LIÈGE université Gembloux Agro-Bio Tech

EAAP 2019

Wallonie recherche CRA-W

Zootechnical parameters added to the milk MIR spectra as predictive value to estimate CH_4 emissions

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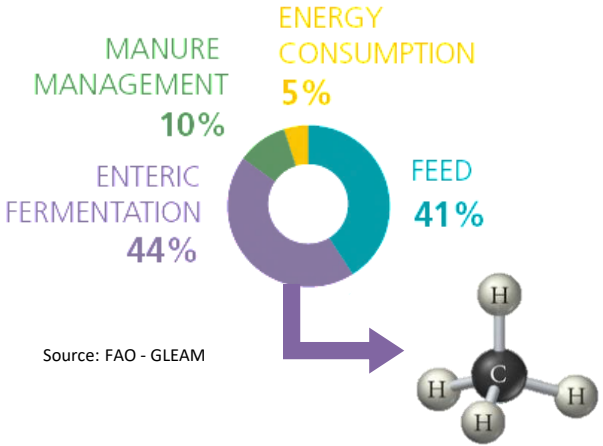
Context

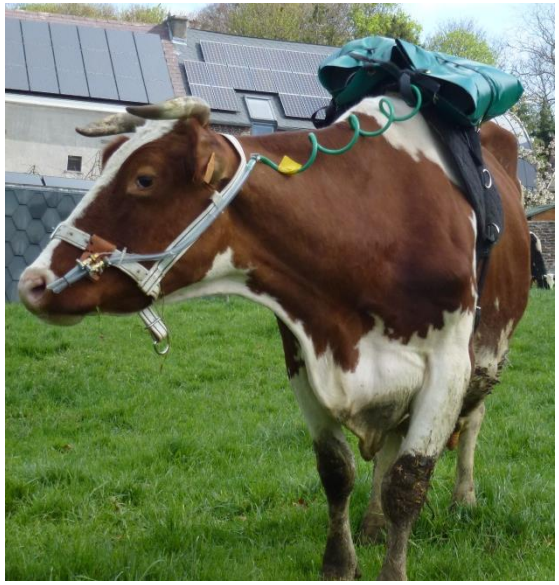
→ Efforts from each sector to reduce GHG emissions

→ Importance of enteric fermentation in agriculture →

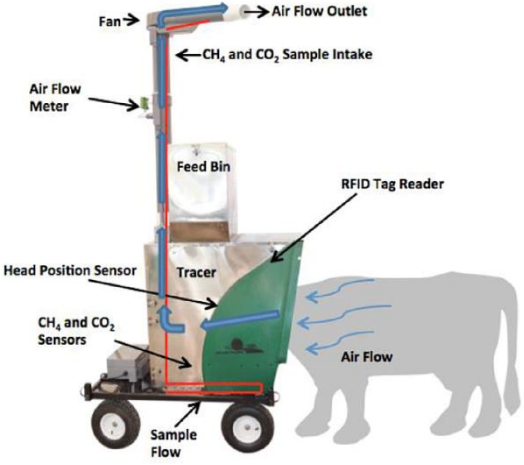


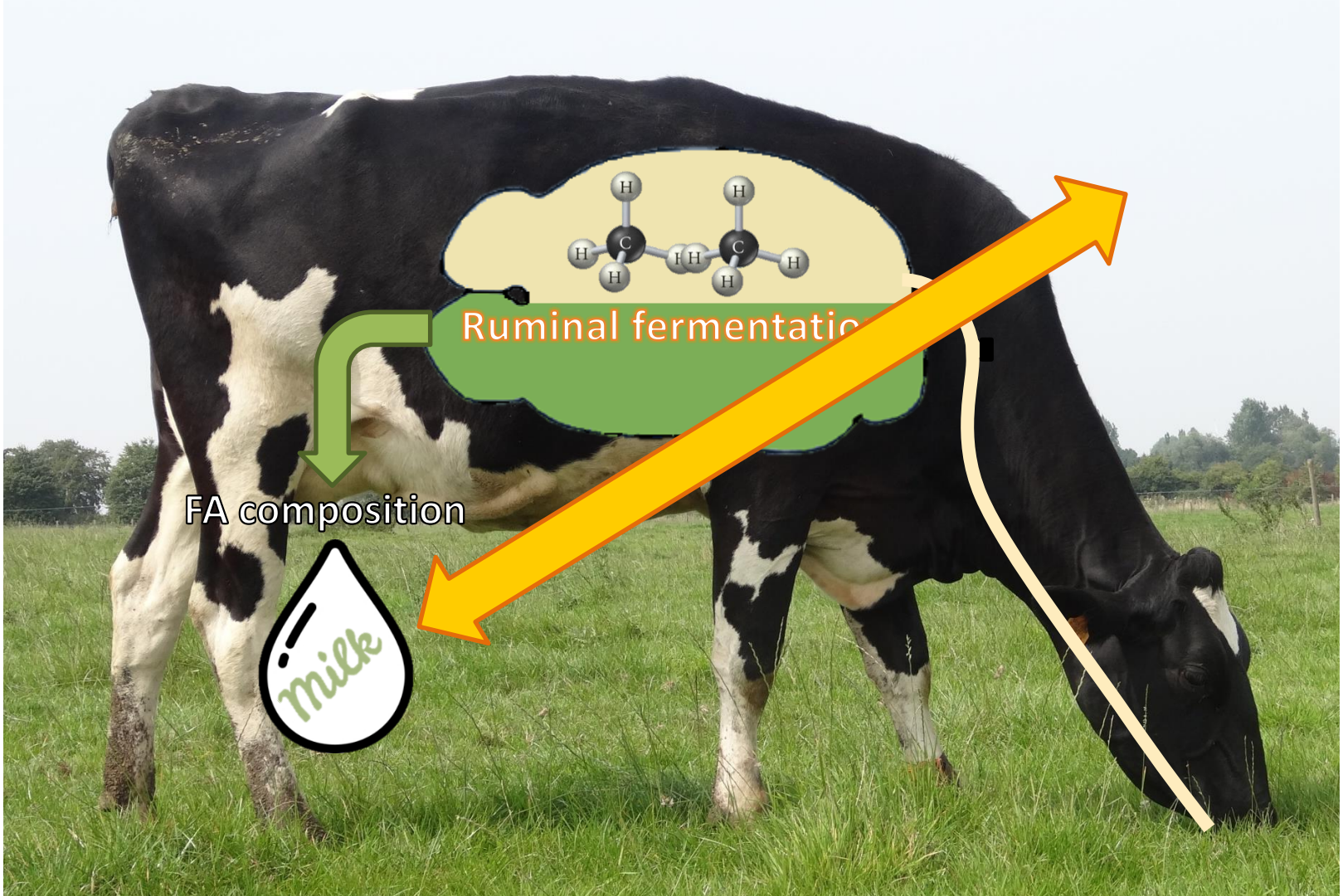
→ CH_4 measurements to establish the link with - diet

