Mid-infrared prediction of cheese yield from milk and its genetic variability in first-parity cows

F.G. Colinet[1], T. Troch[1], S. Vanden Bossche[1], H. Soyeurt[1], O. Abbas[2], V. Baeten[2], F. Dehareng[2], E. Froidmont[2], G. Sinnaeve[2], P. Dardenne[2], M. Sindic[1], and N. Gengler[1]

[1] *University of Liège, Gembloux Agro-Bio Tech, Belgium*
[2] *Walloon Agricultural Research Center, Belgium*

Introduction

- Cheese manufacture and yield
  - Economical importance
  - Empirical and theoritical formula for cheese yield (CY)
    - Generally based on some factors:
      - ✓ Milk fat content
      - ✓ Milk protein content
      - ✓ Milk casein content
      - ✓ Moisture
      - ✓ Salt
      - ✓ …

Introduction

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

Objectives

- To determine CY of fresh milk at large scale
  - Expressed as fresh Individual Laboratory Cheese Yield (ILCYf)
  - Fast method using small quantity of milk
  - Adapted to Walloon dairy cattle (multi-breed)
  - MIR spectrometry already implemented in milk labs

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➔ **MIR chemometric method for ILCYf prediction**

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➔ **MIR chemometric method for ILCYf prediction**

- To study the genetic variability of predicted ILCYf
  - First-parity Holstein cows in Wallonia (Belgium)

MIR chemometric method

- Sampling
  - Wallonia
  - Spectra and reference data variability: several criteria
    - Milk sampling: individual or bulk milk
    - Breed: Dual Purpose Belgian Blue, Holstein, Red-Holstein, Montbeliarde and Jersey
    - Time of sampling: morning milking, evening milking mix of 50% morning & 50% evening milk samples

➔ **258 fresh samples collected**

MIR chemometric method

- Analysis
  - Milk lab (Comité du Lait, Battice, Belgium)
    - FT-MIR
  - Fresh Individual Laboratory Cheese Yield (ILCYf)
    - g coagulum / 100 g milk
    - Determined according to Hurtaud *et al.* 1995 (Ann. Zootech. 44, 385-398)
    - Intra-assay variation coefficient = 3.2%
    - Sample analyzed in duplicate

MIR chemometric method

- Methods
  - Modified Partial Least Square regressions (Shenk & Westerhaux, 1991)
  - Use of a first derivative pretreatment
    - To correct the baseline drift
  - Detection of spectral outliers
    - Based on Mahalanobis distance
  - Use of a repeatability file
    - Spectra from the same samples analyzed on different spectrometers

MIR chemometric method

- Methods
  - Internal cross-validation (50 groups)
    - To determine the number of factors
    - To assess the robustness of equation
  - T-outlier test
    - Compared observed and predicted values
    - Samples with T-outlier value > 2.5 were discarded
    - Maximum 5 tests performed

➔ **22 additional samples discarded**

MIR chemometric method

- Calibration equation
  - Statistical parameters of final dataset

Parameters	
Mean	26.8 g/100g
Standard deviation (SD)	6.5 g/100g
Range	34.1 g/100g (from 13.8 to 47.9)

  - Calibration

Parameters	
Standard error of calibration (SE_C)	2.6 g/100g
Calibration coefficient of determination (R^2_C)	0.83

MIR chemometric method

- Calibration equation
  - Statistical parameters to assess the accuracy

Parameters	
Standard error of cross-validation (SE_{CV})	2.8 g/100g
Cross-validation coefficient of determination (R^2_{CV})	0.81
RPD = SD / SE_{CV}	2.27
RER = Range / SE_{CV}	12.0

MIR chemometric method

- Calibration equation
  - Statistical parameters to assess the accuracy

Parameters	
Standard error of cross-validation (SE_{cv})	2.8 g/100g
Cross-validation coefficient of determination (R^2_{cv})	0.81
RPD = SD / SE_{cv}	2.27 > 2
RER = Range / SE_{cv}	12.0 > 10

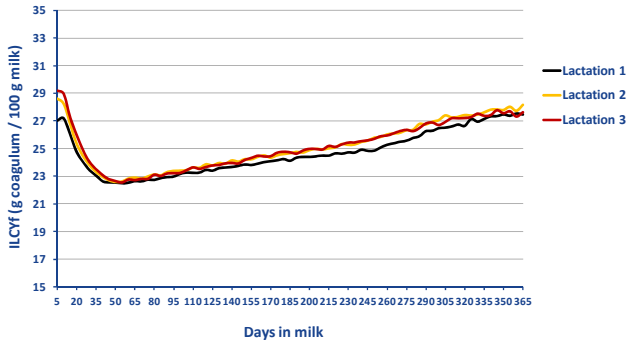
➔ **Calibration equation: good practical utility**

