Phenotypic analysis of blood β-hydroxybutyrate predicted from cow milk mid-infrared spectra

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Hyperketonemia

- Abnormal concentrations of circulating ketone bodies;
- A frequent early lactation metabolic disorder;
- It occurs when the cow is unable to cope with the high energy demand for milk production in early lactation.

(Herdt, 2000; Duffield et al., 2009; McArt et al., 2013; Berge & Vertenten, 2014)

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Relevant economic losses for farmers

(Herdt, 2000; Duffield et al., 2009; McArt et al., 2013; Berge & Vertenten, 2014)

HYK indicator

- β-hydroxybutyrate (BHB) concentration in blood is commonly used to dignose HYK;

BLOOD BHB ANALYSIS

through:

- Reference laboratory quantification;
- Cow-side ketone tests for semi-quantitative measurements.

(McArt et al., 2013; Iwersen et al., 2009; Oetzel, 2004)

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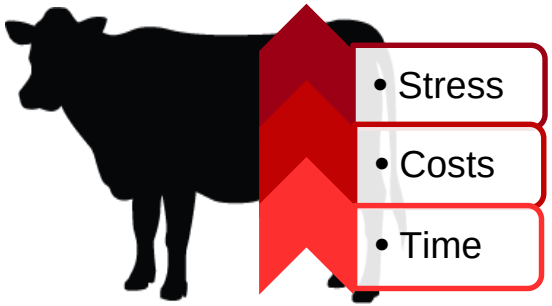
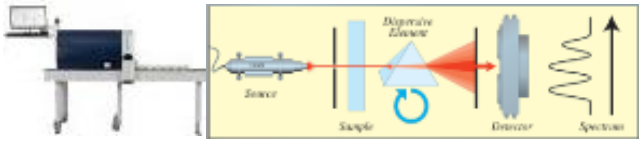




Mid-infrared spectroscopy useful tool to develop prediction models

(Grelet et al., 2019; Luke et al., 2019; Benedet et al., 2019)

Objective of the study

To investigate phenotypic variation of predicted blood BHB in the most important Italian cattle breeds

Data

- Large spectral dataset collected between 2011 and 2016;
- 707 multi-breed herds located in North Italy (Bolzano province);
- 32,706 first test-day record (5-35 days in milk) of Brown Swiss (13,579), Holstein-Friesian (10,559), and Simmental cows (8568);

Previously developed prediction model was applied to spectral data to obtain predicted blood BHB concentrations. (Benedet et al., 2019)

Blood BHB prediction model

Fitting statistics[1] of blood metabolites predictions in calibration and cross-validation (Benedet et al., 2019)

Trait[2]	n	Mean	SD	NV	LV	SEC	R^2	SECV	R^2_{cv}	RPD_{cv}
BHB, mmol/L	295	0.73	0.46	120	9	0.26	0.70	0.28	0.64	1.61
NEFA, mmol/L	294	0.48	0.34	50	7	0.22	0.57	0.23	0.53	1.45
BUN, mmol/L	294	3.76	0.96	90	10	0.60	0.61	0.65	0.54	1.47
Glucose, mmol/L	294	3.00	0.52	60	8	0.44	0.29	0.47	0.20	1.11
Triglycerides, mmol/L	293	0.09	0.02	50	7	0.02	0.25	0.02	0.16	1.12
Cholesterol, mmol/L	295	3.19	1.08	50	5	0.82	0.42	0.85	0.39	1.28
GOT, IU/L	294	97.06	32.43	50	4	27.49	0.28	28.34	0.24	1.14
GPT, IU/L	295	18.64	4.60	40	10	4.15	0.18	4.72	0.05	0.97

[1]n = number of samples; NV = number of variables; LV = latent variables; SEC = standard error of calibration; R^2 = coefficient of determination in calibration; SECV = standard error of prediction in cross-validation; R^2_{cv} = coefficient of determination in cross-validation; RPD_{cv} = ratio of performance to deviation in cross-validation;

[2]NEFA = non-esterified fatty acids; GOT = glutamic oxaloacetic transaminase; GPT = glutamic pyruvic transaminase.

