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Reconstructing representative daily milk FT-MIR spectra from partial milking robot samples using machine learning

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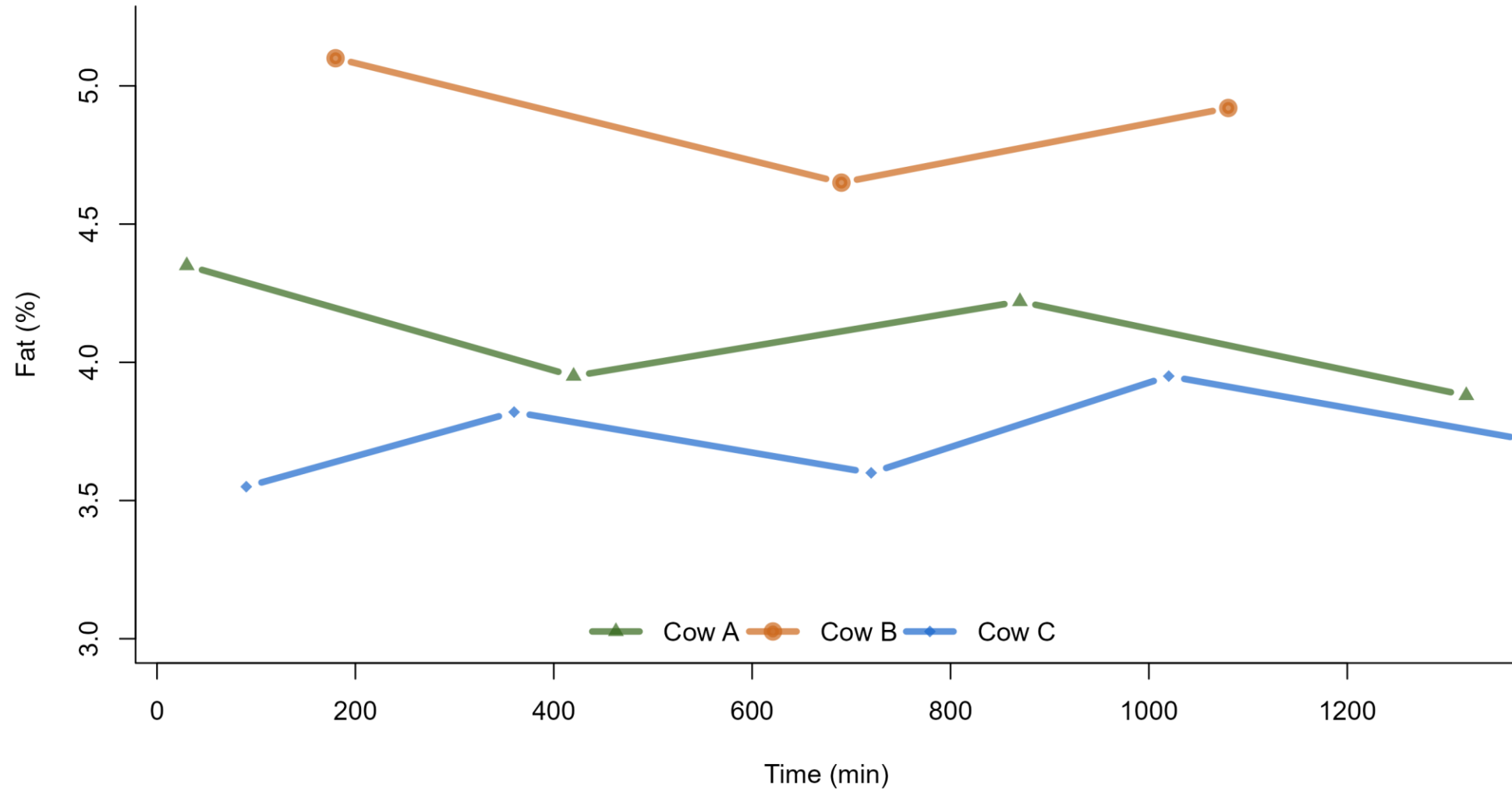
Automated Milking System (AMS)



- Increasingly common in modern dairy farming.
- One out of four dairy farms in Denmark and Sweden
- Continuous collection of data.

