



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. H el ene Soyeurt**

- MRO (DHI) and milk lab joining forces to collect MIR spectra during routine milk performance recording

► In a very short time....

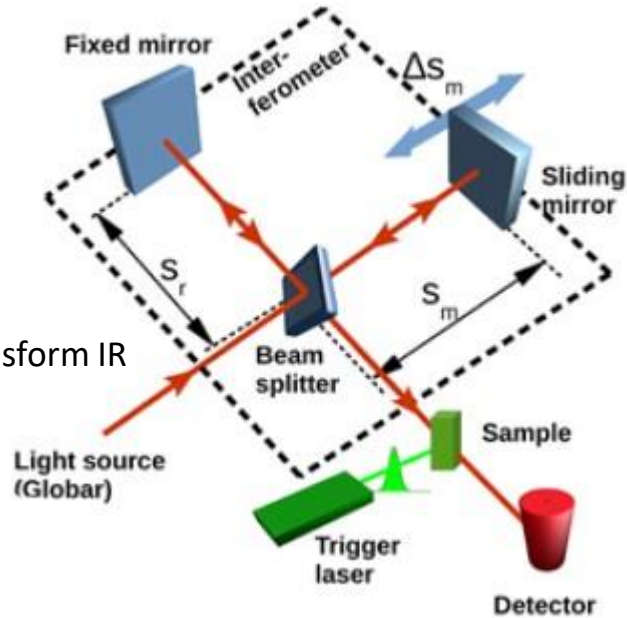
- From very few herds to all herds in the Walloon Region

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

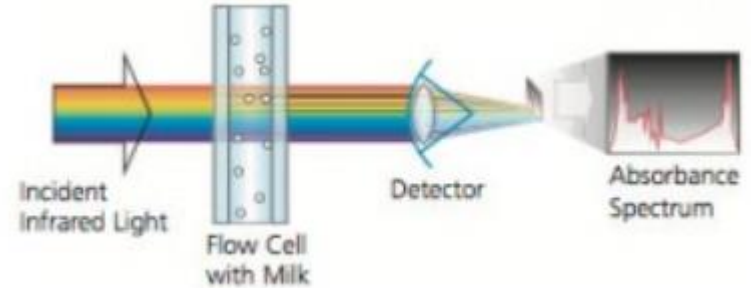


What is MIR Spectrometry?

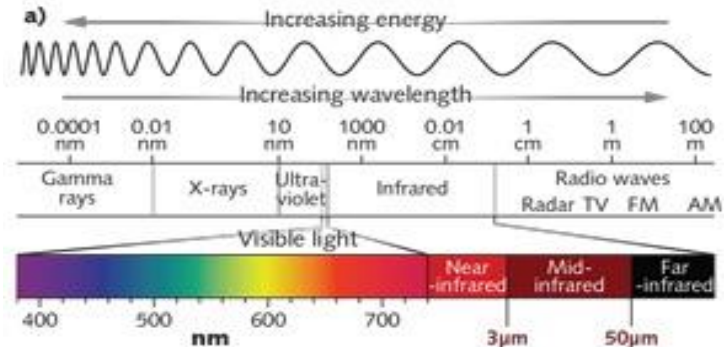


Fourier transform IR (FT-IR)

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© Seddon et al., 2016, bioOptics world



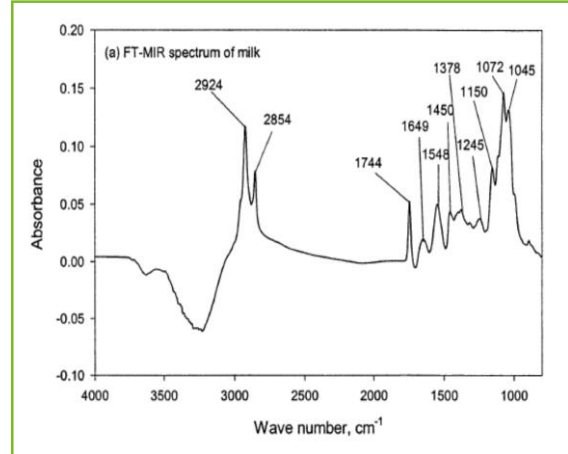
Internationalization....

