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Evaluation of green forage intake and digestibility in ruminants using near infrared reflectance spectroscopy (NIRS): Developing a global calibration

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Abstract

The objective of this study was to evaluate the potential of near infrared reflectance spectroscopy (NIRS), applied to forage and/or faeces, to estimate the *in vivo* organic matter digestibility (OMD) and the organic matter voluntary intake (OMVI, g/kg metabolic weight [$BW^{0.75}$]) for a wide range of

Abbreviations: BW, body weight; CEL, cellulose; CP, crude protein; DM, dry matter; H, standardized distance; ADL, acid detergent lignin; NIRS, near infrared reflectance spectroscopy; OM, organic matter; OMDcel, *in vitro* organic matter digestibility coefficient; OMD, *in vivo* organic matter digestibility coefficient; OMVI, organic matter voluntary intake; PCA, principal components analysis; R, reflexion; R^2, coefficient of determination; RPD, standard error of reference database/standard error of cross validation; S.D., standard error of reference database; S.E., standard error of regression; SEC, standard error of calibration; SECV, standard error of cross validation.

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temperate forages. Two different databases, in terms of forage species and development stages were studied. The first one included two grass species and two forage mixtures for which OMD and OMVI were continuously measured during the grass-growing seasons (spring and summer). The second one contained a large set of grass and legume species and forage mixtures (142 trials) for which OMD and OMVI were measured.

Forage and faeces samples were submitted to NIRS analysis and predictive calibrations were developed from forage spectra, faeces spectra, forage and faeces subtracted spectra, and faeces and forage concatenated spectra. Working on faecal spectra (alone or concatenated) enabled us to develop the best calibration equations for both OMD and OMVI estimation. The coefficient of determination (R^2) was greater than 0.8. The standard error of cross validation (SECV) for OMD and OMVI was 0.021 and 4.51 g/kg $BW^{0.75}$, respectively, and the accuracy was similar to that obtained with other predictive methods. With regard to the faecal spectra (second derivative mode), the fat absorbency at wavelengths of 1730, 2310 and 2350 nm was higher when the corresponding forage was highly digestible and ingestible.

In conclusion, applying NIRS to faeces is a rapid and easy analytical method that could be an interesting tool for managing grazing ruminants and optimising their performance.

Keywords: NIRS; Faecal spectra; Grass quality; Feeding management tool

1. Introduction

The performances of herbivores when grazing depend directly on forage digestibility and intake. Measuring these parameters for herd management at pasture can be difficult, costly, time consuming, labour intensive and not suitable over long periods. The digestibility of ingested grass is usually estimated by chemical analyses of samples collected in the field. This is based on determining the regression between forage parameters defined in laboratory and *in vivo* measurements. Common laboratory analysis methods include that described by Tilley and Terry (1963) and *in vitro* enzymatic digestibilities (Bartiaux-Thill and Oger, 1986; De Boever et al., 1988; Aufrère and Demarquilly, 1989). With these methods, accuracy is generally good, with a residual error of prediction of 0.015–0.030 units of digestibility (Peyraud, 1998). However, the accuracy of such regressions is a function of the method used to collect field samples that are as representative as possible of the ingested diet. To overcome this difficulty, ingested diet can be obtained by using oesophageal-fistulated animals (Ward et al., 1982; Holechek et al., 1982; Forbes and Beattie, 1987; Stuth et al., 1989), but this practice has an adverse effect on animal welfare. In addition, on heterogeneous pasture such sampling methods are not always representative of diets selected by animals. Coates et al. (1987) showed that diet legume percentages of extrusa collected from oesophageal-fistulated steers, non-resident on pasture, were poorly correlated with those ingested by non-fistulated steers resident on pasture ($R^2 = 0.127$). Jones and Lascano (1992) suggested that this difference could be linked to the sampling strategy of extrusa (difference between morning and afternoon extrusa) or to behavioural differences in diet selection between resident and non-resident cattle. For instance, fasted or satiated oesophageal-fistulated cattle introduced in pasture do not have the same diet selection. Other methods have been developed to estimate grass digestibility by measuring such chemical faecal parameters as