ITN Marie-Curie GreenHouseMilk Project ,WP-2

Relationship between milk composition estimated from mid-infrared and methane emissions in dairy cows

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3-4 Dec, Wageningen

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Outline of Presentation

- Part I – Genetic parameters for methane indicators obtained from Mid-infrared spectroscopy (MIR) of milk fatty acids
- Part II – Development of calibration equation from direct MIR spectra of milk samples (Belgium + Ireland)
- Part III – Genetic parameters for these (obtained from part II) methane indicator traits
- Part IV – Publications, conferences, trainings and future plans

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Part I

Genetic parameters for methane indicators obtained from MIR of milk fatty acids

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Introduction

- Methane (CH_4) is the largest contributor to total greenhouse gas emitted by the dairy sector.
- CH_4 is 21 times more potent to CO_2 in greenhouse effect.
- Generally CH_4 is measured by respiration chamber or Sulphur hexafluoride (SF_6) method in animals.
- Phenotype gap for direct methane measurement leads to indirect indicators:
    - Milk fatty acids in milk
    - Direct MIR prediction from milk
    - Residual food intake

IPCC (2007), FAO (2010), EU (1998), Johnson (1994), Koch et al. (1963), Chilliard et al. (2009), Dijkstra et al. (2011), Dehareng et al. (2012)

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Why genetics

- Genetic selection of animal having low CH_4 emissions
  - ✓Additive
  - ✓Permanent

Objectives

- Predictions of CH_4 emissions (indicators)
- Estimation of genetic parameters
- Correlations with other economic traits

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MIR CH_4 indicators

Milk samples

MIR spectra

FA analysis (gas chromatography)

CH_4 predicted by FA contents

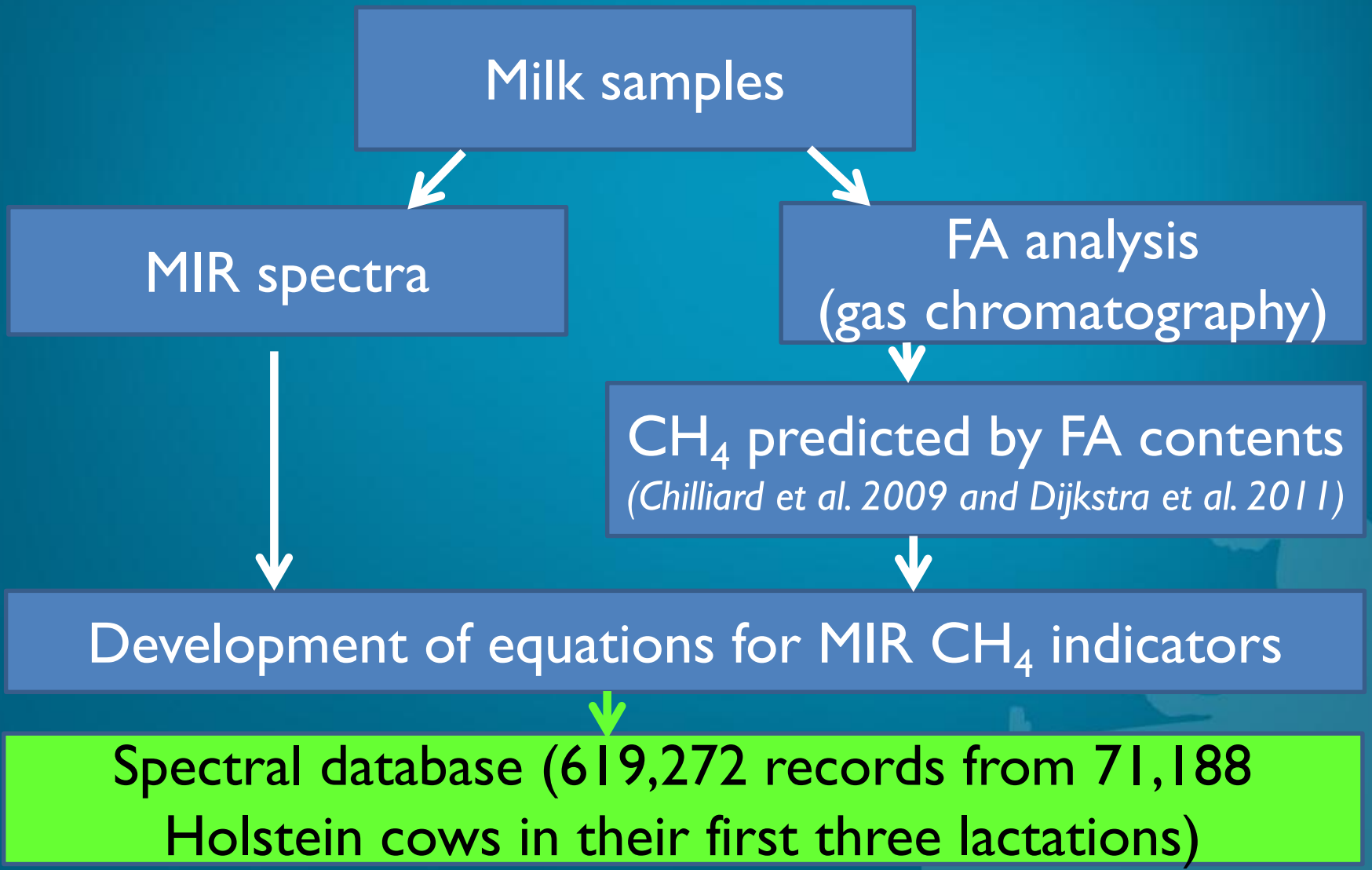
(Chilliard et al. 2009 and Dijkstra et al. 2011)