- ▶ 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)



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

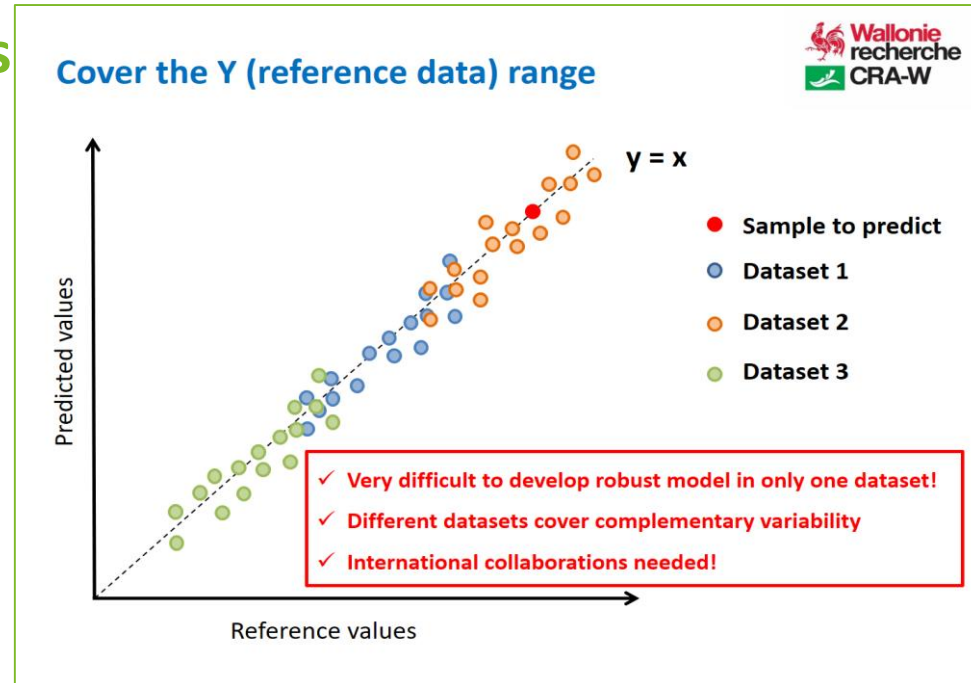
TimeStamp	Wavelength	Wavenumber	Absorbance	...																													
4/12/13 10:01	Normal	1060	0.174367	0.169028	0.161095	0.152462	0.144269	0.136975	0.129671	0.118177	0.109347	0.109655	0.107614	0.102021	0.987768	0.957773	0.93279	0.913417	0.897826	0.882442	0.86322	0.839696	0.802468	0.760545	0.714041	0.666707							
4/12/13 10:01	Normal	2	0.16347	0.94474	1	1060	0.126163	0.124816	0.123445	0.122033	0.119433	0.118992	0.117793	0.116796	0.115701	0.114515	0.113392	0.108876	0.102934	0.102448	0.102006	0.988904	0.961699	0.939316	0.92006	0.901861	0.872948	0.841548	0.807286	0.772186	0.737486		
4/12/13 10:01	Normal	5	0.16347	0.94476	1	3	1060	0.132829	0.131338	0.127571	0.121764	0.115967	0.110084	0.102983	0.097631	0.090495	0.084778	0.080864	0.051302	0.027905	0.0199765	0.016056	0.015603	0.015761	0.015887	0.016026	0.016519	0.02008	0.016093	0.016091	0.020107		
4/12/13 10:01	Normal	8	0.16347	0.94477	1	4	1060	0.120971	0.119658	0.118248	0.116995	0.115937	0.115063	0.114385	0.113729	0.113079	0.112474	0.110883	0.101231	0.10675	0.103948	0.100414	0.080754	0.056015	0.031984	0.019283	0.002859	0.008305	0.015893	0.01297	0.018158	0.016377	
4/12/13 10:02	Normal	7	0.16347	0.94478	1	5	1060	0.187169	0.152516	0.144443	0.135664	0.128477	0.121215	0.112611	0.117421	0.111153	0.101408	0.086773	0.066382	0.040092	0.009913	0.018788	0.002084	0.016164	0.007338	0.016561	0.015781	0.015171	0.012744	0.013929	0.014822	0.016997	
4/12/13 10:02	Normal	8	0.16347	0.94479	1	6	1060	0.119709	0.117823	0.116319	0.115054	0.114053	0.113302	0.112766	0.112032	0.110818	0.109617	0.107632	0.102933	0.101729	0.098248	0.051526	0.025137	0.004793	0.008846	0.017214	0.015806	0.012983	0.012489	0.013626	0.014326		
4/12/13 10:02	Normal	9	0.16347	0.94480	1	7	1060	0.124763	0.121322	0.119118	0.117612	0.116624	0.115845	0.115203	0.114673	0.114029	0.113081	0.111819	0.109962	0.106489	0.030662	0.096138	0.061131	0.040168	0.021439	0.006693	0.001282	0.017516	0.0044219	0.0081172	0.014647	0.0167757	
4/12/13 10:02	Normal	10	0.16347	0.94481	1	8	1060	0.130054	0.128637	0.128349	0.128046	0.127545	0.126919	0.126036	0.125014	0.123748	0.122444	0.111002	0.091795	0.075051	0.038748	0.007782	0.017797	0.05153	0.030002	0.01138	0.004609	0.0187339	0.004427	0.011139	0.009066	0.012328	
