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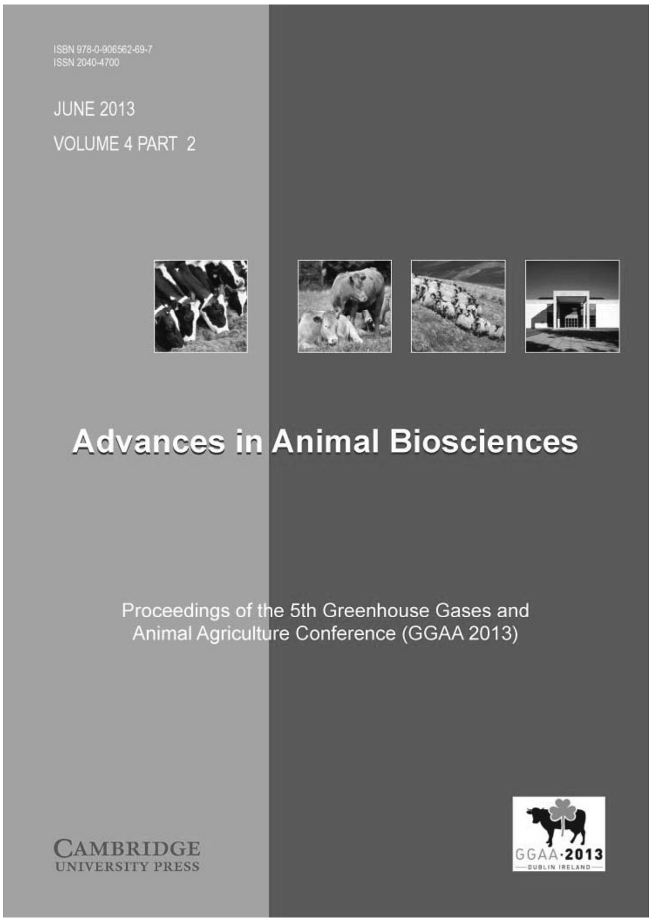

Prediction of the individual enteric methane emission of dairy cows from milk mid-infrared spectra

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Introduction The livestock sector is considered the largest producer of methane (CH_4) from anthropogenic sources, world wide contributing 37% of emissions (FAO, 2006). An important step to study and develop mitigation methods for livestock emissions is to be able to measure them on a large scale. However, it is difficult to obtain a large number of individual CH_4 measurements with the currently available techniques (chambers or SF_6). The aim of this study was to develop a high throughput tool for determination of CH_4 emissions from dairy cows. Anaerobic fermentation of food in the reticulorumen is the basis of enteric CH_4 production. End-products of that enteric fermentation can be found in the milk (e.g., volatile fatty acids). Therefore individual enteric CH_4 emissions could be quantified from whole milk mid-infrared (MIR) spectra which reflect milk composition and can be obtained at low cost (e.g., national milk recording). Prediction equations of individual CH_4 emissions (determined using the SF_6 method) from milk MIR spectra have been established (Dehareng *et al.,* 2012; Soyeurt *et al.*, 2013). The results presented here are the improvement of this methodology by using a multiple breed and country approach.

Material and methods A total of 452 daily CH_4 measurements were obtained using the SF_6 technique (Johnson, 1994). During the measurement period a 40ml sample of milk was collected from each cow at each milking (morning and evening) and was analyzed by MIR spectrometry. These two spectra were averaged proportionally to milk production to generate one spectrum per CH_4 measurement. The reference data used have two origins: Holstein cows at the CRA-W in Belgium (performed in duplicate); and Jersey, Holstein and Holstein-Jersey crossbred cows at Teagasc Moorepark in Ireland. To include as much variability as possible, measurements were performed on 146 different cows of mixed parity (63, 36, 18, 29 cows in parity one to four+, respectively). Cows had also received many different diets: a basic diet enriched in maize or fresh grass or with supplemented linseed, total mixed ration, starch based (corn silage) morning ration with a fibrous (straw, grass silage) evening ration or grazed perennial ryegrass. The calibration model used to relate milk spectral data to CH_4 emissions was developed using Foss WINISI 4 software. The spectral regions used were: 972-1,589cm^{-1}, 1,720-1,782cm^{-1} and 2,746-2,970cm^{-1}. A first derivative was applied to spectral data followed by PLS regression. The number of factors was determined by a 50-group cross-validation which was also used to estimate the robustness of the equation. Calibration coefficient of determination (R^2c), cross-validation coefficient of determination (R^2cv), standard error of calibration (SEC), and the standard error of cross-validation (SECV) were calculated.

Results Calculated R^2c and R^2cv are greater than 0.70 (Table 1). R^2c (0.76) was lower than in previous equations 0.85 (Dehareng, *et al.,* 2012), 0.81 (Soyeurt *et al.*, 2013), yet the difference between the R^2c and the R^2cv was slighter (0.06 vs. 0.13 and 0.09, respectively) as was the difference between the SEC and the SECV (6.1 g/d vs. 27 g/d and 8.5 g/d, respectively). This reflects an increase of the robustness of the equation. The present equation is based on 452 measurements (in place of 77 and 196, respectively) and additional variability has been introduced through inclusion of data from Jersey and crossbred cows with no decrease in statistical parameters.

Table 1 Equation statistical parameters

	N	s.d.	R^2c	R^2cv	SEC	SECV
g CH_4/day	452	126.4	0.76	0.70	62.0	68.7

Conclusions These results confirm the possibility to predict enteric CH_4 emissions from whole milk MIR spectra. This equation used a calibration dataset of wider variability than those used in previous analyses, yet the robustness of prediction was much improved. This improved equation will be useful in large scale studies to link enteric CH_4 emission to diet, genetics (Kandel *et al*., 2013), management and geographical location, with the objective to develop tools to mitigate enteric CH_4 emissions.

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