CH_4 predicted by FA contents

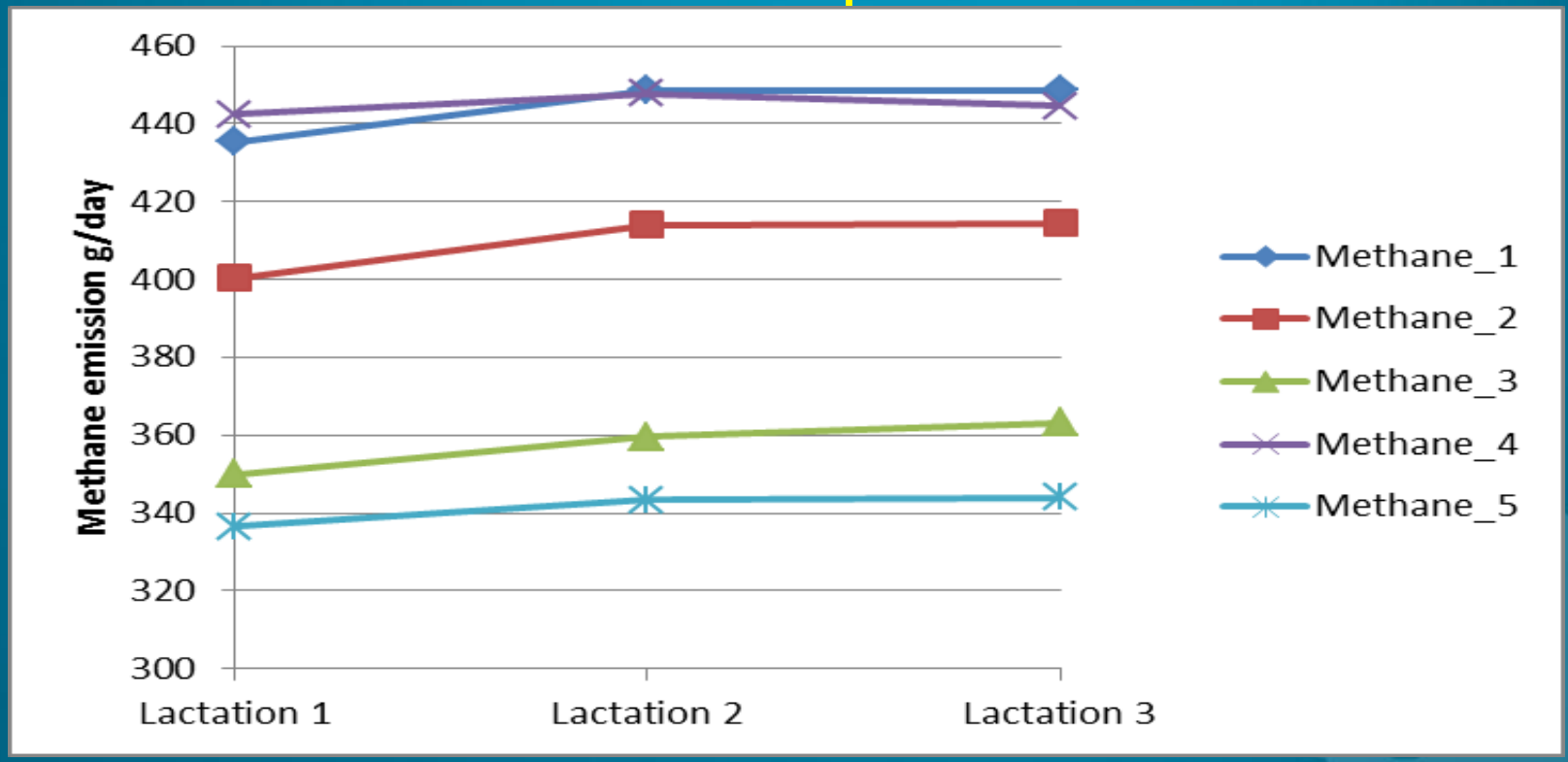
Prediction	Equation	R^2	Reference
Methane1 *g/day*	9.97 x (C8:0 to C16:0) - 80	**0.88**	Chilliard et al. 2009
Methane2 *g/day*	-8.72 x C18:0 + 729	**0.88**	
Methane3 *g/day*	282 x C8:0 + 11	0.81	
Methane4 *g/day*	16.8 x C16:0 - 77	0.82	
Methane5 *g/kg DM, 17.7 kg DM/day*	24.6 + 8.74 x C17:0 anteiso – 1.97 x trans-10+11 C18 :1 – 9.09 x C18 :1 cis-11+ 5.07 x C18 :1 cis-13	0.73	Dijkstra et al. 2011

