Largest possible (and expected) variability
  - In reference phenotypes
  - But also **in spectral data**
    - I.e., spectra used during calibration process should cover expected range of spectra used when predicting



Calibration Needs….

- Largest possible (and expected) variability
  - In reference phenotypes
  - But also in spectral data

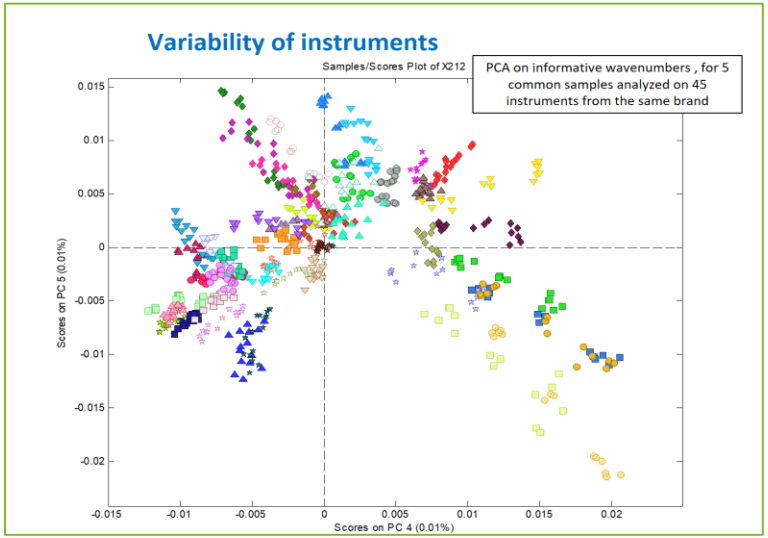
➔ Importance of **international collaborations** obvious

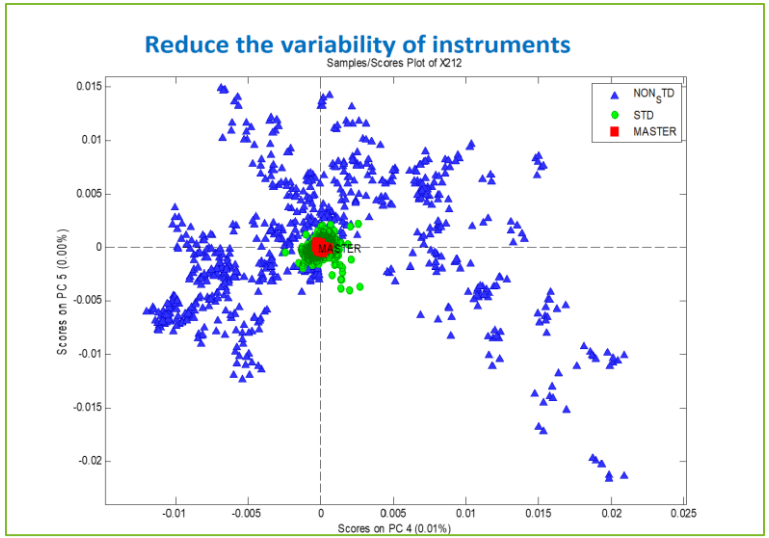
International Innovative Calibrations….

- Important “**organizational**” innovation
  ➔ calibration as an “**open**” process (🡐 more common in near-infrared)
- **Open means** here:
  - New, international, partners join by simply adding relevant reference (and validation) data to the data pool

  ➔ **Access to prediction equations + updates when new partners arrive**
- Other advantages:
  - All partners keep **full control** over their **own data**
  - **Only equation developing entities** (here CRA-W and ULiège-GxABT) have **access to all data** and **only for equation building**

Standardization of MIR Spectra….





