SmartCow

an integrated infrastructure for increased research capability and innovation in the European cattle sector

Milk mid-infrared spectra to estimate rumen fermentation parameters

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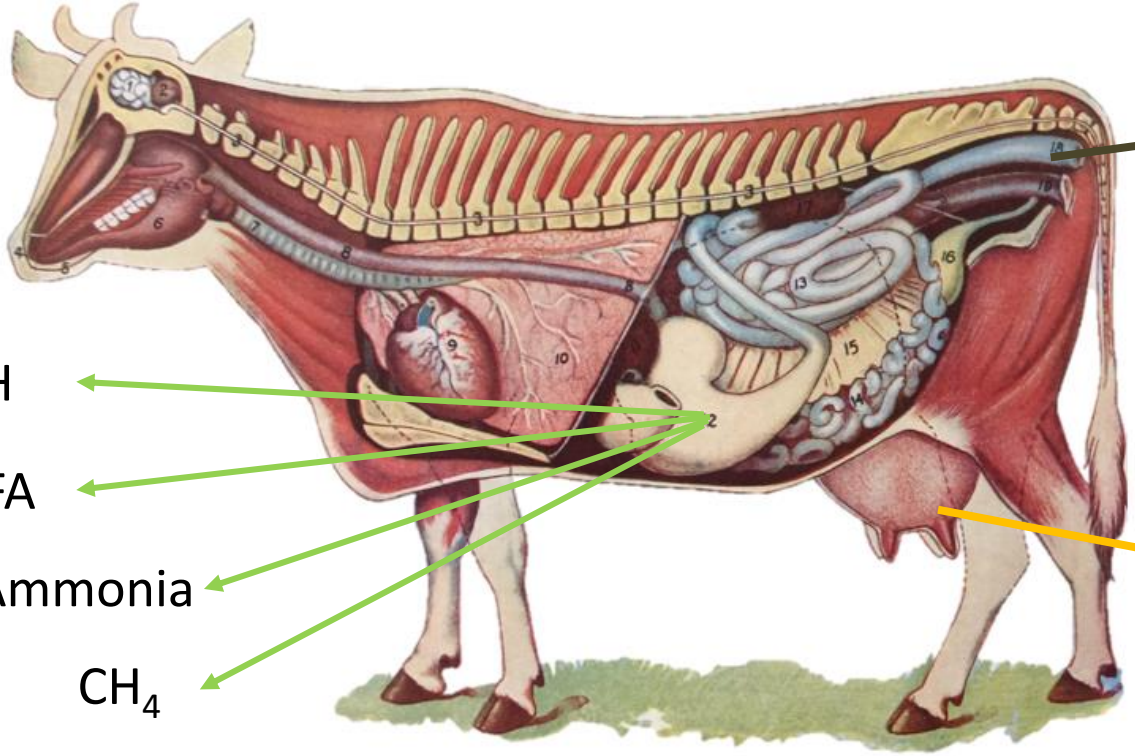
Rumen parameters

- Interests to measure and monitor rumen parameters
  - Animal health
  - Animal welfare
  - Enconomy
  - Ecology

- Sampling rumen juice and measuring methane emissions
  - Invasive
  - Labourious
  - Expensive analyses or apparatus

Proxies for rumen parameters - Smartcow Focus (WP 6.2)