R^2 *represents the relationship between the* SF_6 CH_4 *data and the predictors*

MIR CH_4 indicators



Estimated daily CH_4 emission from MIR CH_4 indicators



If we calculate for 365 days, the estimated CH_4 emission is 115 to 162 kg /year from one cow

Model : Single trait random regression test day

$$y=X\beta+Q(Zp+Zu)+e$$

y: separate 5 MIR CH_4 indicators and milk traits

β: herd x test day, 24 classes of days in milk, and 3 classes of age at calving → fixed effects

p: random permanent environmental effects

u: additive genetic effects, e: random residual effect

Q: coefficients of 2nd order Legendre polynomials

X and Z: incidence matrices

Variance components were calculated by REML.

Heritability

Indicators	Averaged daily heritability		
	Lact 1	Lact 2	Lact 3
Methane_1 (g/day)	0.34	0.37	0.34
Methane_2 (g/day)	0.30	0.33	0.30
Methane_3 (g/day)	0.29	0.39	0.22
Methane_4 (g/day)	0.35	0.40	0.38
Methane_5 (g/day)	0.16	0.17	0.14

0.21 (FTIR measurement) Lassen et al., 2012

0.35 (IPCC 2006; Gross energy 6%) de Haas et al., 2011

0.15 Sheep; direct measurement (Chamber) Vercoe et al., 2011

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Phenotypic and Genetic Correlations

Traits	Methane_2	Methane_3	Methane_4	Methane_5	Milk yield	Fat content	Protein content
Methane_1	0.99	0.56	0.88	0.62	-0.05	0.23	0.23
Methane_2		0.57	0.87	0.65	-0.05	0.21	0.25
Methane_3			0.32	0.24	0.25	0.00	0.05
Methane_4				0.65	-0.17	0.29	0.16
Methane_5					-0.15	0.17	0.20
Milk yield						-0.37	-0.36
Fat content							0.50

- +ve phenotypic correlations among MIR CH_4 indicator traits
- Low –ve phenotypic correlation with milk production except methane_3
- +ve phenotypic correlations with milk fat and protein contents

Phenotypic and Genetic Correlations

Traits	Methane_1	Methane_2	Methane_3	Methane_4	Methane_5	Milk yield	Fat content
Methane_2	0.98						
Methane_3	0.56	0.61					
Methane_4	0.81	0.76	0.20				
Methane_5	0.69	0.67	0.11	0.73			
Milk yield	-0.19	-0.18	-0.12	-0.11	-0.02		
Fat content	0.54	0.53	0.31	0.43	0.29	-0.50	
Protein content	0.33	0.38	0.18	0.16	0.15	-0.36	0.58

- +ve genetic correlations among MIR CH_4 indicator traits
- Low –ve genetic correlation with milk production

- +ve phenotypic correlations with milk fat and protein contents

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Part II

Development of calibration equation to predict CH_4 from direct MIR spectra of milk samples (Belgium + Ireland)

P. B. Kandel[1], A. Vanlierde[2], F. Dehareng[2], E. Froidmont[2], P. Dardenne[2], E. Lewis[3], F. Buckley[3], M. Deighton[3], S. McParland[3], N. Gengler[1] and H. Soyeurt[1,4]

