

Mid-infrared predictions of cheese yield from bovine milk

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Context

- Cheese manufacture
 - Economical importance
 - Empirical & theoretical formula for cheese yield (CY)
 - ✓ Based on some factors:
 - Milk fat content
 - Milk protein content
 - Milk casein content
 - Moisture
 - Salt
 - ...

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Context

- Cheese yield
 - Influence of animal selection on milk component
 - ➔ also on milk processability
 - Interest for studying CY at large scale

But the CY measurement on a large number of individual samples is

 - ✓ Time consuming
 - ✓ Skilled staff

Request for a CY prediction without the need of the prior determination of milk composition

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Objective

- To investigate the potential use of Mid Infrared (MIR) spectrometry in order to predict cheese yield

Why MIR spectrometry ?

- ➔ Small quantity of milk and fast method
- ➔ Already implemented in milk labs to measure the contents of fat, protein, lactose, and urea in milk

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Material and methods

- Sampling
 - Walloon Region of Belgium
 - Variability of spectra: several criteria
 - ✓ Milk sampling: individual or bulk milk
 - ✓ Breed: Dual Purpose Belgian Blue, (Red) Holstein, Montbéliarde and Jersey
 - ✓ Time of sampling: morning milking, evening milking or mix of 50 % morning & 50 % evening milk samples

➔ 157 samples collected (October 2009 – May 2010)

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Material and methods

- Analysis
 - Milk Lab (Comité du Lait, Battice, Belgium)
 - ✓ MIR Foss MilkoScanFT6000 spectrometer
 - ✓ Analysed traits: fat, protein, lactose, somatic cell count (SCC) and pH
 - ✓ SCC ➔ Somatic Cell Score (SCS)

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Material and methods

- Analysis
 - Individual Laboratory Cheese Yield (ILCY) were determined according to Hurtaud *et al.*, 1995 (Ann. Zootech. 44, 385-398)
 - ✓ g dry coagulum / 100 g milk dry matter
 - ✓ 2 samples discarded due to poor coagulation

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Material and methods

- MIR-Chemometric methods
 - WINISI III software
 - Partial Least Square (PLS) regressions
 - Use (or not) of a 1st derivative pretreatment (1stDer)
 - ✓ Permits to correct the baseline drift
 - Detection of outlier spectrum
 - ✓ Based on PCA and Mahalanobis distance
 - Use (or not) of a repeatability file (RepFile)
 - ✓ Spectra from the same samples analysis on different spectrometers

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Material and methods

- MIR-Chemometric methods
 - Statistical parameters
 - ✓ Mean and standard deviation (SD)
 - ✓ Standard error of calibration (SEC)
 - ✓ Calibration coefficient of determination (R^2_c)
 - Internal validation by leave one out cross-validation

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Material and methods

- MIR-Chemometric methods
 - Statistical parameters to assess the accuracy
 - ✓ Standard error of cross-validation (SECV)
 - ✓ Cross-validation coefficient of determination (R^2_{cv})
 - Efficiency of calibration
 - ✓ $RPD = SD / SECV$

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Material and methods

- MIR-Chemometric methods
 - T-outlier test
 - ✓ Compare observed and predicted values
 - ✓ Samples with T outlier value > 2.5 were discarded
 - ✓ Maximum 5 tests performed

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Material and methods

- MIR-Chemometric methods
 - 4 methods tested
 - ✓ PLS
 - ✓ PLS + RepFile
 - ✓ PLS + 1stDer
 - ✓ PLS + 1stDer + RepFile

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Results

- Characterization of the 155 samples

Trait	Mean	SD
Fat (%)	3.81	1.03
Protein (%)	3.57	0.50
Lactose (g/100 mL)	4.83	0.27
DM (%)	12.82	2.57
SCS	3.18	1.96
pH	6.67	0.07
ILCY (g dry coagulum / 100 g milk DM)	62.8	12.6

DM = Dry Matter; SCS = Somatic Cell Score;
ILCY = Individual Laboratory Cheese Yield

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Coefficient of Variation = 20 %

DM = Dry Matter; SCS = Somatic Cell Score;
ILCY = Individual Laboratory Cheese Yield

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Results

- Observed correlations among milk components

	Fat	Protein	Lactose	DM	SCS	pH
ILCY	0.50***	0.47***	-0.20*	0.24**	0.31***	0.07 ^{NS}

ILCY = Individual Laboratory Cheese Yield; DM = Dry Matter;
SCS = Somatic Cell Score; * = P-value < 0.05;
** = P-value < 0.01; *** = P-value < 0.001; NS = non significant

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Results

- Calibration equations

Methods	No. outlier spectra	T-outlier test	
		Iteration	No. outlier
PLS	3	5	15
PLS + RepFile	3	5	23
PLS + 1 st Der	1	4	12
PLS + 1 st Der + RepFile	1	3	22

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Results

Similar R^2_C and R^2_{CV}
Low RPD

- Calibration equations

	PLS	PLS RepFile	PLS 1 st Der	PLS 1 st Der RepFile
N	137	129	142	132
SD	12.00	11.56	11.97	11.81
No. of factor	6	5	9	9
R^2_C	0.72	0.66	0.76	0.76
R^2_{CV}	0.68	0.62	0.66	0.68
RPD	1.75	1.61	1.70	1.76

SD = Standard Deviation; R^2_C = Calibration Coefficient of determination;
 R^2_{CV} = Cross-Validation Coefficient of determination;
RPD = ratio of SD to the standard error of cross-validation

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Results

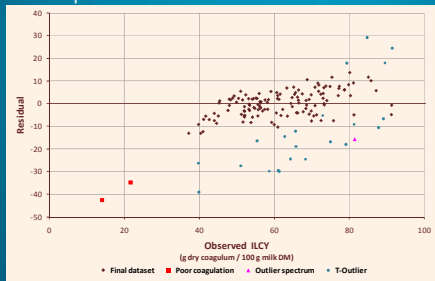
- Developed equation using PLS + 1stDer + RepFile
- Scatter plot of Observed vs. Predicted ILCY

SEC = 5.73
SECV = 6.72
 R^2_C = 0.76
 R^2_{CV} = 0.68
Slope = 1.03

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Results

- Developed equation using PLS + 1stDer + RepFile
- Scatter plot of Residuals vs. Observed ILCY



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Conclusions

- R^2_C and R^2_{CV} of developed equations
 - Interesting coefficients of determination
 - But < 0.80
- RPD < 2

➔ First results are promising for the prediction of an indicator for ILCY from MIR spectrum
 ➔ Dataset should be enriched with new samples in order to better control the variability

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Perspectives

- Improvement with additional samples
- Use of the developed equation
 - Walloon Database: 1,800,000 spectra
 - Study of ILCY variability in the Walloon dairy cattle
 - ✓ Detection of potential effects of breed, season, DIM...
 - Development of a genetic evaluation

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Thank you for your attention



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- Acknowledgments for financial support
 - European Commission (ERDF) and SPW – DGO3 through projects Interreg IVa BlueSel and D31-1255/S1
 - National Fund for Scientific Research through travel grant for attending EAAP annual meeting
- Acknowledgments for collaboration
 - Milk Committee of Battice (Belgium)
 - Walloon Breeding Association (AWE asbl)
 - Walloon dairy breeders

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