4/12/13 10:02	Normal	11	0.16347	0.94482	1	9	1060	0.130022	0.124496	0.124292	0.120249	0.118809	0.117566	0.116428	0.115381	0.113917	0.111954	0.101834	0.078005	0.049107	0.01273	0.086743	0.057698	0.034465	0.015091	0.004662	0.0175259	0.0047636	0.0112061	0.0070916	0.0121041	0.0167209	
4/12/13 10:02	Normal	12	0.16347	0.94483	1	10	1060	0.130874	0.128211	0.127239	0.126186	0.125169	0.124369	0.12361	0.123097	0.122594	0.117933	0.1104	0.081610	0.056653	0.024923	0.089759	0.048312	0.032446	0.012182	0.006537	0.008056	0.0159762	0.0115064	0.0194117	0.0196971	0.02004	
4/12/13 10:02	Normal	13	0.16347	0.94484	1	11	1060	0.130736	0.115663	0.114584	0.113582	0.112654	0.111732	0.110924	0.110138	0.109415	0.108684	0.107661	0.106256	0.104251	0.101609	0.098748	0.057631	0.030723	0.008221	0.008975	0.014703	0.005058	0.002649	0.0078961	0.0147007	0.020045	0.025273
4/12/13 10:02	Normal	14	0.16347	0.94485	1	12	1060	0.122582	0.122403	0.121325	0.119821	0.118405	0.116949	0.115382	0.114492	0.113413	0.112326	0.111261	0.110192	0.109091	0.108281	0.107329	0.106334	0.101789	0.088403	0.052532	0.029252	0.005183	0.008808	0.012262	0.0125216	0.0124778	0.0188664
4/12/13 10:02	Normal	15	0.16347	0.94486	1	13	1060	0.110111	0.116793	0.115476	0.114508	0.113484	0.112413	0.111311	0.110285	0.109263	0.109315	0.108292	0.107372	0.102855	0.046113	0.061168	0.045482	0.033022	0.0121761	0.007304	0.006655	0.006083	0.0173304	0.0079063	0.012961	0.012961	
4/12/13 10:02	Normal	16	0.16347	0.94487	1	14	1060	0.1198159	0.118971	0.117866	0.116683	0.115627	0.114488	0.113487	0.112485	0.111483	0.110485	0.109485	0.108485	0.107485	0.106485	0.105485	0.104485	0.103485	0.102485	0.101485	0.100485	0.099485	0.098485	0.097485	0.096485	0.095485	
4/12/13 10:02	Normal	17	0.16347	0.94488	1	15	1060	0.1178401	0.116982	0.116028	0.115061	0.114139	0.113216	0.112291	0.111364	0.110436	0.109507	0.108578	0.107649	0.10672	0.105793	0.104864	0.103935	0.103006	0.102077	0.101148	0.100219	0.09929	0.098361	0.097432	0.096503	0.095574	
4/12/13 10:02	Normal	18	0.16347	0.94489	1	16	1060	0.1168304	0.116048	0.114987	0.113866	0.112727	0.111571	0.110398	0.109208	0.107994	0.106757	0.105508	0.104248	0.102977	0.101695	0.100402	0.099098	0.097783	0.096457	0.095121	0.093774	0.092417	0.091049	0.089671	0.088283	0.086885	0.085478