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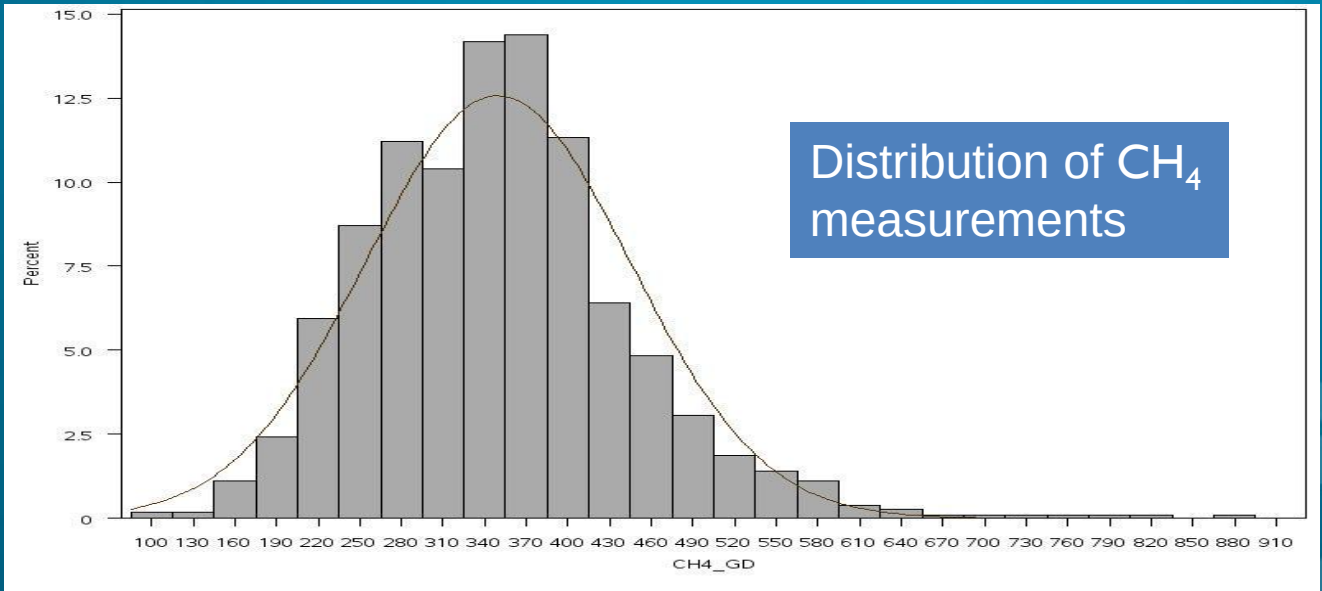
SF_6 CH_4 measurement (g/day)
(TEAGASC, Ireland)

- Total SF6 measurements : 3670 from 348 animals
- Breed: Holstein, Jersey and HxJ
- Measurement period: 1-9 days and 2-3 times per year
- From lactation 1 to lactation 7



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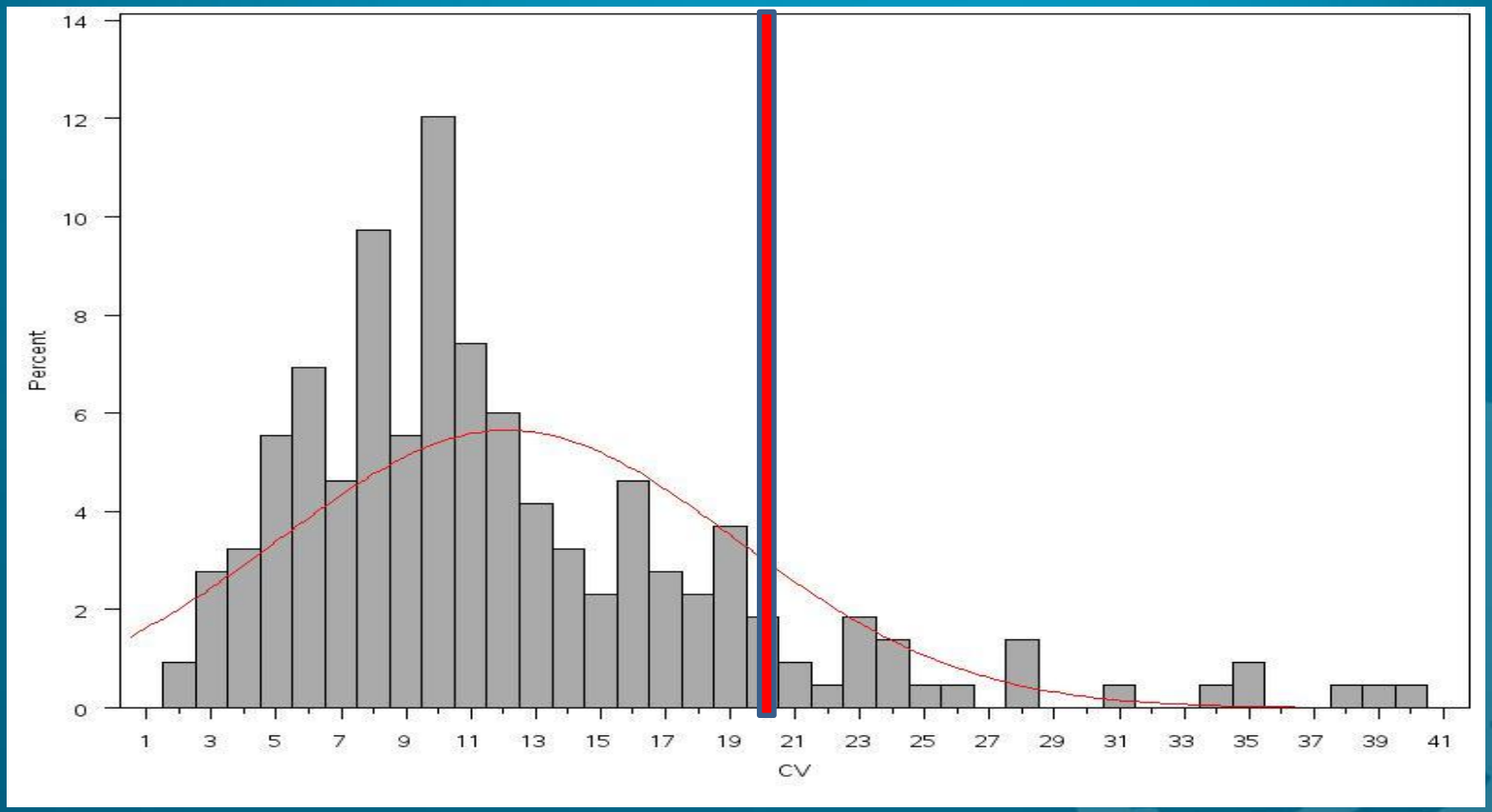
Data cleaning

