PREDICTING NUTRIENT VALUES OF ELEPHANT GRASS (*PENNISETUM PURPUREUM*) USING NEAR INFRARED REFLECTANCE SPECTROSCOPY (NIRS) AT DISNEY'S ANIMAL KINGDOM

Shannon Livingston, MSc,[1] Alejandra Renjifo BSc [2] and Eduardo V. Valdes, PhD[2]*

[1]University of Florida, Department of Animal Sciences, Gainesville, Florida, 32611; [2]Disney's Animal Kingdom, PO Box 10,000, Lake Buena Vista, Florida, 32830

Abstract

From May to December each year, the African elephants (*Loxodonta africana africana*) at Disney's Animal Kingdom receive elephant grass (*Pennisetum purpureum*) as a significant portion of their diet. Near infra-red reflectance spectroscopy (NIRS) is used to quickly predict the nutrient quality of the forage. Samples of elephant grass have been collected since 2003 and used to develop calibration equations. As more samples are added to the calibration sets, the NIRS is able to more accurately predict the levels of certain organic nutrients in the forage. Prediction of levels of ADF, NDF and fat improved when compared to previous calibrations with fewer samples. As more samples are collected and added to the calibration equations, it is expected that the ability of NIRS to accurately predict nutrient levels in *Pennisetum purpureum* will continue to improve.

Introduction

From May to December, the African elephants (*Loxodonta africana africana*) at Disney's Animal Kingdom (DAK) receive up to 1/3 of their daily diet as elephant grass (*Pennisetum purpureum*). For adults, this may translate to over 50 kg per day per animal. By monitoring nutrient content of the major food items, adjustments are able to be made to the proportions of the items in the diet to maintain the desired nutrient balance. It could become very expensive to send regular feed samples for analysis via wet chemistry, in addition to the fact that the results of those samples may not be received in a timely manner. Near infrared reflectance spectroscopy (NIRS) has emerged as a fast, inexpensive and environmentally friendly alternative to wet chemistry analysis that has been used to successfully monitor quality of forages[2,3,8] as well as other diet items used by zoos.[5,6] At DAK, NIRS is used to monitor the quality of food items such as the elephant grass fed to the elephants and other forages.

The main objective of this study was to assess the accuracy of NIR calibrations for elephant grass, previously developed at DAK for several quality parameters. ese historical calibrations have been updated by adding more samples to the calibration sets.

Methods

The elephant grass fed to the African elephants at DAK is presently grown at the browse farm tended by Disney Horticulturalists and located on site at DAK, Lake Buena Vista, Florida. Approximately 5.7 hectares are dedicated to its cultivation, which presently contains 7650 plants. The plants are harvested between 1.8 and 2.4 meters in height, with 2 to 3 harvests per season.

The Disney browse farm has been providing the elephant grass since the fall of 2004. Prior to that time, the elephant grass was purchased from an external supplier.

Samples were collected throughout the growing seasons of 2003 to 2006. After collection, a portion of each sample was freeze dried (Labconco model 77530, Kansas City, MO) for 72 hours and ground using a 1 mm screen (Retsch grinder model ZM100, Newtown, PA) before scanning in the near infrared region of the spectrum (400 – 2500 nm). The remainder of the collected sample was sent for conventional wet chemistry analysis. The samples from 2003 were sent to Cornell University, Nutritional and Environmental Analytical Services (Ithaca NY). Samples from years 2004 to 2006 were tested at Dairy One Laboratories (Ithaca NY). Samples were analyzed for percent moisture, crude protein (CP), acid detergent fiber (ADF), neutral detergent fiber (NDF), lignin, total soluble carbohydrates (TSC) and fat. Gross Energy (GE) (kcal/g) analysis was conducted in house using a Parr 6300 bomb calorimeter (Parr Instruments, Moline IL).

The spectra were collected using a Foss NIR scanning spectrophotometer model 6500 (Foss USA, Laurel MD) following the method previously described.[5] The NIR calibrations were conducted by applying Partial Least Squares and using the full NIR spectrum as reported by Martens and Naes.[1] Thirty six samples were added to the calibration set previously developed by Valdes and Renjifo[7] for a total of 64 scanned samples. Approximately 30 samples were used to calibrate for each nutrient. Samples not used for calibration development were run as prediction sets to validate the NIR calibrations. Calibrations were developed for dry matter (DM), CP, ADF, NDF, Lignin, fat, GE and TSC.