(Cogato et al., 2021; Hassoun et al., 2023; Zagidullin et al., 2023)

Evolution of milk fat over a day



Correction for Fat and Protein



THE GLOBAL STANDARD
FOR LIVESTOCK DATA

Procedure 1 of Section 2 of ICAR Guidelines - Computing 24-hour Yields

Methods to calculate 24-hour yields in Automatic Milking Systems

Computing 24-hour Yields

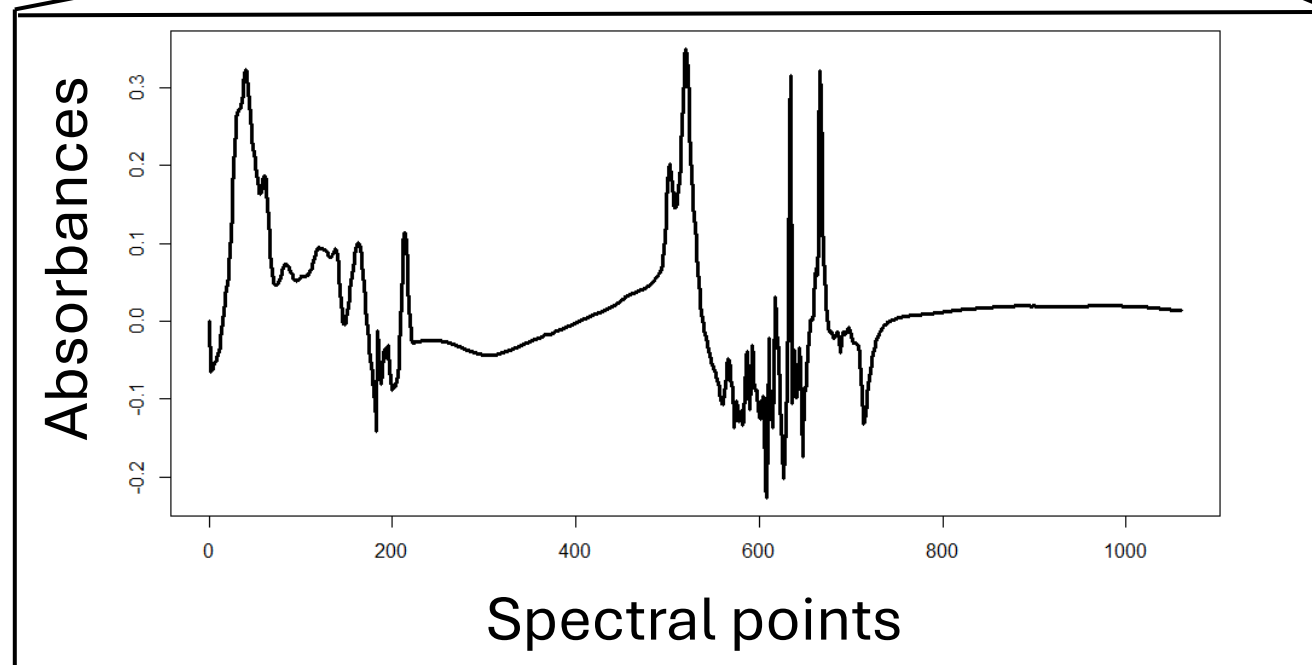
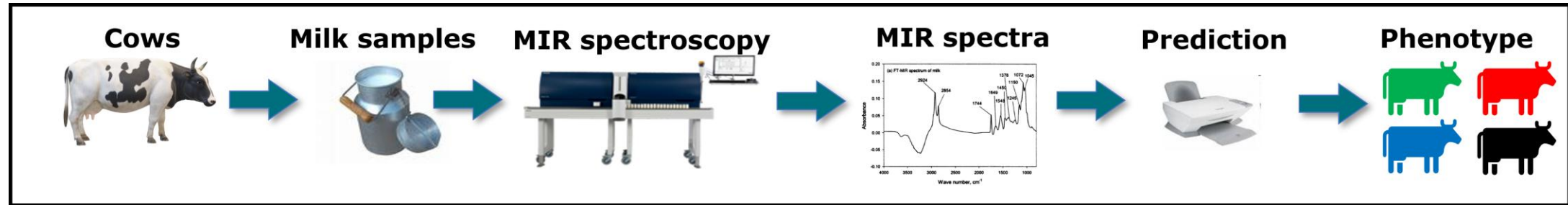
Version June, 2023