Statistical analysis

$$y_{ijklmnop} = \mu + B_i + P_j + D_k + M_l + Y_m + H_n + (B \times P)_{ij} + (B \times D)_{ik} + (B \times M)_{il} + (P \times D)_{jk} + + cow_o\ (B_i) + \varepsilon_{ijklmnop}$$

FIXED EFFECTS:

B_i = breed>BS, HF, SI;

P_j = parity>first, second, third, fourth and later lactation;

D_k = days in milk>3 classes of 10 days each;

M_l = month of sampling>January to December;

Y_m = year of sampling>2011 to 2016;

H_n = herd>707;

RANDOM EFFECTS:

cow_o = cows>19,211;

Analysis of variance

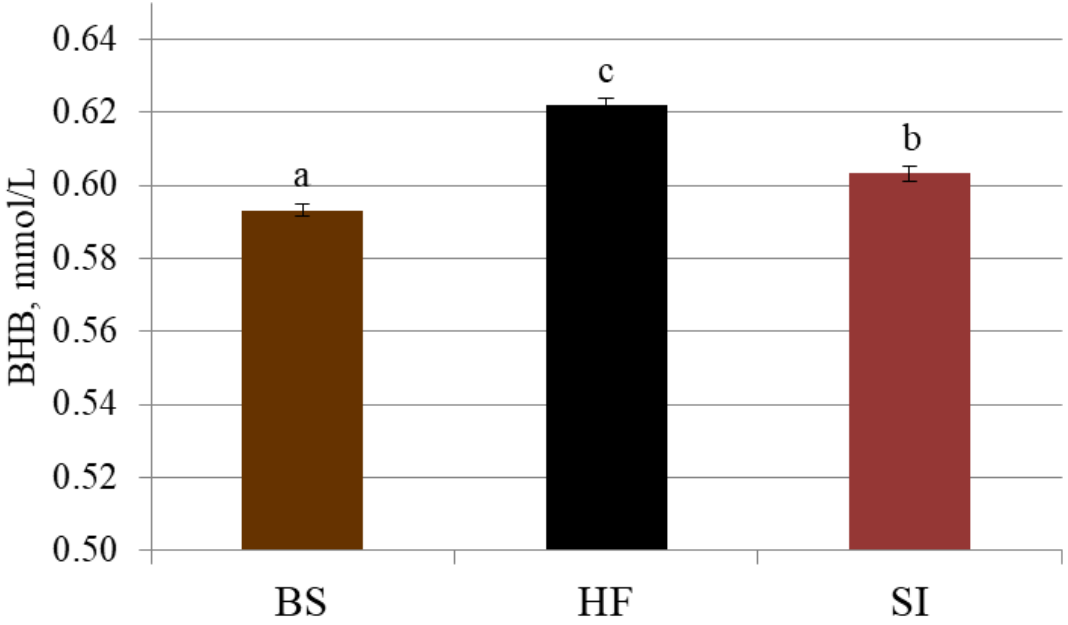
Significance of fixed effects included in the analysis for predicted blood BHB (N = 32,706)

Effect	Classes	Significance
Breed	3	***
Parity	4	***
DIM	3	***
Month	12	***
Year	6	***
Herd	707	***
Breed*Parity	3*4	***
Breed*DIM	3*3	***
Breed*Month	3*12	***
DIM*Parity	3*4	***

