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Online quality analysis of raw milk: from concept to validation

B. Aernouts, *J. Diaz Olivares, I. Adriaens and W. Saeys*

70th Annual Meeting of the European Federation of Animal Sciences

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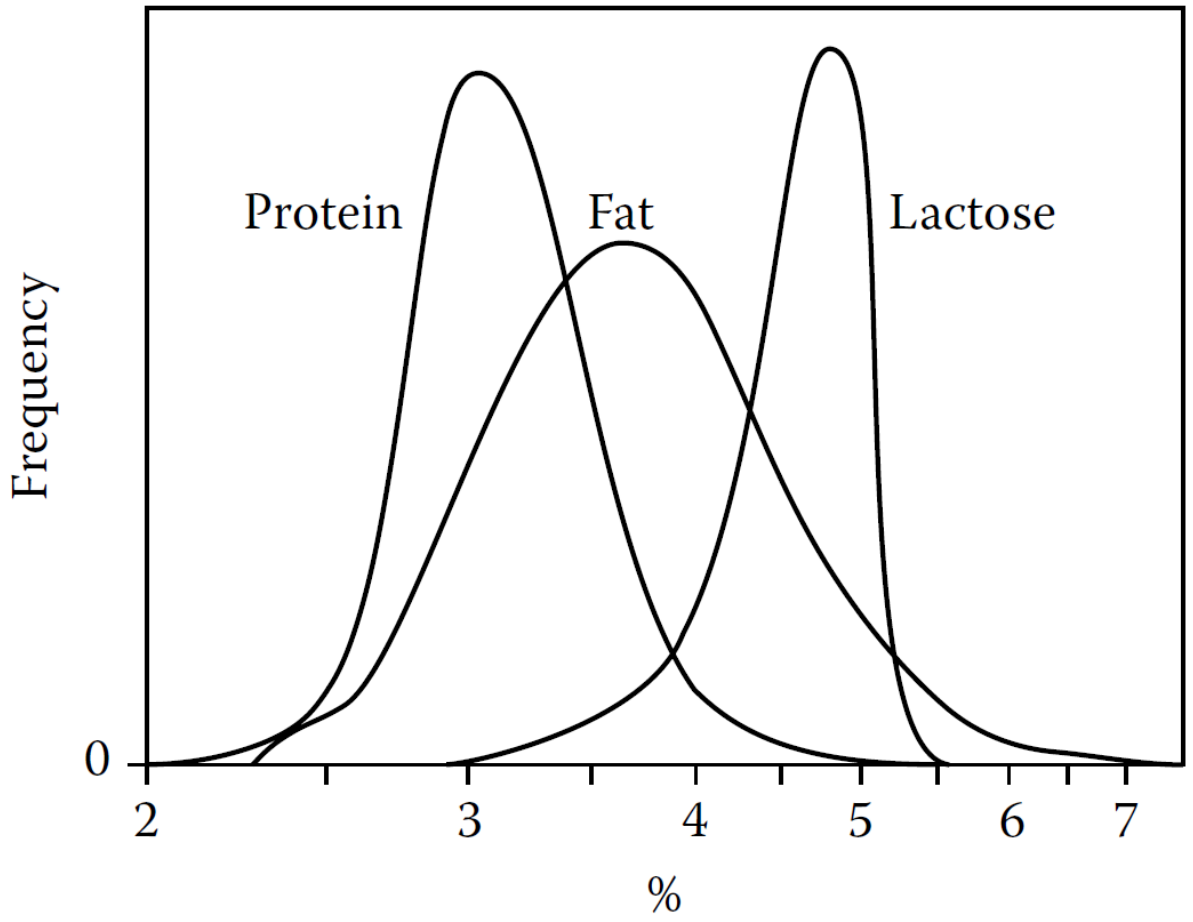
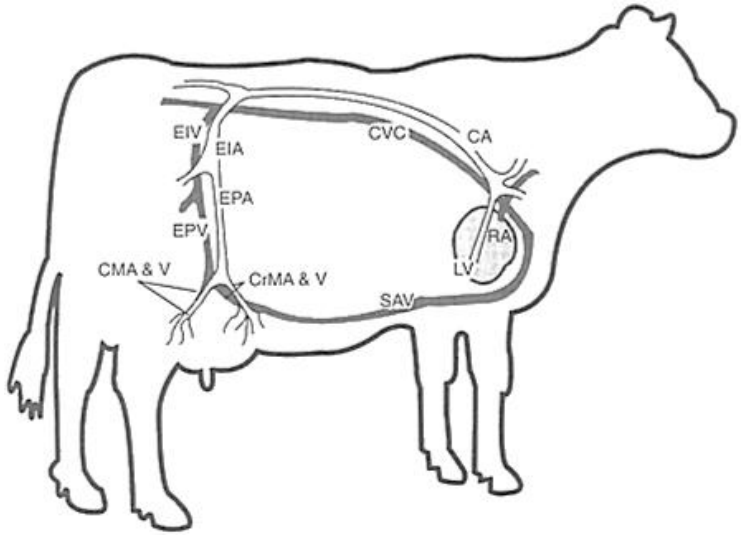
Milk composition



