

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

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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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SCS	2.21	1.00
pH	Coefficient of Variation = 14 %	
TA (D°)	16.27	2.27

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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

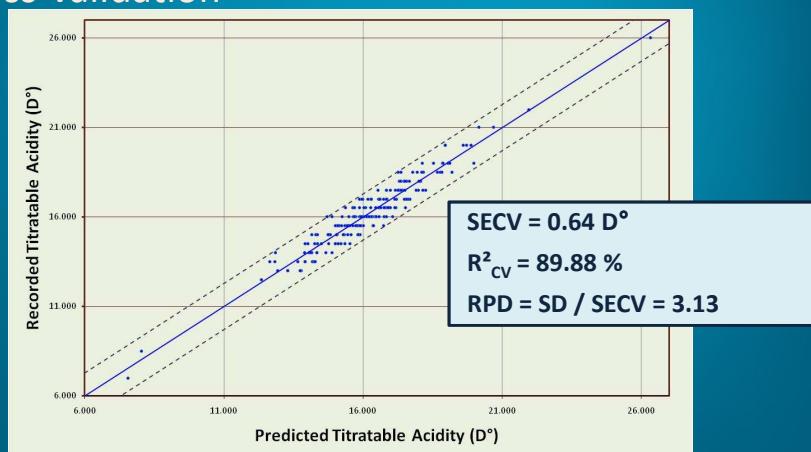
- 10 factors
- Mean ± SD = 16.22 D° ± 2.01 (n = 203)
- SEC = 0.56 D°
- R²_C = 92.25 %

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Results

■ Cross-validation



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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)

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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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- Walloon dairy breeders