J. Dairy Sci. 98:2150–2160
http://dx.doi.org/10.3168/jds.2014-8764

Standardization of milk mid-infrared spectra from a European dairy network

C. Grelet,[1] J. A. Fernández Pierna,[1] P. Dardenne, V. Baeten, and F. Dehareng[2]
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J. Dairy Sci. 100:7910–7921
https://doi.org/10.3168/jds.2017-12720

Standardization of milk mid-infrared spectrometers for the transfer and use of multiple models

C. Grelet,* J. A. Fernández Pierna,* P. Dardenne,* H. Soyeurt,† A. Vanlierde,* F. Colinet,† C. Bastin,‡ N. Gengler,† V. Baeten,* and F. Dehareng*[1]
*Valorization of Agricultural Products Department, Walloon Agricultural Research Center, 5030 Gembloux, Belgium
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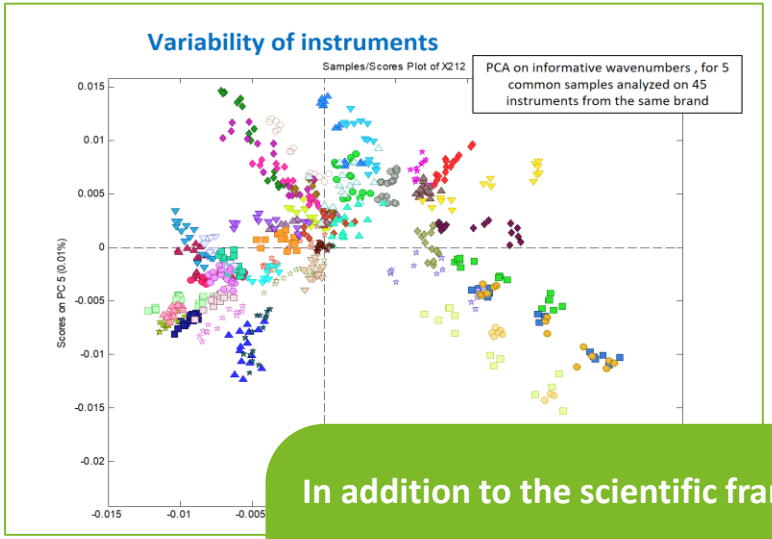
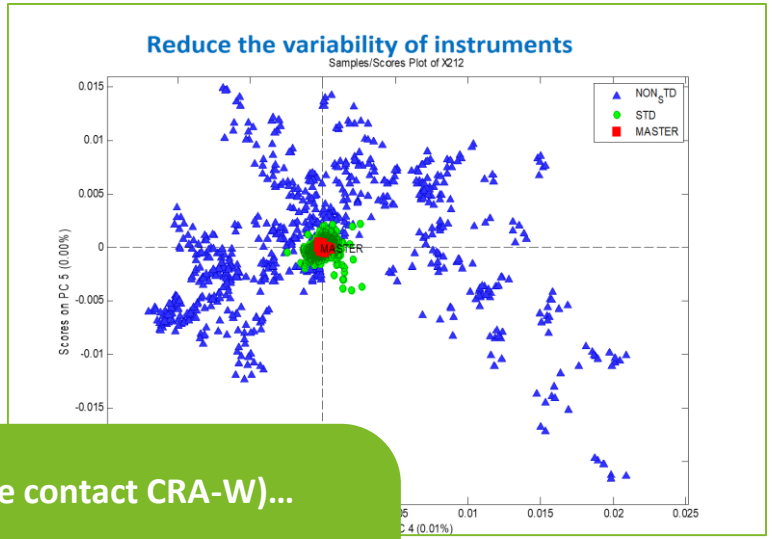
‡Walloon Breeding Association, B-5590 Ciney, Belgium

Standardization of MIR Spectra….





In addition to the scientific framework (please contact CRA-W)…

Commercial services were started by EMR (European Milk Recording)

please visit: www.milkrecording.eu

Two Successful Examples of Consortia….

- Fatty acids (FA)

J. Dairy Sci. 94:1657–1667
doi:10.3168/jds.2010-3408

Mid-infrared prediction of bovine milk fatty acids across multiple breeds, production systems, and countries

H. Soyeurt,*†[1,2] F. Dehareng,‡[1] N. Gengler,*† S. McParland,§ E. Wall,‡ D. P. Berry,§ M. Coffey,# and P. Dardenne‡
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#Sustainable Livestock Systems Group, Scottish Agricultural College, Bush Estate, Penicuik, Midlothian, EH26 0PH, United Kingdom