Walstra *et al*., 2006

Health screening

- Milk production



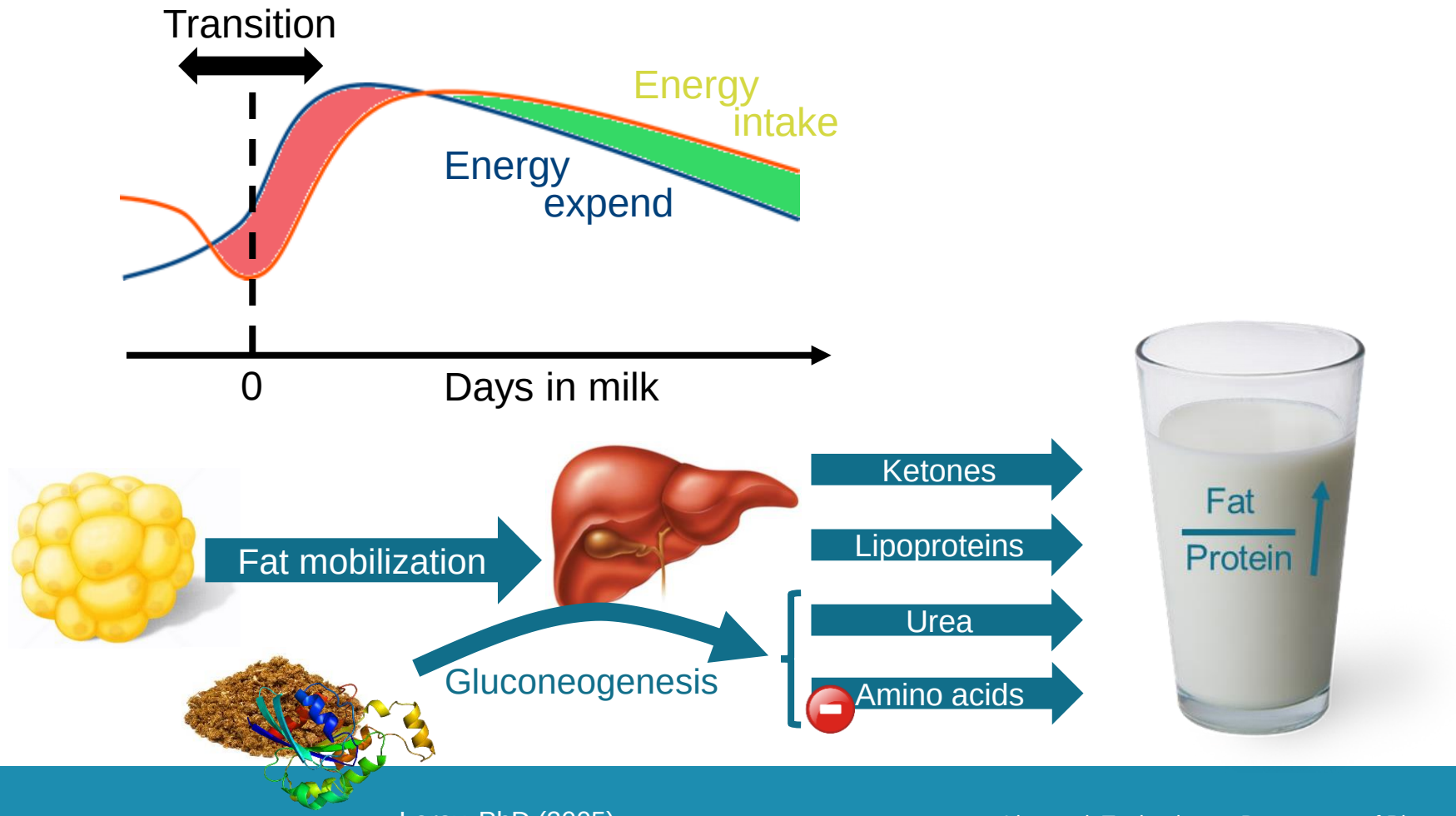
- 1 liter milk = 400 – 500 liter blood flow

  → Intensive interaction

Hamann & Krömker, Livest. Prod. Sci. 48 (1997)