Measurement period less than 3 days –removed

CV more than 20% within measurement period- removed



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After cleaning; SF_6 methane measurement (g/day)

Number of SF_6 measurements	3050
Number of animals	309
CH_4/day (Mean ±SD)	383.56 ±94.44

BUT not all had corresponding MIR

	Ireland	Belgium
Number of SF_6 measurements	**285**	**196**
CH_4/day (Mean ±SD)	356.99 ±101.64	466.13 ±101.87

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Calibration for CH_4 equation

- 485 samples from both Belgium and Ireland were available to predict CH_4 directly MIR
- After removing potential outliers in MIR spectra and CH_4
- Final calibration equation

N	425
Mean (Reference value)	394.58 g/day
SD	109.81 g/day
SECV (standard error of cross validation)	54.04 g/day
R^2cv (cross validation coefficient of determination)	75.81
RPD (residual predictive deviation)	2.03

Part III

Genetic parameters for methane indicator traits obtained directly from MIR spectra

P. B. Kandel[1], M-L. Vanrobays[1], A. Vanlierde[2], F. Dehareng[2], E. Froidmont[2], P. Dardenne[2], S. McParland[3], N. Gengler[1] and H. Soyeurt[1,2]

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Equation applied to Walloon spectral database (Holstein)

Traits	Lactation 1 (N=338,917)	Lactation 2 (N= 221, 420)	Lactation 3 (N=119,107)
CH4/day	547.19 ±111.09	559.79 ±112.34	558.23 ±114.11
CH4/kg of FPCM	24.25 ±8.25	22.09 ±8.58	20.88 ±8.53
FPCM (kg/day)	23.98	27.58	29.32
Fat yield (kg/day)	0.93	1.08	1.16
Protein yield (kg/day)	0.79	0.91	0.95

FPCM (Fat protein corrected milk) = Raw milk (kg)* {0.337+0.116*fat content (%)+ 0.06 protein content (%)} (FAO, 2010)

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Same Model : Single trait random regression test day