*** P < 0.001

Breed effect

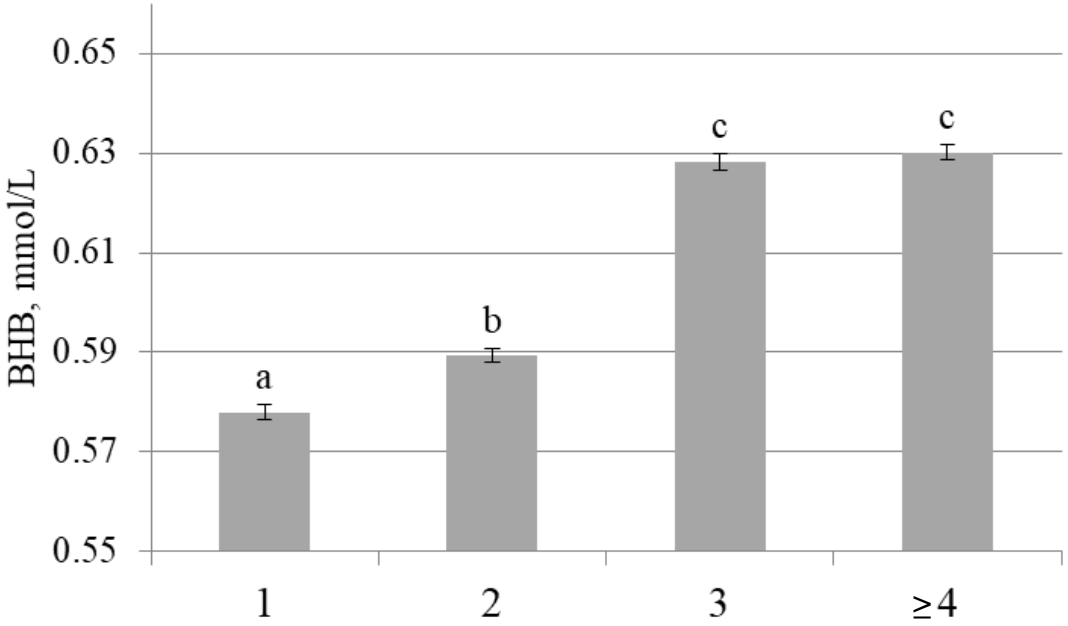
Least squares means of blood BHB in Brown Swiss (**BS**), Holstein-Friesian (**HF**), and Simmental (**SI**) cows



$^{a,b,c}P < 0.05$

Parity effect

Least squares means of blood BHB across parity



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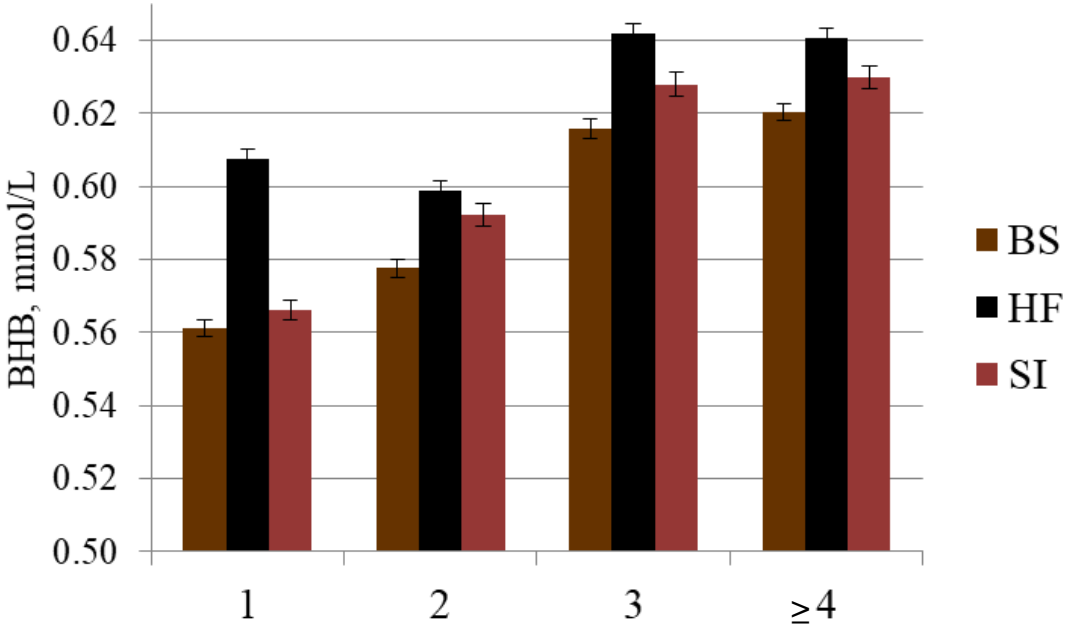
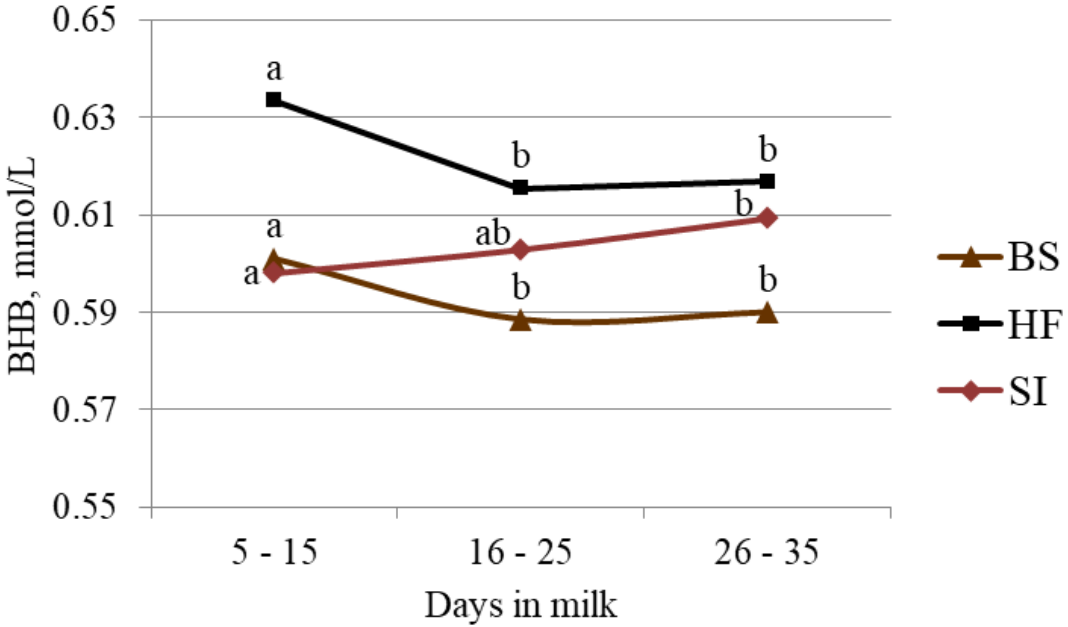
Parity*Breed effect