- MIR based methane (CH_4) proxy

Animal, page 1 of 8 © The Animal Consortium 2012
doi:10.1017/S1751731112000456

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

F. Dehareng[1*†], C. Delfosse[1*], E. Froidmont[2], H. Soyeurt[3,4], C. Martin[5], N. A. Vanlierde[1] and P. Dardenne[1]

[1]*Valorisation of Agricultural Products Department, Walloon Agricultural Research Centre, B-5030 Gembloux, Belgium;* [2]*Department of Agricultural Research Centre, B-5030 Gembloux, Belgium;* [3]*Animal Science Unit, Gembloux Agro Bio-Tech, University of Liège, B-503 Fund for Scientific Research, B-1000 Brussels, Belgium;* [5]*UR1213 Herbivores, INRAClermont-Theix Research Centre, F-63122 Saint Ge*

J. Dairy Sci. 98:5740–5747
http://dx.doi.org/10.3168/jds.2014-8436

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

A. Vanlierde,*[1] M.-L. Vanrobays,†[1] F. Dehareng,* E. Froidmont,‡ H. Soyeurt,† S. McP M. H. Deighton,# F. Grandl,‖ M. Kreuzer,‖ B. Gredler,¶ P. Dardenne,* and N. Gengler†
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#Agriculture Research Division, Department of Economic Development, Jobs, Transport and Resources, Ellinba 3821 Victoria, Australia
‖ETH Zürich, Institute of Agricultural Sciences, 8092 Zürich, Switzerland
¶Qualitas AG, 6300 Zug, Switzerland

J. Dairy Sci. 101:7618–7624
https://doi.org/10.3168/jds.2018-14472

***Short communication*: Development of an equation for estimating methane emissions of dairy cows from milk Fourier transform mid-infrared spectra by using reference data obtained exclusively from respiration chambers**

A. Vanlierde,* H. Soyeurt,† N. Gengler,† F. G. Colinet,† E. Froidmont,‡ M. Kreuzer,§ F. Grandl,# M. Bell,‖ P. Lund,¶ D. W. Olijhoek,¶ M. Eugène,** C. Martin,** B. Kuhla,††[1] and F. Dehareng*
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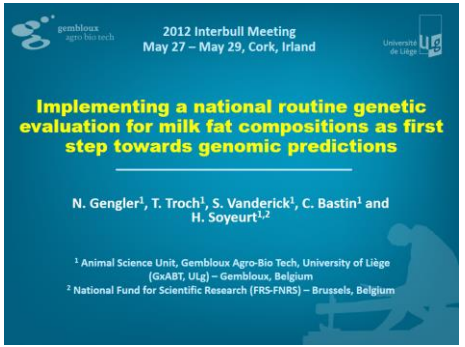
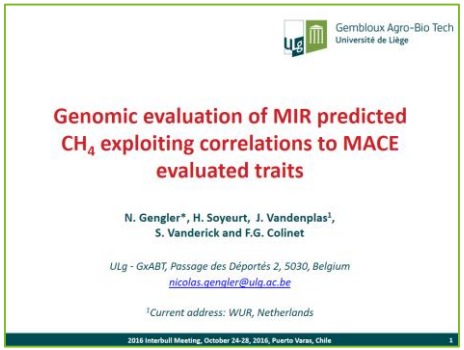
¶Department of Animal Science, AU Foulum, Aarhus University, 8830 Tjele, Denmark
**UMR Herbivores, INRA, VetAgro Sup, Université Clermont Auvergne, 63122 Saint-Genès-Champanelle, France
††Leibniz Institute for Farm Animal Biology (FBN), Institute of Nutritional Physiology, 18196 Dummerstorf, Germany

Creating Opportunities in Dairy Cattle Breeding

- Milk fat composition
  - First reported in 2010
  - Some progress in 2012



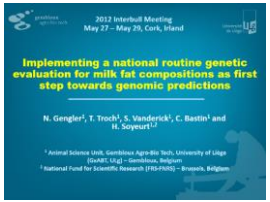
- MIR based CH_4 proxy
  - First reported in 2016



However These Studies Also Showed Challenges….

- Definitions of novel traits, quality of data, e.g.:
  - CH_4 traits and proxies, different FA prediction equations
- Quantity and deepness of data, no international evaluations
- Modeling of these traits, e.g.:
  - FA ➔ massive multi-variate, multi-lactation, test-day models
  - CH_4 ➔ needs to address very many different traits recorded on different time scales, on different related animals in different environments
- Genomics making things even more complex
- And often forgotten: “economics” in a very wide sense… ➔ “a” values
  - Because the crucial question is “why” should we select for a novel trait!

