Assessing the potential of faecal NIR spectra for the prediction of feed efficiency in dairy cows

[1]Silvia Ampuero Kragten, [2,3]Thorsten Haak, [3]Karl-Heinz Südekum, [2]Fredy Schori

[1]Agroscope, Method Development and Analytics, 1725 Posieux, Switzerland,
[2]Agroscope, Ruminant Nutrition and Emissions, 1725 Posieux, Switzerland,
[3]University Bonn, Institute of Animal Science, Bonn, Germany

Agroscope

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Confederation

Federal Department of Economic Affairs,
Education and Research EAER
Agroscope

UNIVERSITÄT BONN

fondation sur la croix

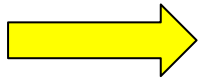
Content

- Feed efficiency
- Set up
- Materials & Methods
- NIR prediction models
- Conclusions

Agroscope

Background

- Improved feed efficiency (FE):
  More products (milk, meat) with less feed



Reduction of production costs
More sustainable production system

- AIM: Assess the potential of NIRS-faeces as a phenotyping tool to predict FE

FE expressed as:

- **FCR,** feed conversion ratio:
  dry matter intake (DMI) / energy-corrected milk yield
- **NUE,** nitrogen use efficiency:
  milk N yield / N intake per day
- **RFI, REI & RNI,** residual intake (feed, energy, nitrogen):
  effective – expected (DMI, energy & nitrogen) intake

Expected DMI, NE_L & nitrogen were derived from Swiss feeding recommendations for ruminants

Set up, 6 trials:

MIR spectra
- Liquid milk (76 x 3)
- MilkoScan RM (Foss)
- 920 -1'600 cm^{-1} & 1'689 – 3'008 cm^{-1}
- Standardized spectra (Grelet et al, J. Dairy Sci. 98:2150-2160)

NIR spectra
- Freeze dried faeces (132 x 3)
- Freeze dried milk (132 x 3)

Holstein (HO) & Swiss Fleckvieh (FT) → Adaptation period: 21 days → Measurement period: 7 days

(grazing – stall fed; primiparous –multiparous; mid – late lactation)

Milk (pooled per day) on days 1, 4 & 7
Faeces pooled per measurement period
(faeces of last trial also sampled as 3 days pool and 1 day)

Laboratory analysis
(milk, faeces, feed & feed leftovers)

Reference data calculation
(Feed conversion ratio: **FCR**;
Nitrogen use efficiency: **NUE**;
Residual feed, energy & N intake: **RFI, REI, RNI**)

PREDICTION MODELS

Agroscope

Set up, 6 trials:

year	2018	2018	2019	2019	2022	2022
N samples (132):	28	28	28	16	16	15
Farm	Sorens	Sorens	Sorens	Posieux	Posieux	Posieux
Feeding location	Pasture	Pasture	Pasture	Barn	Barn	Barn
Feeding treatment	-	-	-	-	*required potein	reduced protein
Breed	HO, FT	HO, FT	HO, FT	HO	HO	HO
Parity (% primiparous)	64	64	14	25	50	38
Days in Milk (d)	128 (±29)	222 (±35)	122 (±35)	233 (±18)	153 (±30)	147 (±24)
Milk (kg/d)	22.5 (±3.6)	16.0 (±3.6)	21.9 (±4.7)	22.6 (±3.0)	31.1 (±4.2)	29.5 (±5.1)
Body weight (kg)	577 (±43)	617 (±53)	618 (±43)	670 (±48)	691 (±56)	673 (±71)
DMI (kg DM/d)	14.0 (±2.1)	14.5 (±1.6)	15.6 (±1.8)	20.9 (±1.8)	23.3 (±1.8)	21.8 (±2.4)
Herbage	13.3 (±1.6)	14.2 (±1.6)	14.6 (±1.7)	19.9 (±1.8)	-	-
Concentrate	0.7 (±1.1)	0.3 (±0.3)	1.0 (±1.0)	0.7 (±0.0)	1.2 (±0.2)	1.3 (±0.2)
****Total mixed ration**	-	-	-	-	22.2 (±1.8)	20.5 (± 2.5)
FCR	0.66 (±0.08)	0.89 (±0.20)	0.79 (±0.13)	0.88 (±0.08)	0.68 (±0.05)	0.68 (±0.04)
NUE	0.29 (±0.03)	0.21 (±0.03)	0.30 (±0.06)	0.19 (±0.02)	0.33 (±0.03)	0.34 (±0.03)
RFI (kg DM/d)	-2.17 (±1.87)	-0.88 (±1.84)	-0.59 (±1.85)	0.17 (±1.48)	-0.59 (±1.48)	-0.78 (±1.31)
REI (MJ NEL/d)	-20.05 (±10.32)	-3.68 (±11.06)	-17.68 (±11.67)	2.86 (±7.16)	-14.84 (±9.35)	-14.74 (±8.13)
RNI (g N/d)	3.01 (±36.58)	91.5 (±45.61)	-8.36 (±49.25)	272.81 (±38.6)	76.93 (±28.71)	9.75 (±23.11)