Health screening

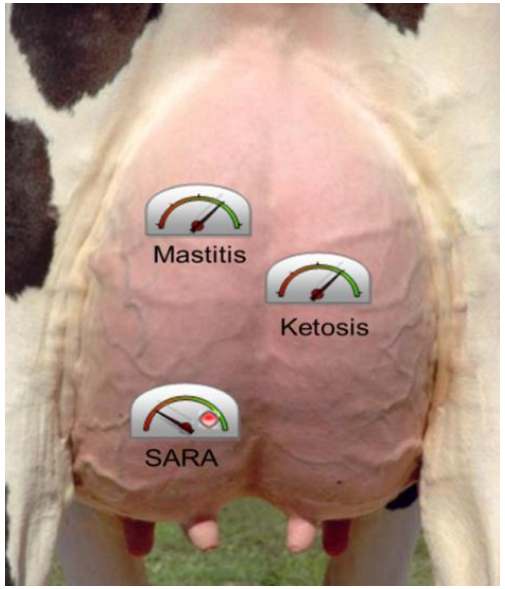
- Example: Negative energy balance



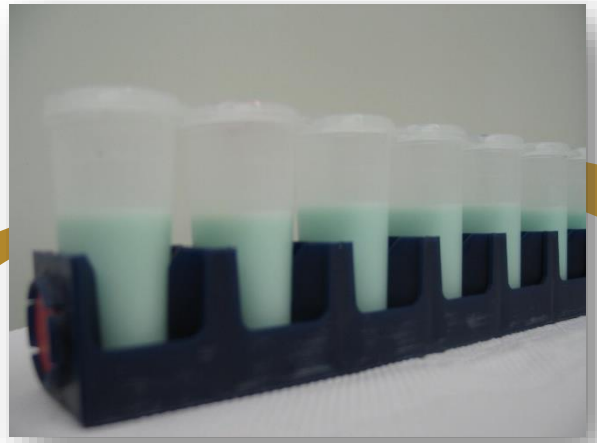
Leroy, PhD (2005)

Health screening

- Infectious diseases
  - Mastitis -> lactose ↓
- Metabolic diseases
  - Negative Energy Balance -> Ketosis -> Fat / Protein ↑
  - Rumen Acidosis (SARA) -> Fat < Protein
- Nutrition optimization
  - Optimizing energy/protein ratio
  - Optimizing N feeding -> Urea



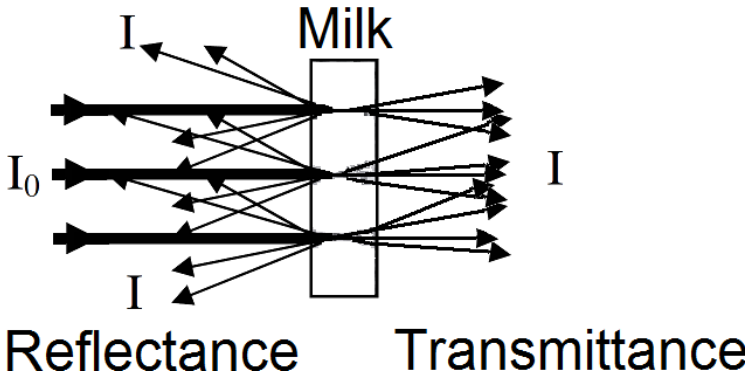
Today’s practice



FOSS Milkoscan

NIR technology

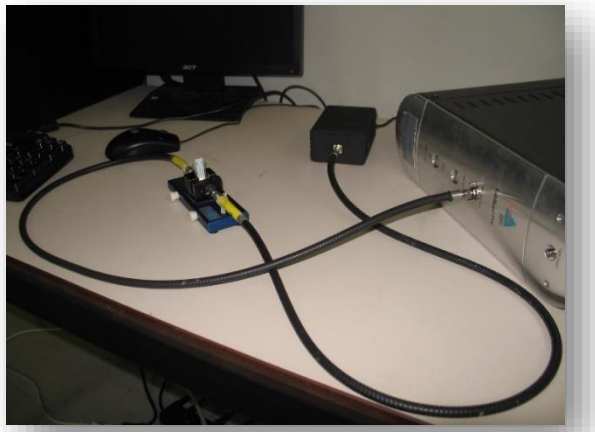
- Fast
- Accurate
- Non-destructive
- No sample preparation
- Low price
- Possible to measure online



