Potential estimation of titratable acidity in cow milk using mid-infrared spectrometry

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Context

- Interest of MIR spectrometry
  - Review of Soyeurt H., ICAR 2010
  - The technological abilities of milk

Context

- Estimation of technological abilities
  - Finer and more accurate estimations
    - ✓ Better support to farmers/producers
    - ✓ Finer management of the herd
    - ✓ Improve transformation yields

Context

- Cheese making process
  - Global cheese yield
  - Milk coagulation properties
    - ✓ up to 40 % of variation among cows **(Ikonen *et al.*, 2004)**
- Factors influencing milk coagulation kinetics
  - Coagulation enzyme
  - Protein and calcium contents in milk
  - Temperature
  - Acidity **(O'Callaghan et al., 2001)**

Context

- Titratable acidity (TA)
  - TA influences all phases of milk coagulation
  - Developed acidity results from bacterial activity
    - ✓ Lactic acid
    - ✓ Collection, transportation, and transformation of milk
  - Fresh milk
    - ✓ Some components: carbondioxide, citrates, casein, albumin/globulin and phosphates
    - ✓ Buffer action

Objective

- To investigate the potential use of MIR spectrometry in order to predict TA
  - TA recorded as Dornic degree
  - Walloon Region of Belgium
  - Multibreed

Material and methods

- Sampling
  - Walloon Region of Belgium
  - Large 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 or mix of 50 % morning & 50 % evening milk samples

Material and methods

- Analysis
  - 225 samples
  - Milk Lab (Comité du Lait, Battice, Belgium)
    - ✓ MIR Foss MilkoScanFT6000 spectrometer
    - ✓ Analysed traits: fat, protein, free fatty acid (FFA), urea, lactose, dry matter (DM), somatic cell count (SCC) and pH
    - ✓ SCC ➔ Somatic Cell Score (SCS)

Material and methods

- Analysis
  - Titratable acidity
    - ✓ Recorded as Dornic degree (D°)
    - ✓ 0.1 N NaOH solution
    - ✓ Consumption of NaOH to shift the pH value from 6.6 to 8.4 (phenolphthalein)

Material and methods

- Calibration procedure
  - First derivative pretreatment
  - Partial least square regressions
  - 22 outliers
  - Statistical parameters
    - ✓ Mean and standard deviation (SD)
    - ✓ Standard error of calibration (SEC)
    - ✓ Calibration coefficient of determination (R^2_C)

Material and methods

- Calibration procedure
  - Cross-validation
    - ✓ To determine the number of factors
    - ✓ To assess the accuracy of equation
    - ✓ Partitioning randomly the calibration set: 102 groups
  - Statistical parameters to assess the accuracy
    - ✓ Standard error of cross-validation (SECV)
    - ✓ Calibration coefficient of determination (R^2_{CV})
    - ✓ RPD = SD / SECV

Results

- Characterization of the samples

Trait	Mean	SD
Fat (%)	3.88	1.03
Protein (%)	3.49	0.52
FFA (mmol/100 g of Fat)	5.63	8.62
Urea (g/100 mL)	0.023	0.011
Lactose (g/100 mL)	4.85	0.35
DM (%)	12.66	1.25
SCS	3.31	1.90
pH	6.69	0.09
TA (D°)	16.27	2.27

* FFA = Free Fatty Acid; DM = Dry matter; SCS = somatic cell score; D° = Dornic degrees.

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Coefficient of Variation = 14 %

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Results

- Observed correlations among milk components

	Fat	FFA	Protein	Urea	Lactose	DM	SCS	pH
TA (D°)	0.04^{NS}	0.13^{*}	0.39^{***}	0.18^{**}	0.21^{**}	0.26^{***}	-0.16^{*}	-0.32^{***}
Fat	-	0.41^{***}	0.42^{***}	0.13^{*}	-0.19^{**}	0.89^{***}	0.18^{**}	-0.18^{**}
FFA		-	0.68^{***}	0.41^{***}	-0.17^{**}	0.50^{***}	0.04^{NS}	-0.38^{***}
Protein			-	0.30^{***}	-0.07^{NS}	0.69^{***}	0.10^{NS}	-0.26^{***}
Urea				-	0.18^{**}	0.25^{***}	-0.18^{**}	-0.01^{NS}
Lactose					-	0.11^{NS}	-0.40^{***}	0.66^{***}
DM						-	0.07^{NS}	-0.06^{NS}
SCS							-	-0.19^{**}

FFA = Free Fatty Acid; DM = Dry matter; SCS = somatic cell score; D° = Dornic degrees.
* = *P*-value < 0.05; ** = *P*-value < 0.01; *** = *P*-value < 0.001; NS = non significant.