- genetics → Large scale studies

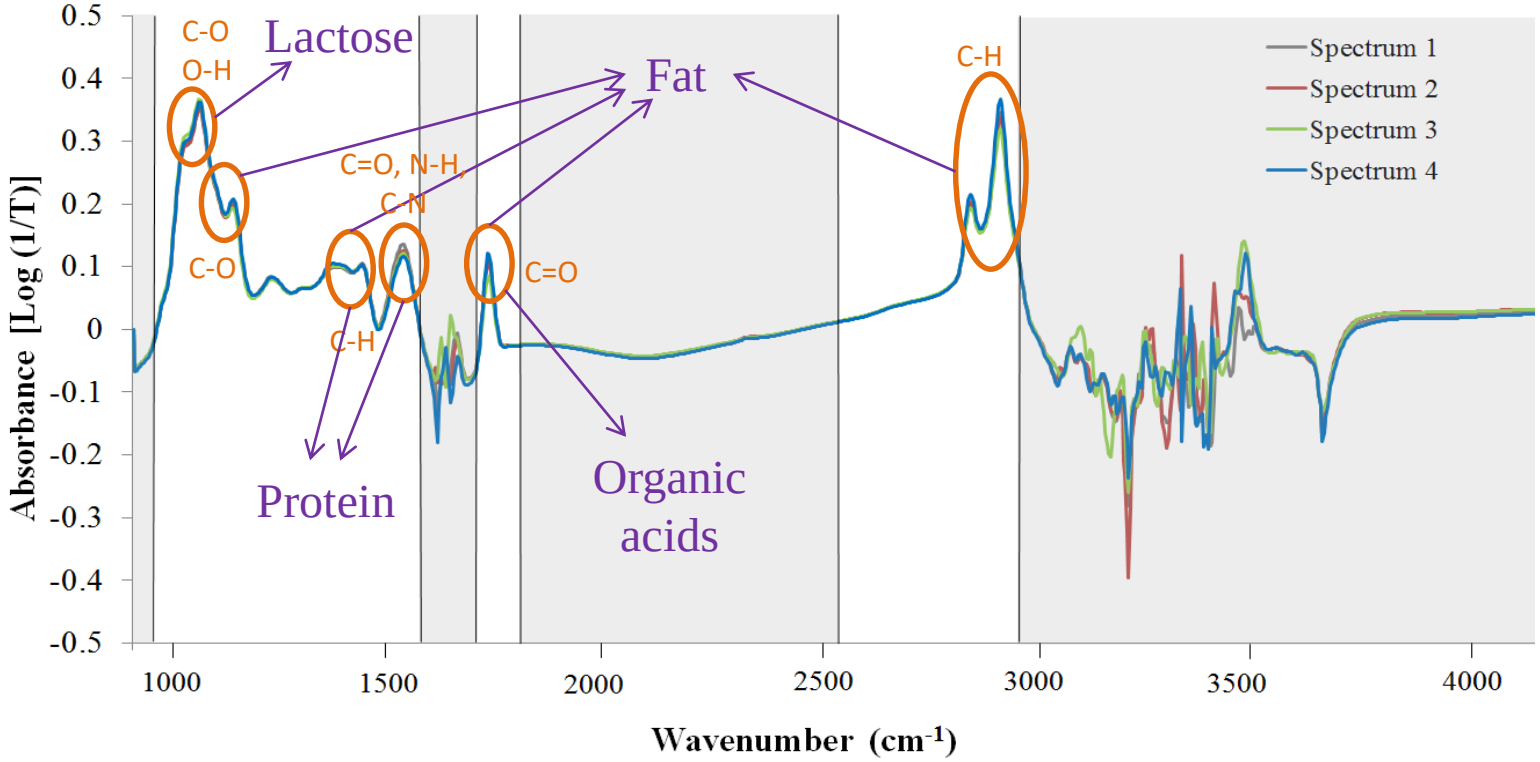


→ Need of a proxy
to consider individual variability

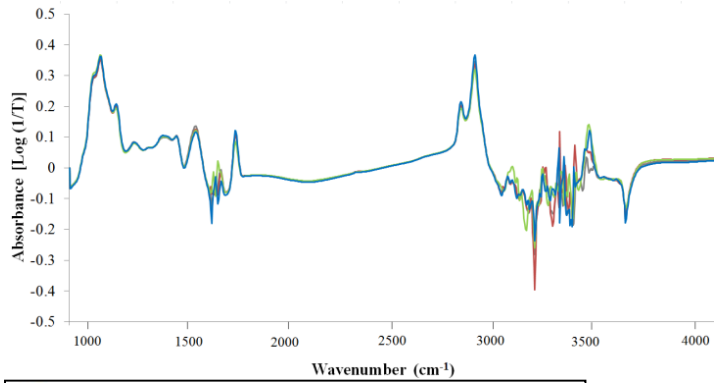


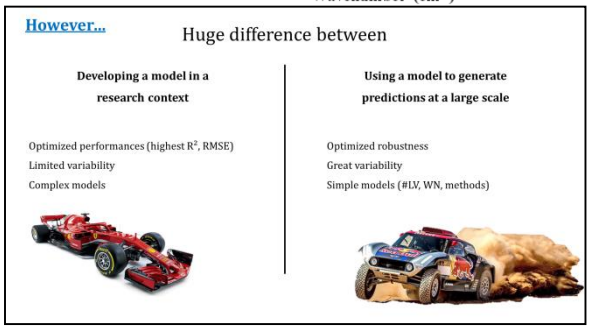

Ruminal fermentatio
FA composition
Milk

Milk FT-MIR spectra as a proxy for enteric CH_4



Development of equations to estimate CH_4 from milk FT-MIR spectra



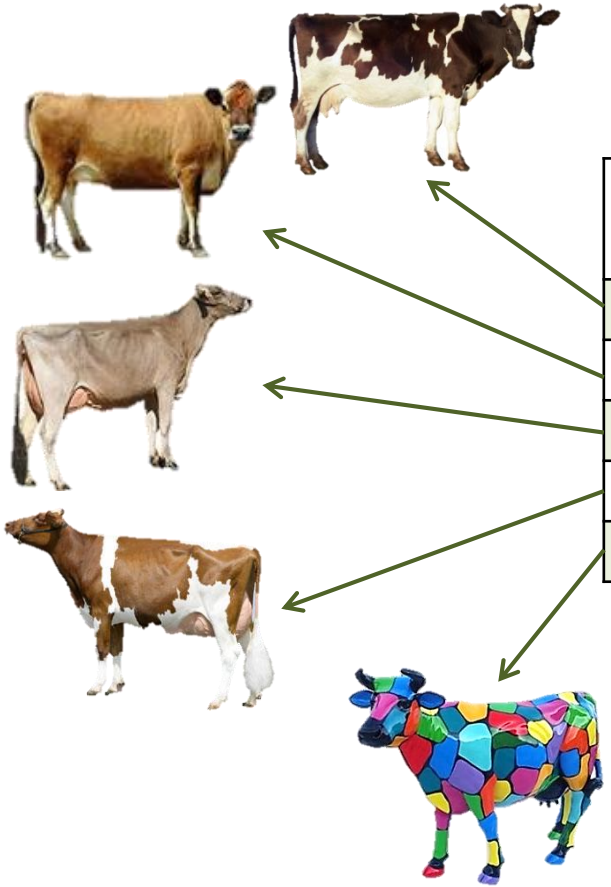


