Predicting Diet Quality of Donkeys via Fecal-NIRS Calibrations

Negusse F. Kidane,[1] Jerry W. Stuth,[2] and Douglas R. Tolleson[3]

Authors are [1]Former Graduate Student, [2]Kelleher Professor (deceased), and [3]Assistant Research Scientist, Department of Rangeland Ecology and Management, Texas A&M University, College Station, TX 77843–2126, USA.

Abstract

Successful applications of fecal-near infrared reflectance spectroscopy (fecal-NIRS) techniques have been reported for ruminant animals. Information on the ability of fecal-NIRS to characterize diet quality in equines is lacking. The objective of these studies was to determine the potential of fecal-NIRS to predict diet quality of free-grazing equines. Two independent in vivo feeding trials, one in Texas (United States) and one in Kenya, were conducted to generate paired samples of diet chemistry:fecal spectrum (D:F). Using 20 female donkeys (*Equus asinus*), 14 (10 US, 4 Kenya) in vivo pen feeding trials were conducted to generate 140 (100 US, 40 Kenya) D:F paired samples. Over 25 species of forage and crop residues ranging from 3.3% to 21.4% crude protein (CP) were used to blend unique diets. Three CP predictive equations based on paired samples from US alone, Kenya alone, US + Kenya combined, and one predictive equation for digestible organic matter (DOM) from US alone were developed. The standard errors of calibration (SEC) and R^2 values were 0.77 and 0.97, 0.97 and 0.95, and 0.88 and 0.90, respectively, for the US, US + Kenya, and Kenya CP equations. The US DOM equation resulted in an SEC of 2.58 with a corresponding R^2 of 0.60. Validation of the US CP equation using an independent dataset resulted in standard error of prediction (SEP) and R^2 of 1.79 and 0.82, respectively, indicating acceptable predictive ability. The validation results (SEP = 15.56) for the US DOM equation were not satisfactory. We calibrated and validated fecal-NIRS equations to predict the DOM and CP contents of diets for donkeys. Crude protein content of diets was predicted with acceptable levels of accuracy, but prediction of diet digestibility was less successful. The degree of accuracy obtained for CP equations indicated that fecal-NIRS can be considered as a tool for routine nutritional management of donkeys.

Resumen

El uso adecuado de la técnica de espectroscopia de reflexión infrarroja (fecal-NIRS) ha sido tradicionalmente utilizado para rumiantes, mientras que se ha tenido un uso restringido para caracterizar la dieta de equinos. El objetivo de estos estudios fue determinar el potencial de la técnica fecal-NIRS para predecir la calidad de la dieta de equinos en libre pastoreo. Se llevaron a cabo dos pruebas independientes de alimentación (en Texas [USA] y Kenia) para generar muestras apareadas de la composición química de la dieta:espectro fecal (D:F). Teniendo como sujetos de estudio 20 burras (*Equus asinus*), 14 de USA y 4 de Kenia, se realizaron pruebas de alimentación in vivo para generar 140 (100 de USA, 40 de Kenia) muestras apareadas D:F. Para elaborar dietas únicas, se utilizaron más de 25 especies de forraje y residuos de cosecha con un contenido de proteína cruda (CP) que fluctuó de 3.3 a 21.4%. Se desarrollaron tres ecuaciones para predecir PC basadas en muestras apareadas de USA, Kenia, y una combinación de USA + Kenya, y una ecuación de predicción de la materia orgánica digestible (MOD) con muestras de USA. Los errores estándar de la calibración (SEC) y los valores R^2 fueron 0.77 y 0.97, 0.97 y 0.95, y 0.88 y 0.90, respectivamente, para las ecuaciones de predicción de PC de USA, USA + Kenya, y Kenia. La ecuación para predecir MOD de USA resultó en un SEC de 2.58 con una R^2 de 0.60. La validación de la ecuación para PC de USA que uso un banco de datos independiente dio lugar al SE de la predicción (SEP) y un R^2 de 1.79 y 0.82, respectivamente, indicando aceptable habilidad predictiva de la ecuación. Los resultados de la validación (SEP = 15.56) para la ecuación MOD de USA no fueron satisfactorios. Se calibró y validó las ecuaciones para determinar MOD and CP de la dieta de burros mediante la técnica fecal-NIRS. El contenido de proteína cruda de la dieta fue predicho con niveles aceptables de exactitud, mientras que la predicción de la digestibilidad de la dieta fue menos acertada. El grado de exactitud obtenido para las ecuaciones de CP indicó que fecal-NIRS puede ser considerado como herramienta para el manejo alimenticio de rutina en burros.

Key Words: crude protein, digestible organic matter, *Equus asinus*, free-grazing, near infrared reflectance spectroscopy

INTRODUCTION

Donkeys (*Equus asinus*) are important sources of draft power for transport and crop production in smallholder agriculture (Pearson et al. 2001). They play a significant role in the socioeconomic life of millions of resource-poor people in developing countries (Ghebreab et al. 1999). According to the Food and Agriculture Organization (2003), there are more than 40 million donkeys worldwide, of which about 13 million are found in Africa. The East Africa region accounts for more than 45% of the total donkey population of the continent. However, in many countries the potential of donkeys as draft animals has not been fully utilized (Pearson and Quassat 2000) largely because of poor nutrition (Aganga et al. 2000). Widespread nutritional constraints are caused mostly by a lack of forages or supplementary feed, and inadequate management of the resources (Muvirimi and Ellis-Jones 1999).