Feaces

NIR spectra

Poster 72-17 – Donato Andueza

pH

VFA

Ammonia

CH_4

Milk

MIR spectra

Veterinarial *ex libris* – Internal bovine anatomy - 1920

Development of proxies to estimate rumen parameters → Milk MIR spectra

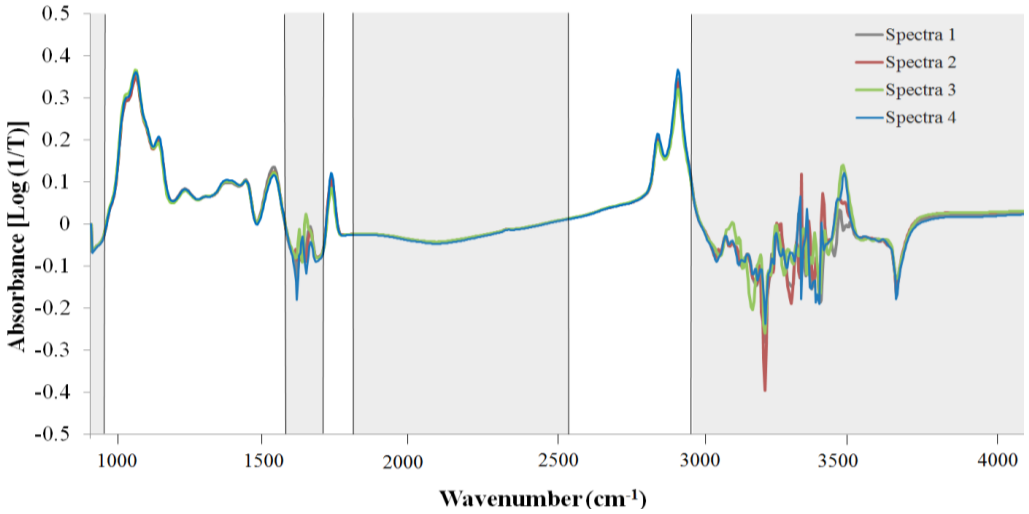
pH

Ammonia

VFA

CH_4

+ Corresponding Milk MIR spectra



Sources of variability in reference datasets

Zootechnical level

- Breed
- Individual variability
- Diet composition
- Diet volume
- …

Sampling level

- Moment - Time before/after feeding
- Sampling location in the rumen?
- Canula/probe/bolus?
- Salivary contamination?
- Standardized apparatus?
- …

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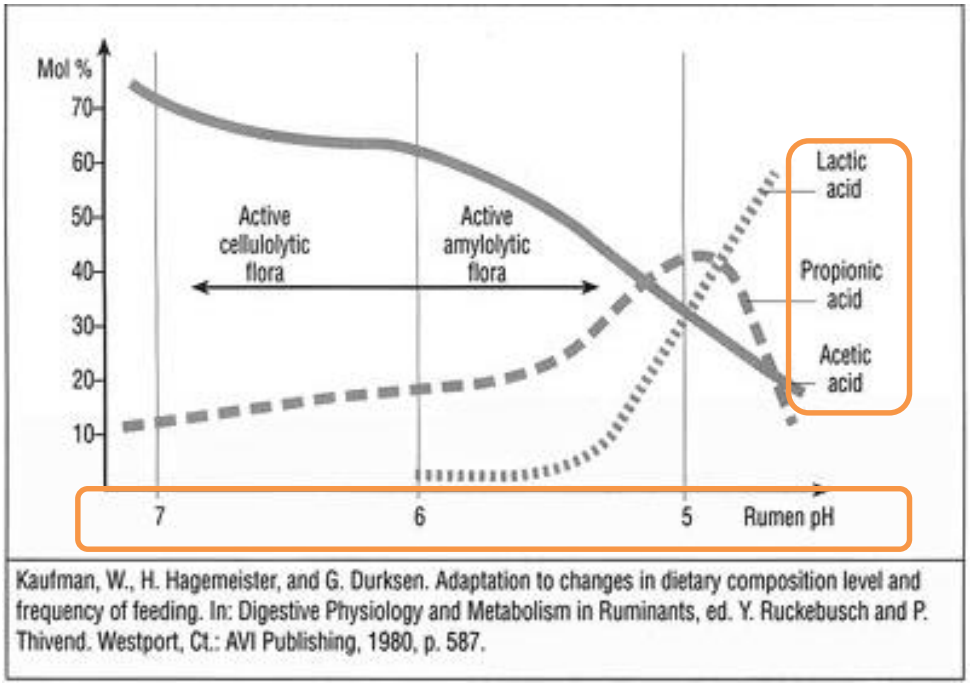
Rumen Juice - Datasets

	CRA-W	INRAE	INRAE	INRAE	FBN
Moment feeding	H0, +2, +4	H-1	H+3	H0, +1.5, +3.5, +5.5, +11.5, +21.5	H-1, +45min
N data	12 * 3	79	28	19 * 6	58 *2
Delay Rumen juice - Milk spectra	D-day	4 days	7-8 days	D-day, -1, +1	D-day, -1, +1
Spectral standardization	Ok	Ok	Ok	To be done	Ok

VFA - pH

Ammonia

Rumen Juice – pH and Volatile Fatty Acids (VFA)



Kaufman, W., H. Hagemeister, and G. Durksen. Adaptation to changes in dietary composition level and frequency of feeding. In: Digestive Physiology and Metabolism in Ruminants, ed. Y. Ruckebusch and P. Thivend. Westport, Ct.: AVI Publishing, 1980, p. 587.

