Short Communication: A Novel System to Estimate Protein Degradability in Legume and Grass Hays[1]

M. E. Dorshorst and P. C. Hoffman
Department of Dairy Science,
University of Wisconsin-Madison 53706

ABSTRACT

Previous research from our laboratory has demonstrated that near-infrared reflectance spectroscopy has utility in predicting rumen-undegradable protein (RUP) contents of legume and grass silages. This study was conducted to evaluate whether application of previous research techniques could yield a useful near-infrared reflectance spectroscopy RUP prediction system for legume and grass hays. Legume and grass hays (n = 106) were evaluated for RUP content by in situ techniques in four ruminally cannulated cows. In situ RUP for legume and grass hays averaged 25.9% CP and ranged from 14.6 to 45.5% CP, respectively. We developed a near-infrared reflectance spectroscopy RUP calibration equation for the legume and grass hay data set using in situ RUP contents as base data. This procedure resulted in an acceptable (R^2 = 0.87, SE = 2.46% CP) near-infrared reflectance spectroscopy equation to predict RUP content of legume and grass hays. Data suggest that near-infrared spectroscopy predicts RUP contents of legume and grass hays with accuracies similar to legume and grass silages.
(**Key words:** hay, near-infrared, protein degradation)

Abbreviation key: NIRS = near-infrared reflectance spectroscopy.

Recently our laboratory conducted a series of studies (3, 4, 5) exploring the utility of using near-infrared reflectance spectroscopy (**NIRS**) to predict RUP contents of legume and grass silages. Our initial work (5) led to the development of an NIRS RUP equation for legume and grass silages that performed well under field conditions. While promising, the development of an NIRS RUP equation for legume and grass silages falls short of industry needs. Because dairy cattle are fed different types of forages, a more robust set of NIRS RUP prediction equations for forages would be desirable. Because of our initial success, we postulated that development of NIRS RUP prediction equations for other forages should be feasible. In this study, we used our previous techniques (3, 4, 5) to explore the utility of NIRS to predict the RUP contents of legume and grass hays.

In 1998 and 1999, legume and grass hay samples (n = 208) from the north central region of the United States were collected and then ground through a 2-mm Wiley mill (Arthur H. Thomas, Philadelphia, PA) screen and saved for in situ analyses. A subsample was reground through a 1-mm UDY mill (UDY Corp., Boulder, CO) screen and packed into a cylindrical sample holder equipped with a quartz window and scanned according to the procedures of Marten et al. (6) on a near-infrared reflectance spectrophotometer (model 6500: NIR Systems, Perstop Analytical, Silver Spring, MD) with a spinning cup holder. Spectra were saved with center and select procedures implemented using Intrasoft International software [version 2.0 (8)]. We selected a total of 106 spectrally different legume and grass hays for NIRS and in situ RUP determination. The CP (1) and NDF (2, 7) contents of the hay samples (n = 106) were determined. The in situ RUP contents of the legume and grass hays (n = 106) were also determined with previously described calibrated cow in situ techniques (5). A NIRS calibration equation for in situ derived RUP content of legume and grass hays was explored. Calibration was made using a modified least squares regression method and the number of terms in the equation was varied until no significant or relevant improvement in the coefficient of determination or standard error of calibration could be determined. Different math transformations (8) were explored and the (2, 10, 10, 1 transformation) math equations with three terms in the equation offered the best prediction of RUP content of legume and grass hays.

Summary statistics for the CP, NDF, and RUP contents of the 106 legume and grass hays are presented in Table 1. In general, the legume and grass hays were of variable quality with CP ranging from 10.7 to 29.7% and NDF ranging from 26.8 to 61.5% of DM. Likewise, in situ RUP contents ranged from 14.6 to 45.5% CP with a mean RUP of 25.9% CP. Background CP, NDF, and RUP values suggest the legume and grass hay data

Received October 12, 1999.
Accepted February 4, 2000.
Corresponding author: P. C. Hoffman. e-mail: pchoffman@facstaff@wisc.edu.
[1]Supported by federal Hatch funds and the College of Agricultural and Life Sciences, University of Wisconsin, Madison 53706.

Table 1. Calibration and validation statistics for near-infrared spectroscopy analysis of legume and grass hays.[1]

Item	RUP	CP	NDF
	% CP	(% of DM)	
Data set (n = 106)			
Minimum	14.6	10.7	26.8
Maximum	45.5	29.7	61.5
x	25.9	22.1	40.2
SD	7.2	4.0	7.4
Calibration			
Transformation	2,10,10,1	. . .	. . .
PLS, terms	3	. . .	. . .
R^2	0.87	. . .	. . .
SEC, % CP	2.46	. . .	. . .
Validation			
r^2	0.83	. . .	. . .
SECV, % CP	2.84	. . .	. . .
Bias, % CP	1.48	. . .	. . .

