Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Département fédéral de l'économie,
de la formation et de la recherche DEFR
Agroscope

Hes·so
Haute Ecole Spécialisée
de Suisse occidentale
Fachhochschule Westschweiz
University of Applied Sciences and Arts
Western Switzerland

Master of Science HES-SO in Life Sciences

Development of a proxy for feed efficiency prediction in dairy cows based on Mid-Infrared spectra

Marlyse Raemy

CHEMICAL DEVELOPMENT & PRODUCTION

EIA-FR

Advisor: Dr. Michal Dabros // In collaboration with Agroscope

DESCRIPTION

Challenges of milk production increase nowadays, therefore the use of efficient dairy cows is important. An easy and accurate estimation of feed efficiency (FE) may help to control production costs, to ensure better use of limited resources, to minimize the environmental footprint associated with milk production, and even to select more efficient dairy cows.

Feed efficiency can be defined as ratios or differences between input (e.g. dry matter intake DMI) and output (milk and / or meat). It can be expressed in different traits:

Feed Conversion Ratio (**FCR**): Dry Matter Intake (kg/d) / Energy Corrected-Milk (kg/d)

Nitrogen Use Efficiency **(NUE**): milk Nitrogen yield / Nitrogen intake

Residual Nitrogen Intake (**RNI**): difference between the observed and the estimated N intake

Residual Feed Intake (**RFI**): difference between observed and estimated DMI

Residual Energy Intake (**REI**): difference between observed and estimated Net Energy of Lactation intake

The used milk samples came from experiments conducted at Agroscope by the Ruminant Nutrition and Emission Research Group on the topic of efficient dairy cows with different diets (herbage in pasture, herbage in barn, and a total mixed ration reduced in protein).

Different pretreatments were tested on the spectral data:
- Multiplicative Scatter Correction (**MSC**)
- Standard Normal Variate (**SNV**)
- Savitzky-Golay smoothing and derivative (**SG**)
- **SG & MSC** and **SG & SNV**

The spectral data were consequently analyzed utilizing Principal Components Analysis (**PCA**) and Partial Least Square (**PLS**) regression.

The resulting models were finally evaluated towards an independen validation scheme.

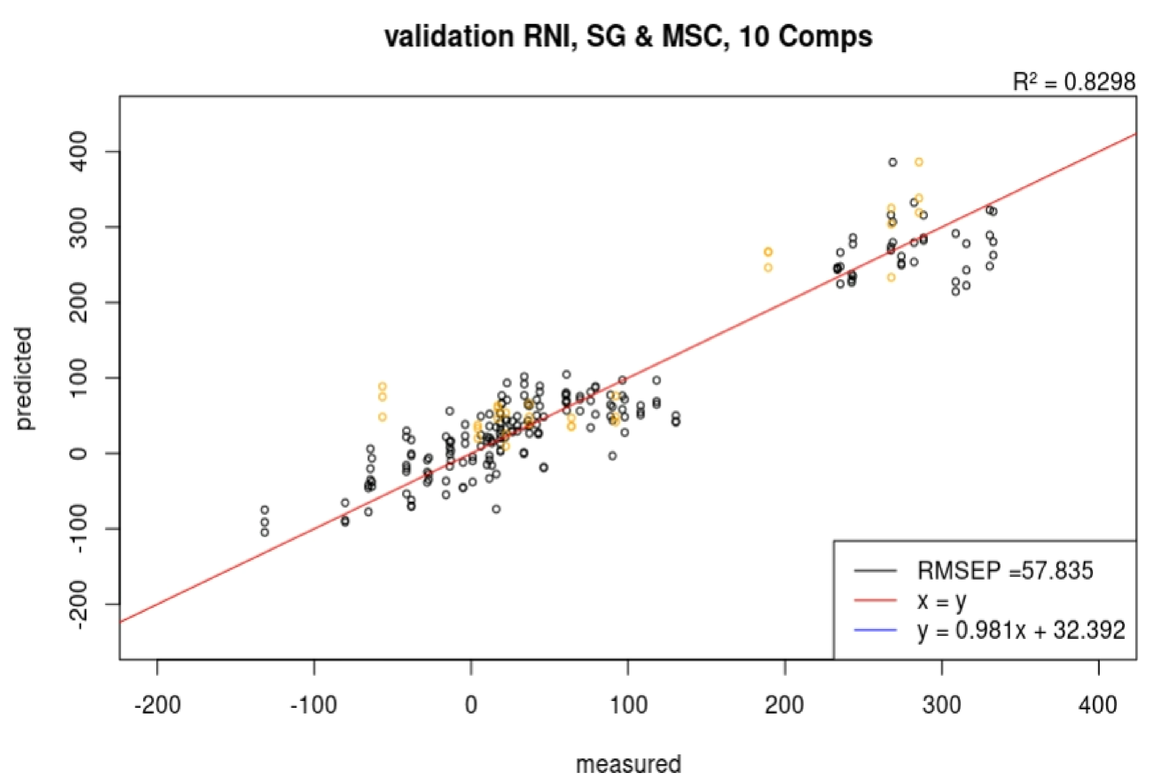
OBJECTIFS

The aim of this master thesis is **to predict the individual FE traits** of dairy cows using the **MIR** spectral profile of milk and PLS regression. The used milk samples came from **experiments conducted at Agroscope** by the Ruminant Nutrition and Emission Research Group on the topic of efficient dairy cows.