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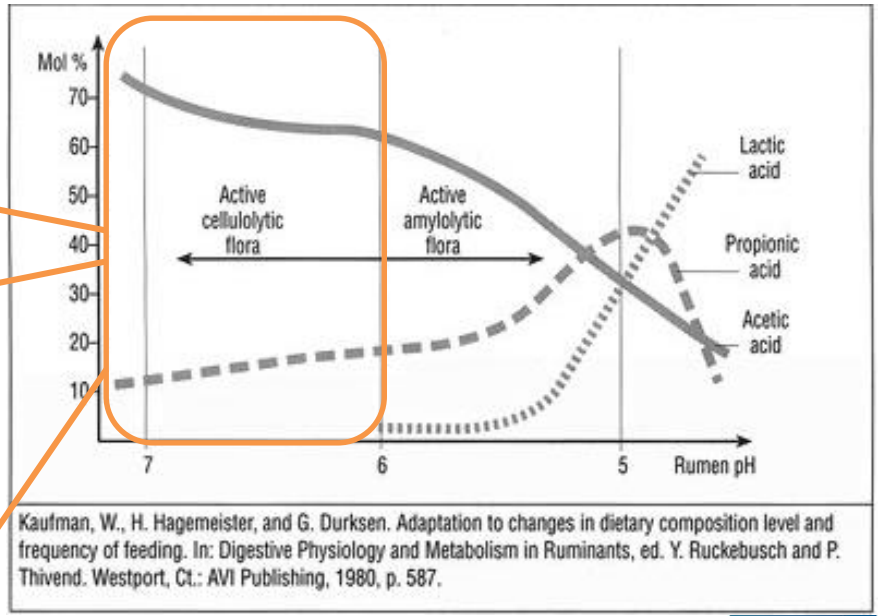
Rumen Juice – pH

Poor variability to calibrate
No problematic health status to discriminate

- Historical data (INRAE)
  - 3 trials
  - N = 68
    - Sampling 1 hour **before** eating : N = 44

      min : 6.8 ; max : 7.5
    - Sampling 3 hours **after** eating : N = 24

      min : 6.0 ; max : 7.8



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- Smartcow TNA data (INRAE)
  - 1 trial
  - N = 20
    - Sampling 0, 1.5, 3.5, 5.5, 11.5 hours after feeding : N = 19 for each timing

      +3.5H → min : 6.1 ; max : 6.6

Test to develop a proxy based on milk MIR spectra

Sampling 1 hour **before** eating

N	R^2c	SEC	R^2cv	SECV
44	0.1	0.15	0.0	0.17

Sampling 3 hours **after** eating

N	R^2c	SEC	R^2cv	SECV
43	0.3	0.33	0.24	0.34

No sufficient vairiability in this database

→ To enrich

→ Dedicated trials?

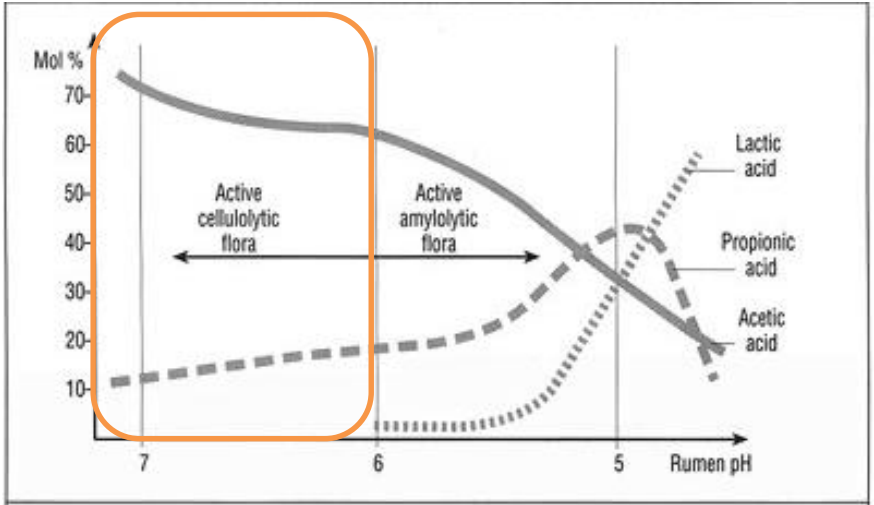
→ Standardised protocols!

