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Gembloux Agro-Bio Tech - Université de Liège vous prie

de lui faire l'honneur d'assister à la défense publique de la dissertation originale que

Monsieur ZHANG Lei,

Titulaire d'un diplôme de *master of agriculture*,

présentera en vue de l'obtention du grade et du diplôme de

DOCTEUR EN SCIENCES AGRONOMIQUES ET INGENIERIE BIOLOGIQUE,

le 26 janvier 2021, à 13h30 précises en visioconférence :

https://eu.bbcollab.com/guest/c9b7aa11dfb94fb48ad90770597e5eb5

Cette dissertation originale a pour titre :

« Prediction of feed efficiency based on test-day liveweight of dairy cows estimated using animal characteristics and milk mid-infrared spectra ».

Le jury est composé comme suit :

Président : Prof. J. BINDELLE, Professeur ordinaire,
Membres : Prof. H. SOYEURT (Promotrice), Prof. N. GENGLER, Prof. Y. BROSTAUX, M. F. DEHARENG (CRA-W), Dr E. FROIDMONT (CRA-W), Dr A. VANLIERDE (CRA-W).

UNIVERSITE DE LIEGE – GEMBLOUX AGRO-BIO TECH – SERVICE INSCRIPTIONS ET APPARITORAT
Passage des Déportés, 2 - 5030 Gembloux - Belgique
Téléphone +32(0)81 62 23 45 - Fax +32(0)81 62 21 68 - www.gembloux.ulg.ac.be

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Summary

Due to the increasing world population, the consumption of milk and dairy products is raising. Optimizing the production of milk under the economic and environmental constraints is a challenge. In this context, knowing the feed efficiency (FE) of dairy cow is a key issue. Unfortunately, the acquisition of such records at individual and large scales is unfeasible. So, the current thesis aims to fill this gap by developing a FE predictive tool for dairy sector available at large and individual scales. To achieve this objective, the FE was assessed by calculating the ratio of fat and protein corrected milk (FPCM) to dry matter intake (DMI). Although FPCM is already routinely available, this is not the case for DMI. However, a literature equation exists to predict DMI from FCM, bodyweight (BW) and the number of weeks of lactation. Recently, a methodology using the milk mid-infrared (MIR) spectrometry combined with the animal characteristics was developed to predict test-day BW records, leading to open new perspectives about the use of FE related traits for management and breeding purposes. So, the final achievement of this thesis is the development and the implementation of a FE prediction tool from traits easily recorded by dairy herd improvement (DHI) organizations, including namely the BW estimation. To achieve this objective, 3 main research activities were conducted in this thesis.

The first research aimed to increase the calibration set and to apply feature selection algorithms during the modeling in order to improve the BW models' robustness and accuracy. Indeed, the presence of less informative variables in a prediction equation could impact negatively its robustness. Three feature selection algorithms were applied on 280 predictors to select the most informative ones from a dataset containing 5,920 records: partial least squares regression (PLS) combined with sum of ranking difference (SRD), PLS combined with uninformative variables elimination (UVE), and the output of Elastic net regression (EN). Parity, days in milk (DIM), milk yield (MY), and two MIR spectral points were selected as the most relevant variables to predict BW. Validation root mean square errors (RMSEp) of 60 kg were obtained for both PLS and EN regressions employing these 5 predictors, suggesting a better robustness of these models compared to the ones without MIR or using all 277 MIR variables. The RMSE values of validation set coming from another brand of spectrometer were around 64 kg.

The second research work focused on the implementation of a BW equation in practice. Indeed, some poor quality BW predictions can be obtained using poor quality spectral data or by applying the model on samples for which the variability was not included in the calibration set. So, the objective of this work was to develop data cleaning methods easy to implement by DHI to ensure the quality of BW predictions. So, 3 data cleaning procedures and their combinations were tested on a DHI dataset containing 346,818 records: the deletion of 1% of extreme high and low predicted values (M1), the deletion of records when the global-H (GH) distance was greater than 5 (M2), and the deletion of records if the absolute fat residual value was higher than 0.30 g/dL of milk (M3). The interest of those procedures was assessed by estimating the root mean square differences (RMSD) between fat, protein, and fatty acid traits predicted by the MIR spectrometry internally and externally. All methods allowed to decrease RMSD, the gain ranged from 0.32% to 41.39%. Based on the obtained results, the “M1 and M2” combination should be preferred to be more parsimonious in the data loss as it had the higher ratio of RMSD gain to data loss. However, to ensure the lowest RMSD, the “M2 or M3” combination was the most relevant.

Based on these 2 first works, FE records were easily obtained at large and individual scales and cleaned appropriately. Then, in order to assess the relevancy of the FE tool, the final work of this thesis consisted to study the behaviors of BW and FE predictions obtained from the 5 developed equations within and between lactations as well as per test month and compared them to the ones observed in the literature using reference values. Subsets of Heibei (N=288,607) and Walloon (N=379,472) DHI datasets were used. Even if the BW equations did not differ a lot based on the prediction performances, differences were observed on the DHI datasets and clustered the equations within 2 groups: the ones including 5 predictors and the one using the parity, DIM, MY, and the full MIR spectral data. The final one depicted a more expected evolution within lactation with a drop of BW around 30-50 days in milk and then an increase. This was not observed for the other equations suggesting a lack of MIR information to take into account sufficiently the individual variability of BW. The annual trend observed for this equation was also more expected with a BW drop during the grazing period. However, the differences in FE predictions obtained using BW estimated from different equations were less marked, suggesting a low sensibility of FE predictions to a moderate variation of BW. The validation RMSE reached 0.05 suggesting a good accuracy for this FE indicator.

In conclusion, the FE tool developed in this thesis can be implemented by DHI organizations based on the BW equation including milk, parity, DIM, and the 277 MIR spectral points. However, some additional investigations are still needed before the use of a such tool by DHI. Indeed, even if preliminary results obtained in this thesis suggested a moderate heritability of FE trait, a study with the newly developed BW equations could be done as we have observed that the past BW equation tended to overestimate BW. Moreover, knowing the relationships between FE predictions with other traits having economic interest is required before any use. A reflection about the best way to communicate the results to the farmers must be also started. Finally, the FE tool was based on an equation predicting DMI. For the future, it could be also of interest to measure the relevancy of this equation by using DMI reference data.