Calibration Needs....

- ▶ Largest possible (and expected) variability
 - In **reference phenotypes**

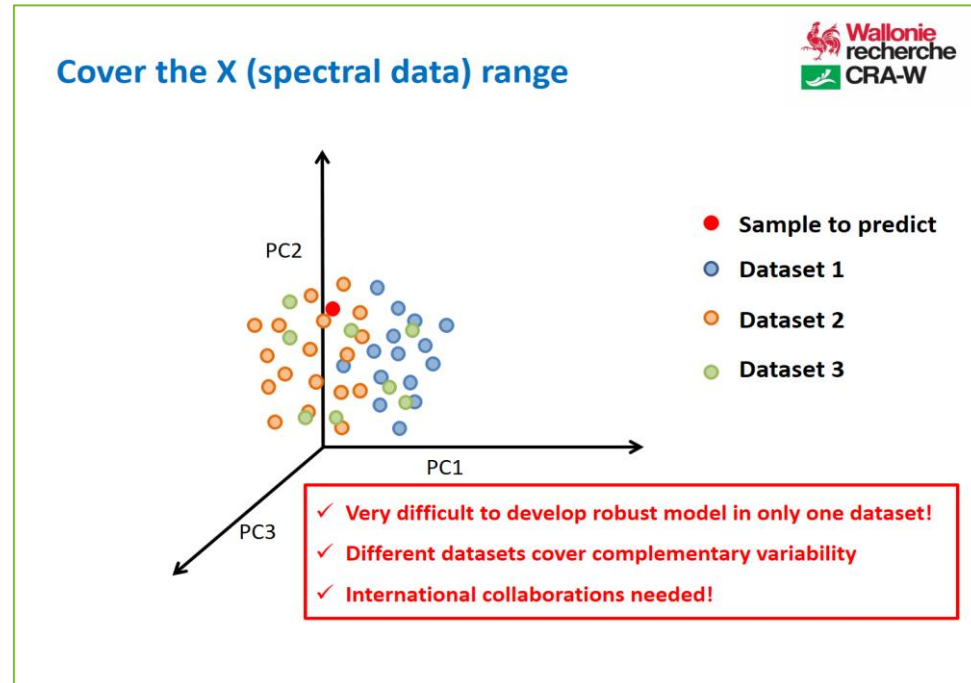
- › E.g., if values between 1 and 10 are expected, reference data from 1 to 10 are needed for calibration, potentially 1/10 of each





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....