Rumen Juice – VFA

- Consideration of C2, C3, C4, iC4, C5, iC5

- Same conclusion than for pH regarding the variability of reference datasets available

→ Poor variability to calibrate
No problematic health status to discriminate



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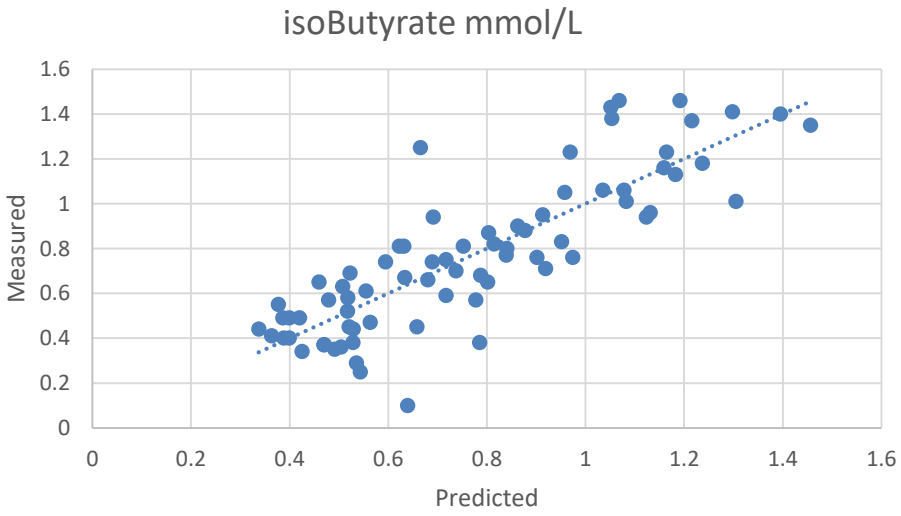
Rumen Juice – VFA + Milk MIR spectra

INRAE (Historical) mmol/L -1h

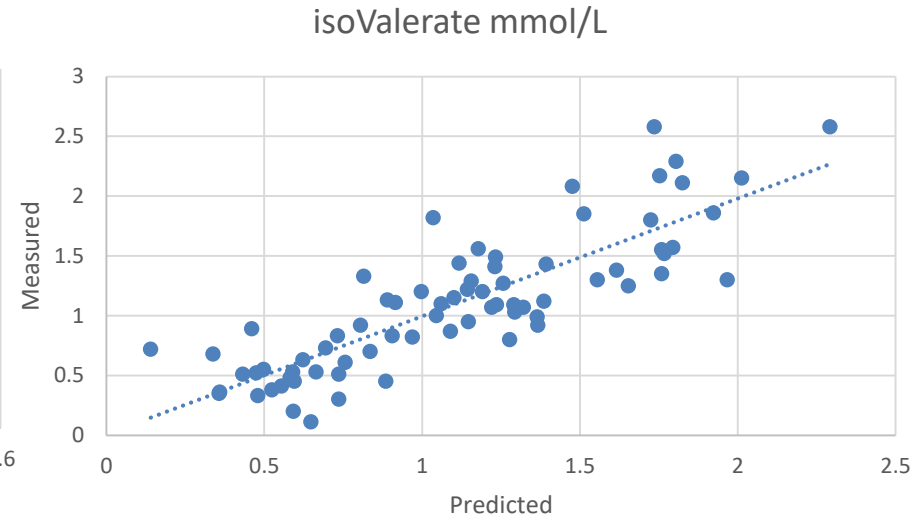
N=75

VFA	R^2c	SEc	R^2cv	SECV
Acetic	0.34	15	0.16	17
Propionic	0.09	5	0.00	5
Butyric	0.15	3	0.03	3
isoButyrate	0.68	0.2	0.44	0.2
Valeric	0.25	0.9	0.17	0.9
isoValerate	0.68	0.3	0.37	0.5