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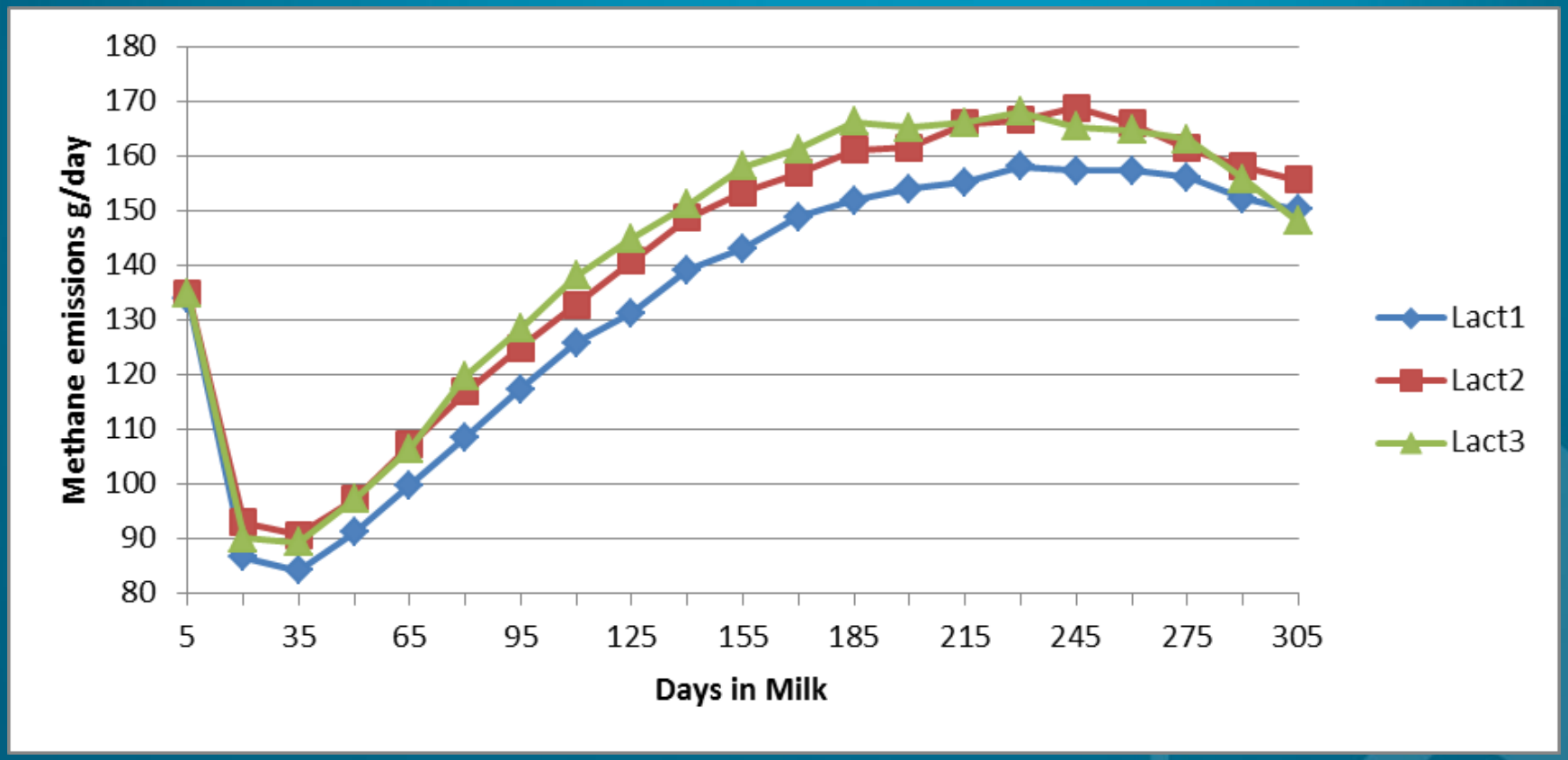
MIR CH_4 (g/day)in different stage of Lactation