Current Status of FA Genomic Evaluations



- Progress since 2012
  - FA equations now very stable
  - Progress in Walloon genomic evaluation methodology
    - › External predictor traits ← MACE for milk, fat%, prot% → simple model
    - › Use of correlated traits ←
    - › Extending cow reference population

J. Dairy Sci. 98:9044–9050
http://dx.doi.org/10.3168/jds.2015-9894
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Integration of external estimated breeding values and associated reliabilities using correlations among traits and effects

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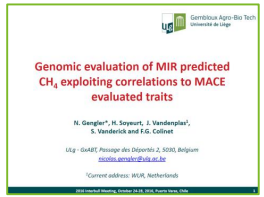
†National Fund for Scientific Research, 1000 Brussels, Belgium
‡Research and Development Department, Walloon Breeding Association, 5590 Ciney, Belgium

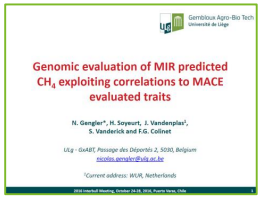
  - Still how to define “economics” for FA very uncertain
- Further progress pending
  but → FA excellent **biomarkers** for cow health, management…

Current Status of CH_4 Genomic Evaluations


Genomic evaluation of MIR predicted CH_4 exploiting correlations to MACE evaluated traits

- Progress since 2016
  - CH_4 equation evolving ➔ SF_6, chambers, soon Greenfeed
    - Expanding international collaboration for MIR equation
  - "Residual CH_4 " = "MIR CH_4" - "Expected CH_4" ➔ MACE for M, F%, P%, …
    - Blend in Walloon genomic evaluation system
  - International collaboration in the context of genomic evaluation
    - Sharing reference populations, data, SNP MACE ?
- Two important issues
  - Important to **get clear message** about r_g between CH_4 and its MIR proxy
    - International collaboration needed
  - **Generating index**: correlations to other traits and "economics" for CH_4

Current Status of CH_4 Genomic Evaluations


Gembloux Agro-Bio Tech
Université de Liège

Genomic evaluation of MIR predicted CH_4 exploiting correlations to MACE evaluated traits

N. Gengler*, H. Soyeurt, J. Vandenplas†, S. Vanderick and F.G. Colinet

ULg - GxABT, Passage des Déportés 2, 5030, Belgium
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†Current address: WUR, Netherlands

- Progress since 2016
  - CH_4 equation evolving ➔ SF_6, chambers, soon Greenfeed
    - Expanding international collaboration for MIR equation
  - "Residu[illegible] M, F%, P%, …
    - Ble[illegible]
  - Interna[illegible]on
    - Sh[illegible]
- Two imp[illegible]
  - Import[illegible] its MIR proxy
    - International collaboration needed
  - **Generating index**: correlations to other traits and "economics" for CH_4

After some failed efforts also in an international context…
recently projects were approved…
…pending final financing approval

Conclusions

- **Wallonia first**
  - Getting access to MIR data and researching its use on large scale
- Opened **very early opportunities**
  - However we faced also challenges (and lack of funds)
  - International collaboration, still room to do more
- Early focus of FA and CH_4, **good choices?**
  - Economic values, availability of data???
- **Future focus**
  - Still CH_4 ➔ collaborations + funding
  - FA ➔ animal health, wellbeing, … (with other MIR based biomarkers)
  - Some still "**hidden**" work closer to the market as e.g., "cheese making"

Conclusions

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  -
  -
- Ear
  -
- **Futu**
  - Still CH_4 ➔ collaborations + funding
  - FA ➔ animal health, wellbeing, … (with other MIR based biomarkers)
  - Some still "**hidden**" work closer to the market as e.g., "cheese making"

I think we can all agree today:

There are countless opportunities in MIR based breeding

Acknowledgements

- Support throughout the Futurospectre partnership
  - AWE – Comité du Lait – CRA-W – ULiège-GxABT
- CECI Consortium for computational resources
- Service Public de Wallonie (SPW – DGO3, Belgium)
- National Fund for Scientific Research
- Support by different European Projects:

ROBUSTMILK

GPLUSE Genotype plus Environment Integration for a more sustainable dairy production system

GREENHOUSE MILK

OptiWIR

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