Result: Prediction

- Data editing
  - Walloon MIR spectral database
    - > 2 500 000 spectra
    - Routinely collected since 2007 by milk recording
  - Outliers discarding
    - Based on Mahalanobis distance computing using 234 MIR spectra of the final calibration dataset as reference
      - ✓ Upper standardized Mahalanobis distance cut off : 3
    - Below 0.5 percentile and above 99.5 percentile

Result: Prediction

- Averaged MIR predicted ILCYf throughout first three lactations

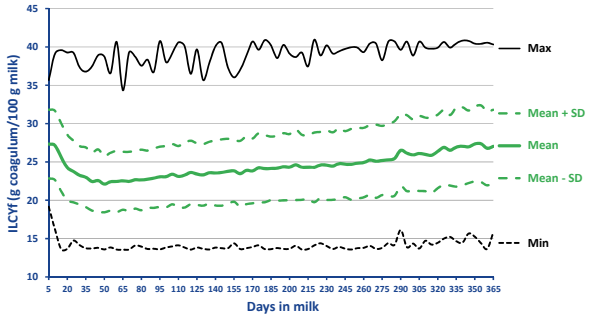


Genetic variability

- Data editing
  - After edits:
    - 7 870 first-parity Holstein cows from 101 herds
      - ✓ Cows with ≥ 4 predicted ILCYf and known parents
      - ✓ > 58 000 animals in extracted pedigree file
    - > 51 000 records for MIR predicted ILCYf

Genetic variability

- Data
  - Average MIR predicted ILCYf = 24.2 g/100g (± 4.5 g/100g)
  - MIR predicted ILCYf throughout first lactation



Genetic variability

- Single-trait random regression animal test-day model

$$y = X\beta + Q\,(Zp + Za) + e$$

Genetic variability

- Single-trait random regression animal test-day model

$$y = X\beta + Q\,(Zp + Za) + e$$

- β = fixed effects
  - Herd x test day
  - Lactation stage (classes of 5 days)
  - Gestation stage
  - Age at calving x season of calving x lactation stage

Genetic variability

- Single-trait random regression animal test-day model

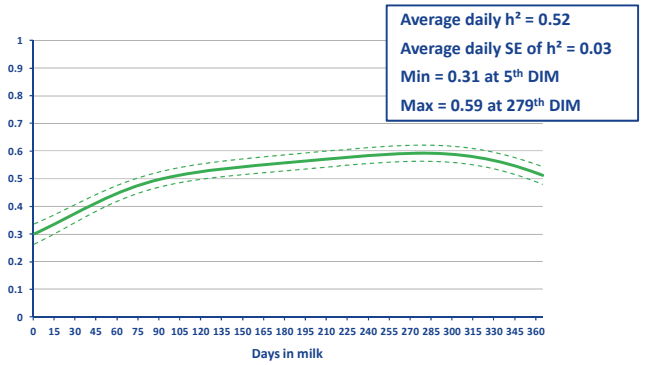
$$y = X\beta + Q\,(Zp + Za) + e$$

- p = permanent environment random effect
- a = additive genetic random effect
  - Regression curves modelled with 2nd order Legendre polynomial

- Variances components estimated by AIREMLF90 (Misztal, 2012)

ILCYf heritability

- Daily heritability throughout first lactation



Conclusions

- MIR chemometric methods
  - Developed equation
    - R^2_{cv} = 0.81
    - RPD > 2 and RER > 10
  - ➔ **Good practical utility**
  - ➔ **Results are promising for the prediction of fresh Individual Laboratory Cheese Yield from MIR spectrum**
- Genetic variability study
  - Moderate daily heritability
  - ➔ **Potential of selection for ILCYf**

Next steps

- Improvement with new samples
- Study of phenotypic and genetic correlations of ILCYf with
  - milk production traits
  - other milk components
  - milk technological properties
- Feasibility/opportunity to develop a genetic evaluation ?

Thank you for your attention

- Acknowledgments for financial support
  - Service Public de Wallonie SPW – DGO3 and European Commission (ERDF) through projects D31-1255/S1 **ProFARMilk** and INTERREG IVA **BlueSel**
- Acknowledgments
  - CECI for computational resources
  - Milk Committee of Battice
  - Walloon Breeding Association (AWE asbl)
  - Walloon dairy breeders

Corresponding author's e-mail: Frederic.Colinet@ulg.ac.be