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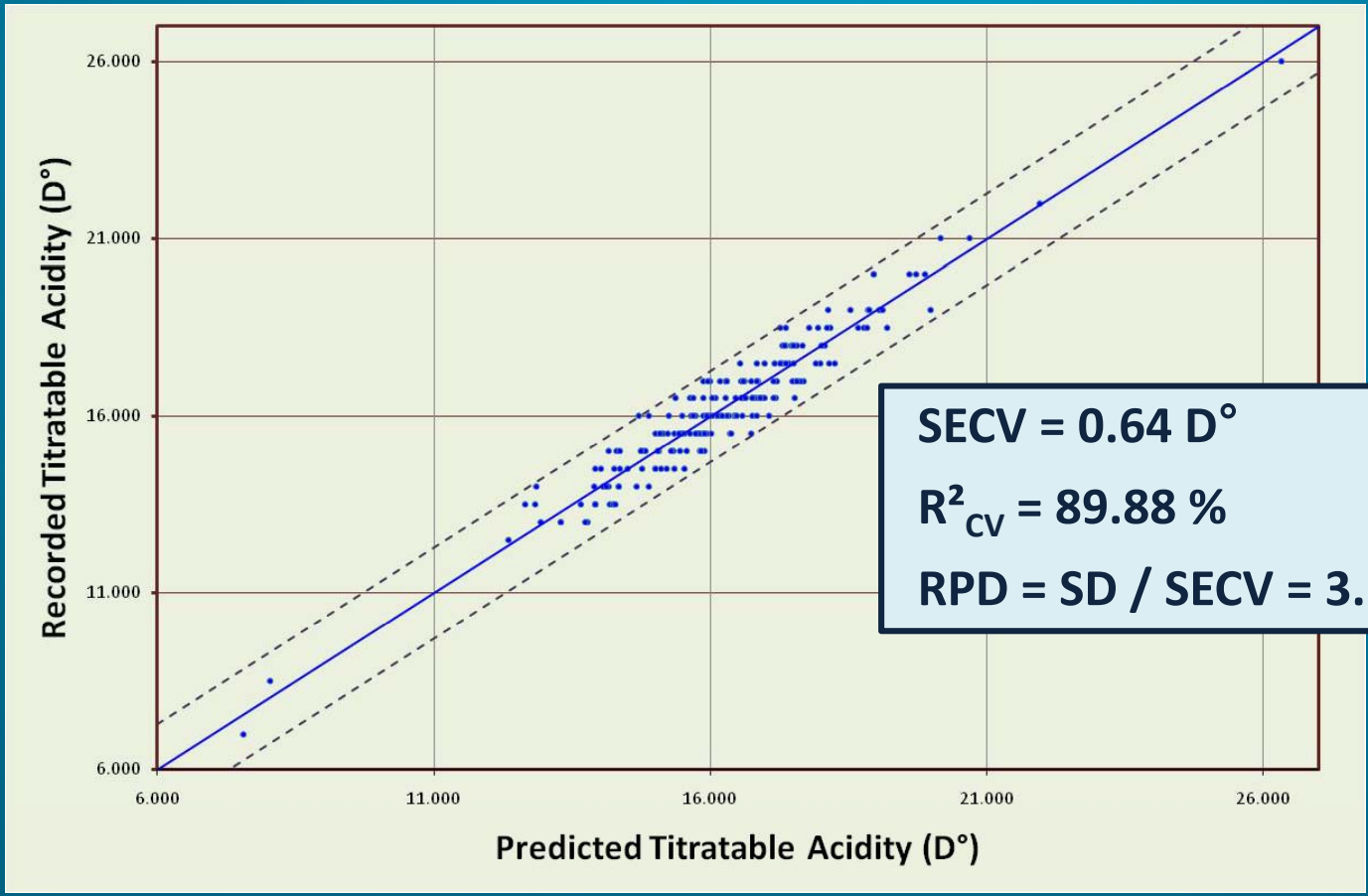
Results

- Statistical parameters
  - 10 factors
  - Mean ± SD = 16.22 D° ± 2.01 (n = 203)
  - SEC = 0.56 D°
  - R^2_C = 92.25 %

Results

- Cross-validation



Conclusions

- R^2_C and R^2_{CV}
  - High and around 90 %
  - Higher than observed correlations (max 39 %)
- RPD > 2

➔ Feasibility of TA prediction in bovine milk from MIR spectrum

➔ Calibration equation: good predictor and usable in most applications (including research)

Perspectives

- Validation with new set of samples
- Use of this equation
  - Walloon Database: 900,000 spectra
  - Study of TA variability in the Walloon dairy cattle
    - ✓ Detection of potential effects of breed, season, DIM...
  - Development of a genetic evaluation
  - TA breeding values + others traits = a new economic index for cheese making abilities ?

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