Prediction of blood β-hydroxybutyrate and hyperketonemia based on milk mid-infrared spectra in dairy cows

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ZUCHT DATA

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Introduction

- ✓ Hyperketonemia occurs due to an excessive energy deficit in early-lactation dairy cows
- ✓ Detected by blood metabolites, such as β-hydroxybutyrate (BHB)
- ✓ Biochemical composition of milk is linked to health status and metabolism
- ✓ Mid-infrared (MIR) spectroscopy is routinely used to measure milk composition
- ✓ MIR spectra are thus a potential alternative to predict blood BHB content and identify cows at risk for hyperketonemia

Aim

- ✓ Develop prediction equations for blood BHB concentration using milk MIR spectroscopy
- ✓ Discriminate cows with hyperketonemia from healthy ones

Methods

Dataset

- ✓ 1005 observations of daily BHB concentration and MIR spectra
- ✓ BHB measured from capillary cow blood by a handheld device
- ✓ 1st and 2nd test-day in early lactation
- ✓ September 2020 to March 2021
- ✓ 662 Fleckvieh and Holstein cows from 49 farms

Prediction models

- ✓ Regression analysis for **BHB concentration** (log10 transformed)
- ✓ Discrimination analysis for **hyperketonemia class** (based on BHB threshold)
- ✓ Prediction variables: **212** selected 1st derivative **MIR spectra & test-day variables** (i.e. milk yield, fat%, protein%, lactose%, days in milk, lactation)
- ✓ 10-fold random external validation by cow or farm
- ✓ Different machine learning algorithms: **Partial least squares** (PLS), **Support Vector Machine** (SVM), **Artificial Neural Network** (ANN)

Results

Table 1. Fitting statistics of BHB prediction models based on MIR spectra in different validation settings

	Validation by cow			Validation by farm		
	PLS	**SVM**	**ANN**	**PLS**	**SVM**	**ANN**
RMSE	0.240	0.235	0.240	0.272	0.267	0.257
R	0.555	0.571	0.562	0.448	0.468	0.469
R^2	0.312	0.330	0.319	0.206	0.224	0.225
RPD	1.117	1.190	1.199	1.030	1.040	1.084
RPIQ	1.429	1.472	1.496	1.229	1.294	1.342

RMSE = root mean square error; R = correlation between predicted and observed BHB; R^2 = coefficient of determination; RPD = ratio performance deviation; RPIQ = ratio performance interquartile distance.

Table 2. Performance of hyperketonemia classification models based on MIR spectra and test-day variables in different validation settings

	Validation by cow			Validation by farm		
	PLS	**SVM**	**ANN**	**PLS**	**SVM**	**ANN**
Global Accuracy	0.697	0.725	0.712	0.686	0.699	0.699
Sensitivity	0.678	0.705	0.677	0.636	0.686	0.650
Specificity	0.704	0.733	0.723	0.703	0.702	0.716
PPV	0.441	0.481	0.460	0.431	0.430	0.447
NPV	0.865	0.877	0.866	0.847	0.873	0.854

PPV = positive predictive values; NPV = negative predictive values.