*The Swiss "Feeding Recommendations for Ruminants": Green book, Agroscope Fütterungsempfehlungen für Wiederkäuer (admin.ch)

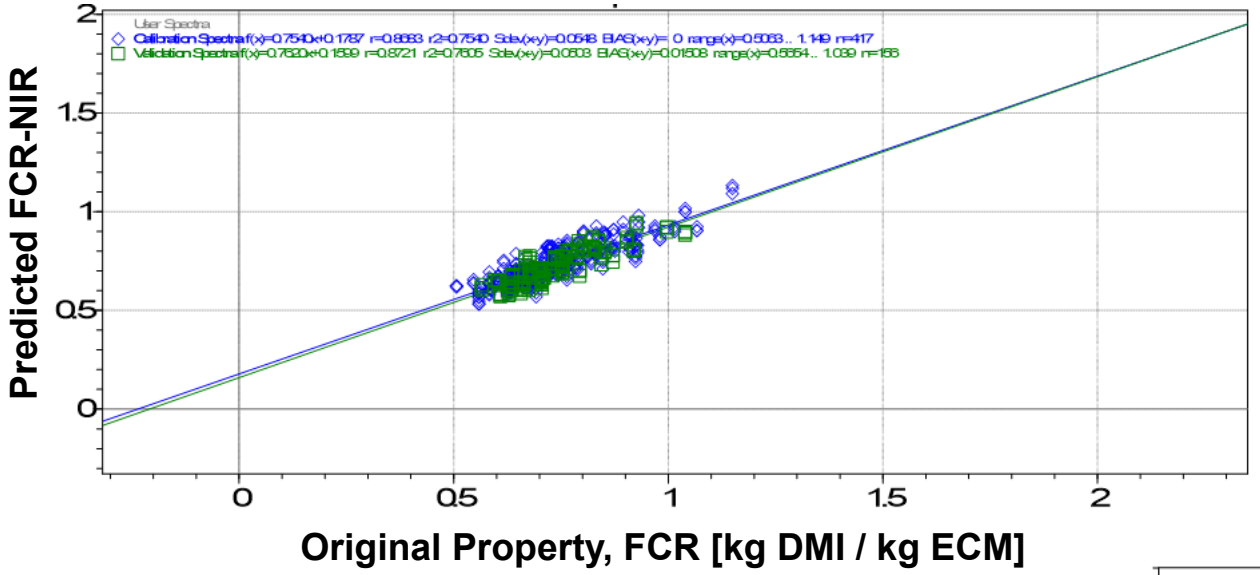
**TMR composition, on dry matter basis: 35.6 % corn silage, 23.1 % grass silage, 28.9 % dry forage, 11.1 % concentrates and 1.3 % minerals

