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
      - …

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

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**

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)**

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)

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

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

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

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

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

Material and methods

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

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

Results

- Observed correlations among milk components

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

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

Results

- Calibration equations

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

Results

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

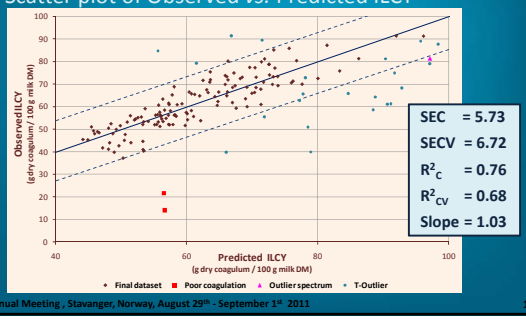
- Calibration equations

	PLS	PLS RepFile	PLS 1stDer	PLS 1stDer 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

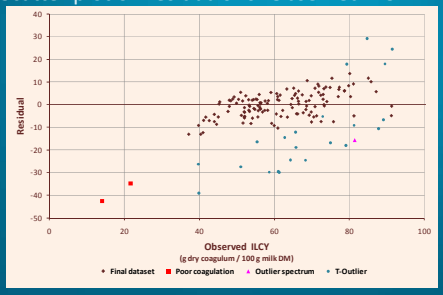
Results

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



Results

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



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**

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

Thank you for your attention

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