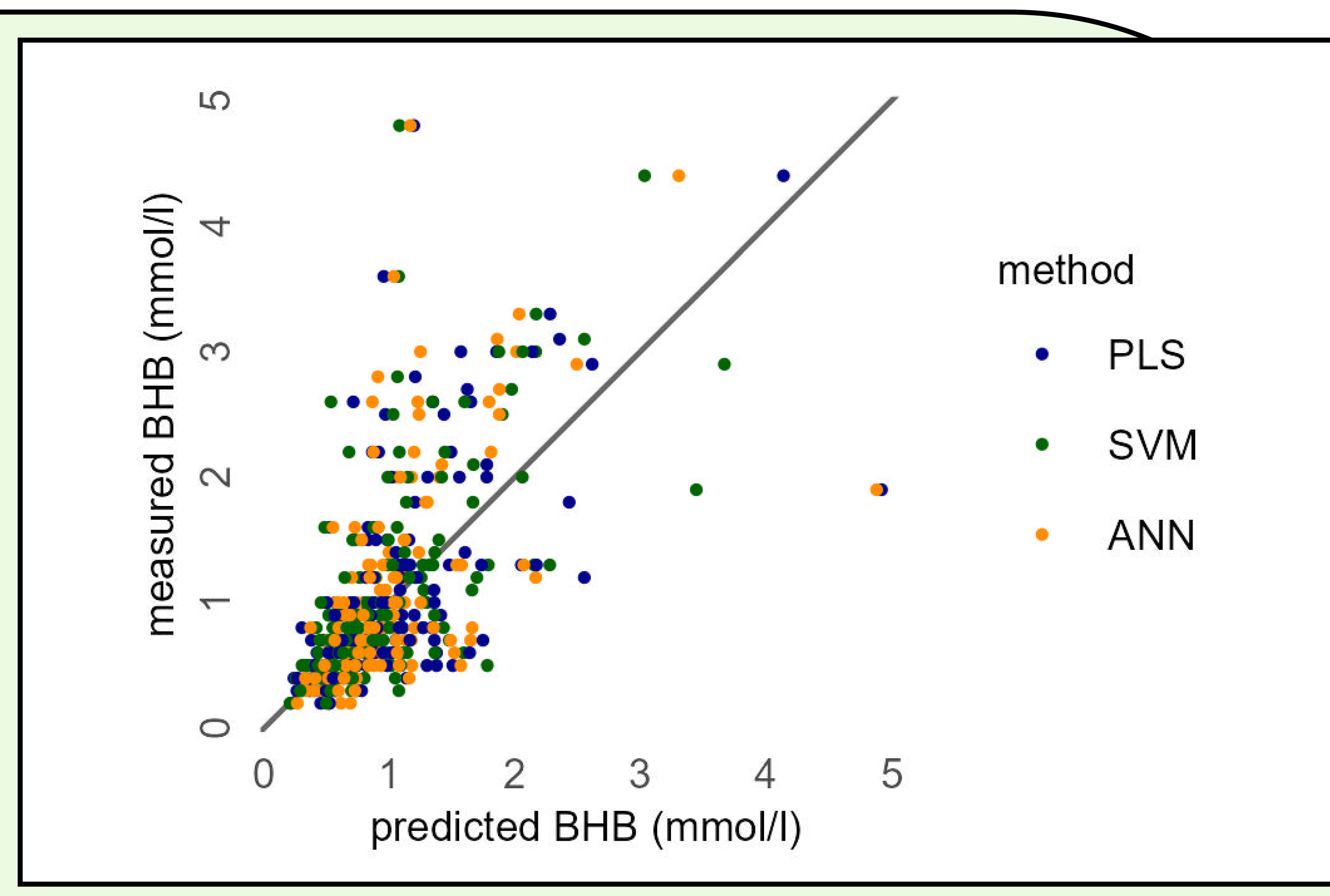

Figure 1. Relationship between measured and MIR-predicted BHB content in cow blood in validation by cow for different machine learning algorithms

