



A preliminary evaluation of the use of mid infrared spectroscopy to develop calibration equations for determining faecal composition, intake and digestibility in sheep

Gary Lyons^{a,*}, Shekhar Sharma^b, Aurelie Aubry^a, Eugene Carmichael^b, Ronald Annett^{a,1}

^a Agriculture Branch, Agri-Food and Biosciences Institute (AFBI), Large Park, Hillsborough, BT26 6DR, UK

^b Plant Health and Environmental Protection Branch, AFBI, Newforge Lane, Belfast, BT9 5PX, UK

ARTICLE INFO

Article history:

Received 4 February 2016

Received in revised form 17 August 2016

Accepted 19 August 2016

Keywords:

FTIR

Sheep

Feed

Intake

Digestibility

Faecal analysis

ABSTRACT

The aim of this study was to investigate the application of Fourier Transform Infrared (FTIR) spectroscopy to provide calibration equations for assessing faecal composition, intake and digestibility in sheep. Four grass-based feed types and corresponding faecal samples were collected from two separate sheep digestibility experiments. The feed ($n = 41$) and faecal samples ($n = 132$) were analysed for chemical composition, digestibility, were scanned using FTIR spectroscopy and intakes were recorded. Data were analysed using principle component analysis and partial least squares (PLS) regression techniques for calibration equation development. Calibration accuracy and performance were assessed by calculating regression coefficient of cross validation (R^2_{cv}) and the ratio of performance to deviation (RPD value) respectively. Results indicated that the composition of feed and faecal samples along with associated digestibilities and intakes were significantly different for a number of parameters studied. Some of the PLS regression equations generated were comparable to those reported in the published literature, and based on calibration statistics and performance those developed for faecal ash and neutral detergent fibre were good and could be used for quantification ($R^2_{cv} = 0.9-0.8$, $RPD = 3.0-2.5$); those for acid detergent fibre, lignin, feed ash intake and dry matter digestibility (DMD) were adequate for qualitative analysis and screening ($R^2_{cv} = 0.8-0.7$, $RPD = 2.3-2.0$); and the calibration equations for dry matter, nitrogen, dry matter intake, gross energy, gross energy intake and gross energy digestibility were poor and unsuitable for prediction ($R^2_{cv} \leq 0.7$, $RPD \leq 1.8$). Further development of calibration equations and in particular the prediction of DMD, could be of benefit to animal scientists and the livestock industry.

Crown Copyright © 2016 Published by Elsevier B.V. All rights reserved.

Abbreviations: ADFom, acid detergent fibre without amylase and exclusive of ash; Lignin (sa), lignin determined by solubilisation of cellulose with sulphuric acid; DM, dry matter; GE, gross energy; N, nitrogen; NDFom, neutral detergent fibre without amylase and exclusive of ash; AshI, ash intake; DMI, dry matter intake; GEI, gross energy intake; NI, nitrogen intake; DMD, dry matter digestibility; GED, gross energy digestibility; FTIR, Fourier Transform infrared; F.NIRS, faecal Near Infrared spectroscopy; PCA, principle component analysis; PLS, partial least squares regression; SD, standard deviation; R^2_c/R^2_{cv} , regression coefficient of calibration/cross validation; SEC, standard error of calibration; SECV, standard error of cross validation; RPD value, ratio of performance to deviation.

* Corresponding author.

E-mail address: gary.lyons@afbini.gov.uk (G. Lyons).

¹ Present address: G. E. McLarnon & Sons, 126 Moneynick Road, Randalstown, Antrim, BT41 3HU, UK.

<http://dx.doi.org/10.1016/j.anifeedsci.2016.08.014>

0377-8401/Crown Copyright © 2016 Published by Elsevier B.V. All rights reserved.

1. Introduction

The sheep industry has recently been under a period of sustained financial pressure and improvements in production efficiency are required to underpin the future sustainability of sheep production, especially in hill areas (Annett et al., 2011; Speijers et al., 2009). Meeting energy requirements without over or underfeeding lambs and ewes is one of the producer's most important challenges, as this will help to maximise lamb growth and ewe fertility. Grass silage is the most common forage offered to pregnant ewes in the United Kingdom and Ireland and research has been undertaken to develop optimal feeding strategies for ewes offered grass silage-based feeds (Annett et al., 2013). Digestion trials are the most effective way to assess forage digestibility and feed intakes, with harvested forage fed to confined animals for several days during which consumption and faecal output are measured. Near Infrared (NIR) spectroscopy has been used extensively to predict forage quality (Park et al., 1997; Givens and Deaville, 1999) and more recently it has provided an alternative approach to digestibility trials to improve the understanding of nutrition and ecology of grazing herbivores, directly relating faecal NIR (F.NIR) spectra to attributes of the diet (Dixon and Coates, 2009).