=> Peeters and Galesloot (2000)

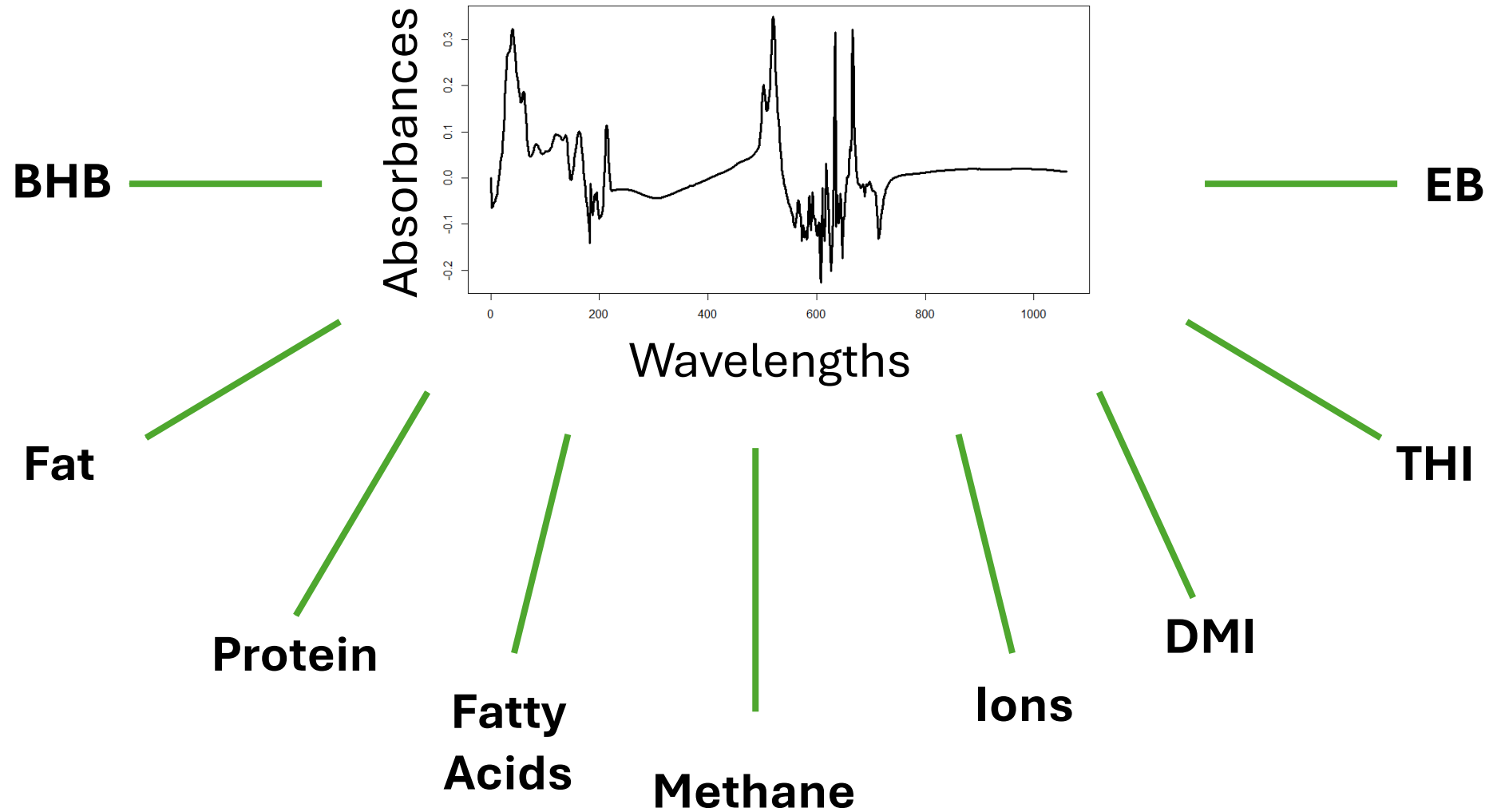


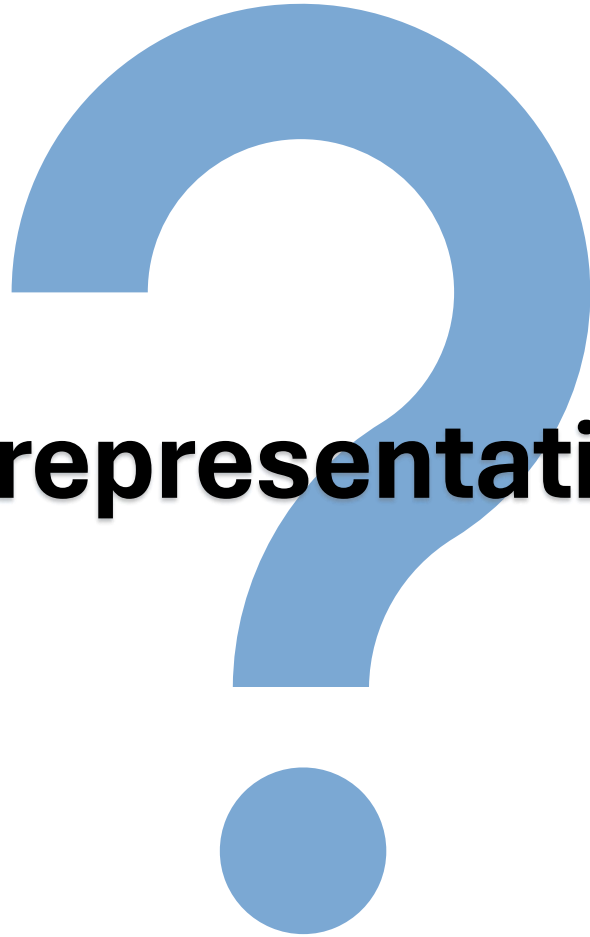
What about other traits than Fat and Protein?

What is Fourier Transform mid-infrared spectrometry ?



Predictions? Phenotypes ?





Can we create a representative daily spectrum?

Datasets



Data used to train the methods or find coefficients

Data Train: Fat and Prot

- 3 farms
- 227 Milk Recording Events
- Between 2014 and 2025
- 1,428 cows
- 39,395 records

Data Train: Spectra

- 2 farms
- 130 Milk Recording Events
- Between 2013 and 2025
- 450 cows
- 10,239 records

Data Validation

- 7 farms
- 7 Milk Recording Events
- Between Feb and April 2025
- 873 cows
- 2,465 records

All samples were analyzed.

Methods for estimation of Fat and Prot 24h

1. PG = ICAR Certified: Peeters and Galesloot (2000)
2. WA = Weighted average
3. LM = Linear regression

Methods for estimation of Fat and Prot 24h

1. PG = ICAR Certified: Peeters and Galesloot (2000)

With only one milking:

$$\%FAT_{24h} = a + b \times \%FAT + c \times \%PROT + d \times MI + e \times MY + f \times pMY$$

 6 coefficients (a, b, c, d, e et f)

	Milking Interval (minutes)				
	Class	]0;361[	[361;511[	[511;701[	[701;1441[
$\frac{\%FAT}{\%PROT}$	<1.1	1	2	3	4
	[1.1;1.25[	5	6	7	8
	[1.25;1.4[	9	10	11	12
	>1.4	13	14	15	16

16 classes of 6 coefficients
(a, b, c, d, e and f)

Methods for estimation of Fat and Prot 24h

2. WA = Weighted average

With more than one milking:

$$\%FAT24h = \frac{\sum (\%FAT \times MY)}{\sum MY}$$

Methods for estimation of Fat and Prot 24h

3. LM = Linear regression

With one or more milking:

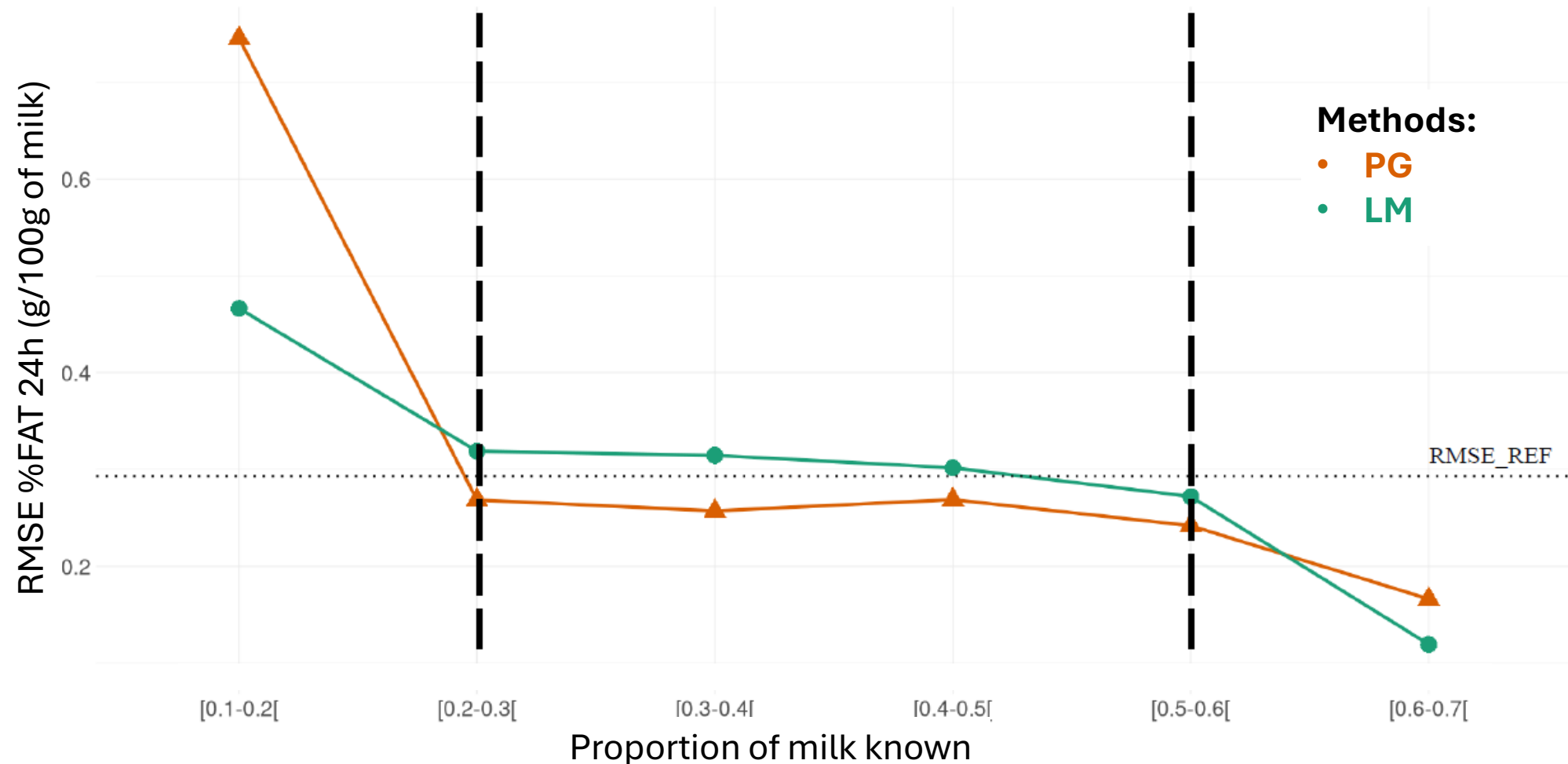
$$\%FAT24h = \frac{FAT_{known} + FAT_{pred}}{\sum MY}$$