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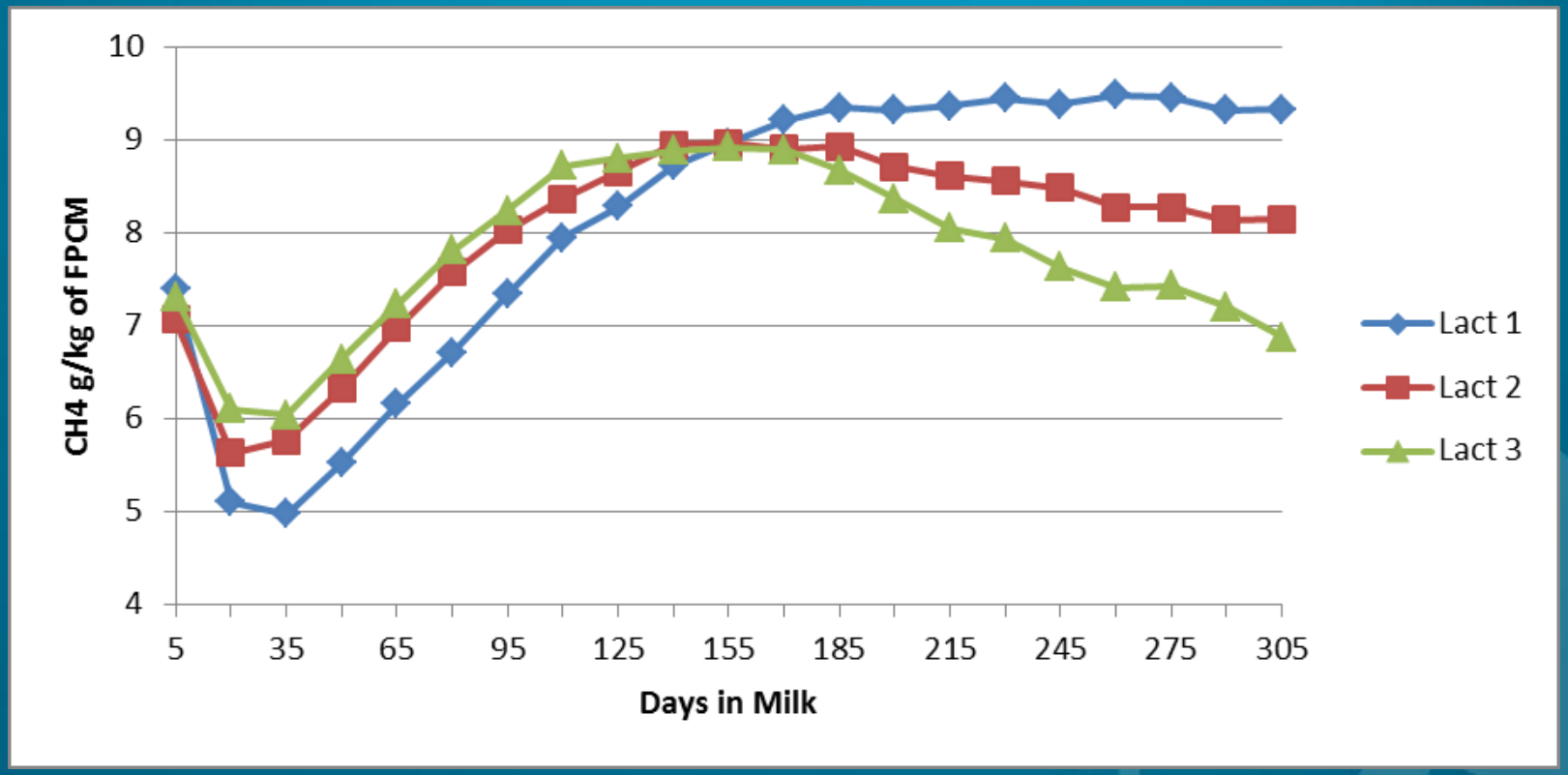
MIR CH_4 (g/kg of FPCM) in different stage of Lactation



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Heritability

Indicators	Averaged daily heritability		
	Lact 1	Lact 2	Lact 3
CH_4 (g/day)	0.08 *±0.005*	0.09 *±0.005*	0.08 *±0.006*
CH_4 g/kg of FPCM	0.14 *±0.007*	0.11 *±0.008*	0.13 *±0.011*

Phenotypic and Genetic Correlations

Traits	CH_4 (g/day)	CH_4 (g/kg FPCM)	FPCM	Fat yield	Protein yield
CH_4 (g/day)		0.45	-0.04	0.14	-0.02
CH_4 (g/kg FPCM)			-0.77	-0.59	-0.70
FPCM				0.88	0.93
Fat yield					0.71
Protein yield					

- Almost no phenotypic correlation between CH_4 g/day with production traits
- High –ve phenotypic correlation between CH_4 g/kg FPCM with milk production traits

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Phenotypic and Genetic Correlations

Traits	CH_4(g/day)	CH_4 (g/kg FPCM)	FPCM	Fat yield	Protein yield
CH_4 (g/day)					
CH_4 (g/kg FPCM)	0.57				
FPCM	0.04	-0.73			
Fat yield	0.07	-0.66	0.95		
Protein yield	0.05	-0.69	0.94	0.81	

- Very low genotypic correlation between CH_4 g/day with production traits
- High –ve genetic correlation between CH_4 g/kg FPCM with milk production traits

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Conclusions

- Possible predictions of MIR CH_4 indicators
- CH_4 emissions has genetic components
- Genetic variability of CH_4 production seems to exist

Part IV

Publications, conferences, trainings and future plan

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Publications

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1. Kandel P .B., H. Soyeurt and N. Gengler. 2012. Estimation of genetic parameters for methane indicator traits based on milk fatty acids in dual purpose Belgian blue cattle. Communications in Agricultural and Applied Biological Sciences. Vol 77, Page 21-5. PMID: 22558750.
2. Kandel P. B., N. Gengler and H. Soyeurt. 2012. Genetic parameters for mid-infrared methane indicators based on milk fatty acids in dairy cows. Submitted to Journal of Applied Animal Research.
3. Kandel P. B., H. Soyeurt and N. Gengler. 2012. Genetic parameters for methane indicator traits based on milk fatty acids in Dual Purpose Belgian Blue cattle (Poster). http://hdl.handle.net/2268/125415
4. Kandel P. B., A. Vanlierde, F. Dehareng, E. Froidmont, N. Gengler, and H. Soyeurt (2012).Genetic parameters for methane indicator traits based on milk fatty acids in cows. J. Dairy Sci. Vol. 95, Suppl. 2:683-684 (Conference proceeding).
5. Vanrobays M.-L., A. Vanlierde, P. B. Kandel, E. Froidmont, F. Dehareng, H. Soyeurt, N. Gengler. 2012. Relationships between methane emissions of dairy cattle and farm management (Poster). http://orbi.ulg.ac.be/handle/2268/114530.
6. Soyeurt, H., A. Vanlierde, F. Dehareng, E. Froidmont, J.A. Fernández Pierna, C. Grelet, C. Bertozzi, P. B. Kandel, N. Gengler and P. Dardenne. 2012. Individual methane indicators easily recorded for dairy cattle. Submitted Journal of Dairy Science.