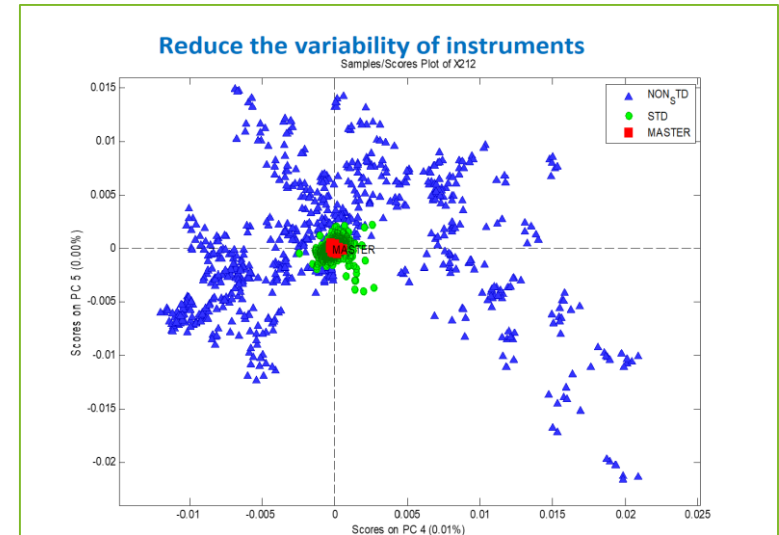
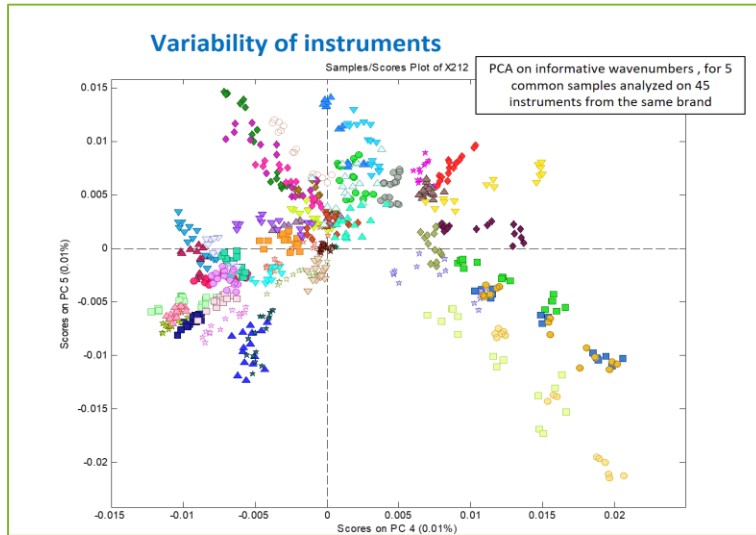
- ▶ Largest possible (and expected) variability
 - In reference phenotypes
 - But also in spectral data

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

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 Walloon Agricultural Research Center, Valorisation of Agricultural Products Department, 24 Chaussée de Namur, 5030 Gembloux, Belgium

