Development of a Method for the Fast and Complete Assessment of Quality Characteristics in Undried Grass Silages by Means of an NIR-Diode Array Spectrometer

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Introduction Traditionally, the determination of grass silage is very time consuming and needs a lot of manpower and chemicals. The advantages of conventional laboratory NIRS instruments are well known but their disadvantage lies in their lacking suitability for on-farm use. A new type of spectrometer based on diode arrays may be used for this purpose. However, these new instruments still need to be calibrated for an accurate estimate of the fermentative and nutritive value of wet and unchopped grass silage.

Materials and methods Stored grass silage samples from the North of Germany covering four cuts of each of the years from 2000 to 2003 were available for calibration. For NIRS-analysis the frozen silages were thawed, equilibrated to room temperature and then carefully mixed. NIRS measurements were performed using a Corona 45 NIR high resolution diode array spectrometer (equipped with 256 InGaAs-diodes in the range 960-1690 nm) of Carl Zeiss Jena GmbH. Samples were measured using the turntable sample presentation device in Petri dishes of 200 mm diameter from below and the mean of 2x2 replicate spectra calculated. After transformation of the averaged spectra into WinISI format, a range of scatter correction procedures was performed. Multivariate data analysis of math treated spectra (1,6,6,1) and reference parameters were performed using modified partial least squares regression with 8 terms and a single pass for outlier removal (WinISI 1.50). The original calibration set consisted of 149 representative samples of all four harvest years. For truly independent validation 57 new samples from the last harvest of 2003 with a lower than average silage quality were used. The following reference parameters were employed and expressed as % of dry matter (DM): CP (Kjeldahl-N x 6.25), WSC (Anthrone method), CF (Weende method), ADF/NDF (modified van Soest), pH (electrometrically by a pH-meter), short chain fatty acids (HPLC from an acid silage extract). DM was assessed by oven drying at 105°C and corrected for losses of volatiles according to Weissbach & Kuhla (1995).

Table 1 Description and statistics of calibration and validation

Parameter	Scatter	Calibration				Validation				
		Mean	sd	SEC	R^2	Mean	sd	SEP(C)	Bias	R^2
DM	MSC	36.7	8.0	1.1	0.98	38.9	10.9	1.7	0.3	0.98
CP	None	17.0	2.7	1.5	0.69	15.7	2.8	1.4	1.1	0.78
WSC	None	3.0	2.8	1.4	0.75	4.1	3.5	1.6	-0.1	0.82
CF	MSC	27.1	3.3	1.4	0.82	27.3	2.7	1.6	-1.3	0.67
ADF	None	32.0	3.7	1.7	0.80	32.6	4.0	2.2	-2.0	0.72
NDF	None	51.3	5.8	2.5	0.81	53.1	5.0	3.0	-1.7	0.63
PH	SNV-D	4.4	0.4	0.2	0.76	4.7	0.5	0.3	0.0	0.66
Lactic acid	None	7.1	4.0	1.6	0.84	4.5	2.7	1.5	-0.1	0.73
Butyric acid	MSC	0.3	0.6	0.4	0.55	1.1	1.1	0.7	0.4	0.65

Scatter correction: None (no scatter correction); SNV-D (standard normal variate after de-trending); MSC (multiple scatter correction) dry matter (% of fresh matter), CP: crude protein, WSC: water soluble carbohydrate, CF: crude fibre, ADF: acid detergent fibre, NDF: neutral detergent fibre

Results Unlike in classic NIRS measurements on dried and ground forages, our samples contain a large amount of water which may interfere with the NIR measurement of relatively weak N-H and C-H-bands. Nevertheless, our initial calibration for fermentative and nutritive parameters of grass silage performed satisfactorily (Table 1). It showed potential even in a validation set which deviated from the calibration set by nature of a high proportion of poorly fermented silages.

Conclusions Further improvements in the analytical potential of the above method are anticipated by enhancing the variation in the calibration set. This will allow more complex NIR regression models to be developed so that both the systematic and random error component can be reduced.

References

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