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Exchange & Visits
(Exchange must be within the GHM network)

Partner	Description	Period	Outcome
TEAGSAC, Ireland	Research, Report, *Publication*	Apr 2012 to Aug 2012	• Compilation of performance data from herds with SF_6 CH_4 measures • Calibration of Prediction model and addition to Walloon calibration model • *Study the phenotypic and genetic variability of CH4 indicators predicted by MIR on Irish Data*

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Visited Conferences and Meetings

DESCRIPTION	DATE	TOPIC OF PRESENTATION	OUTCOME
GreenHouseMilk Network meeting, Paris, France	01/12/2011-02/12/2011	Estimation of methane and its variation across different breeds of cattle predicted from milk fatty acids	Oral presentation of research work Networking with other ESRs and partner institutions
17th Phd Symposium on Applied Biological Sciences, Leuven, Belgium	10/02/2012	Estimation of genetic parameters for methane indicator traits based on milk fatty acids in Dual Purpose Belgian Blue cattle	Oral and Poster presentation of research work
GreenHouseMilk ESR Network meeting, SAC, Edinburgh, UK	13/02/2012 - 14/02/2012	Genetic parameters for methane indicator traits based on milk fatty acids in cows	Presentation of research; planning of exchange and training
British Society of Animal Science , Annual Meeting University of Nottingham, UK	23/04/2012-26/04/2012	Participant	Symposium for Graduate students, funding applications writing, Learned soft skills
ICAR and Interbull meeting, Cork, Ireland	31/05/2012	Participated on Foss: Milk Analysis Workshop	Meeting with industry people, to calibrate traits on Foss machine
International Conference on Quantitative Genetics, Edinburgh, UK	17/06/2012-22/06/2012	Estimation of genetic parameters for methane indicator traits based on milk fatty acids in Dual Purpose Belgian Blue cattle	Poster presentation
Joint Annual Meeting, American Dairy Science Association, Phoenix AZ, USA	15/7/2012-19/7/2012	Genetic parameters for methane indicator traits based on milk fatty acids in cows	Oral Presentation
Irish Cattle Breeding Federation, Dairy and Beef Industry Consultation Meeting Portlaoise, Ireland	25/7/2012	Consultation with industry people about their thinking and readiness to adopt greenhouse gas mitigation breeding objective on their breeding program	Open discussion and networking

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Participated (International) courses

UNIVERSITY/ INSTITUTE	DATE	TOPIC OF COURSE	OUTCOME
Wageningen University, The Netherlands	17/11/2011	Nutrition and fat metabolism in dairy cattle	Effect of fat supplement in Poly Unsaturated fatty acids Interaction with Dairy industry people
University Catholique Louvain, Belgium	Oct-Nov 2011	Training for users of computing devices and mass storage	Linux operations High memory computing
Aarhus University, Denmark	05/12/2011-09/12/2011	Dairy cow lactations, profiles, nutrient allocation and energy balances	Lactation profile , energy use and genetic basis of negative energy balance
Walloon Agricultural research Center, Belgium	27/02/2012-02/03/2012	Training on infrared spectroscopy and chemo metrics	Sampling and analysis skill of infrared spectroscopy, Calibration procedure
INRA-Agro Paris-Tech, France	07/02/2013-12/02/2013	"How I Learned to Stop Worrying (about the math) and Love Modelling"	(proposed)

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Collaboration map within GHM

Secondment

- TEAGASC, Moorepark, Ireland (Apr-Aug 2012)

Projects

- Sharing real methane data (across whole lactation): Purna <-> Yvette (Wageningen)

Writing

- Literature reviews with a small group of students e.g. genetics (Marcin, Purna, Karolina)

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Plan

Validation

- Validation of Scottish data of CH_4 measurements (Collaboration map)

Genetic Parameter

- Multi-trait Model
- Economic index with other traits of Walloon breeding scheme
- Luxembourg Data
- Ireland data

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Plan

Publications

- Genetic Parameter of Direct MIR predicted methane
- Genetic correlations with other economic and functional traits

Conferences

- GGAA 2013
- One international conference; EAAP or ADSA or AAABG 2013

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