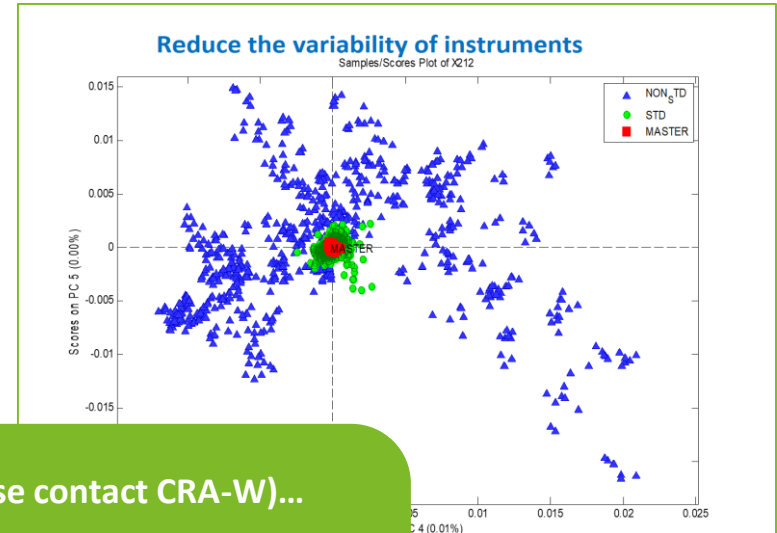
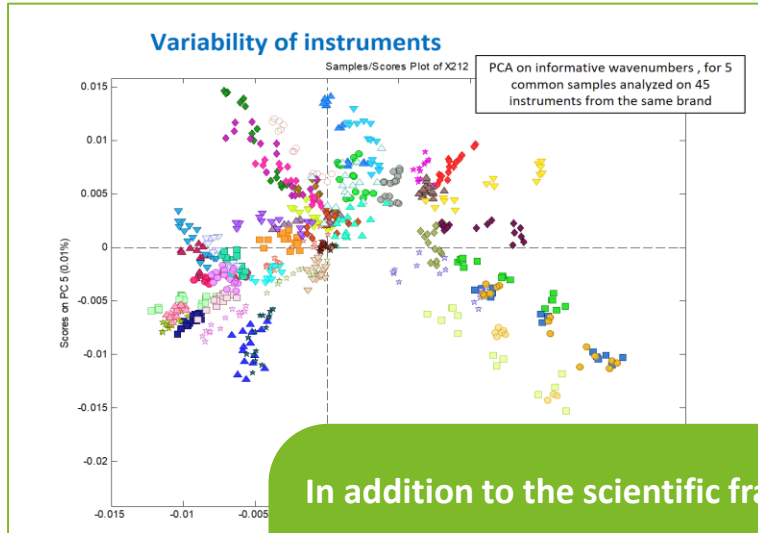


J. Dairy Sci. 100:7910–7921
<https://doi.org/10.3168/jds.2017-12720>
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Standardization of milk mid-infrared spectrometers for the transfer and use of multiple models

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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

J. Dairy Sci. 98:21
<http://dx.doi.org/10.3181/jd.2005-12-100>
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Standardization of milk recording

C. Grelet,¹ J. A. Fernández Piñero,²
Wallon Agricultural Research Center, Gembloux, Belgium



...eters

Vanlierde,^{*} F. Colinet,[†] C. Bastin,[‡]

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Two Successful Examples of Consortia....

► Fatty acids (FA)



J. Dairy Sci. 94:1657–1667
doi:10.3168/jds.2010-3408
© American Dairy Science Association®, 2011.

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

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[#]Sustainable Livestock Systems Group, Scottish Agricultural College, Bush Estate, Penicuik, Midlothian, EH26 0PH, United Kingdom

► MIR based methane (CH₄) 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. Froidmont², H. Soyeurt^{3,4}, C. Martin⁵, N. A. Vanlierde¹ and P. Dardenne¹

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J. Dairy Sci. 98:5740–5747
http://dx.doi.org/10.3168/jds.2014-8436
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Hot topic: Innovative lactation-stage-dependent prediction of methane emissions from milk mid-infrared spectra

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^{||}ETH Zurich, Institute of Agricultural Sciences, 8092 Zurich, Switzerland
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J. Dairy Sci. 101:7618–7624
https://doi.org/10.3168/jds.2018-14472

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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. Grandi,[#] M. Belli,^{||} P. Lund,[¶] D. W. Olijhoek,[¶] M. Eugène,^{**} C. Martin,^{**} B. Kuhla,^{††} and F. Dehareng^{*}

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^{††}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

gembloux agro bio tech
2010 Interbull Meeting
May 31 – June 4, Riga, Latvia
Université de Liège

Genetic Evaluation for Milk Fat Composition in the Walloon Region of Belgium

N. Gengler^{1,2}, S. Vanderick¹, V. Arnould¹, H. Soyeurt^{1,2}

¹ Animal Science Unit, Gembloux Agro-Bio Tech, University of Liège (GxABT, ULg) – Gembloux, Belgium
² National Fund for Scientific Research (FRS-FNRS) – Brussels, Belgium

gembloux agro bio tech
2012 Interbull Meeting
May 27 – May 29, Cork, Ireland
Université de Liège