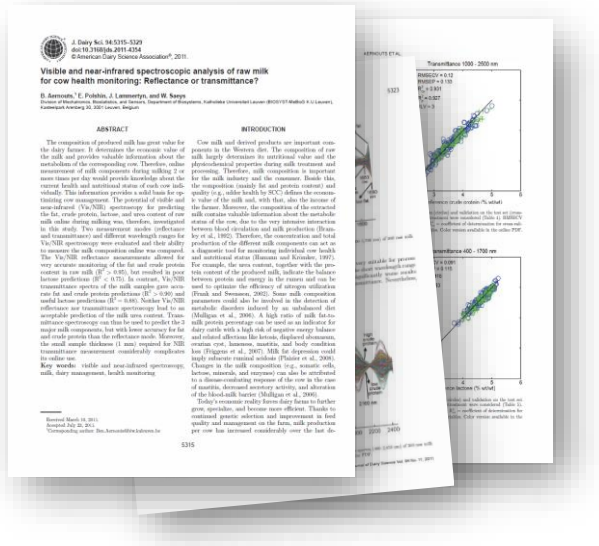
In the past…

Reflectance

Transmittance



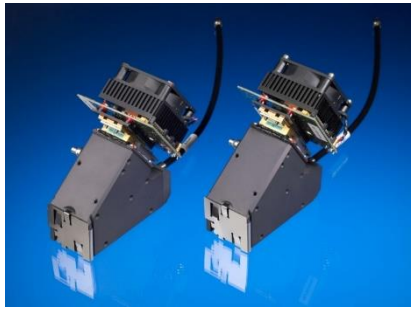
	RMSEP (% *w*/*w*)	
Component	Reflectance	Transmittance
Fat	0.05	0.04
Protein	0.10	0.13
Lactose	0.18	0.12

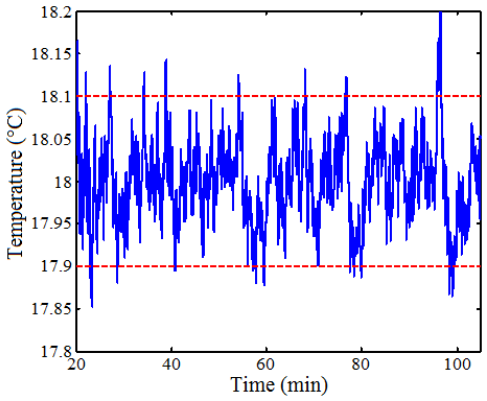

Visible and near-infrared spectroscopic analysis of raw milk for cow health monitoring: Reflectance or transmittance?

Aernouts *et al.*, J. Dairy Sci. 94 (2011)

Development of NIR sensor

- Diode array (1000 -1700 nm)
  - Robust, fast, compact, cost-efficient
- Temperature-controlled housing
  - Protection of electronics
    - Ammoniak
    - Dust, moisture
  - Stable spectrometer readings
- By-pass
  - 2 mm cuvette
  - Reflectance and transmittance





Experiment 1

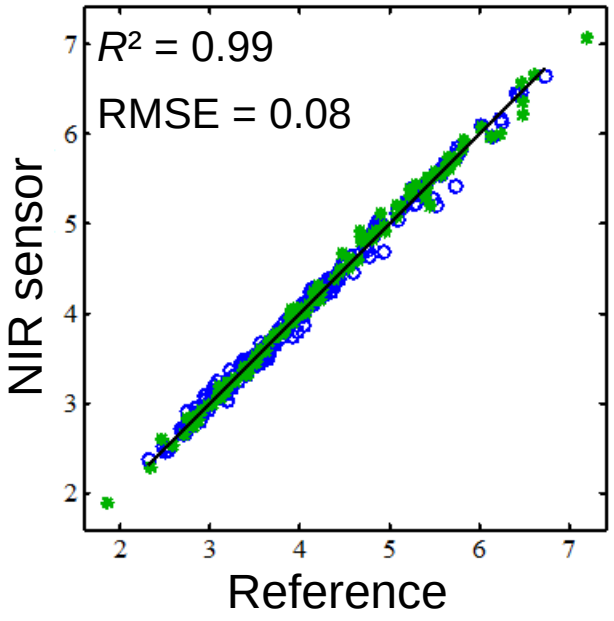
- Offline
- Stored samples: 2 – 3 days, 4°C, preservative
- 230 calibration samples (13 farms)
- 120 validation samples (6 farms)

Milk component	Method	RMSEP (% *w*/*w*)	
		KU Leuven sensor	Literature
Fat	Trans.	0.08	0.04[1]
	Refl.	0.10	0.04[1,2]
Protein	Trans.	0.09	0.13[1]
	Refl.	0.11	0.10[1]
Lactose	Trans.	0.09	0.12[1]
	Refl.	0.14	0.12[2]

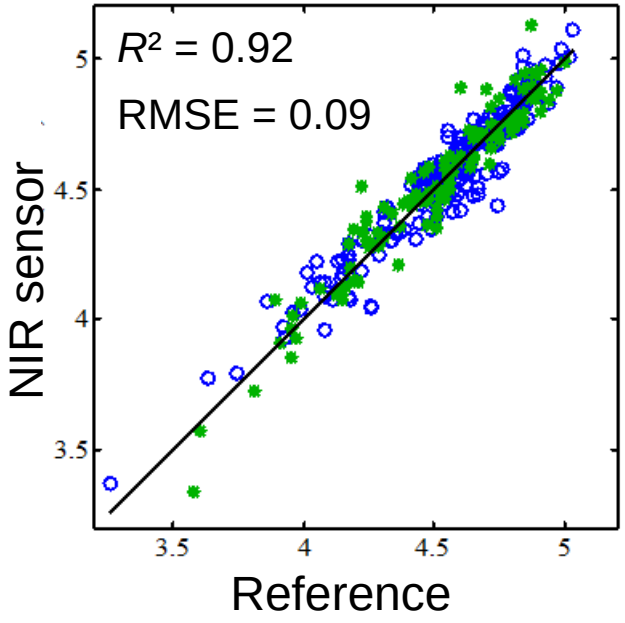
[1]Aernouts *et al.*, 2011
[2]Melfsen *et al.*, 2012