[1]PLS = Partial least squares, SEC = standard error of calibration, and SEVC = standard error of cross validation. Transformation values equal order of derivative function, segment length (nanometers), segment length (nanometers) of first smoothing, and segment length (nanometers) of second smoothing.

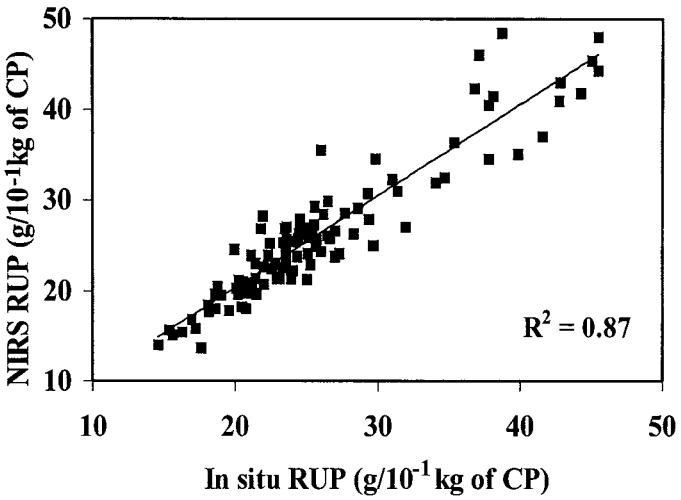

Figure 1. The relationship of RUP contents of legume and grass hays derived in situ or by near-infrared reflectance spectroscopy using an equation developed for legume and grass hays. (■) RUP, SE = 2.46 g/10^{-1} kg of CP.

set (n = 106) was robust and suitable for NIRS equation development (8).

Development of a NIRS RUP equation for legume and grass hays proved to be fruitful. Calibration and cross validation statistics of the 106 legume and grass hays are presented in Table 1. The R^2 of 0.87 and the standard error of calibration of 2.46% CP indicated reasonable accuracy in predicting legume and grass hay RUP content using NIRS. These equation statistics are nearly identical to those observed in our previous experiment (5), in which NIRS was used to predict RUP contents of legume grass silages.

A graphic representation of the NIRS RUP equation for legume and grass hay is presented in Figure 1. Cross validation statistics (8) indicated reasonably good performance of the equation with an r^2 of 0.83 and a standard error of cross validation 2.84% CP. These data support our previous observations (3, 4, 5) that NIRS can predict in situ RUP contents of forages.

The objective of this research was to explore the utility of an NIRS to predict RUP contents of legume and grass hays. Data indicate that NIRS has utility in predicting RUP contents of legume and grass hays. We were successful in developing a separate and accurate NIRS equation for legume and grass hays. Commercial application of this NIRS equation may be feasible.

REFERENCES

1 Association of Official Analytical Chemists. 1990. Official Methods of Analysis. 15th ed. AOAC, Arlington, VA.
2 Goering, H. K., and P. J. Van Soest. 1970. Pages 8–11 *in* Forage Fiber Analyses (Apparatus, Reagents, Procedures, and Some Applications). Agri. Handbook No. 379. ARS-USDA, Washington, DC.
3 Hoffman, P. C., N. M. Brehm, D. K. Combs, L. M. Bauman, J. B. Peters, and D. J. Undersander. 1999. Predicting the effect of proteolysis on ruminal crude protein degradation of legume and grass silages using near-infrared reflectance spectroscopy. J. Dairy Sci. 82:756–763.
4 Hoffman, P. C., N. M. Brehm, D. K. Combs, L. M. Bauman, J. B. Peters, and D. J. Undersander. 1999. Prediction of laboratory and in situ protein fractions in legume and grass silages using near-infrared reflectance spectroscopy. J. Dairy Sci. 82:764–770.
5 Hoffman, P. C., N. M. Brehm, J. J. Hasler, L. M. Bauman, J. B. Peters, D. K. Combs, R. D. Shaver, and D. J. Undersander. 1999. Development of a novel system to estimate protein degradability in legume and grass silages. J. Dairy Sci. 82:771–779.
6 Marten, G. C., J. C. Halgerson, and J. H. Cherney. 1983. Quality prediction of small grain forages by near infrared reflectance spectroscopy. Crop Sci. 23:94–101.
7 Mertens, D. R. 1992. Critical conditions in determining detergent fibers. Page C-1 *in* Proc. Natl. Forage Testing Assoc. Forage Anal. Workshop, Denver, CO. Natl. Forage Testing Assoc. Omaha, NE.
8 Shenk, J. S., and M. O. Westerhaus. 1991. Infrasoft International Software for Near Infrared Instruments. NIR Systems Inc., Silver Spring, MD.