ENHANCING METABOLIC MONITORING DURING EARLY LACTATION USING NEFA IN BLOOD AS ADDITIONAL REFERENCE INDICATOR

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Introduction

- Hightest metabolic stress for cows occurs during early lactation
- Fat-protein-ratio in milk is important, but has limits
- Analytic standard for detection of hyperketonemia: Concentration of beta-hydroxybutyric acid (BHBA) in blood
- Indicator for fat mobilization: Concentration of non-esterified fatty acids (NEFA) in blood
- Higher concentrations of NEFA in blood are associated with health problems in cows as shown in a paper by Tremblay et al. 2018. J. Dairy Sci. 101 (8): 7311–7321

Dataset and prediction models

- Available datasets consist of milk sample analysis data with MIR FTIR spectra and blood samples collected between 5 and 50 days in milk
- Models use a traffic light system with two different references:

Concentration of NEFA in blood	Concentration of BHBA in blood and fat-protein-ratio (FPR)
Indicator for dangerous metabolic stress Early warning message	Indicator for risk of hyperketonemia Alert message
Cutoff-Values: Low Risk (NEFA < 0.39 mmol/l) Medium Risk (NEFA ≥ 0.39 mmol/l and < 0.7 mmol/l) High Risk (NEFA ≥ 0.7 mmol/l)	Cutoff-Values: Low Risk (BHBA < 1.2 mmol/l, FPR < 1.5) Medium Risk (BHBA ≥ 1.2 mmol/l or FPR ≥ 1.5) High Risk (BHBA ≥ 1.2 mmol/l and FPR ≥ 1.5)

- Linear Discriminant Analysis used as model algorithm
- Models use milk FTIR spectra, lactation number, day in milk and milk yield

Update of dataset and prediction models

- Models used since 2018 in a test phase, since 2019 routinely integrated in standard performance recording reports for farmers
- Predicted class decided using the posterior probability to belong to the Low Risk class with probability thresholds
- Original calibration dataset contained only dual-purpose Simmental cows (predominant breed in Bavaria)
- New data available for Holstein and Brown Swiss from Q Check and Bavarian follow up projects were combined with initial dataset

Initial dataset

- Farms: 26
- Animals: 381
- Samples: 1038

New dataset

- Farms: 103
- Animals: 4058
- Samples: 16923

- New models and evaluation!

Criteria for evaluation

- Important for the farmer: Accuracy of the status messages – percentage of correct status messages
- Limitation: Dependence on prevalence – the percentage of the reference classes in the calibration datasets
- Benchmark percentages:
  Percentage of correct green status messages = reference and prediction green -> Higher values are better
  Minimize percentage of incorrect red status messages = reference green and prediction red -> Lower Values are better

Datasets

- NEFA Reference
- Early Warning Messages

Reference Traffic Light Class	Initial Dataset Number of Samples/ Percentage		New Dataset Number of Samples/ Percentage	
Green	551	53	13038	78
Yellow	277	27	2671	15
Red	210	20	1214	7
All	1038		16923	

- BHBA/FPR Reference
- Alert Messages

Reference Traffic Light Class	Initial Dataset Number of Samples/ Percentage		New Dataset Number of Samples/ Percentage	
Green	782	75	12514	74
Yellow	214	21	3708	22
Red	42	4	701	4
All	1038		16923	

Change in prevalence for the NEFA reference -> New calibration necessary!

Prevalences New Dataset

- NEFA Reference
- Clear differences in prevalence between breeds

Reference Traffic Light Class	Simmental Samples / Prevalence %		Holstein Samples / Prevalence %		Brown Swiss Samples / Prevalence %	
Green	6095	70	5021	83	1922	86
Yellow	1652	19	764	13	255	111
Red	857	10	291	5	66	3
All	8604		6076		2243	

- BHBA/FPR Reference
- Smaller but existing differences between breeds

Reference Traffic Light Class	Simmental Samples / Prevalence %		Holstein Samples / Prevalence %		Brown Swiss Samples / Prevalence %	
Green	6352	74	4433	73	1729	78
Yellow	1863	22	1431	24	414	18
Red	389	5	212	3	100	4
All	8604		6076		2243	

Establish thresholds for each breed!