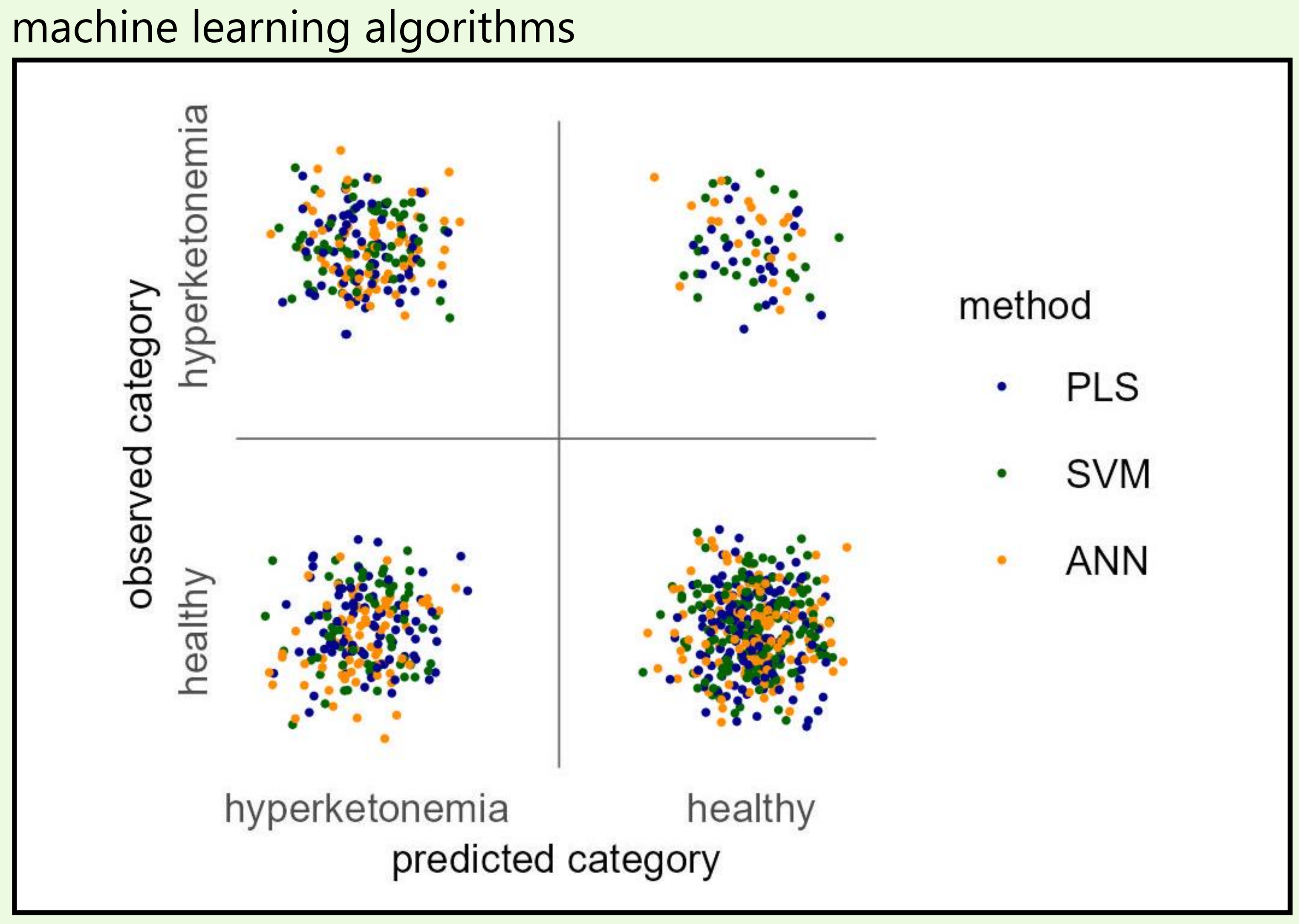

Figure 2. Comparison of observed and MIR-predicted hyperketonemia categories in validation by cow for different machine learning algorithms

Discussion

- ✓ Prediction of blood BHB concentration from milk MIR spectra possible but with moderate precision
- ✓ Classification of cows for hyperketonemia with reasonable accuracy
- ✓ However, high proportion of false positive classifications
- ✓ Various machine learning algorithms give similar results
- ✓ Results of developed models may be compared to currently implemented indicators for further assessment
- ✓ Genetic parameters of MIR-predicted BHB traits should be evaluated

Conclusion

- ✓ Potential to monitor cows with hyperketonemia using MIR spectral data
- ✓ Possibility to generate large-scale novel phenotypes for animal breeding

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