Animal Feed Science and Technology 192 (2014) 48–61

Contents lists available at ScienceDirect

Animal Feed Science and Technology

journal homepage: www.elsevier.com/locate/anifeedsci

Prediction of faecal output and hay intake by cattle from NIRS estimates of faecal concentrations of orally-dosed polyethyleneglycol

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ARTICLE INFO

Article history:
Received 28 October 2013
Received in revised form 26 March 2014
Accepted 1 April 2014

Keywords:
Faecal near-infrared reflectance spectroscopy
External markers
PEG
Feeding level
Intake prediction

ABSTRACT

Polyethyleneglycol 6000 (PEG) was selected as a potential indigestible estimator of faecal output in cattle. NIRS-calibration equations of faecal PEG content were obtained with faeces from hay-fed cows added with 0.00–0.10 g PEG content/g faeces. A digestibility trial was conducted with 8 dry cows in digestibility cages for two 3-week periods, during which half the cows received either a Low (9 kg hay, as fed) or High (12 kg hay) feeding level (FL), and were dosed daily during the last 10 days either 175 (Low) or 235 (High FL) g PEG/d. In the last 4 days total faeces were collected, and on the last day rectal samples were grabbed every 4 h during 24 h. Samples were NIRS-scanned to determine faecal PEG content. Using data from total faecal collection, PEG recovery was not complete (0.957 g/g, s.e. 0.010), therefore faecal output was slightly overestimated with PEG data from total faeces (+0.052 g/g, s.e. 0.089), and so was calculated feed intake, although only significantly in the High FL (+0.060 g/g, s.e. 0.021), while estimates were accurate in the Low FL. Recovery was also incomplete in grab samples (0.928 g/g, s.e. 0.039), and faecal PEG content had a large per cow within-day variability (0.40), and the bias of estimation of faecal output was high at any sampling time. The use of a daily composite of all grab samples per-cow reduced the variability of faecal PEG contents, and bias of estimations was below 0.10. It is concluded that dosing PEG and analysing PEG faecal contents with NIRS provides reasonably accurate estimates of faecal output and forage intake in cattle, provided faecal samples are representative of total faeces produced. This implies frequent faecal grab sampling, including nocturnal collection, which may limit the practical use of this technique under field conditions.

Abbreviations: ADFom, acid detergent fibre expressed exclusive of residual ash; ANOVA, analysis of variance; CP, crude protein; CV, coefficient of variation; DM, dry matter; MW, molecular weight; NDFom, neutral detergent fibre assayed without amylase and expressed exclusive of residual ash; NIRS, near-infrared spectroscopy; PEG, polyethyleneglycol; r, Pearson correlation coefficient; R^2, coefficient of determination for calibration; r^2, coefficient of determination for validation; RER, range error ratio; RPD, ratio of performance to deviation; SD, standard deviation; SEC, standard error of calibration; SECV, standard error of cross validation.

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http://dx.doi.org/10.1016/j.anifeedsci.2014.04.002
0377-8401/

1. Introduction

Livestock performance in extensive production systems is based on the animals' ability to obtain a diet that meets their nutritional requirements, which depends both on the quantity and quality of feed consumed. Many techniques have been developed for the prediction of feed intake from different estimators (Swain and Friend, 2013), including animal performance and/or behaviour, herbage growth and disappearance, among others. While in indoor conditions there are commercial computerized feeding systems that monitor individual feed intake in group-fed cattle (Bach et al., 2004; Chapinal et al., 2007; Blanco et al., 2008), these are not of use in grazing situations, for which different methods have been implemented (Cottle, 2013).

Some of the most frequently used are based on the ratio between faecal output and diet digestibility, or rather, indigestibility, which is either known or estimated (Le Du and Penning, 1982). The coefficient of digestibility can be obtained *in vitro* or *in vivo*, either by total faecal collection or using indigestible markers (internal or external). Choice of markers depends on their degree of faecal recovery, low diurnal variation of their excretion pattern and ease of measurement (Titgemeyer, 1997). Internal markers are inherent to the diet, such as indigestible acid detergent fibre, acid detergent lignin, acid insoluble ash and others (Van Keulen and Young, 1977; Sein and Todd, 1988; Ferret et al., 1999), and have to be determined in both feed and faecal samples.