Least squares means of blood BHB across parity in Brown Swiss (**BS**), Holstein-Friesian (**HF**), and Simmental (**SI**) cows



DIM*Breed effect

Least squares means of blood BHB across early lactation in Brown Swiss (**BS**), Holstein-Friesian (**HF**), and Simmental (**SI**) cows



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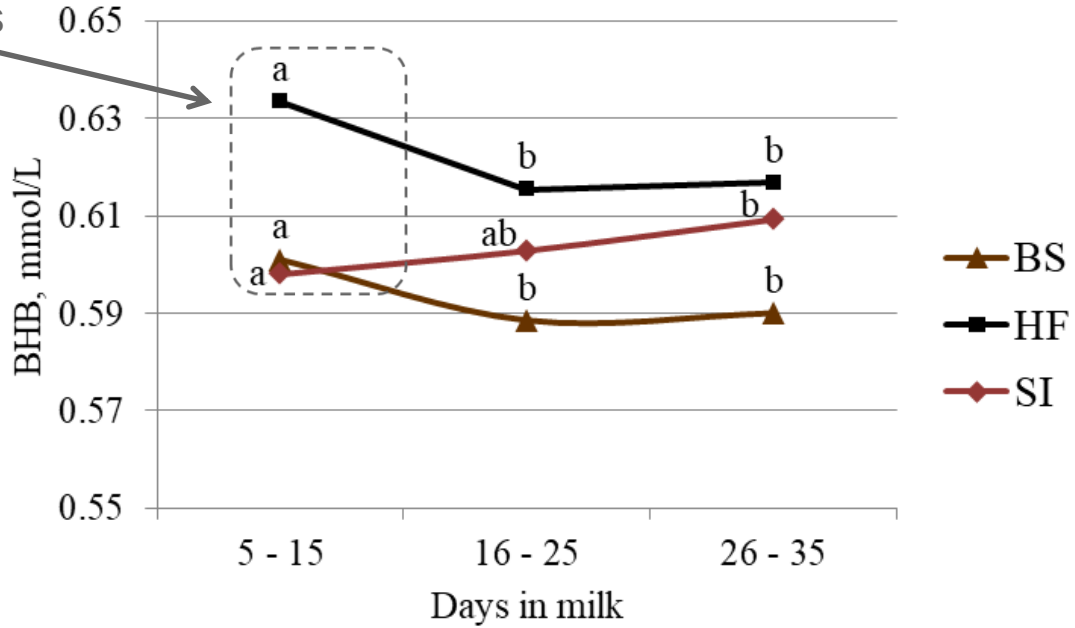
Multiparous animals