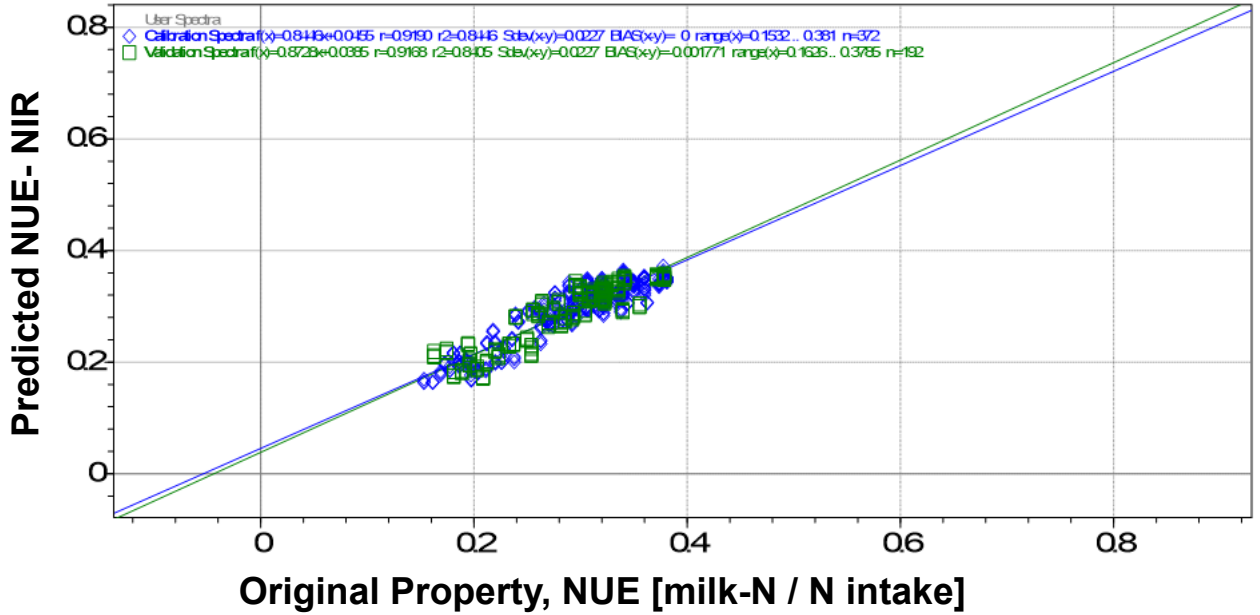
NIR

NIR spectra
- Freeze dried faeces (132 x 3)

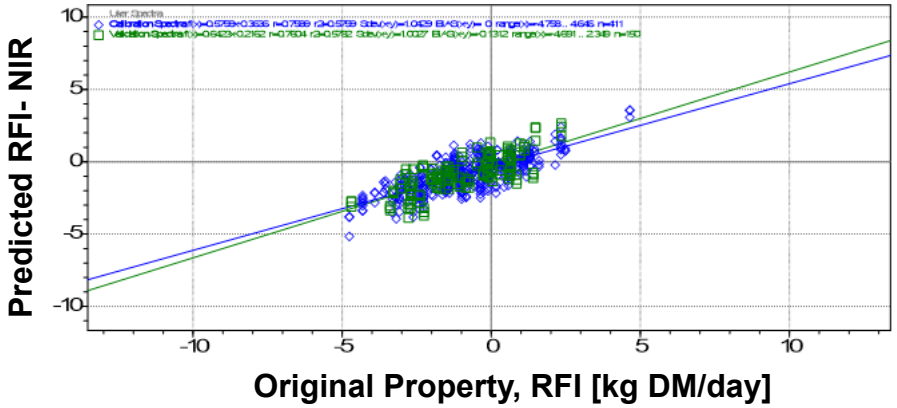
- **FT-NIR spectrometer** (NIRFlex N-500, Büchi, Switzerland)
  - Diffuse reflectance mode
  - Range: 10'000 – 4'000 cm^{-1} [1'000 – 2'500 nm]
  - Resolution: 8 cm^{-1}
  - Replicates: 3 (Average of 32 scans/replicate)
- **Faeces samples**
  - Freeze-dried & milled to 1 mm
- **Prediction Models**
  - PLS, 1st derivative BCAP gap 2, snv, mf
  - Independent validation with ~1/3 of available samples