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Correspondence: Douglas R. Tolleson, Dept of Rangeland Ecology and Management, Texas A&M University, College Station, TX 77843–2126, USA. Email: tolleson@cnrit.tamu.edu

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Management of grazing animals generally requires knowledge of the quality and quantity of nutrients that an animal can obtain from forage. However, a rapid reliable method of determining the diet quality of grazing equines, particularly donkeys, has been lacking. Prior research has focused on estimating forage quality using various analytical methods including chemical procedures (Clark et al. 1995), in vitro (Coleman and Moore 2003), in situ (Adesogan et al. 1998), and marker-based in vivo techniques (Van Soest 1982). Under a free-grazing situation, however, analysis of clipped forage samples only provides quality estimates of plant components that the animal could potentially select. Estimation of diet quality via hand plucking plant species and parts has generally been of limited use due to selectivity of free-ranging animals. As an alternative method, visual appraisal of body condition has also been used to monitor the nutritional status of donkeys (Pearson and Quassat 2000), but body condition reflects only past nutrition (Lyons 1990; Stuth et al. 1999).

Fecal-near infrared reflectance spectroscopy (fecal-NIRS) has the potential for predicting diet quality of free-grazing animals (Lyons and Stuth 1992; Leite and Stuth 1995). Prior fecal-NIRS studies have focused on ruminants, and have successfully been used as routine methods for predicting the diet quality of free-grazing cattle, sheep, goats, deer, and elk (Lyons and Stuth 1992; Leite and Stuth 1995; Ossiya 1999; Awuma 2003; Keating 2005; Showers et al. 2006; Li et al. 2007). However, research involving free-grazing equines, which are hindgut fermenters, is lacking. The objective of this study was to determine the ability of fecal-NIRS to predict dietary crude protein (CP) and digestible organic matter (DOM) in domestic donkeys. We hypothesized that analysis of fecal material via near infrared reflectance spectroscopy would characterize the diet quality of equines (hindgut fermenters).

METHODS

Paired calibration samples for relating diet chemistry:fecal spectrum (D:F) were generated from two independent studies (feeding trials) conducted in Texas (United States) and Kenya. The same protocol generally was used at both sites. Differences between sites will be noted in the following description of procedures.

US Study Site

The US feeding trial was conducted at the Texas A&M University Horse Center in College Station, Texas (lat 30°37′N, long 96°21′W). College Station has a mean annual precipitation of 940 mm and varies from 780 to 1 100 mm; mean temperature ranges from 10°C in January to 30°C in July (US Department of Commerce 1990, cited in Leite and Stuth 1995). The feeding trial was conducted for 11 wk, between December 2002 and February 2003.

Kenya Study Site

The Kenya feeding trial was conducted at the Naivasha Research Center, in the facilities of the Kenya Agricultural Research Institute (KARI). The Naivasha Research Center is located at an altitude of 1 936 m, lat 0°40′S and long 36°26′E, and has a mean annual precipitation of 657 mm (KARI 2004). The trial was conducted for 5 wk during November and December 2003.

Experimental Animal Management

In the US feeding trial, 10 mature female donkeys (five nonpregnant and five pregnant) ranging from 2 to 6 yr of age, and mean initial body weight (BW) of 196.8 ± 51.9 kg were used. In the Kenya trial, 10 mature female nonpregnant donkeys were used. Prior to the initiation of the trial, donkeys were subjected to standard quarantine procedures, dewormed, and vaccinated against West Nile virus, Venezuelan eastern western encephalomyelitis, and tetanus. Donkeys were also subjected to a pregnancy test using ultrasound by a trained practitioner. Following the standard quarantine, donkeys were placed in dry lot at the Equine Nutrition facility housed in 3×4 m individual stalls, and offered coastal bermudagrass hay (*Cynodon dactylon* L.) for 2 consecutive wk. All experimental procedures and facilities were designed in such way as to fulfill the requirements of an approved animal use protocol by the University's Institutional Animal Care and Use Committee.

Diet Preparation

For the US and Kenya feeding trials, 13 and 12 feed types (forage and crop residues) were used to create a total of 100 and 40 unique diets, respectively. At both sites, each feed type was analyzed for CP ($N \times 6.25$) using micro-Kjeldahl procedures (Association of Analytical Chemists [AOAC] 1995) before blending into unique diets. Forages included were tropical as well as temperate grasses, forbs, and browse varying from 3.3 to 21.4% CP. In the US feeding trial, the most frequently used ingredients included alfalfa (*Medicago sativa* L.), bermudagrass (*Cynodon dactylon* L.), little bluestem (*Schizachyrium scoparium* Michx.), and peanut hay (*Arachis fabaceae* L.). In the Kenya feeding trial, wheat straw (*Triticum aestivum* L.), barley straw (*Hordeum vulgare* L.), oat hay (*Avena sativa* L.), maize-stover (*Zea mays* L.), and alfalfa (*Medicago sativa* L.) were the predominant ingredients.

Feeding Trials

In vivo feeding trials were conducted for 11 consecutive weeks at the US site and for 5 consecutive weeks at the Kenya site. The first week (week 0) was designated as an adjustment period during which experimental animals were housed in individual stalls and fed the same diet. Following this period, fecal and diet sample collections for calibration were made for 10 wk in the US trial, and for 4 wk in the Kenya trial. Feed types were changed each week. Given the fact that hindgut fermenters such as donkeys have short digesta transit time, i.e., less than 40 h (Izraely et al. 1989; Pearson et al. 2001), they need at most 4 d to balance their intake, clear out previously undigested diets, and balance their fecal output (Dr G. Potter, personal communication, June 2002). Thus a 7-d in vivo feeding trial consisted of a 4-d adaptation period followed by 3 d of sample collection.

Donkeys were fed twice per day at 12-h intervals (0700 hours and 1900 hours) and had free access to diets between successive feedings. The daily diet allowance for each donkey was determined as 2% BW (as fed) as recommended by