Mid-infrared predictions of milk titratable acidity and its genetic variability in first-parity cows

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Mid-infrared predictions of fresh milk collected (October 2009–June 2010)

- Fresh milk
  - Some components: carbon dioxide, citrates, casein, albumin/globulin and phosphates
  - Buffer action
- Developed acidity results from bacterial activity
  - Lactic acid
  - Collection, transportation, and transformation of milk
- Influence on rennet-coagulation properties

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Objectives

- To determine TA of fresh milk at large scale
  - Fast method using small quantity of milk
  - Adapted to Wallon dairy cattle (multi-breed)
  - MIR spectrometry already implemented in milk labs
- MIR chemometric method for TA prediction
- To study the genetic variability of predicted TA
  - First-parity Holstein cows in Wallonia (Belgium)

Sampling

- Wallonia (Belgium)
- Variability of spectra: 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 or mix of 50% morning & 50% evening milk samples
- 607 fresh samples collected (October 2009 – June 2010)
**MIR chemometric method**

- **Analysis**
  - Milk Lab (Comité du Lait, Battice, Belgium)
  - FT-MIR
  - Titratable acidity
    - Recorded as Dornic degree ($D^*$)
    - N/9 NaOH solution
    - Indicator: Phenolphthalein

- **Methods**
  - **Internal cross-validation (100 groups)**
    - To determine the number of factors
    - To assess the robustness of equation
  - **T-outlier test**
    - Compare observed and predicted values
    - Samples with T-outlier value > 2.5 were discarded
    - Maximum 5 tests performed
  - **41 additional samples discarded**

**MIR chemometric method**

- **Methods**
  - **Modified Partial Least Square regressions**
  - Use of a first derivative pretreatment
    - To correct the baseline drift
  - Detection of spectral outliers
    - Based on Mahalanobis distance
    - **7 samples discarded**
  - Use of a repeatability file
    - Spectra from the same samples analysis on different spectrometers

**MIR chemometric method**

- **Calibration equation**
  - Statistical parameters of final dataset
    - Mean = 16.63 $D^*$
    - Standard deviation (SD) = 1.80 $D^*$
    - Range = 12 $D^*$ (from 10.50 to 22.50 $D^*$)
  - **Calibration**
    - Standard error of calibration = 0.77 $D^*$
    - Calibration coefficient of determination ($R^2$) = 0.82

**MIR chemometric method**

- **Data editing**
  - Walloon MIR spectral database
    - > 2 000 000 spectra
    - Routinely collected since 2007 by milk recording
  - **Outliers discarding**
    - Based on Mahalanobis distance computing using 451 MIR spectra of the final calibration dataset as reference
    - Below 0.5 percentile and above 99.5 percentile
Genetic variability study

- Data editing
  - After edits:
    - 16 457 first parity Holstein cows from 153 herds
    - > 93,000 records for milk, fat, and protein traits
    - > 92,000 records for somatic cell score (SCS)
    - > 64,000 records for lactose content
    - > 46,000 records for pH

- Correlations among observations at the same day

- Single-trait random regression animal test-day model
  \[ y = X\beta + Q(Zp + Za) + e \]
  - \( \beta \) = fixed effects
  - \( p \) = permanent environment random effect
  - \( a \) = additive genetic random effect
  - \( Z \) = regression curves modelled with 2nd order Legendre polynomial
  - Variances components estimated by AIREDMLF90 (Misztal, 2012)
**Conclusions**

- **MIR chemometric methods**
  - Developed equation
    - $R^2_{cv} = 0.80$
    - RPD > 2 and RER > 10
  - Good practical utility
- Results are promising for the prediction of titratable acidity from MIR spectrum

**Next steps**

- Improvement with new samples
- Study of genetic correlations of TA with
  - milk production traits
  - other milk components
  - milk properties
- Optimum for TA in milk?

**Thank you for your attention**

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