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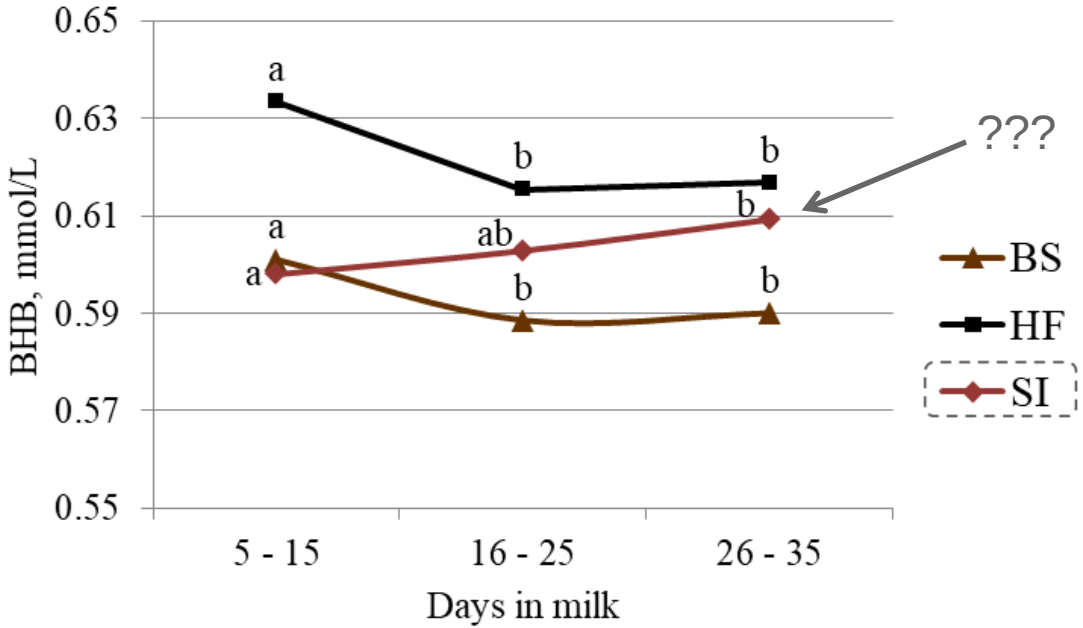

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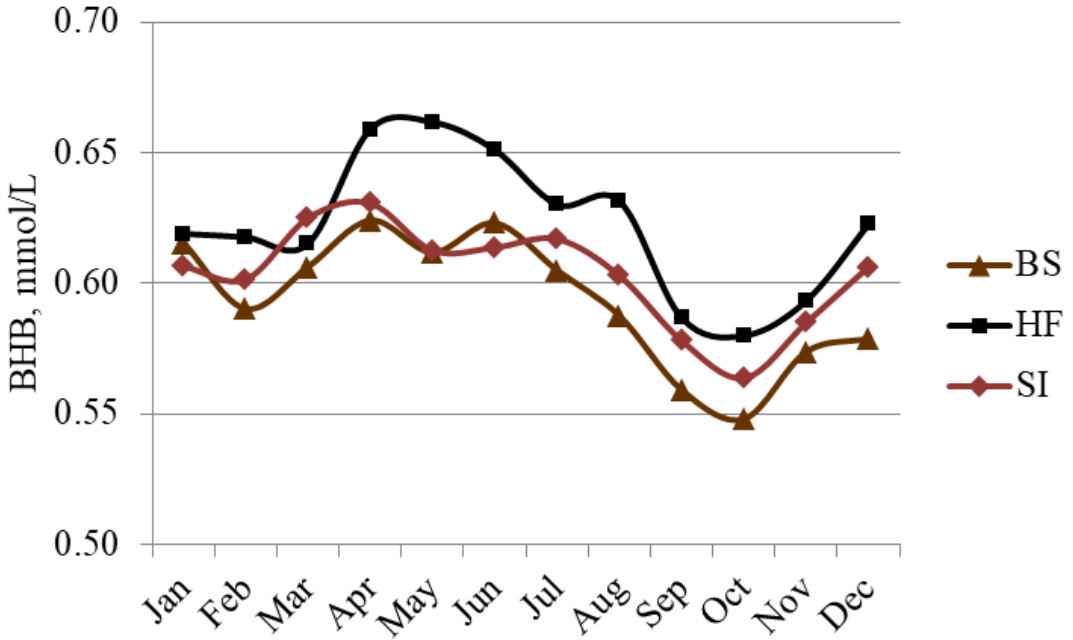
Month*Breed effect