Experiment 1

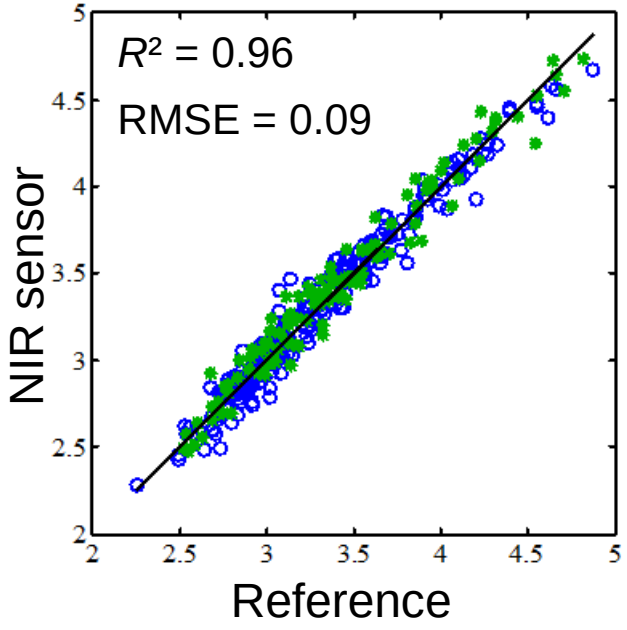
Fat (%*w*/*w*)



Lactose (%*w*/*w*)



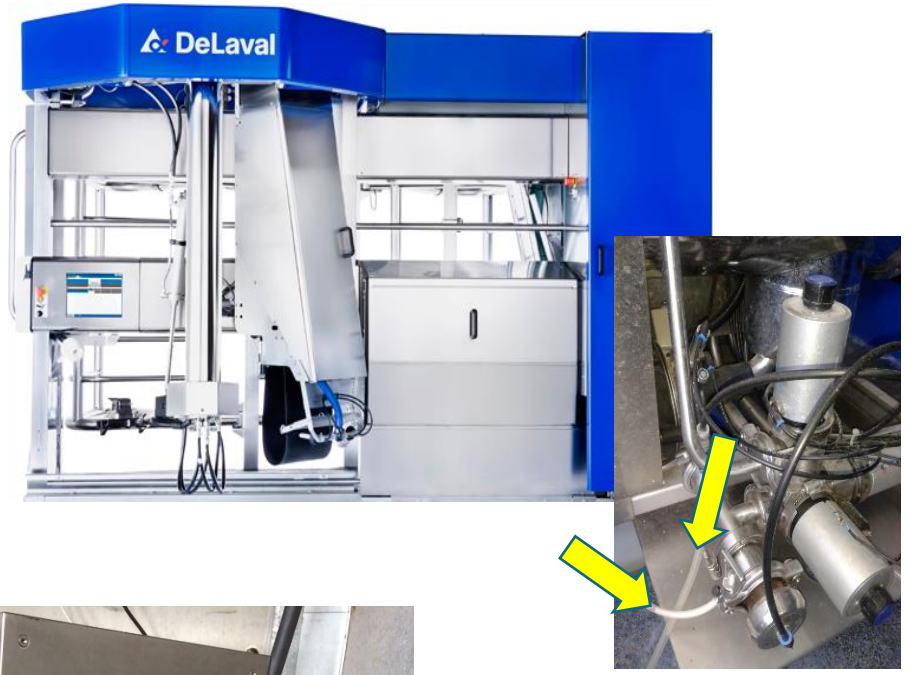
Protein (%*w*/*w*)