The **FE traits** were calculated for every animal independently, and the correlation of the latter with the MIR spectral profile was investigated by means of statistical analysis tools utilizing the open source statistical suite **RStudio®.**

After establishing models for the estimation of FE traits, they can be used for **phenotyping** other **dairy cows**. This would allow the more efficient dairy cows to be differentiated from the inefficient ones, which in turn can have a **positive economic impact** for farmers and an **ecological impact** for the general public.

RESULTS



*Independent validation plot for Residual Nitrogen Intake (**RNI**) (g/d)*

Two groups in the RNI and NUE regression:
- cows fed with herbage in the barn (high values RNI, low NUE)
- cow fed with herbage in pasture or with a reduced protein ratio in barn (low values RNI, high NUE)

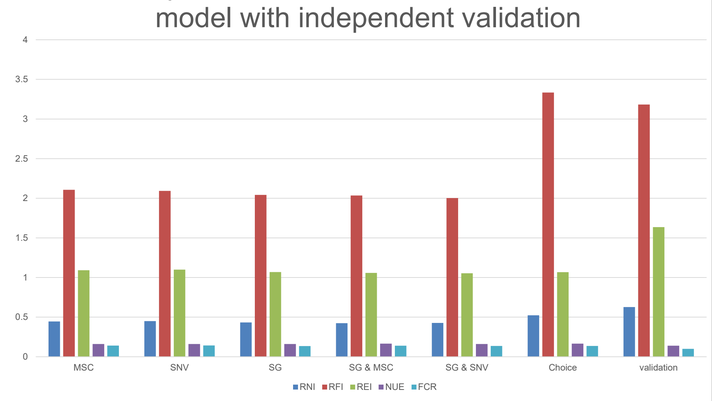
Rations with lower crude protein content were more efficient in regard with RNI and NUE. Dairy cows excrete the excess crude protein.

The independent validation was more promising than the external validation.

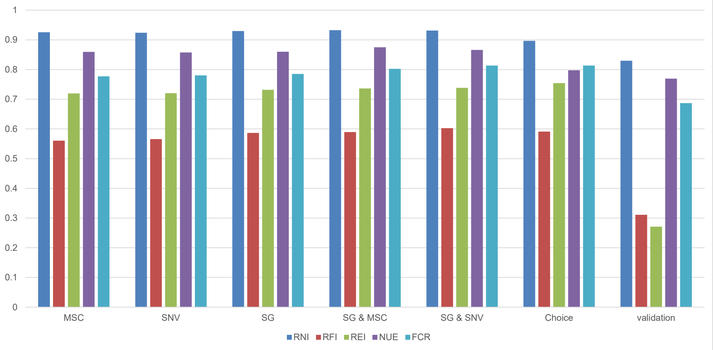
No clear differences in the different pretreatments.

RFI shows the poorest regression and validation characteristics between all the FE traits.

Comparison of the RMSE in the extended model with independent validation



Comparison of the R^2 in the extendend model with independent validation



CONCLUSION

In this study, the **MIR spectra were proven as a useful tool** for the prediction of **the Feed Efficiency criteria**. The **extended prediction model**, which takes into account the data of the two experiments, was a good predictor for its validation set. The **extended prediction model** with all data from different feeding programs might proved that a regression has to be proceeded with a wide variety of data, whether it is for breed, diets or others. In reality, the cow's diets depend on the season, the site of milk production, restriction for cheese production or the climate.

The biggest greater differences were found between the feeding patterns (pasture or barn) and, forage (herbs, corn silage or protein supplement). For the data set that was used, the difference between the breed were not clear. By having other population with different production environments, and combining all the possibilities, the spectra profile might add new information in order to improve the prediction model. Expanding the variability in the dataset to further evolve the models of prediction is then important in order to have achieve greater robustness of the models, and to be able to apply the predictive models to a larger scale. This would be possible by European or even international collaboration.

To conclude, a routine application of the prediction models in dairy production would be for the genetic selection and the management of the livestock. Indeed, with a large set of data, each breed might give differentiated FE values and thus the best individual cow can be selected. The other important application is the dad-to-day herd management. As a matter of fact, the feed efficiency values can give valuable information, like the ideal diet and make understandable the different inter-herd performances.

SWISS UNIVERSITIES APPLIED SCIENCES AND ARTS

MLS | MASTER OF SCIENCE IN LIFE SCIENCES