Rumen Juice – VFA + Milk MIR spectra



N = 75
R^2c = 0.68 - SEc = 0.2
R^2cv = 0.64 - SEcv = 0.2

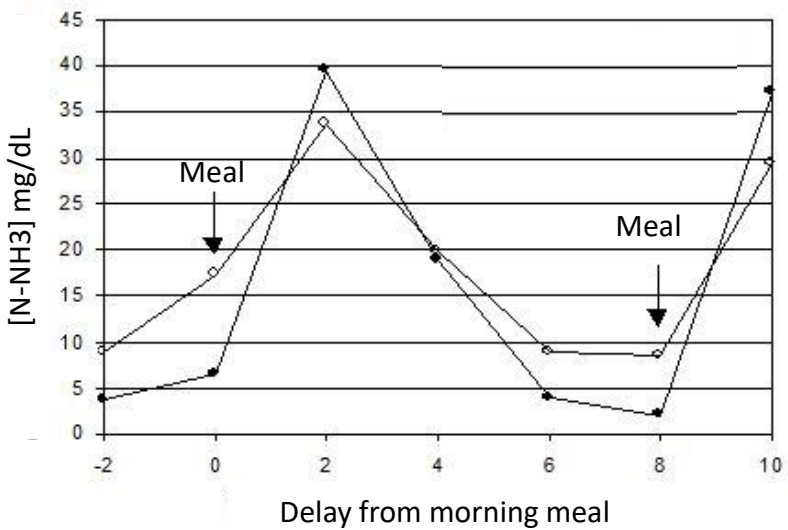


N = 75
R^2c = 0.68 - SEc = 0.3
R^2cv = 0.37 - SEcv = 0.5

→ Not robust but interesting for iC4 and iC5
→ Consider ratios of VFA
→ To enrich (health desorders)
→ Standardised protocols!

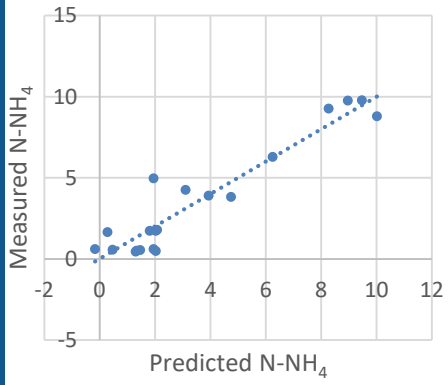
Rumen Juice - Ammonia

	CRA-W	INRAE	INRAE	INRAE	FBN
Value	$N\text{-}NH_3$	$N\text{-}NH_3$	$N\text{-}NH_3$	$N\text{-}NH_4$	NH_3
Moment feeding	H0, +2, +4	H-1	H+3	H0, +1.5, +3.5, +5.5, +11.5, +21.5	H-1, +45min



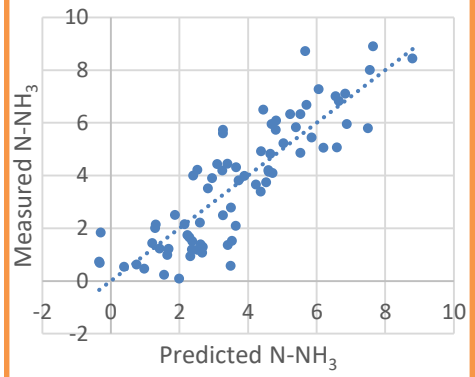
Rumen Juice – Ammonia + Milk MIR spectra