→ Consideration of a maximum of variability

Description of the reference data

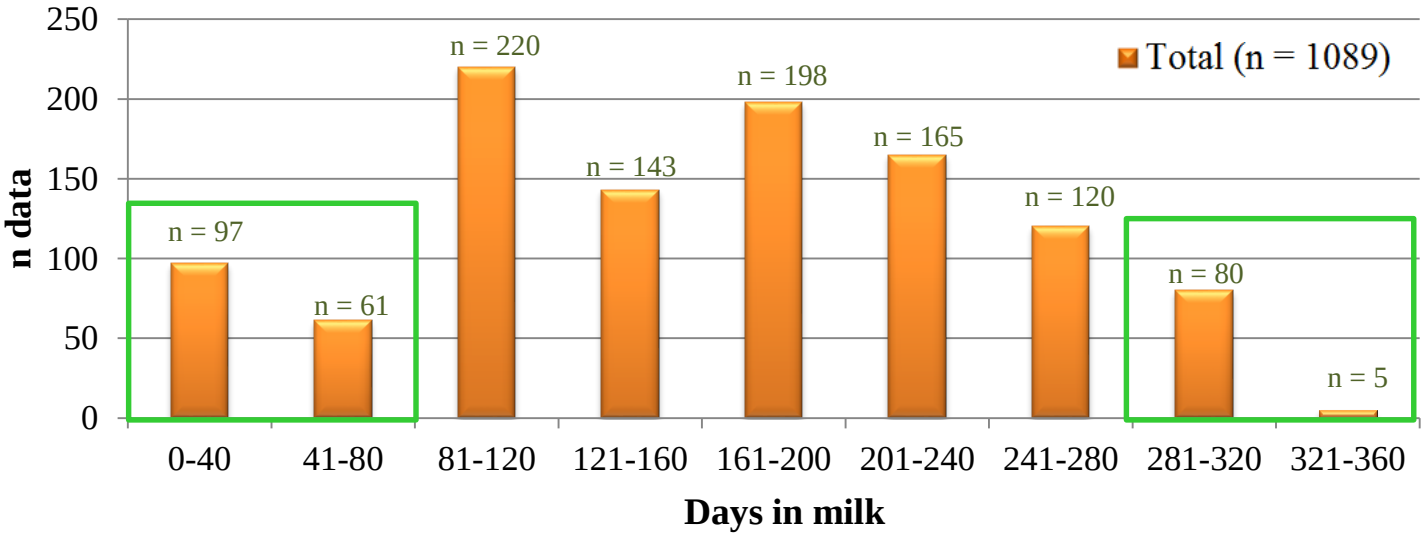
		CH_4 (g/day)	N data	N cows
SF_6		510 ± 105	252	42
		347 ± 89	261	110
	TOTAL	**427 ± 127**	**513**	**152**
Chambers		405 ± 60	207	50
		451 ± 75	135	57
		367 ± 64	129	19
		366 ± 61	81	9
		365 ± 44	24	12
	TOTAL	**400 ± 72**	**576**	**147**
TOTAL		**413 ± 102**	**1,089**	**299**

