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Short communication

Evaluation of botanical and chemical composition of sheep diet by using faecal near infrared spectroscopy

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ABSTRACT

The aim of this study was to use near infrared reflectance spectroscopy (NIRS) to directly predict the chemical composition and forage content of diets consumed by ewes from the analysis of their faeces. Twenty four ewes (46 ± 3 kg BW) placed in individual cages were used. Each animal was randomly allocated to four diets fed in four successive 28-days periods, so that a total of 16 diets were fed (six ewes per diet). Diets were designed to have different contents of neutral detergent fibre and crude protein. Daily rations of 800 g (as-fed) were formulated with alfalfa hay (0–1000 g/kg) or cereal straw (0–800 g/kg) as forage base, different mixtures of maize, peas and lupins, offered as whole grains, and pelleted sunflower meal. Faeces samples were collected at the end of each feeding period, directly from the rectum. A total of 96 faeces samples were dried and ground. The samples were scanned in small ring cups in a FOSS-NIRSystems 6500 SY-II scanning monochromator. Faecal Modified Partial Least Squares calibration equations, selected in terms of standard error of cross validation (SECV) and coefficient of determination (r^2), showed good predictive values for the prediction of dietary botanical ingredients (g/kg) alfalfa (41.9 and 0.98), cereal straw (48.6 and 0.97), maize (89.1 and 0.86), and forage (67.4 and 0.90) or concentrate (67.5 and 0.90) respectively, and also for chemical composition of fed diets (g/kg DM): ash (5.2 and 0.93), crude protein (9.6 and 0.89), ether extract (2.9 and 0.80), neutral detergent fibre (34.5 and 0.95) and non-fibre carbohydrates (38.7 and 0.94), respectively. Lower predictive capacity was obtained for peas (78.0 and 0.43), lupins (37.0 and 0.84) and sunflower meal (6.7 and 0.99), probably due to the limited variability of these ingredients in the diets. These results support the viability of faecal NIRS as a fast and reliable analytical method which allows to accurately predict the botanical composition, proportions of forage ingredients and chemical composition of diets consumed by ewes having free access to a variety of feed ingredients. Future works should be focused both to increase the variability of the diet ingredients and also to validate the models with external samples.

Abbreviations: aNDF, neutral detergent fibre; CP, crude protein; DM, dry matter; EE, ether extract; MPLS, modified partial least squares; MSC, multiplicative scatter correction; NFC, non fibrous carbohydrates; NIRS, near infrared reflectance spectroscopy; r^2, coefficient of determination of cross validation; SEC, standard error of calibration; SECV, standard error of cross validation; SEP, standard error of prediction; SNV, standard normal variate; T, outlier samples.

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1. Introduction

Composition of the food ingested by animals is of paramount importance on the management of extensive farms and for the evaluation of the consumption habits of wild animals (Landau et al., 2006). Farmers need updated information on the nutritive value of forages and supplementary feeds consumed by the animals to manage their nutritional status. This is especially important in the new strategies aiming towards greater efficiency in feeding systems based on the free choice of the food ration, not only the forage but also components of the concentrate (Dixon and Coates, 2009). However, it is difficult to obtain and quantify this information directly, as it requires expensive animal handling that is not always possible. The composition of faeces has been long considered to contain information of the diet consumed by the animal. Hence, the evaluation of faeces has been considered as a good method to monitor many attributes of the fed diet, and some aspects of animal physiology (Dixon and Coates, 2009). Near infrared reflectance spectroscopy (NIRS) has been reported to be a fast, reliable and economic tool to accurately predict different attributes of raw materials and feeds (Williams and Norris, 2001), considered as well as an environmental-friendly analytical solution. NIR analysis of faeces could greatly facilitate the study of the quality and quantity of the diet selected by both domestic and feral grazing herbivores (Dixon and Coates, 2009; Dryden, 2003). In fact, this technology has been successfully used to predict chemical composition and digestibility of the diet through faeces analysis in pigs (Schiborra et al., 2015), rabbits (Núñez-Sánchez et al., 2012), and ruminants (Landau et al., 2006; Dixon and Coates, 2009). Few works have attempted to assess the ability of NIRS evaluation of faeces to predict diet composition in sheep (Li et al., 2007; Decandia et al., 2009), and botanical composition of the diet (Dixon and Coates, 2009; Landau et al., 2008; Glasser et al., 2008; Kneebone and Dryden, 2015). However, it would be interesting to assess the presence of concentrates in the diet, especially under low pasture availability, as reported for cows (Ottavian et al., 2015). In this case, a qualitative model was developed to discriminate animals among two levels of concentrate supplementation. Hence, it would be interesting to test the ability of faecal NIRS to quantify the amount of forage and concentrates percentages of fed diets, and also predict the proportion of the mixed ingredients.

The aim of this work was to develop faecal NIRS calibrations to assess both the botanical and chemical composition of several diets consumed by ewes in a free access basis.

2. Materials and methods

2.1. Samples and reference data determination

The experiment was carried out in accordance with the Spanish regulation on experimental animals. Twenty four Segureña sheep (46 ± 3 kg BW), neither lactating nor pregnant, were used in the assay. Each animal was randomly allocated to four diets fed in four successive periods of 28 days. A total of 16 diets were fed (six ewes per diet). Diets (800 g/d, as-fed) were formulated to have variable contents of neutral detergent fibre (aNDF) and crude protein (CP), by using combinations of forage/non-forage ingredients from 100/0 to 20/80. Forage base was alfalfa (0–1000 g/kg) or cereal straw (0–800 g/kg). In order to get a good digestive and nutritional balance, different mixtures of cereals, legumes and sunflower meal as non-forage ingredients were used: maize (0–800 g/kg), peas (0–300 g/kg) and lupins (0–200 g/kg), offered as whole grains, and pelleted sunflower meal (0–200 g/kg). Visual observation of the troughs revealed that feed offered daily was completely consumed from day to day. Hence, the design of the assay allowed to know the real individual daily intake (g/d) of the different ingredients of fed diets.

Individual faecal samples were collected for two consecutive days at the end of each feeding period, directly from the rectum. A pool sample was originated from mixing 2 days of faeces from each ewe. The total 96 individual faecal samples obtained were dried at 100 °C for 24 h and ground to pass through a 1 mm sieve. After that, the samples were frozen at −20 °C until NIR analyses were performed. Dry matter (DM), ash, crude protein (CP) and ether extract (EE) contents of feed ingredients were determined according to methods 930.15, 942.05, 984.13 and 920.39 of AOAC (2000), respectively, whereas aNDF was determined according to Van Soest et al. (1991). Non fibrous carbohydrates (NFC) were calculated by difference method, as recommended by NRC (2001); NFC = 100 − aNDF − ash − CP − EE.

2.2. NIR spectra collection

Reflectance spectra from dried and ground faeces samples were obtained on a FOSS-NIRSystems 6500 SY-II scanning monochromator (FOSS-NIRSystems, Silver Spring, MD, USA) equipped with a spinning module. Faeces samples were scanned using small ring cups. Spectral absorbance values were recorded from 400 to 2498 nm, every 2 nm. Two capsules per sample were filled for NIR analysis and the average spectra of two subsamples were used for calibration. WINISI II software, version 1.50 (Infrasoft International LLC, State College, PA) was used for spectral data collection.

2.3. Data processing and calibration development

WINISI IV software, version 4.8 (Foss, Denmark) was used for data processing and calibration development. Regression models were performed to predict botanical and chemical composition of fed diets. For that purpose, each faecal spectrum was paired with the information of the diet fed by the corresponding ewe: the proportion (g/kg) of the botanical ingredients