Prediction of methane emissions based on milk fatty acid profiles shows similar performance to milk MIR spectra

Köck Astrid*[1], Linke Kristina[1], Schmid Christoph[2], Auer Franz-Josef[2], Mayerhofer Martin[1], Sölkner Johann[3], Guggenberger Thomas[4], Terler Georg[4], Steinwidder Andreas[4], Ettle Thomas[5], Huber Veronika[5], Gerster Elisabeth[6]

[1] ZuchtData EDV-Dienstleistungen GmbH, Dresdner Str. 89/18, 1200 Vienna, Austria, [2] LKV Austria, Dresdner Str. 89/18, 1200 Vienna, Austria, [3] University of Natural Resources and Life Sciences, Vienna (BOKU), Department of Agricultural Sciences, Institute of Livestock Sciences, Gregor-Mendel-Str. 33, 1180 Vienna, Austria, [4] HBLFA Raumberg-Gumpenstein, Raumberg 38, A-8952 Irdning-Donnersbachtal, Austria, [5] Bayerische Landesanstalt für Landwirtschaft, Institut für Tierhaltung, Tierernährung und Futterwirtschaft, Prof.-Dürrwaechter-Platz 2, 85586 Grub-Poing, Germany, [6] Fachbereich Bildung und angewandte Forschung, Rinderhaltung, Landwirtschaftliches Zentrum Baden Württemberg, Aulendorf, Germany

This study aimed to predict methane (CH4) emissions measured using the GreenFeed system from milk mid-infrared (MIR) spectra collected on 16 commercial Austrian dairy farms.

All farms used similar feeding systems based on grass and maize silage with varying levels of concentrate supplementation and no grazing. The dataset consisted of 807 records from 604 cows. Two partial least squares regression models were developed: one based on milk MIR spectra and another using milk components, including 14 individual fatty acids (FA), fat%, protein%, and lactose%. Milk yield, lactation stage and parity were included as additional predictors. Model performance was evaluated using 5-fold and leave-one-farm-out cross validation.

In 5-fold cross-validation, the MIR-based model showed moderate predictive ability ($r = 0.52$, $R^2 = 0.27$), outperforming the FA-based model ($r = 0.42$, $R^2 = 0.18$). Combining FA with fat%, protein%, and lactose% improved accuracy ($r = 0.44$, $R^2 = 0.20$). Including milk yield, parity, and lactation stage further increased accuracy for both MIR-based ($r = 0.61$, $R^2 = 0.38$) and FA-based models (0.61, $R^2 = 0.37$). Leave-one-farm-out validation resulted in slightly lower accuracies and revealed substantial variability among farms. Models using all predictors performed best (MIR-based: $r = 0.56$, $R^2 = 0.33$ / FA-based: $r = 0.58$, $R^2 = 0.35$). Overall, milk MIR spectra and FA explained only part of the variation in CH4 emissions, mainly capturing metabolic signals related to energy status. Improving prediction accuracy will require additional predictors and advanced modeling approaches to better capture the complex biological, nutritional and environmental drivers of CH4 emissions. Additional analyses are planned using combine