Description of the reference data
→ Breeds

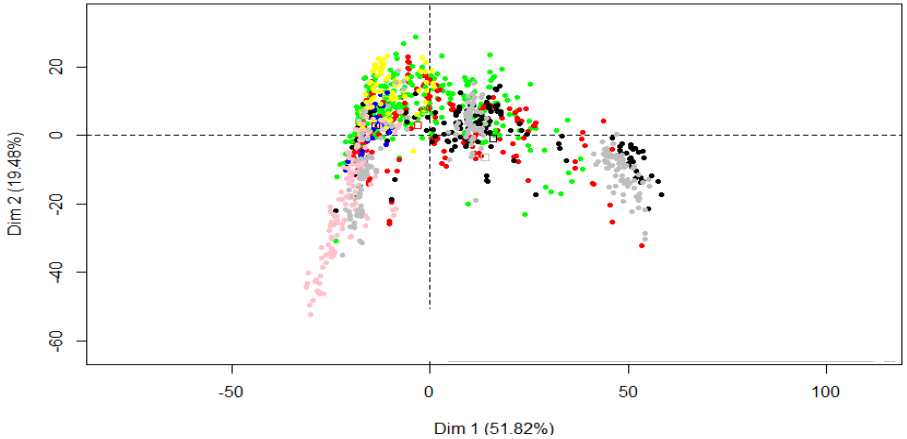


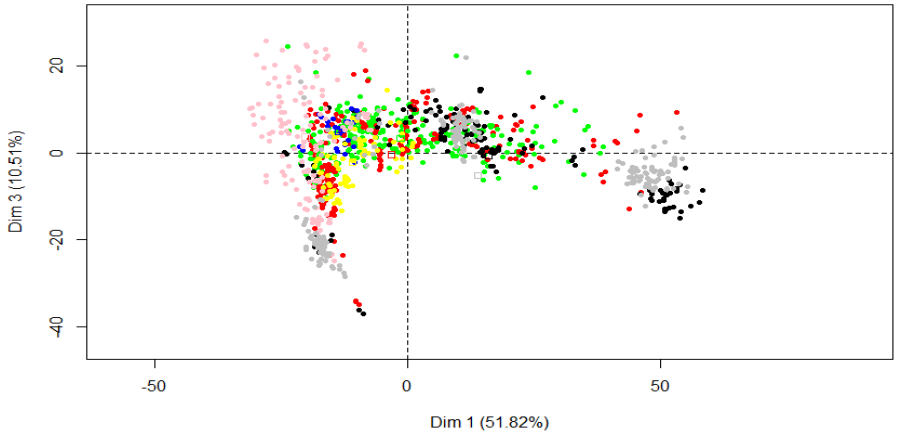
Breed	n data	% of data	n cows	% of cows	CH_4 (g/d) mean ± SD
HO	891	82	222	74	415 ± 107
JER	67	6	10	3	342 ± 42
BS	78	7	39	13	458 ± 69
RH	21	2	8	3	427 ± 74
X	32	3	20	7	391 ± 67

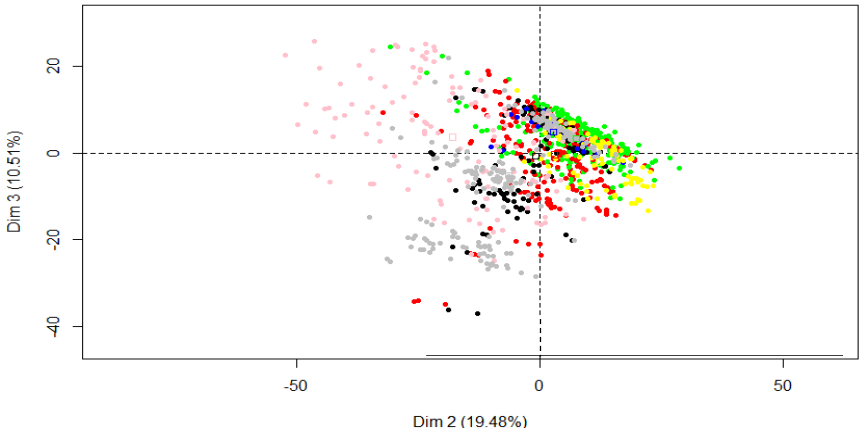
Description of the reference data
→ Lactation stage



Description of the reference data
→ FT-MIR spectra

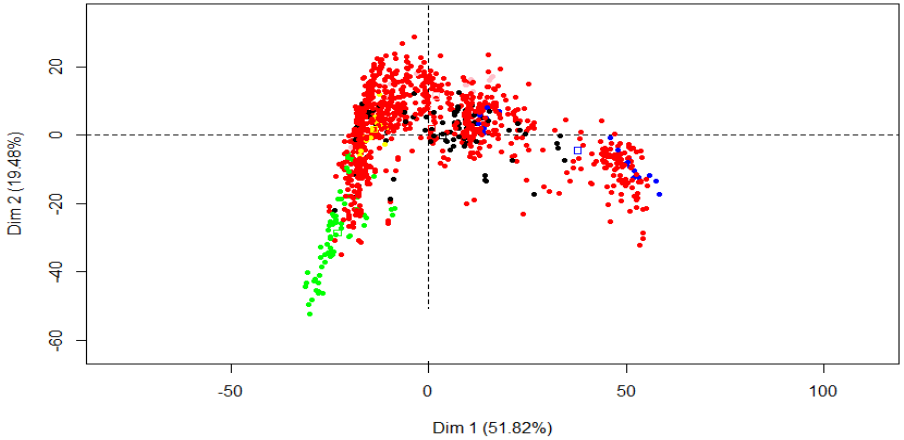


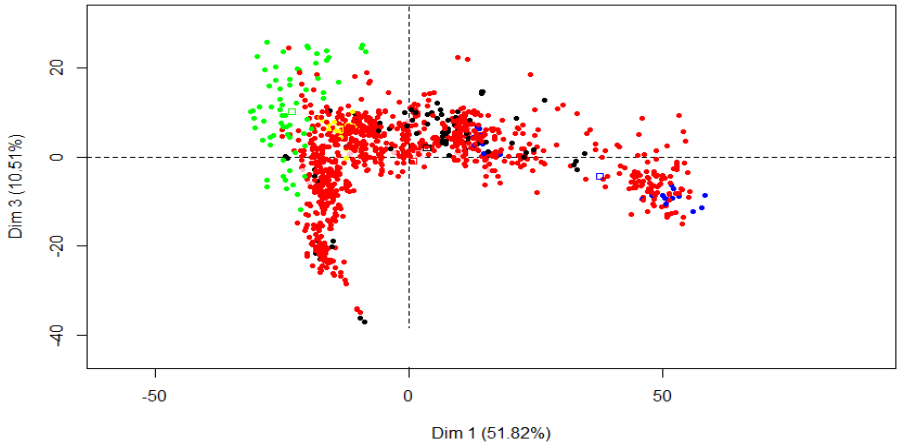


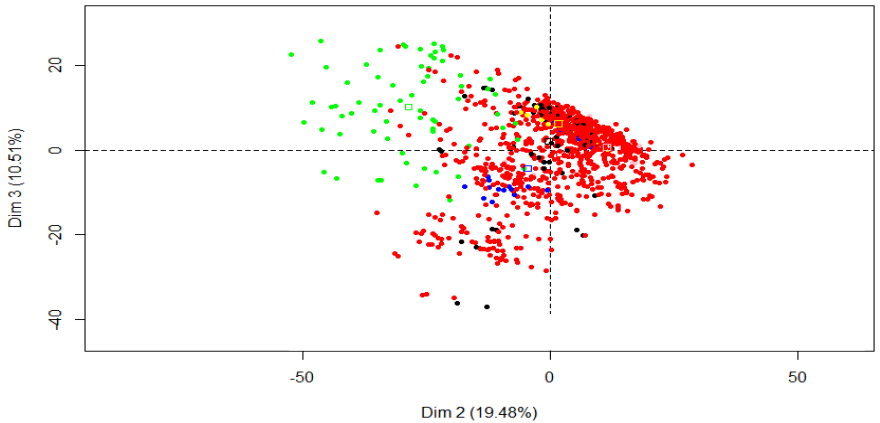


BE
IE
CH
UK
FR
DK
DE

Description of the reference data
→ FT-MIR spectra







HO
JER
BS
RH
SRX
Other

Methods

Milk MIR spectra

Methods

Milk MIR spectra

Standardization

→

J. Dairy Sci. 100:1–12
https://doi.org/10.3168/jds.2017-12720

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

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Integration of the "Days In Milk" (modified Legendre Polynomials)