CRA-w mg/dL
+2h



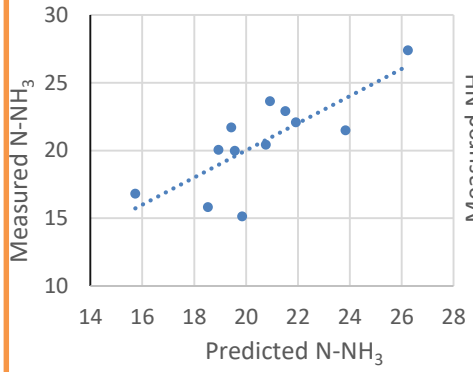
N = 20
R²c = 0.87 - SEc = 1.3
R²cv = 0.50 - SEcv = 2.4

INRAE (Historical) mmol/L
-1h



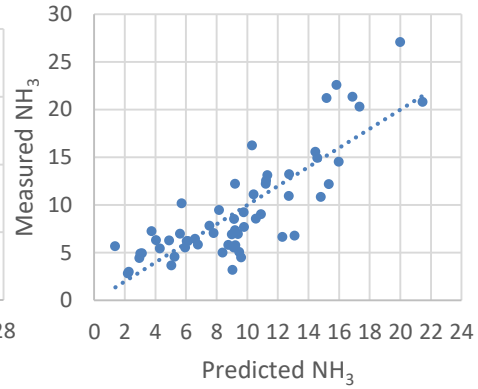
N = 75
R²c = 0.72 - SEc = 1.2
R²cv = 0.61 - SEcv = 1.4