Automatic sampling

Sampling

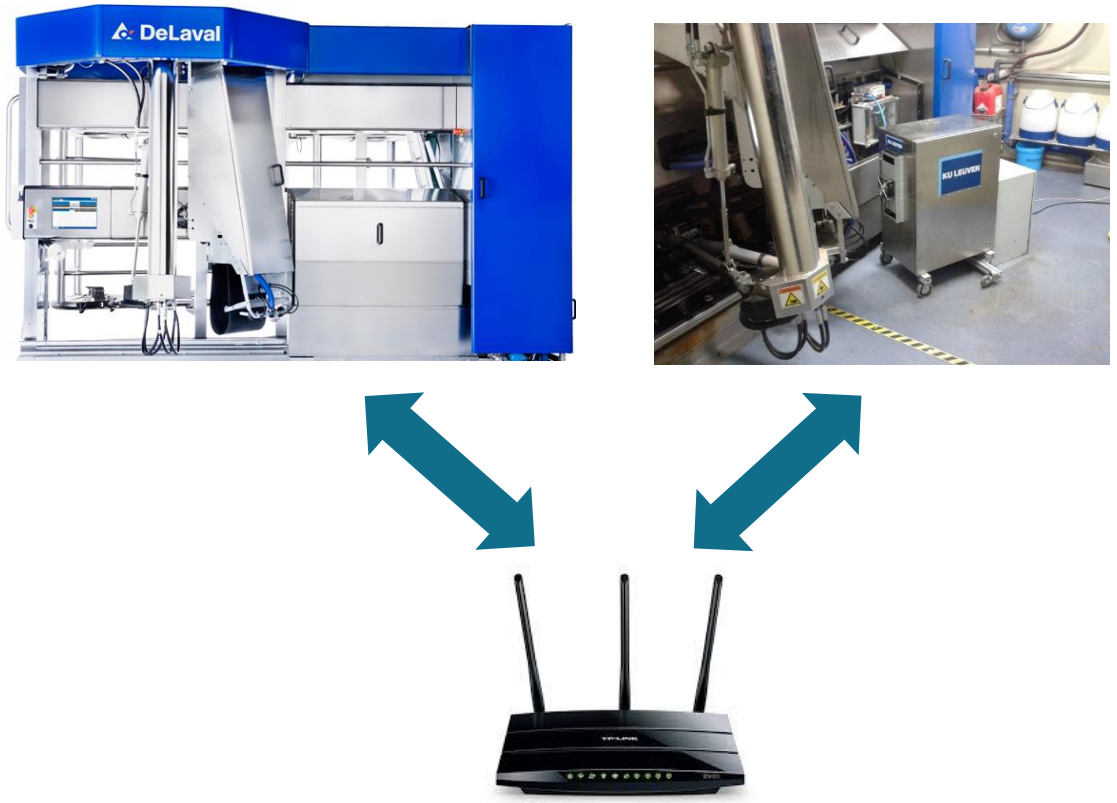
AMS coupling



NIR sensor

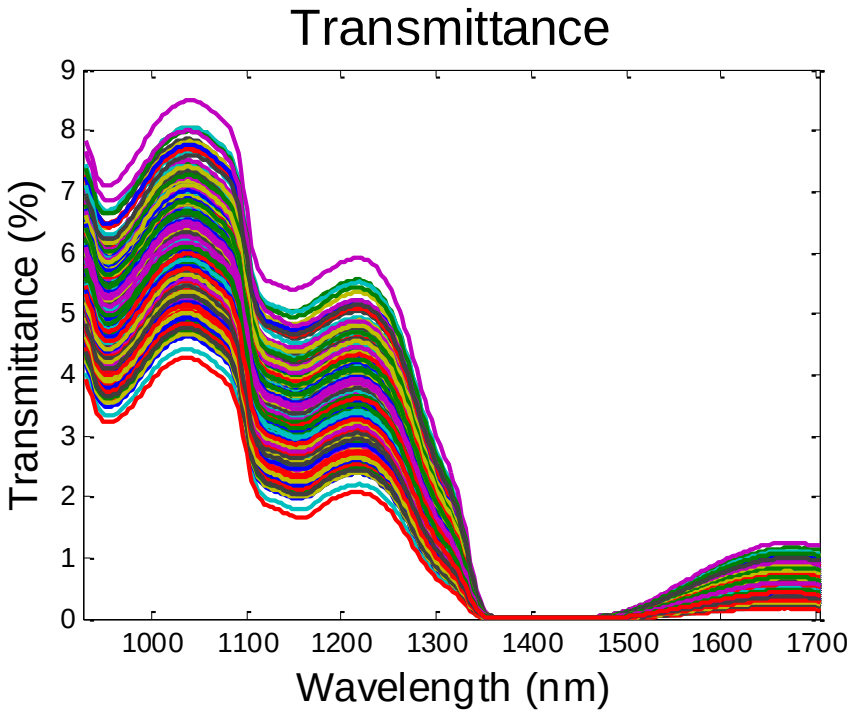
NIR sensor – AMS synchronization

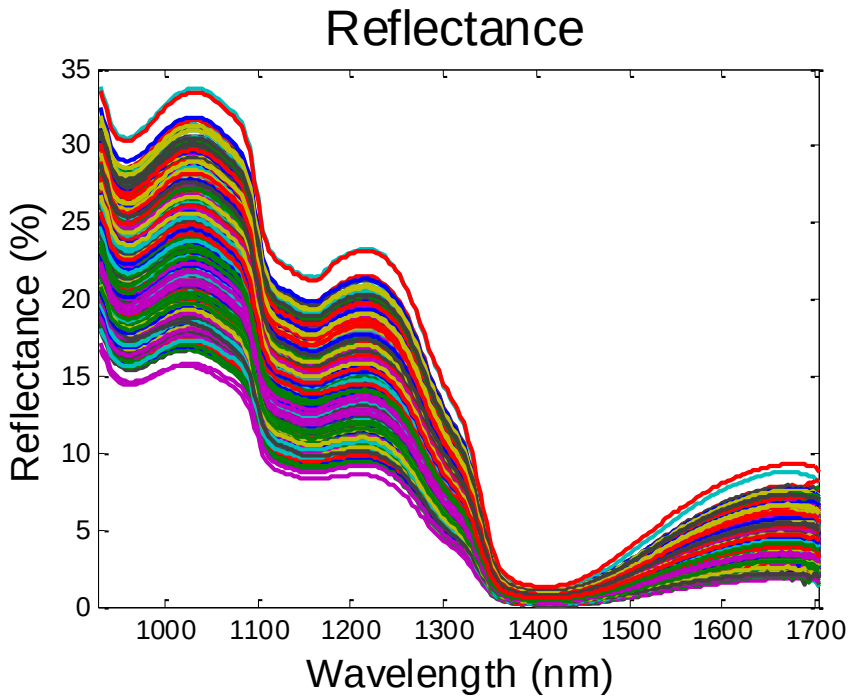
- TCP/IP protocol
  - CowID
  - Milking:
    - Start / end
  - Milking yield
  - Cleaning:
    - Start / end
  - Cleaning type
  - Milk pump:
    - Start / end
  - Bypass valve:
    - Open / close



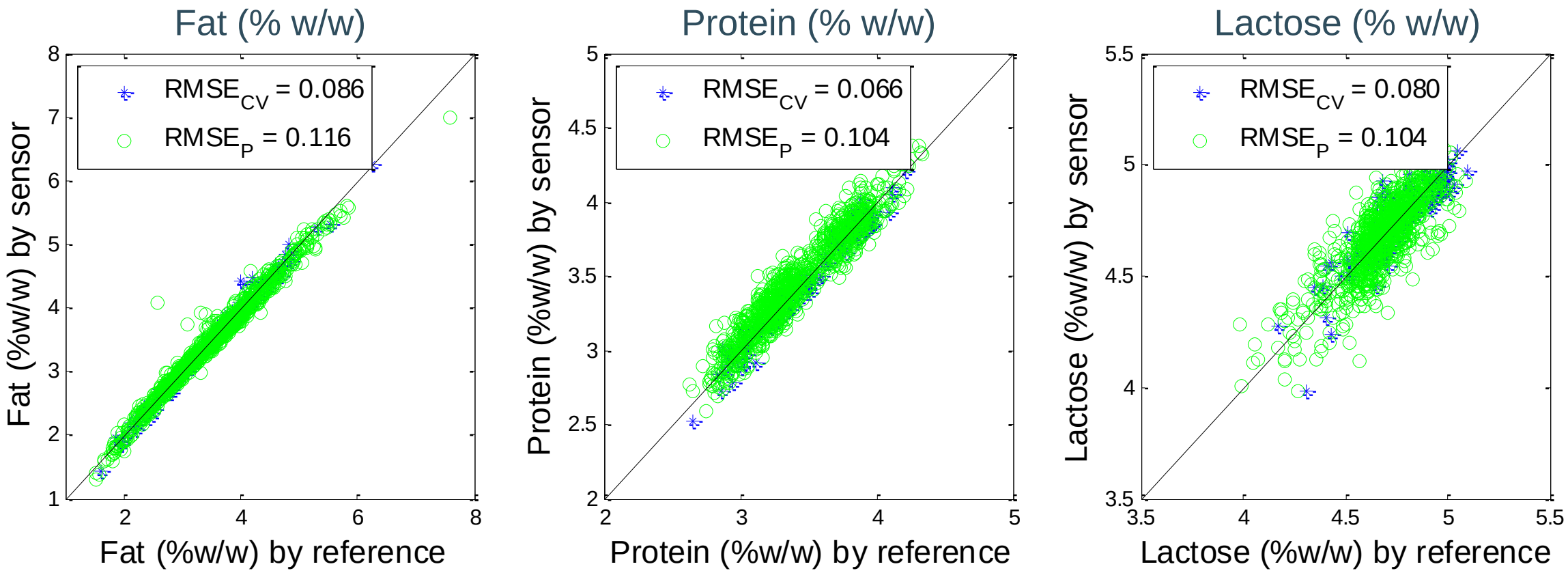
Experiment 2: spectra

- 1 farm, 1 AMS, 41 cows
- 24 May 2017 – 27 July 2017
- 1270 spectra with reference analysis (fat, protein, lactose, urea and SCC)