→

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**

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#Agriculture Research Division, Department of Economic Development, Jobs, Transport and Resources, Ellinbank Centre, Ellinbank, 3821 Victoria, Australia
‖ETH Zürich, Institute of Agricultural Sciences, 8092 Zürich, Switzerland
¶Qualitas AG, 6300 Zug, Switzerland

Methods

Methane measurements

→ Raw data

Methods

Calibration & validations

→ WinISI 4.6 (Foss)

→ PLS

→ 5 groups cross-validation
Randomly 4/5 of data to calibrate, 1/5 to validate (all groups combinations)

→ Cow and Country Dependent External Validation (CCDEV)
20% of cows randomly removed per country
Calibration with the other 80% of cows, validation on the 20%
Loop of 500 repetitions

Equation developped

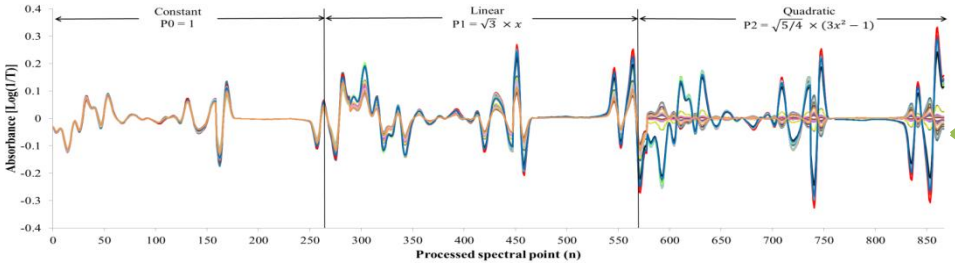
	CH_4 Ref. method	n data	n cows	Origin	Pred. variables	R^2c	SEC (g/d)	R^2cv	SECV (g/d)
Prediction Model	SF_6 & RC	1089	299	BE, IE, CH, UK, FR, DK, DE	MS	0.68	58	0.64	61

	R^2_{CCDEV}	$RMSEP_{CCDEV}$
Prediction model	0.55 ± 0.07	70 ± 4.5

Inclusion of zootechnical information as predictive value

Information easily available

Modified milk FT-MIR spectra (MS)



\+ Daily milk yield (MY)

\+ Parity (P)

\+ Breed (B)

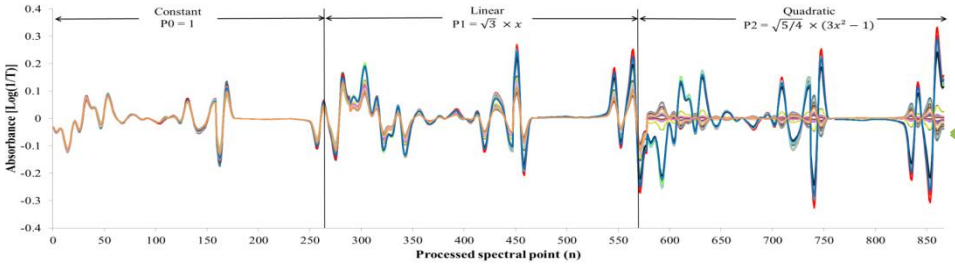
Individually & combined

ID	Spectra				
	Abs 1	Abs 2	…	Abs 866	Abs 867
Cow 1	-0.07288	-0.06950	⋯	0.03138	0.03286
Cow 2	-0.09036	-0.08670	⋯	0.02072	0.02133
Cow 3	-0.08454	-0.08089	⋯	0.01950	0.01944
Cow 4	-0.08449	-0.08105	⋯	0.02084	0.01981
Cow 5	-0.08657	-0.08325	⋯	0.01589	0.01754

Inclusion of zootechnical information as predictive value

Information easily available

Modified milk FT-MIR spectra (MS)



\+ Daily milk yield (MY)

\+ Parity (P)

\+ Breed (B)

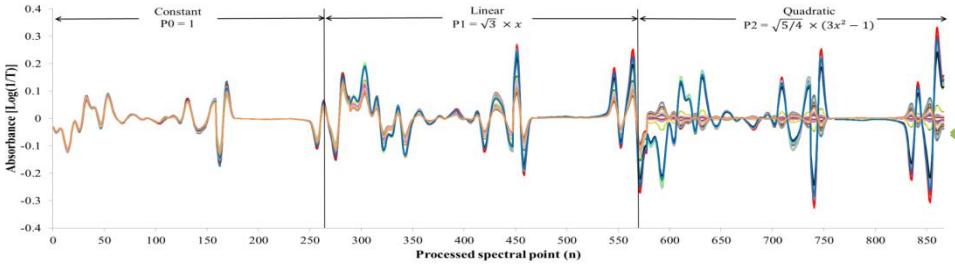
Individually & combined

ID	MY	Spectra		Spectra		
	Abs 1	Abs 2	Abs 865	Abs 866	Abs 867	Abs 867
Cow 1	-0.07288	-0.06950	0.03138	0.03238	0.03286	0.03286
Cow 2	-0.09036	-0.08670	0.02072	0.02172	0.02133	0.02133
Cow 3	-0.08454	-0.08089	0.01950	0.01950	0.01944	0.01944
Cow 4	-0.08449	-0.08105	0.02084	0.02084	0.01981	0.01981
Cow 5	-0.08657	-0.08325	0.01589	0.01589	0.01754	0.01754

Inclusion of zootechnical information as predictive value

Information easily available

Modified milk FT-MIR spectra (MS)



\+ Daily milk yield (MY)

\+ Parity (P)

\+ Breed (B)