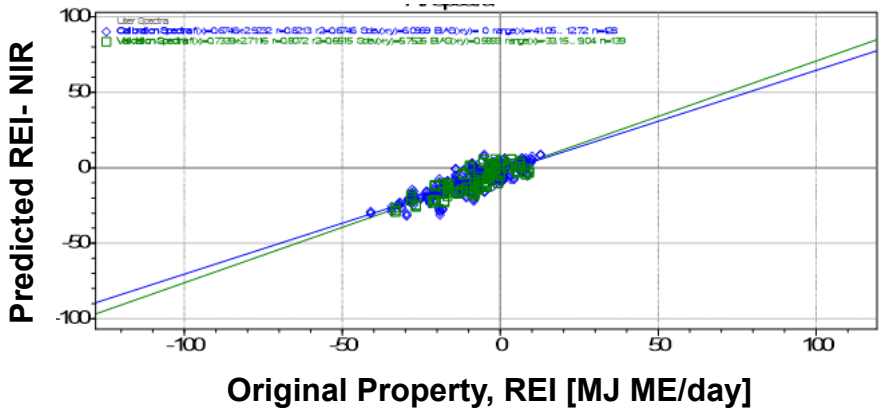
NIR-faeces prediction models for FE

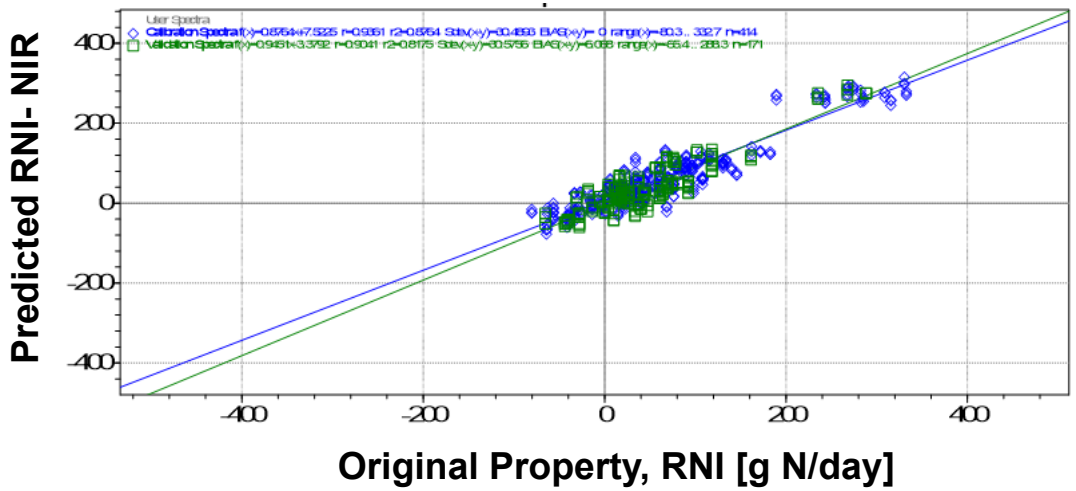




NIR-faeces prediction models for FE



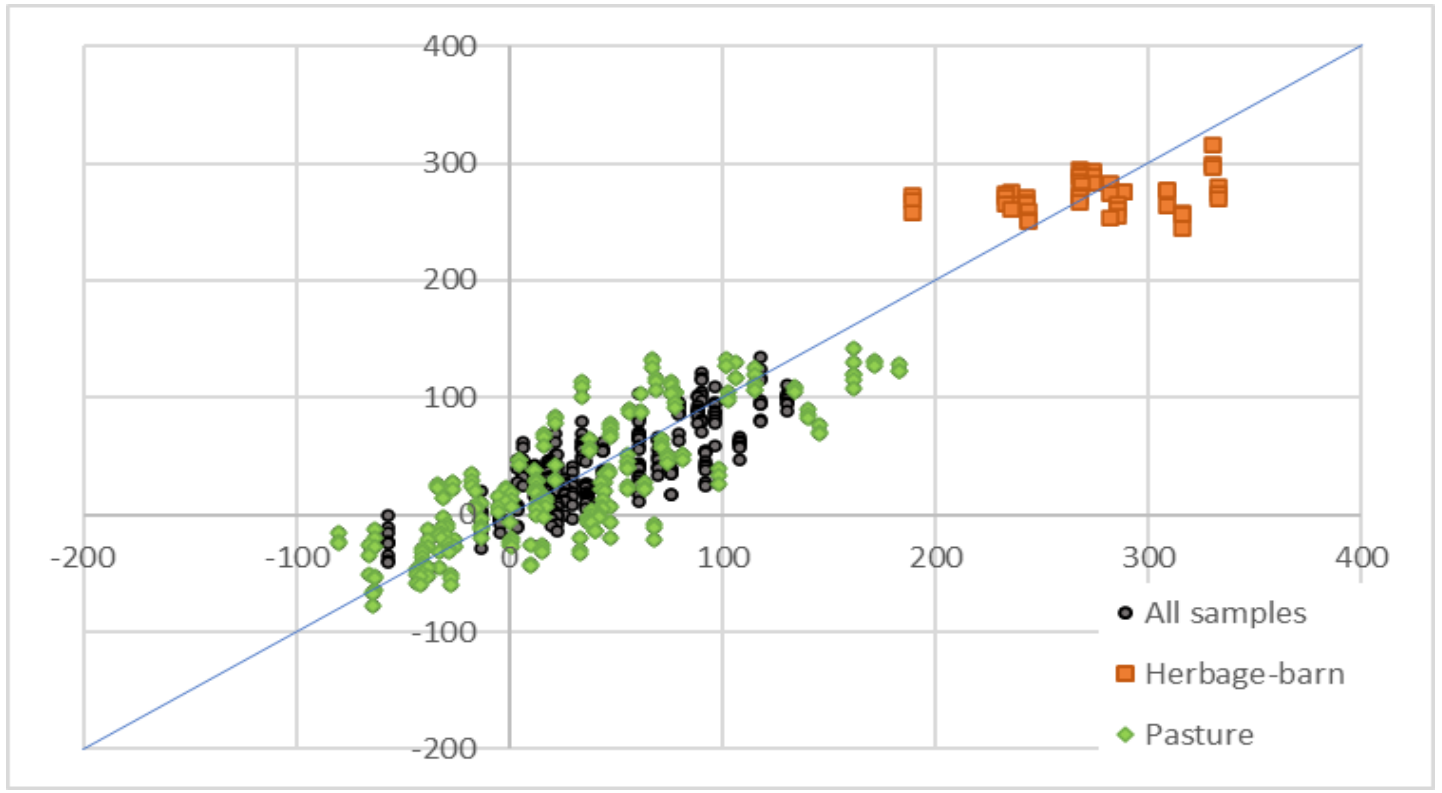




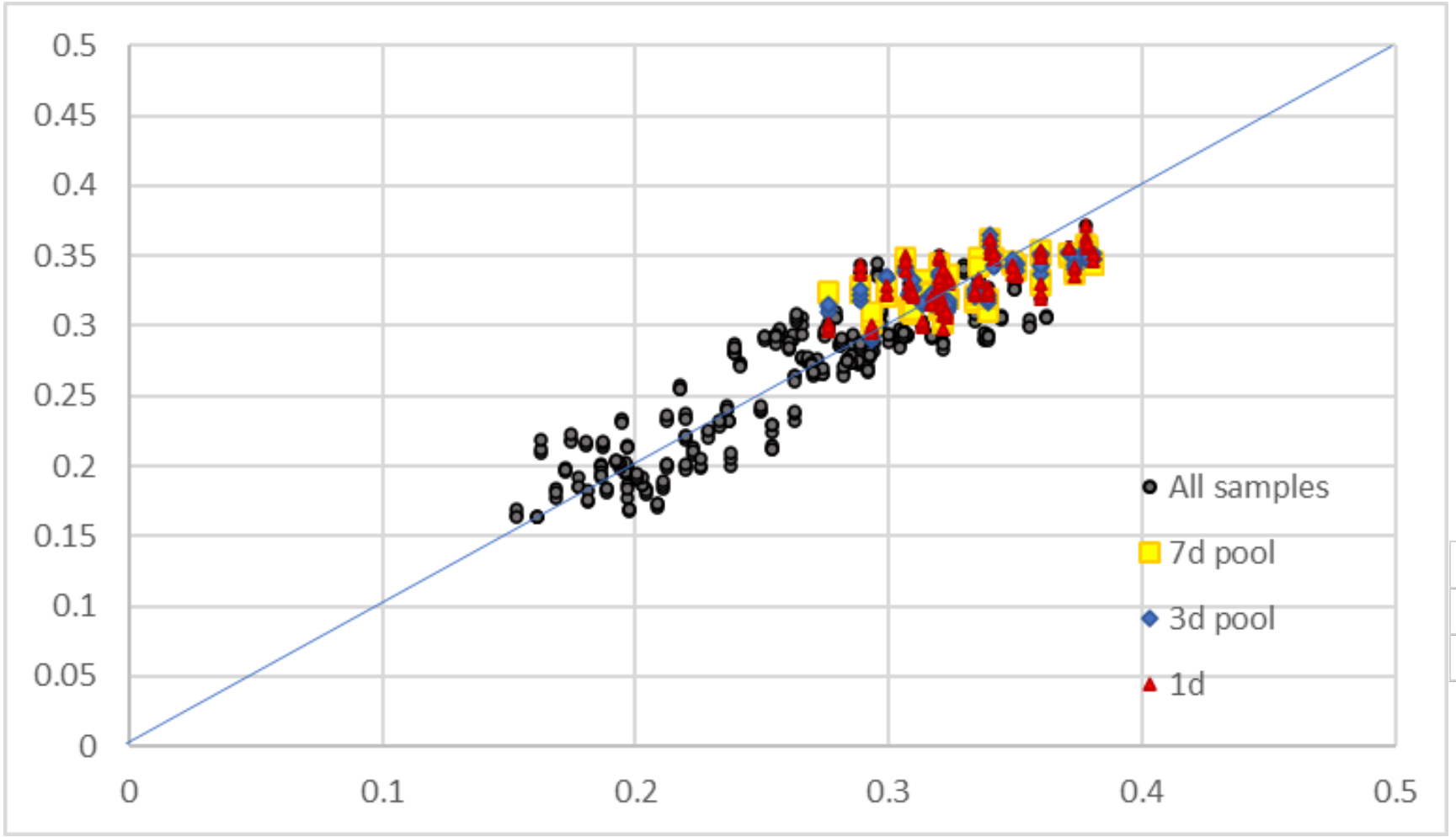
Performance statistics of NIR-faeces FE prediction models

	FCR [kgDMI/kgECM]	**NUE** [milk N/N intake]	**RFI** [kgDM/day]	**REI** [MJ ME/day]	**RNI** [g N/day]
Calibration Set min - max	0.51 - 1.07	0.15 - 0.42	-5.8 - 4.6	-41.0 - 23.5	-80.3 - 308.8
R^2 Calib.Set / R^2 Val.Set	0.75 / 0.76	0.84 / 0.84	0.58 / 0.58	0.67 / 0.65	0.88 / 0.82
SEC / SEP	0.05 / 0.05	0.02 / 0.02	1.0 / 1.0	6.1 / 5.8	30.5 / 30.6
RPD	2.2	2.5	1.6	1.9	2.8

RNI [g N / day], predicted vs reference values



NUE [milk N / N intake], predicted vs reference values



SD pred. error
0.0214
0.0196
0.0210

Conclusions

- NIR-faeces show potential as a phenotyping tool for FE determination.

- Residual nitrogen intake, nitrogen use efficiency and feed conversion ratio show higher RPD values.

- These NIR-faeces prediction models would gain in robustness and applicability by enlarging the variability of the training set (diff. breeds, management, feeding conditions, etc.)

→ Collaborations ?
















Thank you for your attention

S. Ampuero Kragten
silvia.ampuero@agroscope.admin.ch

Agroscope good food, healthy environment
www.agroscope.admin.ch










Agroscope