Other techniques, such as the n-alkanes (Mayes et al., 1986) combine the use of internal and external markers, that have to be dosed to the animal in given amounts and then quantified in the faeces. However, this method requires frequent dosing and an accurate estimation of natural n-alkane herbage content, which depends on an adequate sampling that may not be feasible on heterogeneous pastures. On the other hand, faecal recovery of alkanes is not complete, and a large variability in recovery rates can be observed in beef cattle (Oliván et al., 2007; Morais et al., 2011) associated both to individual variability and feeding level (Cottle, 2013). Moreover, the available techniques for alkane detection are complex and time-consuming, because they require chemical extraction before performing gas chromatography.

Finally, faecal output can be estimated by using only external indigestible markers, one of the most common of which is chromium oxide (Cr_2O_3) (Wagner et al., 1986). However, apart from incomplete recovery, it has the major disadvantage of carcinogenicity associated to analytical procedures for its determination (Delagarde et al., 2010), and therefore there is a great interest in using other markers with satisfactory biological properties that are easy to handle and with reduced risks. Without any markers, more recently Decruyenaere et al. (2012) used near-infrared reflectance spectroscopy (NIRS) applied to faeces for estimating the pasture digestibility and intake of dairy cows, and described the method as highly accurate. Faecal NIRS has been used to predict diet quality (Lyons and Stuth, 1992) and intake (Dixon and Coates, 2009), and coupled with decision support software its utility has also been proven to monitor cattle nutritional status and animal performance (Tolleson and Schafer, 2014). However, precise calibrations need large sets of faecal NIRS spectra from animals with known individual intake, which may not always be available.

Polyethyleneglycol (PEG), an indigestible tannin complexing agent, has been considered as an external marker for determination of digestive contents (Sinha et al., 1970) and faecal output (Hopson and McCroskey, 1972), but this interaction with digestibility and the complex turbidimetric method used for its quantification limited its practical use for this purpose.

Landau et al. (2002) developed a method of PEG determination in faeces of goats by NIRS analysis, and found it to be simple, accurate, and much less laborious than turbidimetry. They suggested that its determination in rectal grabbed samples could be used for the estimation of faecal output in stall-fed goats, at adequate doses and using diets with low tannin content, otherwise tannins and PEG could interact and alter diet digestibility and intake. With adequate calibration, the method has later been used with goats fed tannin-containing diets (Landau et al., 2003, 2005), sheep offered hays (Hassoun et al., 2007) or fresh forages (Andueza et al., 2013) of different qualities and even with grazing sheep (Caja et al., 2009), with varying recovery rates and predictive ability across experiments. Faecal samples have been obtained by total faecal collection or rectal samples grabbed at different times of the day.

Recently, Hassoun et al. (2013) assessed the major factors that could influence the accuracy of the method (level of PEG administered, number of daily doses, forage quality, tannin content, time of faecal grab sampling), and concluded that it provided satisfactory estimates of faecal output and diet intake in sheep. However, the effect of feeding level (FL) and the circadian patterns of faecal PEG excretion considering nocturnal sampling have not been sufficiently studied. Besides, to our knowledge no studies have been carried out using its NIRS-aided analysis with cattle, and the potential interest of using PEG as a marker in this species has not been updated.

This study aimed to determine the convenience of PEG as an external marker of cattle faecal output, by means of NIRS analysis of PEG concentrations in faeces of cows given hay at two feeding levels. The objective was also to analyze the circadian excretion pattern in grab samples of rectal faeces, in order to propose the most adequate sampling procedure allowing for accurate predictions of daily faecal output and forage intake.

2. Materials and methods

2.1. Animals and experimental design

The experimental protocol complied with the Spanish Regulation for Protection of Animals Used for Research and Other Scientific Purposes (Reg. 1201/2005), and was approved by the CITA Animal Experimentation and Ethics Committee.