INRAE (TNA) mmol/L
+1h30



N = 12
R²c = 0.56 - SEc = 2.3
R²cv = 0.13 - SEcv = 3.1

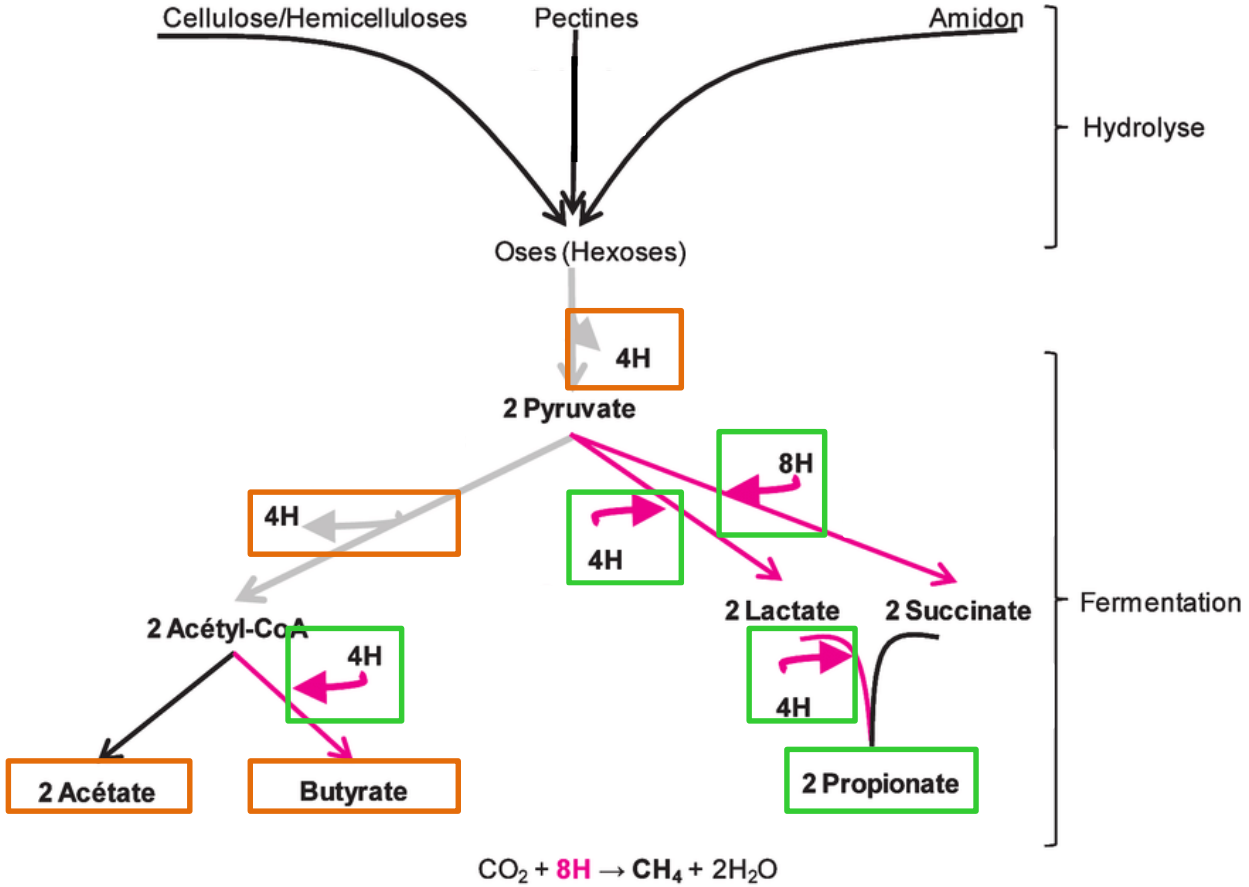
FBN mmol/L
50/50 mean -1h &+45min



N = 58
R²c = 0.64 - Sec = 3.3
R²cv = 0.27 - SEcv = 4.7

→ Interest to consider Milk MIR spectra
→ What is the best timing to consider?
→ To enrich (health desorders)
→ Standardised protocols!

Eructed Methane



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Eructed Methane + Milk MIR specta

- Existing predictive model

CH_4 ref methods	N data	N cows	SD	R^2cv	SEcv (g/d)
SF_6 & RC	1,089	299	102	0.68	57

Vanlierde *et al.* 2020

- Smartcow permitted access to new data (CH_4 (RC) // milk MIR spectra)

→ Validation step

– Historical data from FBN
  - n= 233 from 75 dairy cow
  - 392 ± 55 g/d (min: 214 – max: 546)

– TNA data from WUR
  - n = 28 from 28 dairy cows
  - 416 ± 35 g/d (min: 354 – max: 475)

– WP5 data from UREAD – to be processed
  - 4 dairy cows / 4 periods

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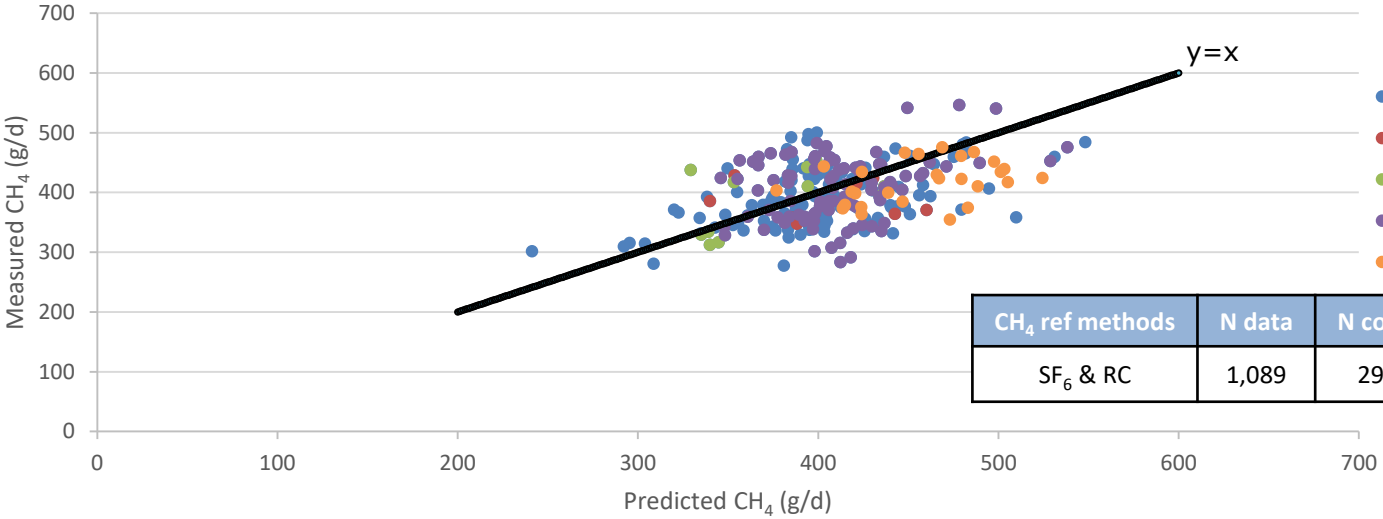
Eructed Methane + Milk MIR spectra

- Prediction of FBN and WUR data with existing model



CH_4 ref methods	N data	N cows	SD	R^2cv	SEcv (g/d)
SF_6 & RC	1,089	299	102	0.68	57

N = 238, SD = 51

R^2p = 0.17 ; SEp = 52g CH_4/d ; RPDp = 2

→ No outliers

→ Error of prediction in line with the model error

→ Detection of high and low emitters

Interest of milk MIR spectra as proxy for rumen parameters but…!