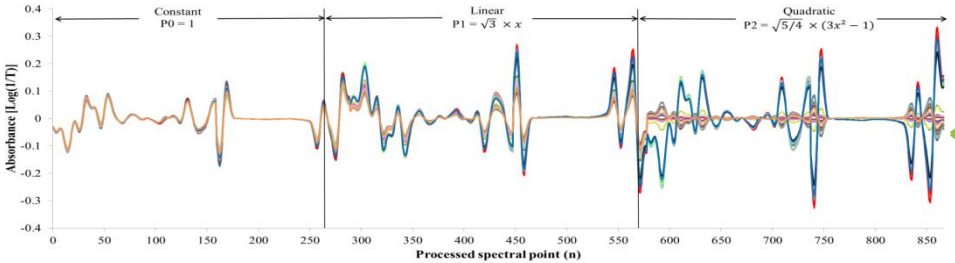
Individually & combined

ID	MPY	Spectra				
		Abs 1	Abs 2	…	Abs 866	Abs 867
Cow 1	24	-0.07288	-0.06950	⋯	0.03138	0.03286
Cow 2	19	-0.09036	-0.08670	⋯	0.02072	0.02133
Cow 3	31	-0.08454	-0.08089	⋯	0.01950	0.01944
Cow 4	26	-0.08449	-0.08105	⋯	0.02084	0.01981
Cow 5	20	-0.08657	-0.08325	⋯	0.01589	0.01754

Inclusion of zootechnical information as predictive value

Information easily available

Modified milk FT-MIR spectra (MS)



\+ Daily milk yield (MY)

\+ Parity (P)

\+ Breed (B)

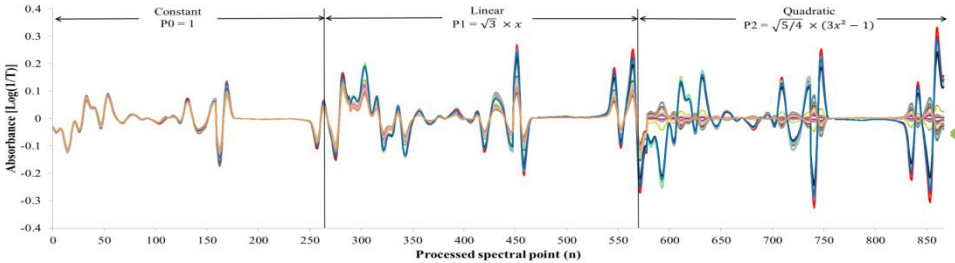
Individually & combined

ID	Breed 1 P	Breed 2 Abs 1	Breed 3 Abs 2	Breed 4 …	Other Breeds Abs 866	Abs 867	Spectra Abs 2	…	Abs 866	Abs 867
Cow 1	1	-0.07288	-0.06950	···	0.03138	0.03286	-0.06950	···	0.03138	0.03286
Cow 2	2	-0.09036	-0.08670	···	0.02072	0.02133	-0.08670	···	0.02072	0.02133
Cow 3	3	-0.08454	-0.08089	···	0.01950	0.01944	-0.08089	···	0.01950	0.01944
Cow 4	3	-0.08449	-0.08105	···	0.02084	0.01981	-0.08105	···	0.02084	0.01981
Cow 5	1	-0.08657	-0.08325	···	0.01589	0.01754	-0.08325	···	0.01589	0.01754

Inclusion of zootechnical information as predictive value

Information easily available

Modified milk FT-MIR spectra (MS)



\+ Daily milk yield (MY)

\+ Parity (P)

\+ Breed (B)

Individually & combined

ID	MY	P	Breed 1	Breed 2	Breed 3	Breed 4	Other Breed	Abs 1	Abs 2	Abs 866	Abs 867
Cow 1	24	1	0	1	0	0	0	-0.07288	-0.06950	0.03138	0.03286
Cow 2	19	2	0	0	1	0	0	-0.09036	-0.08670	0.02072	0.02133
Cow 3	21	3	1	0	0	1	0	-0.08454	-0.08089	0.01950	0.01944
Cow 4	26	3	0	1	0	0	0	-0.08449	-0.08105	0.02084	0.01981
Cow 5	20	1	0	1	0	0	0	-0.08657	-0.08325	0.01589	0.01754

Equations developped

	CH_4 Ref. method	n data	n cows	Origin	Pred. variables	R^2c	SEC (g/d)	R^2cv	SECV (g/d)
Prediction Model	SF_6 & RC	1,089	299	BE, IE, CH, UK, FR, DK, DE	MS	0.68	58	0.64	61
Inclusion of zootechnical information	SF_6 & RC	1,089	299	BE, IE, CH, UK, FR, DK, DE	MS+MY	0.69	57	0.65	60
					MS+P	0.70	56	0.65	60
					MS+B	0.70	56	0.66	60
					MS+MY+P	0.70	56	0.66	60
					MS+MY+B	0.72	54	0.68	58
					MS+P+B	0.71	55	0.67	59
					MS+MY+P+B	0.73	53	0.68	57

Equations developped

	CH_4 Ref. method	n data	n cows	Origin	Pred. variables	R^2c	SEC (g/d)	R^2cv	SECV (g/d)
Prediction Model	**SF_6 & RC**	1,089	299	BE, IE, CH, UK, FR, DK, DE	**MS**	0.68	58	**0.64**	61
Inclusion of zootechnical information	**SF_6 & RC**	1,089	299	BE, IE, CH, UK, FR, DK, DE	**MS+MY**	0.69	57	**0.65**	60
					MS+P	0.70	56	**0.65**	60
					MS+B	0.70	56	**0.66**	60
					MS+MY+P	0.70	56	**0.66**	60
					MS+MY+B	0.72	54	**0.68**	58
					MS+P+B	0.71	55	**0.67**	59
					MS+MY+P+B	0.73	53	**0.68**	57

