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Rapid nutrient evaluation of sorghum silages using two types of near-infrared reflectance spectroscopy

Abstract

This research was designed to develop a set of prediction equations to measure nutrient composition of Kansas sorghum silages using both a portable and a research type near-infrared spectrometer (NIRS). A robust set of equations for dry matter, crude protein, neutral detergent fiber, and acid detergent fiber was developed for a wide range of sorghum phenotypes . NIRS analysis of sorghum silages is feasible with both a tilting filter (portable) and research instrument with a grating monochrometer.

Keywords

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RAPID NUTRIENT EVALUATION OF SORGHUM SILAGES USING TWO TYPES OF NEAR-INFRARED REFLECTANCE SPECTROSCOPY

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Summary

This research was designed to develop a set of prediction equations to measure nutrient composition of Kansas sorghum silages using both a portable and a research type near-infrared spectrometer (NIRS). A robust set of equations for dry matter, crude protein, neutral detergent fiber, and acid detergent fiber was developed for a wide range of sorghum phenotypes. NIRS analysis of sorghum silages is feasible with both a tilting filter (portable) and research instrument with a grating monochrometer.

(Key Words: Sorghum Silage, Nutrient Content, Near-Infrared Reflectance Spectroscopy.)

Introduction

Near-infrared spectrometers, originally designed to test grains, are used widely in the feed and food industries for rapid nutrient analysis. Various models are available. Simple portable systems are based on tilting filters. More sophisticated, expensive models have a grating monochrometer capable of producing a continuous wavelength scan. We developed equations for use with two popular models; one that is suitable for field use and another designed for use in a testing laboratory or research facility.

Experimental Procedures

Two hundred and eighty-eight sorghum silage samples were dried using a forced air-oven (55°C), then ground to 1 mm using a UDY impact mill. Samples were scanned using an NIRS Systems scanning monochrometer unit and immediately placed in a vacuum oven to obtain total dry matter data. A computer program selected 106 scans that differed enough to be useful in developing equations. Those samples were analyzed in duplicate for crude protein (CP), neutral detergent fiber (NDF), and acid detergent fiber (ADF).

Sixty-eight samples were selected by the instrument's computer to be used to develop calibration equations for the monochrometer instrument using the full spectrum. The remaining 38 samples were used for validation. Then, the process was repeated, limiting the software to the wavelengths available to the tilting filter instrument (1900 to 2320 nm).

Results and Discussion

Of the original 68 samples selected for calibration, several were rejected by the instrument's software because the chemical analysis values were outside the expected norm relative to the respective spectra. Neutral detergent fiber had the highest standard error of calibration (SEC) because of variation in samples, whereas the SEC of ADF was slightly lower and also had higher R^2 values. Crude protein appeared to be the most consistent among nutrient values tested and is the only nutrient derived directly from a chemical analysis. The others (moisture, NDF, and ADF) are derived by weights

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both before and after a physical treatment and are highly impirical compared to the direct nitrogen determination used for CP.

Regression equations (Table 2) show that from two to four wavelengths were needed for prediction. Linear equations were formed where B_0 is the intercept, and $B_1...B_n$ are coefficients for the value log 1/R (R is reflectance) at the designated wavelength.

A wide range of sorghum cultivars was used, ranging from high grain-yield grain sorghums to headless, nongrain-producing forage sorghums, and this could account for the lower R^2 values than would be expected from more uniform forage species, such as corn silage or alfalfa hays.

In summary, these data indicate that the development of robust equations for all sorghum silages is feasible and NIRS analysis would be useful for practical determinations of nutritional value.

Table 1. Selected Means, Standard Errors, and Coefficients for Nutrient Components of Sorghum Silage Using Two Types of Near-Infrared Reflectance Spectrometers

Variable	N	Mean	SEC[a]	R^2	SEV[b]	R^2
		Tilting Filter Instrument (1900-2320 nm)				
Dry matter	65	93.46	.91	.65	.94	.62
Crude protein	66	8.31	.56	.86	.58	.85
Neutral detergent fiber	66	51.33	1.83	.87	1.91	.86
Acid detergent fiber	68	32.53	1.30	.90	1.36	.89
		Full Spectrum Instrument				
Dry matter	65	93.46	.79	.73	.83	.70
Crude protein	66	8.28	.52	.88	.54	.87
Neutral detergent fiber	66	51.32	1.70	.89	1.74	.88
Acid detergent fiber	65	32.61	1.13	.93	1.16	.92

[a]SEC = standard error of calibration.
[b]SEV = standard error of validation.

Table 2. NIRS Equation Constants for Nutrient Analysis of Sorghum Silages

		Tilting Filter		Full Spectrum	
Variable	Component	Coefficient	Wavelength	Coefficient	Wavelength
Dry matter	B_0	90.25		75.98	
	B_1	-68.41	2220	-143.00	1812
	B_2	-116.59	2300	-14.86	1908
	B_3			-66.48	1740
	B_4			6.81	624
Crude protein	B_0	20.64		33.46	
	B_1	-21.84	2148	110.17	872
	B_2	-42.55	2196	53.13	1748
	B_3	-30.15	2316	151.69	1228
	B_4	-28.67	2252	-46.91	2028
Neutral detergent fiber	B_0	45.09		90.20	
	B_1	186.40	1948	-121.31	848
	B_2	-202.61	2300	117.05	1740
	B_3	486.44	2276	-103.86	2348
	B_4	-892.82	2108	35.11	2116
Acid detergent fiber	B_0	-2.09		2.40	
	B_1	910.61	2212	214.18	1616
	B_2	-156.37	2308	-500.07	2476
	B_3	-1089.24	2220	-507.69	1652
	B_4			106.28	472