Moments to collect values vary between datasets

Indication of general health status or fermentation profile more than pH or VFA values - no identified « sick » animals in the datasets

→ Too early to conclude especially with datasets available

→ Trial dedicated to this and/or collaborations to enlarge datasets

→  Standardized protocols!

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an integrated infrastructure for increased research capability and innovation in the European cattle sector

Thank you for your attention

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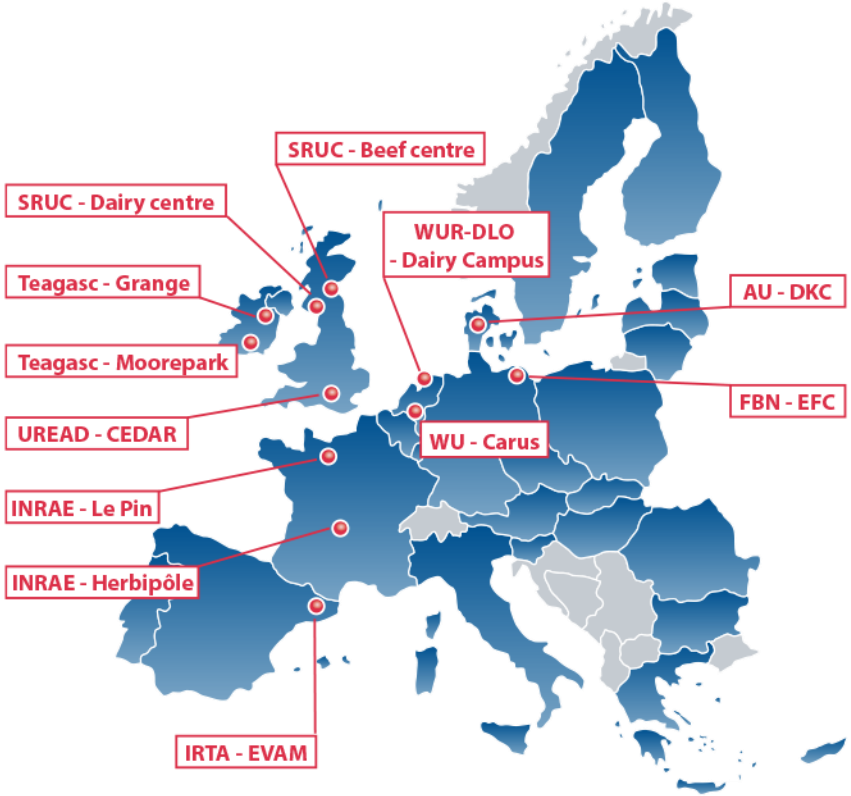
SmartCow at a glance



First-class Cattle Research Infrastructures (RIs) across Europe:

- 11 major RIs distributed in 7 EU countries
- 12 locations, which include 18 installations
- 2500 dairy and 1000 beef cows

- **Networking of RIs** to inventorize resources, harmonize procedures, and share data
- **Joint research activities** to improve experimental methods and phenotyping capability
- **Interaction with stakeholders** to stay in line with industry needs and improve dissemination

http://www.smartcow.eu/stakeholders/

TRAINING PROGRAM

For Scientists, Technicians, Stakeholders, PhD students

- Face-to-face training courses
- Free web-conferences
- One-day study tours in 4 different countries

http://www.smartcow.eu/resources/training/

TRANSNATIONAL ACCESS CALLS

Offers external users (academic and industry) free access to SmartCow RIs

- 30 projects during the 4 years of SmartCow
- Access to around 10,000 cow-weeks

http://www.smartcow.eu/calls/

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