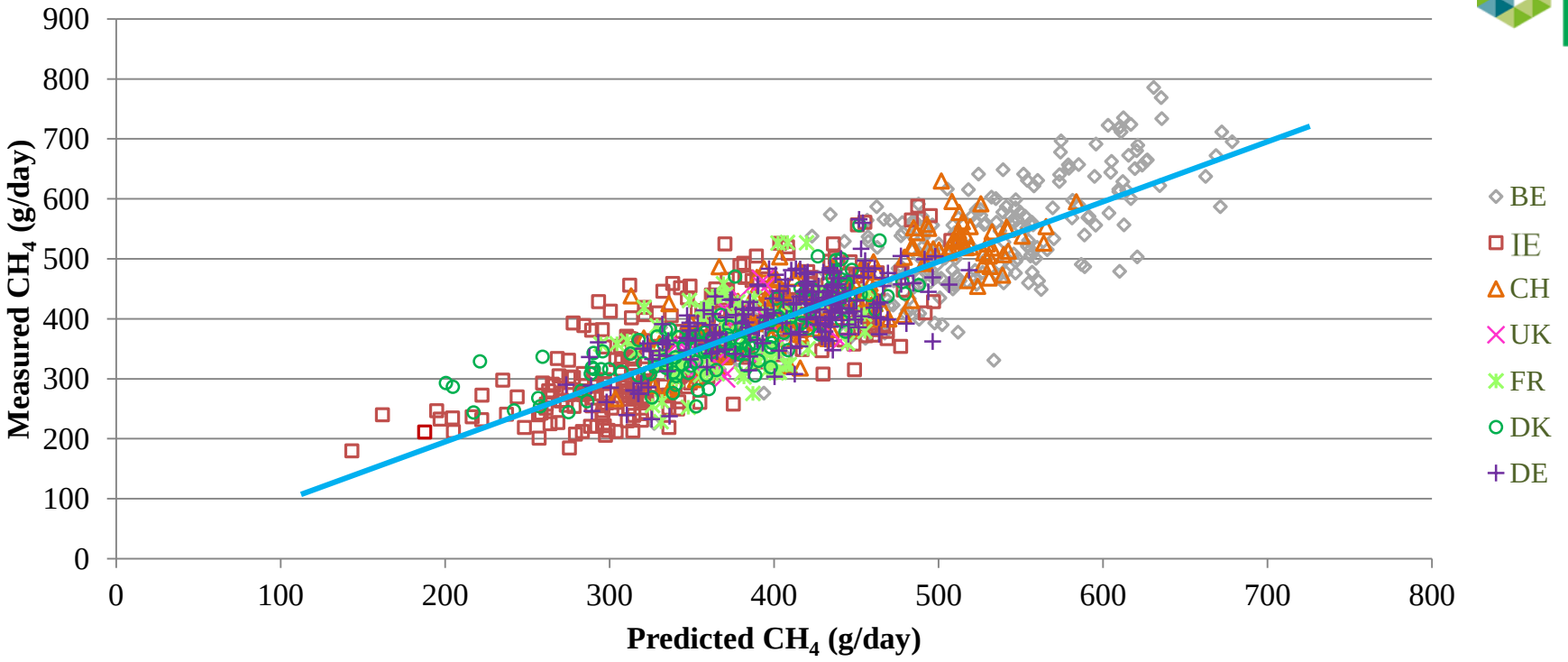
Equations developped

	CH_4 Ref. method	n data	n cows	Origin	Pred. variables	R^2c	SEC (g/d)	R^2cv	SECV (g/d)
Prediction Model	**SF_6 & RC**	1,089	299	BE, IE, CH, UK, FR, DK, DE	**MS**	0.68	58	0.64	**61**
Inclusion of zootechnical information	**SF_6 & RC**	1,089	299	BE, IE, CH, UK, FR, DK, DE	**MS+MY**	0.69	57	0.65	**60**
					MS+P	0.70	56	0.65	**60**
					MS+B	0.70	56	0.66	**60**
					MS+MY+P	0.70	56	0.66	**60**
					MS+MY+B	0.72	54	0.68	**58**
					MS+P+B	0.71	55	0.67	**59**
					MS+MY+P+B	0.73	53	0.68	**57**

Inclusion of zootechnical information as predictive value

Model	Effect on the error of prediction		
	Parity	Country	Breed
MS	***	***	***
MS + MY	***	***	***
MS + P	NS	**	***
MS + B	***	NS	***
MS + MY + P	NS	***	***
MS + MY + B	***	NS	**
MS + P + B	NS	NS	*
MS+ MY + P + B	NS	NS	*

Equations developped



	CH_4 Ref. method	n data	n cows	Origin	Pred. variables	R^2c	SEC (g/d)	R^2cv	SECV (g/d)
Inclusion of zootechnical information	SF_6 & RC	1089	299	BE, IE, CH, UK, FR, DK, DE	MS+MY+P+B	0.73	53	0.68	57

Practical applications

Walloon milk recording Jan. 2016 → Dec. 2017

5 – 365 DIM → n = 929,966

Model	n GH > 5	% GH > 5
MS	52,344	5.6
MS + MY	50,994	5.5
MS + P	50,034	5.4
MS + B	183,454	19.7
MS + MY + P	49,529	5.3
MS + MY + B	143,622	15.4
MS + P + B	150,025	16.1
MS+ MY + P + B	120,637	13.0

Practical applications

Walloon milk recording Jan. 2016 → Dec. 2017

5 – 365 DIM → n = 929,966

Model	HO n = 618,743		JER n = 1,342		BS n = 4,559		RH n = 305		OTHER n = 305,017	
	n GH > 5	% GH > 5	n GH > 5	% GH > 5	n GH > 5	% GH > 5	n GH > 5	% GH > 5	n GH > 5	% GH > 5
MS	33,974	5.5	185	13.8	245	5.4	22	7.2	17,918	5.9
MS + MY	32,743	5.3	184	13.7	246	5.4	22	7.2	17,799	5.8
MS + P	32,459	5.2	183	13.6	238	5.2	22	7.2	17,132	5.6
MS + B	19,202	3.1	232	17.3	215	4.7	104	34.1	163,701	53.7
MS + MY + P	31,711	5.1	178	13.3	232	5.1	20	6.6	17,388	5.7
MS + MY + B	18,211	2.9	230	17.1	198	4.3	86	28.2	124,897	40.9
MS + P + B	18,888	3.1	230	17.1	217	4.8	115	37.7	130,575	42.8
MS+ MY + P + B	18,469	3.0	237	17.7	204	4.5	100	32.8	101,627	33.3

Practical applications

Walloon milk recording Jan. 2016 → Dec. 2017

5 – 365 DIM ➔ n = 929,966

→ GH < 5 → 248,982 spectra removed (67,6% from “OTHER”)

