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Prediction of gas production kinetic parameters of forages by chemical composition and near infrared reflectance spectroscopy

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Abstract

This study was initiated to evaluate the potential of near infrared reflectance (NIR) spectroscopy to predict in vitro gas production parameters of botanically complex herbage samples. A total of 94 herbage samples harvested in natural meadows located in the mountains near León in Northwest Spain were analyzed to determine their chemical composition. In addition, all herbage samples were incubated in vitro in buffered rumen fluid to determine fermentation kinetics using a gas production technique, and scanned in a spectrophotometer to obtain NIR spectra. Prediction equations showed that NIR spectra could explain a high proportion of the variability ($R^2 > 0.94$) related to some in vitro gas production parameters (e.g., fractional rate of fermentation (c) and

Abbreviations: A, asymptotic gas production; ADF, acid detergent fibre; ADIN, acid detergent insoluble N; ADL, acid detergent lignin; c, fractional rate of fermentation; CP, crude protein; d 144, DM disappearance at the end of the fermentation time; ED_{03} and ED_{06}, effective ruminal degradability of DM at different rumen passage rates; GP24 and GP96, gas production at 24 and 96 h of incubation; L, lag time before degradation started; LIG, degree of lignification of the cell wall; MSPE, mean square prediction error; NDF, neutral detergent fibre; NIR, near infrared reflectance; RPD, ratio performance deviation; SEC, standard error of calibration; SE_{CV}, standard error of cross-validation; SEP, standard error of prediction; U^M, U^R and U^D, proportion of MSPE corresponding to the bias, regression and unexplained variance, respectively

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extent of degradation in the rumen at different passage rates (ED_{03} and ED_{06})) of the calibration set ($n = 62$). When these NIR equations were applied to the validation set ($n = 32$), most parameters were satisfactorily predicted with standard errors of prediction (SEP) of 3.88 ml for gas production at 24 h of incubation (GP24), 2.71 ml for asymptotic gas production (A), 0.0038 for c, 0.020 for ED_{03} and 0.018 for ED_{06}, accounting for less than 7% of the corresponding mean value. However, lag time (L) could not be predicted by NIR spectroscopy. The SEP was always lower when NIR spectra were used as predictors in comparison with chemical composition, perhaps because spectra contained information about feed constituents as well as physical properties of the samples. Nevertheless, results suggest the need for improved standardisation of this gas production procedure, to minimise the influence of sources of experimental error to increase repeatability and reproducibility, in order to obtain accurate NIR determination of feed fermentation kinetics and of parameter estimates.

Keywords: Gas production; NIR; Chemical composition; Herbage

1. Introduction

In vivo digestibility predicts the animal response to a dietary treatment, but cannot describe dynamics of nutrient supply. Thus, results are generally restricted to the experimental conditions under which the measurements were made (López et al., 2000). In addition, in vivo digestion studies are expensive and not readily applicable to large numbers of samples, or when small quantities of feedstuff are available. In order to avoid these problems, in vitro and in situ methods have been used extensively in ruminant nutrition studies (Givens and Deaville, 1999). These procedures provide information on fermentation kinetics, which can be incorporated to integrated compartmental models in order to predict events in the rumen (López et al., 2000). However, an in vitro gas production technique (Menke et al., 1979; Menke and Steingass, 1988; Theodorou et al., 1994) is even less animal dependent and can be automated (Cone et al., 1996), thereby considerably reducing labour needs versus in situ methods.

Another technique used in feed evaluation is near infrared reflectance spectroscopy (NIRS), an analytical method that has proved useful in estimating chemical composition (Norris et al., 1976; García-Ciudad et al., 1993; Reeves, 1997; Pram Nielsen et al., 2001) and in vivo digestibility (Guzmán et al., 1996; Gordon et al., 1998; Naydenova et al., 1998; Park et al., 1998) of a wide range of forages. Use of this procedure to predict gas production parameters of forages is of great interest (Murray, 1993), if it could provide information on ruminal fermentation kinetics in a simple, rapid and accurate method and, most importantly, obviate the necessity of using cannulated animals as donours of rumen liquid. There is, however, little information available examining the accuracy of NIRS prediction equations for gas production parameters.

This study was initiated to assess and compare the ability of chemical composition data and NIR spectra to predict gas production parameters of botanically complex herbage samples obtained from natural meadows located in the mountains near León in Northwest Spain.