Least squares means of blood BHB across month of sampling in Brown Swiss (**BS**), Holstein-Friesian (**HF**), and Simmental (**SI**) cows



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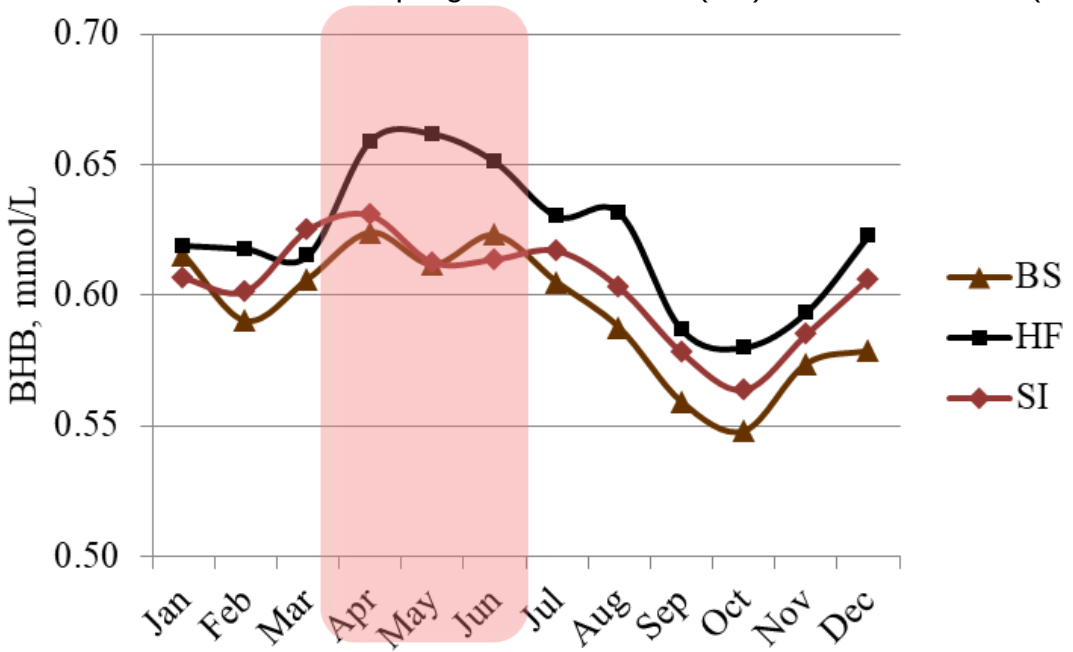