We selected FTIR spectroscopy, a mid infrared technique, as an alternative methodology to NIR spectroscopy. Mid Infrared spectroscopy examines a different part of the electromagnetic spectrum to NIR spectroscopy. It also provides more detailed chemical information on sample composition than NIR spectroscopy, because it measures fundamental molecular vibrations rather than overtones and combination bands (Griffiths and de Haseth, 1986). FTIR spectroscopy has also been used to examine the composition of a wide range of biomaterials including forage grass (Sharma et al., 2012a; Lyons et al., 2013), but there are very few studies investigating relationships between faeces and feed type. Parveen et al. (2008) used the technique to determine if it was possible to discriminate sheep offered different diets based on metabolic fingerprints of blood plasma and faeces, while Moorby et al. (2010) used it to generate data on ingested diet composition from faecal samples, providing information on diet selection in free-ranging cattle and sheep. FTIR spectroscopy has the potential to predict a number of important parameters for sheep nutrition, as an alternative to the widely reported F.NIRS approach, allowing development of an analytical technique which could be of use to researchers in digestibility trials and also producers as a rapid and low cost analytical service. The proposed technique could be effective at studying grazing on hill pastures, where assessment of feed quality and intake from representative samples is particularly difficult. The main aim of this work was to investigate whether variation in spectral absorption bands between feed types and faecal samples could be associated with differences in sample composition, which in turn may be linked to digestibility and intake.

2. Materials and methods

2.1. Experimental design and feed types

Samples of feed types and faeces were collected from two separate digestibility experiments (Trials 1 and 2) conducted at the AFBI Hillsborough research farm. Trial 1 involved 17 first and second cut silages harvested over four years from three separate perennial ryegrass swards of three different varieties (Aberdart, Corbet and Foyle). Silages were individually fed over 9 periods to one year old castrated male sheep of similar body weight ($n=4$ per feed type) and breed (Charollais X). All experimental animals ($n=16$ with 4 groups of 4 sheep) were fed at maintenance energy level, with maintenance metabolisable energy (ME) requirements estimated from their body weight using the equations of AFRC (1993). For each period, two groups of sheep were used, with each of the 4 sheep within a group fed the same diet. Each group of sheep was used for 3–5 periods. Animals were housed individually and offered the experimental diets at the level determined above for 10 days to allow the rumen microbial population to adapt to the new diet. The sheep were then housed in digestibility crates. After 2–3 days adjustment period, feed intake and residues were measured daily for six consecutive days for each animal. Faecal and urine outputs were measured for six consecutive days, starting two days after commencement of the feed intake period. Faeces were weighed daily, bulked for each animal and stored refrigerated at 2–4 °C.

Trial 2 involved two parallel studies using calorimetric chambers examining the effect of age, breed, and feed type on methane emissions from lowland and hill replacement ewes at six, twelve and eighteen months old. In study 1, lowland replacement ewes of three different breed types (Belclare X, Highlander X and Texel X), were fed experimental diets over three periods using animals at 8, 12 and 19 months of age respectively for each period. For this study, 31 animals (8 months old) or 27 animals (12 and 19 months old) were allocated to two diet groups balanced for breed and liveweight. For each period, animals were offered ad libitum either grass nuts (GN) or a diet representative of standard practice, i.e. perennial ryegrass obtained from a lowland pasture (LG; zero grazed; summer diet for 8 and 19 months olds) or perennial ryegrass silage (GS; winter diet for 12 month olds). In study 2 (see Zhao et al., 2016 for details), replacement hill ewes of three breed types (Scottish Blackface, Blackface X, Swaledale X Blackface and Texel X Blackface) were fed experimental diets over three periods using animals at 9, 13 and 17 months. For each period, 36 replacement ewes were allocated to two or three diet groups. Experimental diets included GS, GN, LG or hill grass obtained from a mixed species sward (HG; zero grazed). In both studies 1 and 2, fresh lowland grass was harvested daily from long term leys using a reciprocating cutter bar and hill grass was harvested once a week and stored at –17 °C in sealed plastic bins (30 kg) until fed. Grass silage samples were harvested and conserved from perennial ryegrass swards using the method described by Annett et al. (2013). Grass nuts (pelletized from dried perennial ryegrass) were sourced from a commercial feed supplier (Drygrass South Western Ltd, Burrington, UK) with reported protein and fibre contents of 16 and 21% respectively. The animals were individually housed for at least

Download English Version:

<https://daneshyari.com/en/article/2419217>

Download Persian Version:

<https://daneshyari.com/article/2419217>

[Daneshyari.com](https://daneshyari.com)