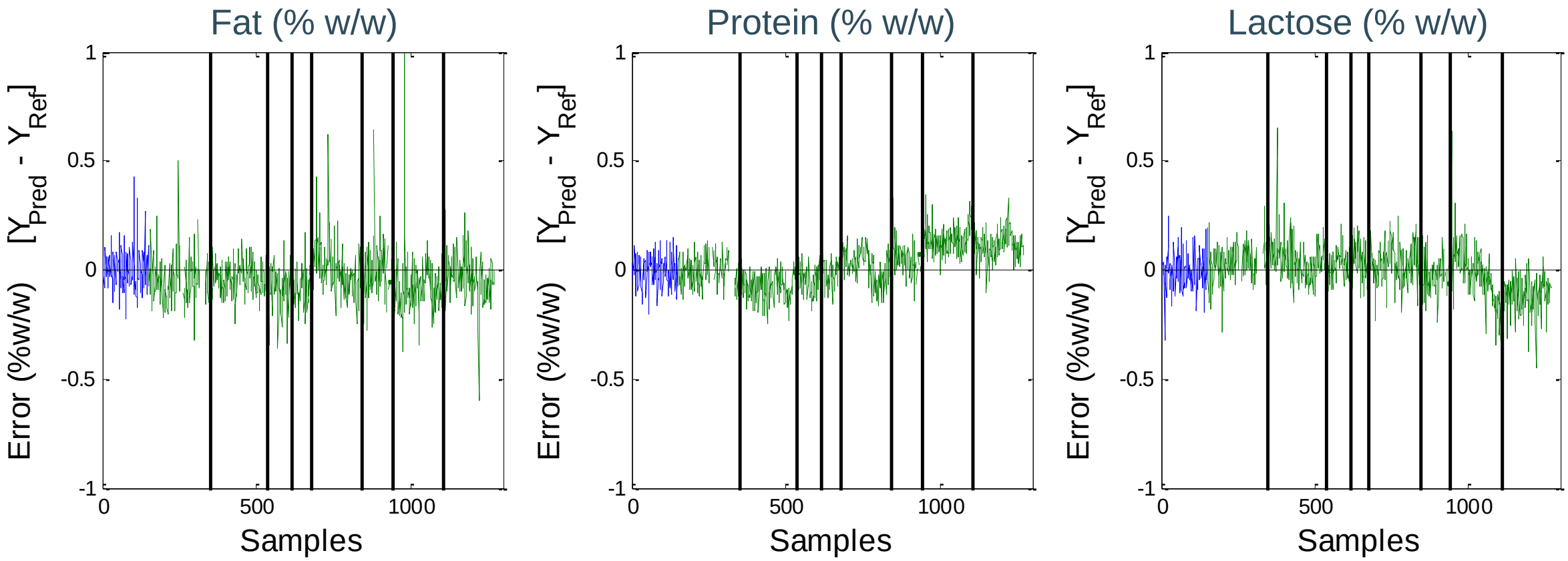


Experiment 2: predicted vs. measured



Blue = calibration set (150 first samples)
Green = independent validation set (last 1120 samples)

Experiment 2: residuals



Blue = calibration set (150 first samples)
Green = independent validation set (last 1120 samples)

Conclusions

- Successful implementation of online NIR sensor:
  - Compatible with Delaval AMS
    - No human intervention!!
  - Robust filling and draining of cuvette
  - Effective cleaning of cuvette and tubes
    - Visible clean (after 10 weeks of continuous measurements)
    - No trend in residues between cleanings
  - Performance comparable with literature

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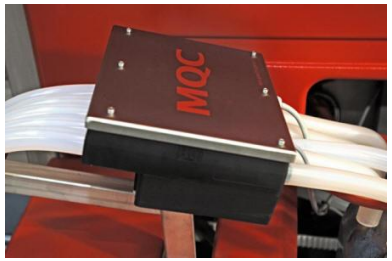
Commercial milk sensors on farm



Milk component	Afimilk Afilab			Lely MQC			
	Kaniyamattam et al., 2014		Hanus et al., 2016	Pecova et al., 2017		Fadul-Pacheco et al., 2018	
	R^2	RMSEP (% w/w)	R^2	R^2	RMSEP (% w/w)	R^2	MAE (% w/w)
Fat	0.116 - 0.518	0.48 - 0.87	0.544	0.275	0.601	0.185 - 0.548	0.28 - 0.47
Protein	0.325 - 0.563	0.23 - 0.42	0.619	0.553	0.349	0.109 - 0.504	0.15 - 0.22
Lactose	0.068 - 0.292	0.22 - 0.35	0	0.492	0.208	0.476	0.081 - 0.12

Milk component	KU Leuven sensor	
	R^2	RMSEP (% w/w)
Fat	0.979	0.116
Protein	0.905	0.104
Lactose	0.564	0.104