Where $FAT_{pred} = MY + MY^2 + \%PROT + MI + pMI$

With MY = Milk Yield, MI = Milking Interval and pMI = previous Milking interval

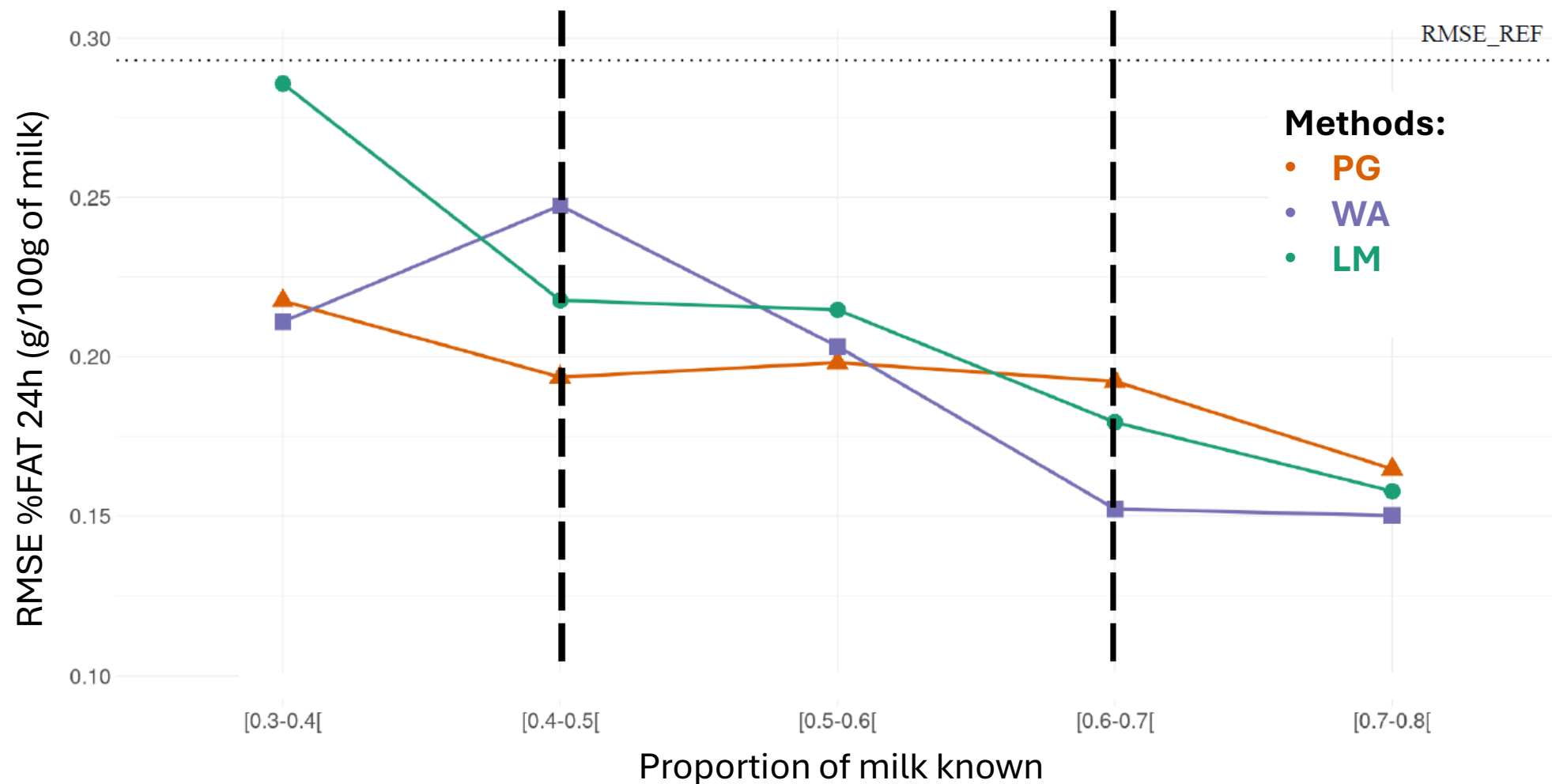
Errors on FAT24h by proportion of milk known

Using only one milk sample:



Errors on FAT24h by proportion of milk known

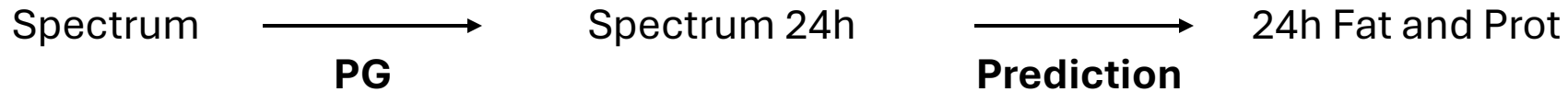
Using only two milk samples:



Methods for estimation of Spectra 24h

Each wavelengths is processed independently:

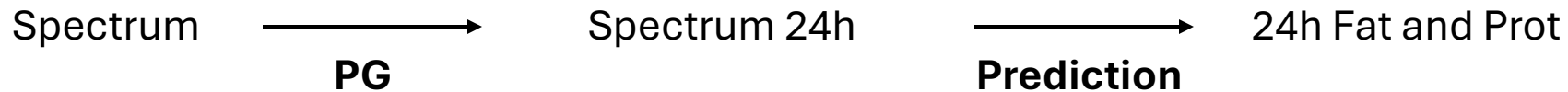
PG1: Peeters and Galesloot with one milk sample



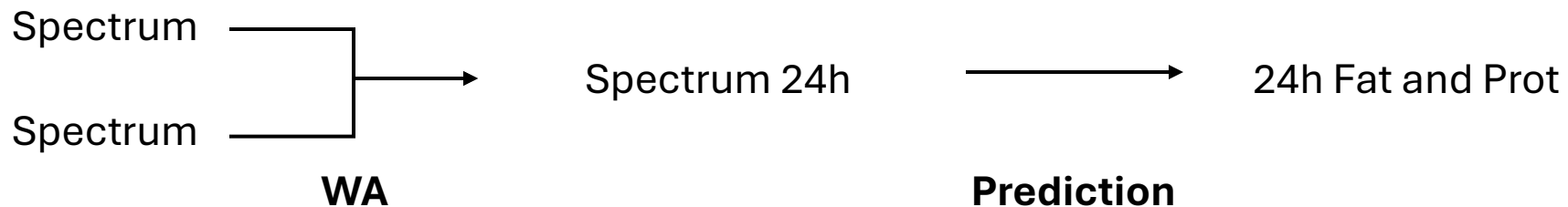
Methods for estimation of Spectra 24h

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PG1: Peeters and Galesloot with one milk sample