→ Holstein cows in RW

→ 150 g/d < predicted CH_4 < 950 g/d (0.12% of the remaining HO records)

➔ n = 538,510

Practical applications

Walloon milk recording Jan. 2016 → Dec. 2017

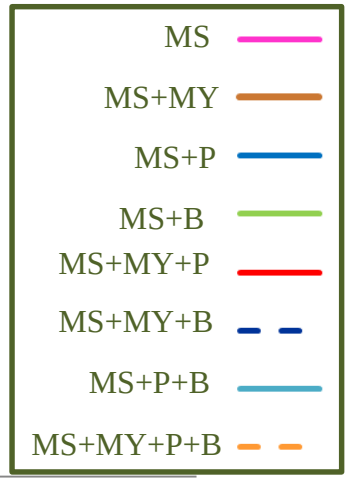
5 – 365 DIM → n = 929,966

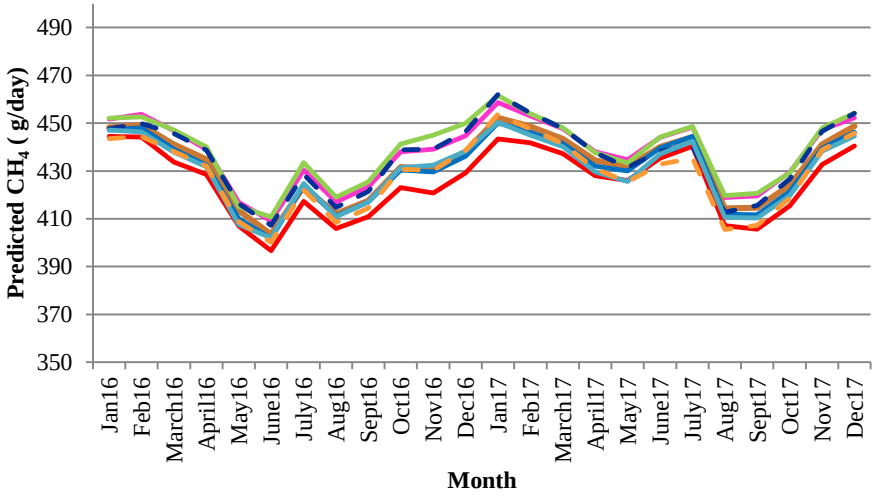
→ GH < 5

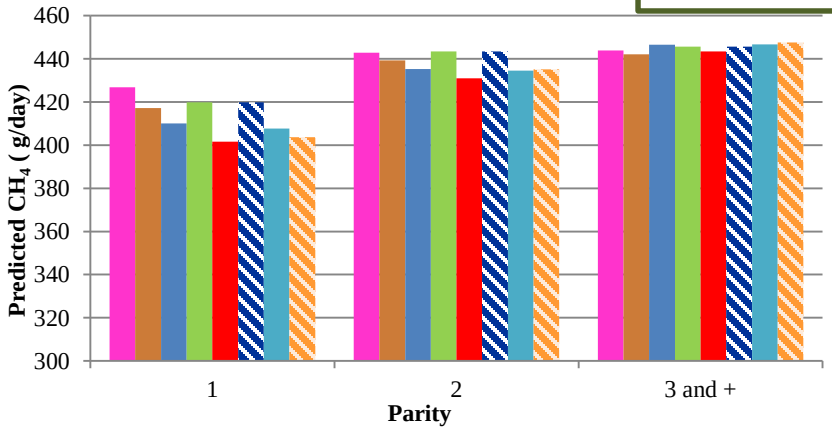
→ Holstein cows in RW

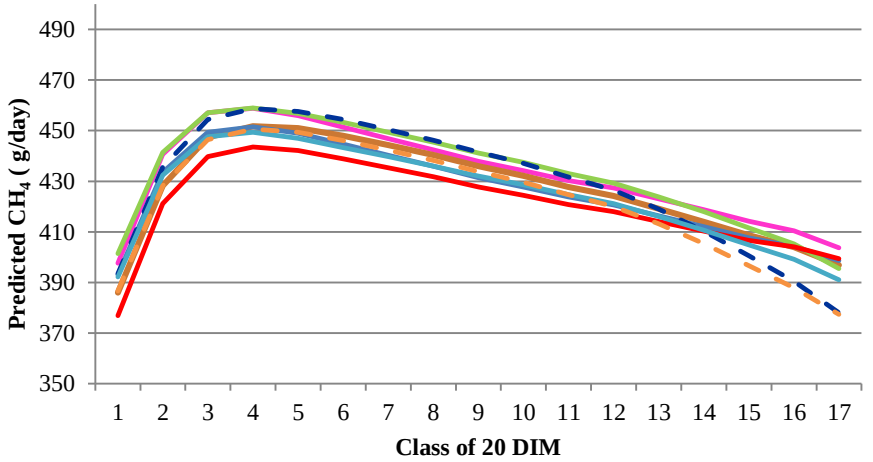
→ 150 g/d < predicted CH_4 < 950 g/d

→ n = 538,510





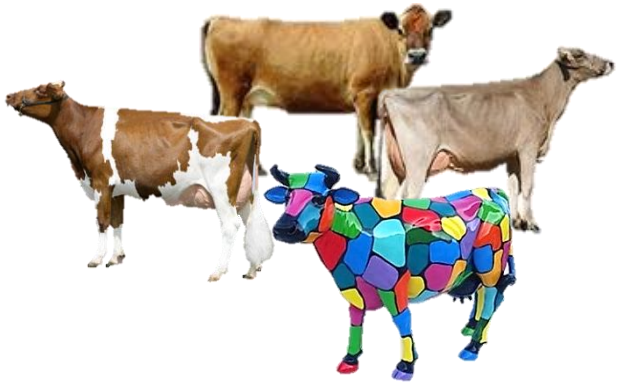




Perspectives for further improvements

- Majority of Holstein reference (82%) → Other breeds ?

➔ Increase the reference data
➔ 1 model/breed?



- Consideration of other relevant parameters as predictors

➔ Diet type, DMI, etc. → Practical applications?

Conclusions

- Milk MIR spectra is a great proxy for large scale studies related to CH_4
- Include MY, P or/and B
  - improve the R^2 and reduce the error of prediction
  - limit external impact on the error of prediction
- Importance to consider the conditions of application
- Need to investigate these models in practical conditions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