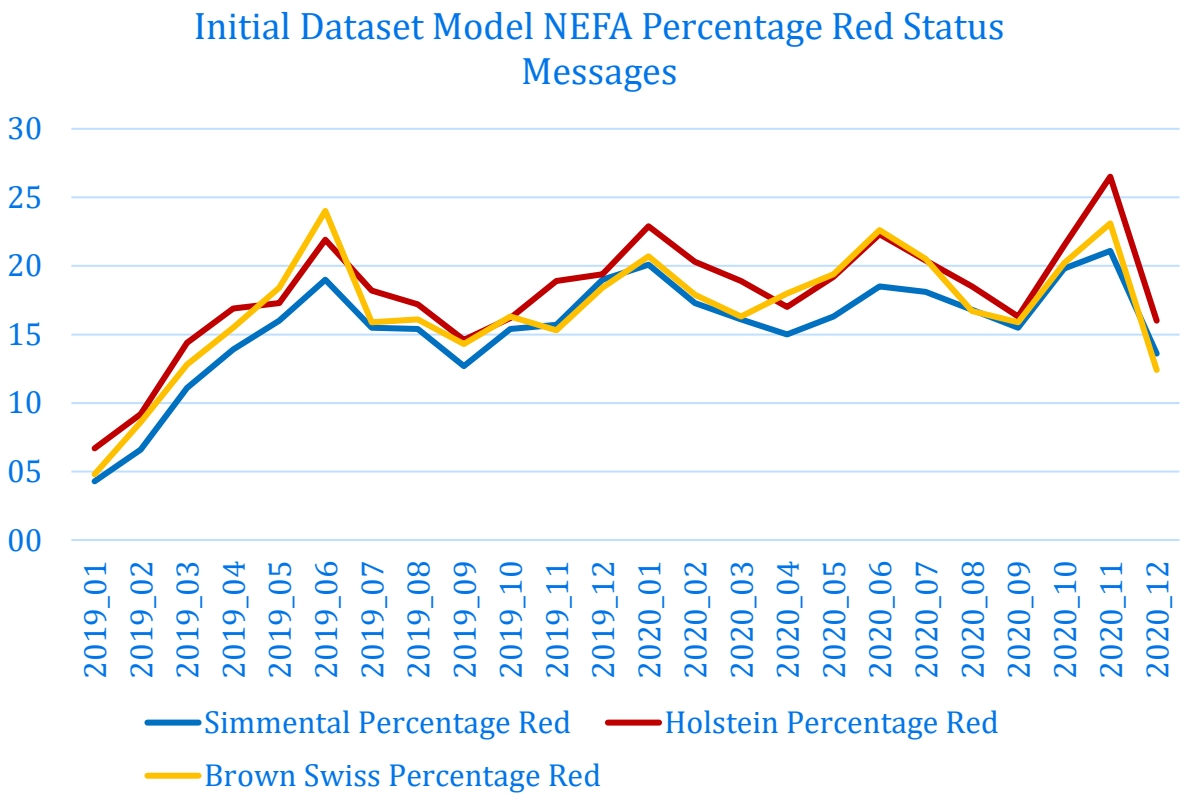
Results NEFA Reference

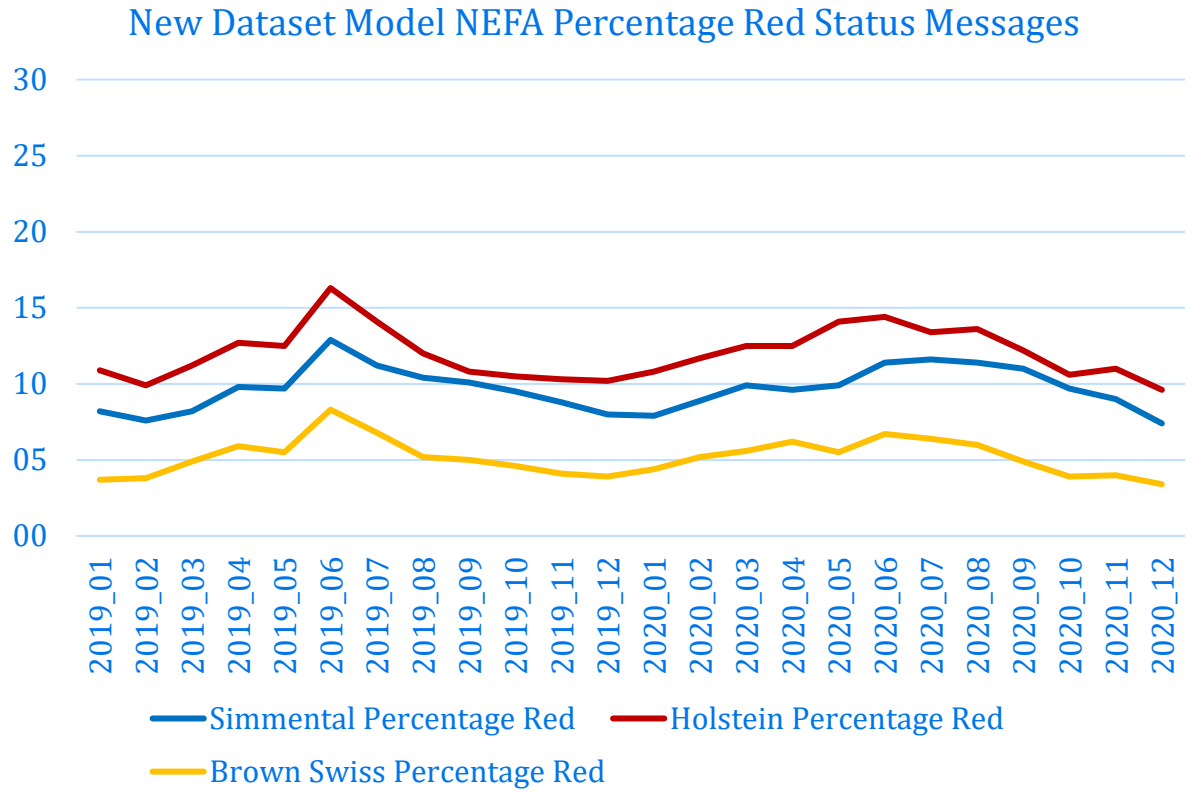
Initial Dataset				
Status Message	Samples	Ref. Green %	Ref. Yellow %	Ref. Red %
Simmental (Yellow < 80 %, Red < 5 %)				
Green	503	73	21	6
Yellow	401	41	32	27
Red	134	13	33	53

- Large improvements in correct green status messages
- Correct red status messages worse due to lower prevalence
- Acceptable for early warning

New Dataset				
Status Message	Samples	Ref. Green %	Ref. Yellow %	Ref. Red %
Simmental (Yellow < 77 %, Red < 16 %)				
Green	6122	85	13	2
Yellow	1277	50	35	15
Red	1205	20	36	44
Holstein (Yellow < 77 %, Red < 10 %)				
Green	5026	92	7	1
Yellow	635	51	36	13
Red	415	21	40	40
Brown Swiss (Yellow < 67 %, Red < 4 %)				
Green	1924	92	7	1
Yellow	224	53	35	12
Red	95	25	46	28

Long Term Comparison NEFA Reference





- Initial Models overestimated the red status messages due to the high prevalence in the calibration dataset
- Impact on farmers low to intermediate because information material stressed the warning character