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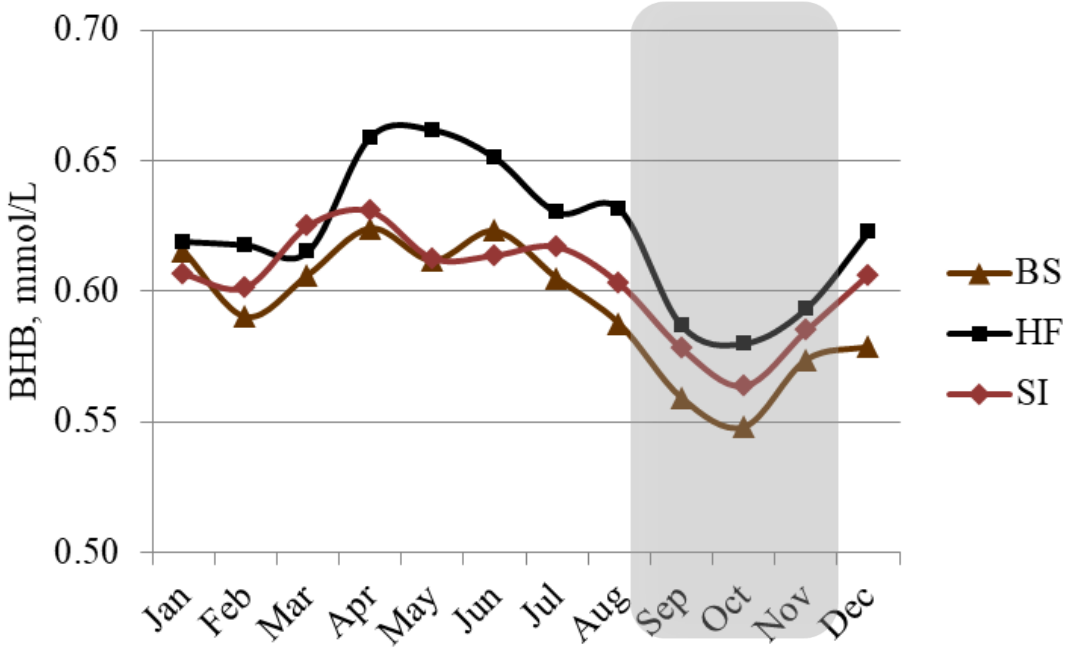

Conclusions and Perspectives

- HF showed the greatest BHB concentrations in blood;
- BHB increased with increasing parity and decreased across DIM (except for SI);
- The greatest BHB values were recorded in spring and early summer;

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MIRS prediction model for blood BHB useful to:

- easily collect data about early lactation cows;
- investigate the associated factors at a population level;
- identify environmental effects to include in within breed genetic evaluation of blood BHB.

Qualität
SÜDTIROL

Sennereiverband Südtirol
Federazione Latterie Alto Adige

Service rund um die Milch · Al servizio del settore latte

THANK YOU!

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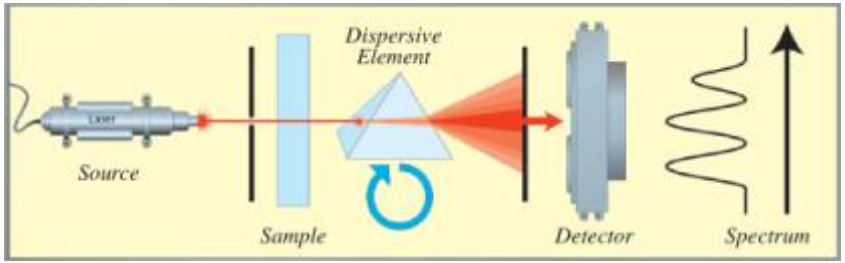
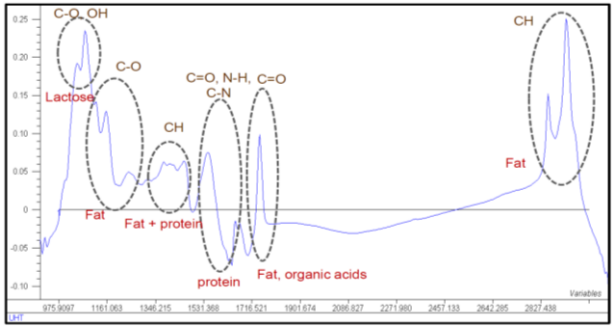
DAFNAE

Università degli Studi di Padova

Mid-infrared spectroscopy

- Mid-infrared (MIR) spectroscopy is the study of interaction between matter and electromagnetic radiation in the mid-infrared region (400-4000 cm^{-1});
- Fast and cost-effective method for predicting and recording milk composition traits;





- Position of the peaks → Qualitative analysis
- Intensity of the peaks → Quantitative analysis