Implementing a national routine genetic evaluation for milk fat compositions as first step towards genomic predictions

N. Gengler¹, T. Troch¹, S. Vanderick¹, C. Bastin¹ and H. Soyeurt^{1,2}

¹ Animal Science Unit, Gembloux Agro-Bio Tech, University of Liège (GxABT, ULg) – Gembloux, Belgium
² National Fund for Scientific Research (FRS-FNRS) – Brussels, Belgium

► MIR based CH₄ proxy

- First reported in 2016

Gembloux Agro-Bio Tech
Université de Liège

Genomic evaluation of MIR predicted CH₄ exploiting correlations to MACE evaluated traits

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¹ Current address: WUR, Netherlands

2016 Interbull Meeting, October 24-28, 2016, Puerto Varas, Chile



However These Studies Also Showed Challenges....

- ▶ Definitions of novel traits, quality of data, e.g.:
 - CH₄ 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
 - CH₄ → 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
- Still how to define “economics” for FA very uncertain

► Further progress pending

but → FA excellent **biomarkers** for cow health, management...



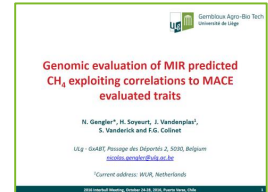
 J. Dairy Sci. 98:9044-9050
<http://dx.doi.org/10.3168/jds.2015-9894>
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Integration of external estimated breeding values and associated reliabilities using correlations among traits and effects

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[†]National Fund for Scientific Research, 1000 Brussels, Belgium
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Current Status of CH₄ Genomic Evaluations



► Progress since 2016

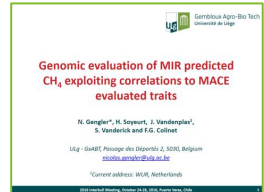
- CH₄ equation evolving → SF₆, chambers, soon Greenfeed
 - › Expanding international collaboration for MIR equation
- “Residual CH₄” = “MIR CH₄” - “Expected CH₄” ← MACE for M, F%, P%, ...
 - › Blend in Walloon genomic evaluation system
- International collaboration in the context of genomic evaluation
 - › Sharing reference populations, data, SNP MACE ?

► Two important issues

- Important to **get clear message** about r_g between CH₄ and its MIR proxy
 - › International collaboration needed
- **Generating index**: correlations to other traits and “economics” for CH₄



Current Status of CH₄ Genomic Evaluations



► Progress since 2016

- CH₄ equation evolving → SF₆, chambers, soon Greenfeed
 - › Expanding international collaboration for MIR equation
- “Residual CH₄”, “MIR CH₄”, “Emissions CH₄” ← MACE for M, F%, P%, ...

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

► Two important

- Importation of MIR proxy
 - › International collaboration needed
- **Generating index**: correlations to other traits and “economics” for CH₄



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 CH₄, **good choices?**

- Economic values, availability of data???

▶ **Future focus**

- Still CH₄ → 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

▶ Wallonia first

- Getting access to MIR data and researching its use on large scale

▶ Opened **very early opportunities**

-
-

▶ Early

-

▶ Future

- Still CH₄ → 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



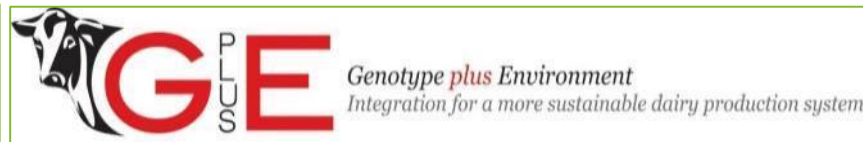
- ▶ Service Public de Wallonie (SPW – DGO3, Belgium)



- ▶ National Fund for Scientific Research



- ▶ Support by different European Projects:



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