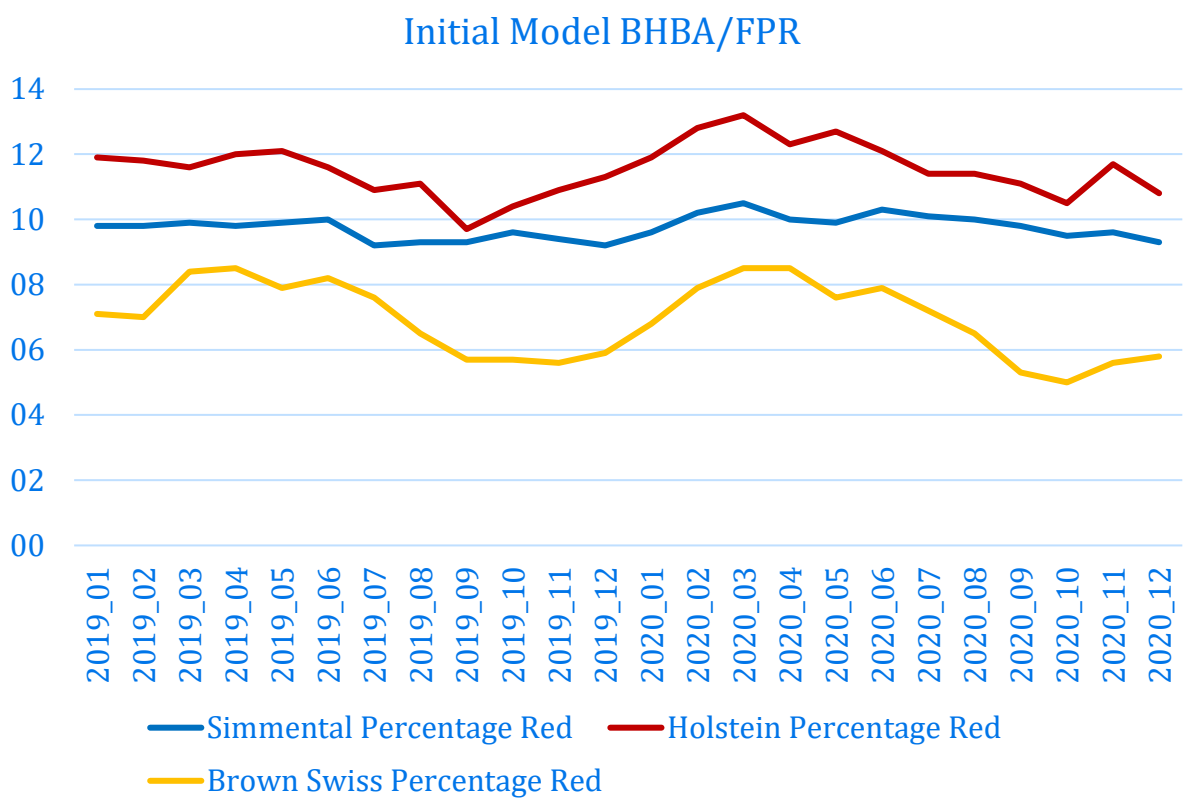
Results BHBA/FPR Reference

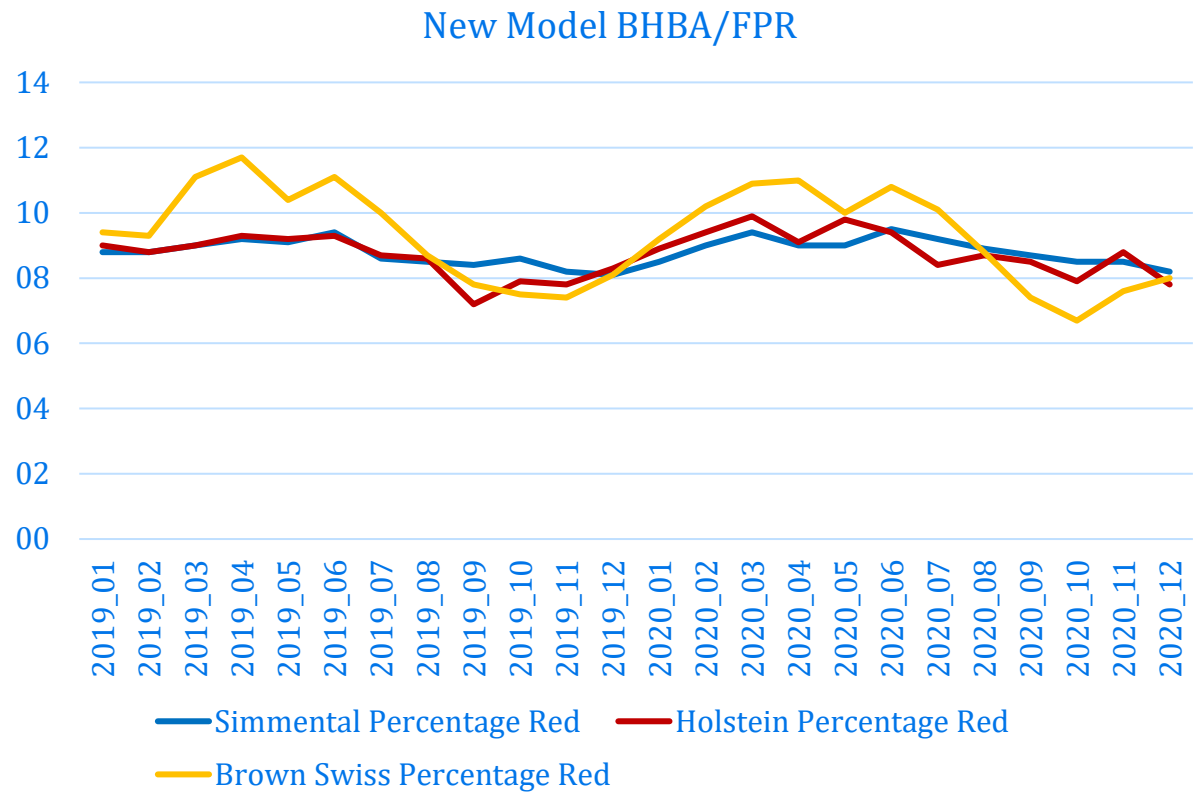
Initial Dataset				
Status Message	Samples	Ref. Green %	Ref. Yellow %	Ref. Red %
Simmental (Yellow < 38 %, Red < 5 %)				
Green	756	93	6	0
Yellow	179	42	50	8
Red	102	0	73	26

- New calibration achieves comparable quality
- Important improvement: Breed specific thresholds

New Dataset				
Status Message	Samples	Ref. Green %	Ref. Yellow %	Ref. Red %
Simmental (Yellow < 29 %, Red < 3 %)				
Green	6352	94	6	0
Yellow	1863	26	65	9
Red	389	0	65	35
Holstein (Yellow < 30 %, Red < 2 %)				
Green	4433	95	5	0
Yellow	1431	17	76	7
Red	212	0	69	31
Brown Swiss (Yellow < 37 %, Red < 7 %)				
Green	1734	94	6	0
Yellow	328	30	59	11
Red	181	0	65	35

Long Term Comparison BHBA/FPR Reference





- Initial Models overestimated red status for Holstein and underestimated for Brown Swiss – New Model and thresholds correct for breed
- Impact on farmers low to intermediate because differences seem acceptable

Conclusions

- Final evaluation of a model should be driven by what the farmer will see – look at the accuracy of status messages
- Results of a model evaluation depend on available data
- New data may require adjustments of models
- Development of models for metabolic monitoring is never truly complete – in addition to new data, new methods and algorithms should be considered

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Thank you for your attention