

Kansas Agricultural Experiment Station Research Reports

Volume 0
Issue 1 *Cattleman's Day (1993-2014)*

Article 833

1991

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Recommended Citation

Garcia-Lagombra, G. and Harbers, L.H. (1991) "Predicting nutritional composition of corn grain using near infrared reflectance spectroscopy," *Kansas Agricultural Experiment Station Research Reports*: Vol. 0: Iss. 1. <https://doi.org/10.4148/2378-5977.2236>

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Predicting nutritional composition of corn grain using near infrared reflectance spectroscopy

Abstract

Corn grain samples collected over several years were used to develop equations for dry matter, crude protein, crude fiber, and ether extract (crude fat). Two computer models were used to select samples having a range of spectra (presumably a range of nutrient values) for developing calibration equations. Both methods selected an unexpectedly small number of samples; however, only the prediction of crude fiber appears questionable. Although coefficients of determination values are expected to be low with a small number of samples, standard errors of validation and prediction are consistently lower than those of standard (AOAC) methods, suggesting that the technology is reliable for nutrient analysis of corn grain.

Keywords

Cattlemen's Day, 1991; Kansas Agricultural Experiment Station contribution; no. 91-355-S; Report of progress (Kansas State University. Agricultural Experiment Station and Cooperative Extension Service); 623; Beef; Corn analysis; Near infrared spectroscopy

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PREDICTING NUTRITIONAL COMPOSITION OF CORN GRAIN USING NEAR INFRARED REFLECTANCE SPECTROSCOPY

G. Garcia-Lagombra and L. H. Harbers

Summary

Corn grain samples collected over several years were used to develop equations for dry matter, crude protein, crude fiber, and ether extract (crude fat). Two computer models were used to select samples having a range of spectra (presumably a range of nutrient values) for developing calibration equations. Both methods selected an unexpectedly small number of samples; however, only the prediction of crude fiber appears questionable. Although coefficients of determination values are expected to be low with a small number of samples, standard errors of validation and prediction are consistently lower than those of standard (AOAC) methods, suggesting that the technology is reliable for nutrient analysis of corn grain.

(Key Words: Corn Analysis, Near Infrared Spectroscopy.)

Introduction

Near Infrared Reflectance Spectroscopy (NIRS) has been widely used for rapidly estimating nutritional composition of cereal grains and feedstuffs. Wet chemistry procedures are lengthy and expensive, so researchers sought ways to reduce cost and analysis time. Because corn grain is of prime importance for ration formulation, a rapid and reliable method for nutritional composition is necessary. NIRS has shown great potential to predict nutritional composition when an appropriate set of calibration samples is chosen.

Although NIRS is high in initial cost and requires trained personnel, it is capable of analyzing many samples in a short time, non-

destructively, and with little or no use of supplies or chemicals.

Experimental Procedures

Two hundred ninety-nine corn grain samples from three consecutive years (1987, 1988, and 1989) were obtained from Peterson Laboratories in Hutchinson, Manhattan Milling Company, and Manhattan Co-op. Those samples covered most of Kansas, as well as several areas of Texas and Oklahoma.

The samples were stored at room temperature, ground in a cyclone-type (UDY) mill, and then frozen. Later, they were thawed and scanned in duplicate with a tilting filter NIRS (Pacific Scientific 4250). The spectra of each sample were averaged, then stored on computer disks for further manipulation.

Samples with unique spectra were chosen by one of two subset programs. The first method picks a sample and eliminates those that are similar. The second method picks a pair of samples and eliminates the closest neighbors. Samples from both sets and additional samples chosen at random for validation were analyzed for dry matter (DM), crude protein (CP), crude fiber (CF), and fat or ether extract (EE) by standard (AOAC) chemical methods. The AOAC data were matched with NIRS spectra to develop and validate NIRS equations.

Results and Discussion

From a total of 229 samples, only seven calibration samples were selected by method 1 and 11 by method 2. Only one sample was found in both sets. This selection process indicates a great deal of similarity among

spectra of the corn samples. When samples are similar in composition, many samples need to be collected to produce reliable calibrations. A single equation was chosen for each nutrient based on a set of statistical criteria. Dry matter information was found at wavelength 2180, crude protein at 1956 and 2078, crude fiber at 2172, and ether extract at 2236.

Table 1 summarizes the standard errors of calibration and validation. The data suggest that chemical values agree fairly well

with calibration scans. Only dry matter and ether extract values were satisfactory with respect to validation samples.

Statistical comparisons of NIRS and AOAC values (Table 2) indicate very small variations between the two methods, which strongly suggests that the equations are adequate. The standard deviation values (SD) for NIRS values are consistently smaller than those for laboratory values, again suggesting that the equations are adequate but that samples with greater variation than those presently available would improve them.

Table 1. Means, Standard Errors and Correlations of Corn Regression Equations

Variable	No.	Range, %	Mean, %	Calibration		Validation		Method
				SE ^a	R ^{2b}	SE ^a	R ^{2b}	
DM	6	85.66-92.00	89.69	0.424	0.899	2.974	0.995	1
CP	10	8.18-10.77	9.46	0.303	.885	0.949	0.213	2
CF	7	0.52-1.58	1.05	0.171	.656	0.131	0.286	1
EE	7	3.42-5.25	4.57	0.196	0.860	0.209	0.998	1

^aSE = standard error.

^bR² = coefficient of determination.

Table 2. Comparison of NIRS Predicted Values vs. Laboratory Analyzed Values of Corn

Variable	No. Values	Mean, %	SD ^a	R ^b	R ^{2c}
DM Lab	24	89.41	2.070	0.370	0.137
DM NIRS		89.26	0.721		
CP Lab	22	9.37	0.700	0.855	0.731
CP NIRS		9.42	0.625		
CF Lab	24	1.09	0.199	0.508	0.258
CF NIRS		1.11	0.140		
EE Lab	24	4.55	0.595	0.738	0.544
EE NIRS		4.59	0.448		

^aSD = standard deviation.

^bR = correlation coefficient.

^cR² = coefficient of determination.