Prediction of blood ß-hydroxybutyrate content in early-lactation New Zealand dairy cows using milk infrared spectra

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Hyperketonemia

- Blood ß-hydroxybutyrate (**BHB**) concentration ≥ 1.2 mmol/L
- Increased occurrence of clinical ketosis, other health disorders, reduced fertility (Compton et al., 2015)
- Herd-level incidence ~68% in the first 5 wk of lactation (Compton et al., 2015)

- National infrared predictions of milk BHB not yet available in NZ
- An alternative is to predict blood BHB concentration

Objective

- To evaluate the ability of milk IR spectra to predict
  - the concentration of BHB in blood
  - the occurrence of hyperketonemia

  in pasture-grazed, early-lactation New Zealand dairy cows

    - for large-scale phenotyping for selective breeding
    - for on-farm management purposes

Dataset

- 553 cows (HO and HOxJE)
- 2 farms (seasonal-calving, pasture-based dairy system)
- Milk infrared spectra collected once a week → Milko-Scan FT1 (Foss Electric A/S, Hillerød, Denmark)
- Blood "prick" sample taken 3 times/wk (1-5 wk of lactation)
- Sampling at 7 am, before fresh allocation of pasture and supplementary feed
- BHB in blood measured using FreeStyle Optimum™ Blood Glucose Monitoring System (Abbott Diabetes Care Ltd., UK)
- June - October 2016

Data analysis

- Average of the 2 measures of blood BHB closest to spectra acquisition
- The regions of the spectra between 1,628 and 1,658 cm^{-1}, 3,105 cm^{-1} and 3,444 cm^{-1}, and 2,966 to 5,010 cm^{-1} were removed
- After outlier elimination
  - 1,910 spectra + BHB
  - from 542 cows
- Spectra transformed using EMSC + 1st derivative

Quantitative prediction models

- PLS regression with a 10-fold cross-validation (R package PLS, Mevik & Wehrens, 2007)…
- 2/3 of the cows in calibration and 1/3 in validation, randomly selected → 10 replicates
- All the records from a cow were in either the calibration or the validation subset

	N Cows	N spectra
Calibration	360	1,267
Validation	182	643

Fitting of quantitative models

- Average fitting statistics (SD) obtained across 10 calibration-validation partitions

	N	#terms	RMSEP	R^2
Calibration	1,267 (11)	24 (4.1)	0.28 (0.01)	0.56 (0.03)
Validation	643 (11)		0.32 (0.03)	0.50 (0.05)

- N: number of records in the datasets
- #terms: number of optimal partial least square components
- RMSEP: root mean squared error of prediction

Discriminant models

- Partial least squares discriminant analysis (**PLS-DA**; Lê Cao et al., 2011), using the R package mixOmics (Rohart et al., 2017)
- 1.2 or 1.4 mmol/L used as a diagnostic reference
- Models developed and tested on the same calibration-validation sets created for testing the quantitative prediction models
- Statistics:
  - Global accuracy
  - Sensitivity
  - Specificity
  - Area under the curve (AUC)
  - Positive predicted value
  - Negative predicted value

Accuracy of discriminant models

	Thresholds			
	BHB ≥ 1.2 mmol/L		BHB ≥ 1.4 mmol/L	
	Calibration	Validation	Calibration	Validation
Prevalence, %	10.1	10.8	6.3	7.1
Global accuracy, %	84.0	81.8	87.4	84.9
Sensitivity, %	81.9	76.2	85.2	76.3
Specificity, %	84.3	82.5	87.5	85.4
Positive predicted value, %	37.1	34.6	31.5	28.2
Negative predicted value, %	97.6	98.9	98.0	98.0
AUC, %	91.6	88.0	94.8	90.9

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Limitations

- Blood metabolites vary considerably in time (reliability of the reference measures)
- Possible time lag between the release of metabolites in blood and modification of milk composition
- Reference values produced by the ketone meter are one-digit values (discrete vs continuous variation)
- The dataset included samples from 2 farms and 1 season only (pasture quality and quantity impact on cow performance)

Conclusions

- The developed prediction models might be used to provide breeding organizations with indicator traits for ketosis
- Potential use as a management tool in New Zealand
  - Infrared spectroscopy will not provide accurate measurements at an individual level, but it can provide information at herd level

What's next

- More samples and farms!
- Measures of other blood metabolites
- Estimates of genetic parameters of the predicted blood BHB and its relationship with production and reproduction
- Genomic predictions for BHB concentration
- Application of other existing calibration equations for milk or blood ketone bodies to New Zealand milk samples ?
- Join reference data from different countries to create more robust equations ?

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