Results and Discussion

The accuracy of the NIR predictions for the parameters studied are given in Table 1. As more samples are added to the calibration sets the accuracy of the calibrations increases, becoming more robust and might better represent the population of samples to be tested. The accuracy of the calibrations were determined by calculating the residual standard deviation (RSD), (root of the mean square error) also called the standard error of the prediction (SEP, Table 1). By adding more samples to the calibration sets, the accuracy of the predictions for percent ADF and percent NDF improved when compared to the original calibrations. The SEP for ADF and NDF were 7.5 % and 4.3 % for the original calibrations and 3.25 % and 3.72 % for the updated calibrations, respectively. The SEP for predicting the percent of fat in the samples also improved from 0.9% to 0.39% for the updated calibration. GE was predicted well by both calibration sets. However, NIR prediction for % TSC were better for the original (0.8) than the updated (2.5) calibrations. The coefficient of variation was high for TSC both in the original (21%) and the updated calibration (42.4%). Low R^2 values for some nutrients may seem to indicate that they are not well predicted by NIR. However, the low R^2 values are likely a product of a small range of values. SEP can provide a better indication of the ability of NIR to accurately predict the nutrient level.[4]

Overall, the ability of NIR to predict the nutrient values of *Pennisetum purpureum* continues to look promising. As more samples are added to the database in the upcoming years, the ability of the calibrations to accurately predict nutrient levels in this forage is expected to increase.

LITERATURE CITED

1. Martens, H. and T. Naes. 1987. In: Near infrared technology in the agricultural and food industries. P. Williams and K. Norris eds. Amer. Assoc. Cereal Chem. St. Paul. Minn.
2. Norris, K.H.; R.F. Barnes; D.E. Moore and J.S. Shenk. 1976. Predicting forage quality by infrared reflectance spectroscopy. J. Anim. Sci. 43:889-897.
3. Reeves III, J.B; T.A. Blosser and V.F. Colenbrander. 1989. Near infrared reflectance spectroscopy for analyzing undried silage. J. Dairy Sci. 72:79-88.
4. Valdes, E. V. 1993. Alternative methods to measure metabolizable energy and other quality parameters in poultry feeds. PhD thesis. University of Guelph.
5. Valdes, E.V.; E.S. Dierenfeld and S.E. Oyarzun. 1995. A preliminary study to measure protein, fat and moisture in whole mice and rats by near infrared reflectance spectroscopy. Proc. 1st Conference on Zoo and Wildlife Nutrition. Nutrition Advisory Group. AZA Toronto, Ont. Canada. 223-227.
6. Valdes, E.V.; E.S Dierenfeld and M.P. Fitzpatrick. 1997. Application of near infrared reflectance spectroscopy (NIR) to measure protein, fat and moisture in fish samples. Proc. 2nd Conference on Zoo and Wildlife Nutrition. Nutrition Advisory Group. AZA. Fort Worth, TX. 159-161.
7. Valdes, E.V. and A. Renjifo. 2003. Chemical analysis of elephant grass (*Pennisetum purpureum*) using near infrared reflectance spectroscopy (NIR). Proc. 5th Conference on Zoo and Wildlife. Nutrition Advisory Group. 4.7. AZA. Minneapolis, MN. 65-68.
8. Valdes, E.V.; L.G. Young; I. McMillan and J.E. Winch. 1985. Analysis of hay, haylage and corn silage samples by near infrared reflectance spectroscopy. Can. J. Anim. Sci. 65:753-760.

Table 1. Prediction of nutrients in elephant grass (*Pennisetum purpureum*) using near infrared reflectance (NIR) spectroscopy.

Parameter	Dry matter, %	Crude Protein, %	Acid Detergent Fiber, %	Neutral Detergent Fiber, %	Lignin, %	Fat, %	TSC,[1] %	Gross energy Kcal/g
N	31	26	23	29	27	31	16	29
R^2	0.04	0.83	0.43	0.71	0.29	0.27	0.5	0.34
Mean lab	90.18	7.44	44.53	71.63	5.92	1.88	5.89	4313.58
Mean NIR	91.14	7.87	43.61	71.48	6.77	1.73	6.72	4270.24
Bias	-0.96	-0.43	0.92	0.15	-0.85	0.15	-0.83	43.34
Range lab	87.7-92.6	4.0-14.8	36.9-48.7	58.6-77.8	3.3-8.4	1.3-2.4	0.6-12.1	3977.1-4640.1
SEP[2]	3.47	1.39	3.25	3.72	1.82	0.39	2.5	158.19

Bias: non-random error or the average difference between the NIR predicted and laboratory values.

[1]TSC = total soluble carbohydrates

[2]SEP = standard error of the prediction