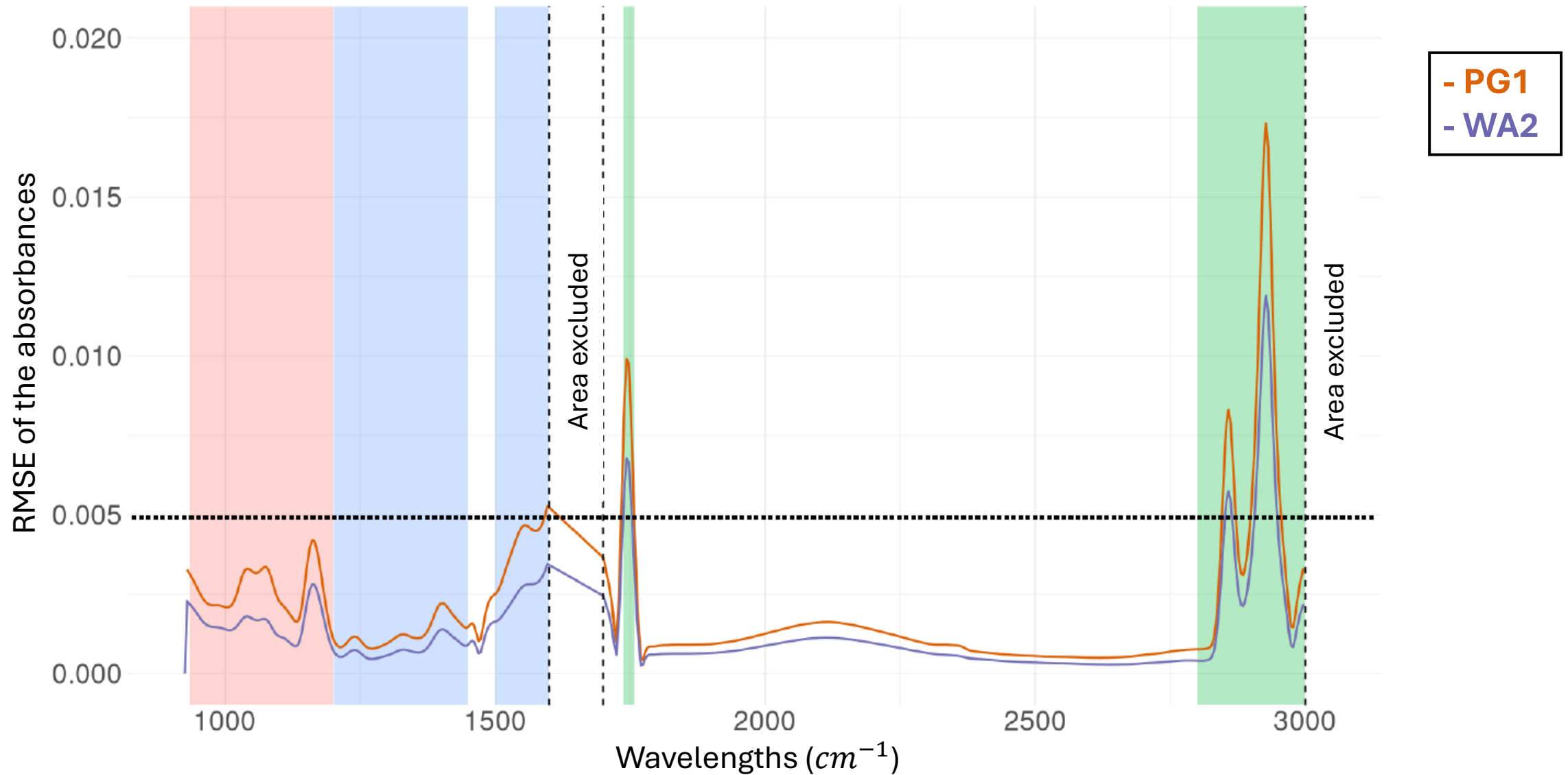


WA2: Weighted Average with two milk samples



RMSE of Spectra 24h

- Lipids Area
- Proteins Area
- Carbohydrates Area



RMSE of Fat and Protein 24h from spectra 24h

RMSE Fat24h (g/100g of milk)		
	one sample	two samples
PG	0.275	0.193
WA	/	0.189
LM	0.311	0.198
PG1 (Spectra)	0.272	0.193
WA2 (Spectra)	/	0.182

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WA2 (Spectra)	/	0.182

RMSE Prot24h (g/100g of milk)	
No correction	0.067
PG1 (Spectra)	0.077

- **Similar performances for Fat**
- **Slightly lower performances for Prot**

Take Home Message

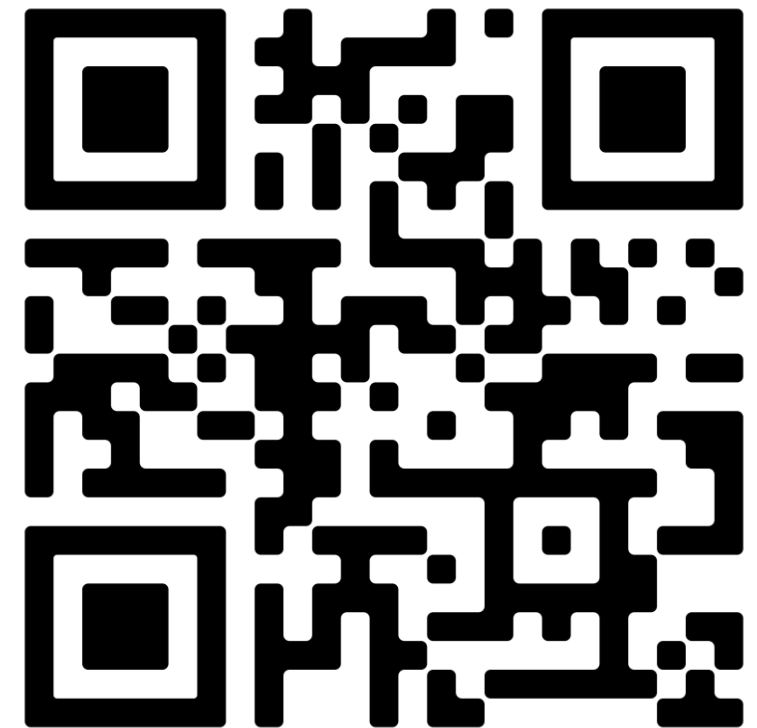
- 1. We can create a daily representative spectrum for AMS milk recording!**
- 2. Results for FAT using spectrum are comparable to Peeters and Galesloot.**
- 3. More results with different prediction equation are coming.**
- 4. Different ways of correcting the spectra are coming.**

Thank you for attention



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Let us discuss!



Linked 