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COMMUNICATION

Prediction performances of portable near infrared instruments for at farm forage analysis

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ABSTRACT

The objective of this study was to evaluate the use of Near Infrared Spectroscopy (NIRS) to analyze maize silage with a portable instrument. The instrument was a Zeiss Corona 45 working between 960 and 1700 nm which was used in Italy, Czech Republic and Poland. Best prediction performances were obtained using the Italian data set. Prediction error were 1.0, 0.16 and 0.4 respectively for DM, CP and NDF on a as is basis. With the instrument from Poland and Czech Republic there were lower accuracy of prediction compared to the Italian dataset, probably for their limited (less than 100 samples) calibration data set. Merging all the data set improved prediction accuracy for CP but not DM. It would appear that some form of instrument standardization is needed before merging data set.

Key words: NIR, Portable instrument, Maize silage

Introduction

In order to ensure maximum production and animal health, diets must be optimized to meet animal requirements (Stone, 2003). The process include feed sampling at farm level, the chemical analysis is sent to the nutritionist which formulate the diet. Using reference lab methods require several days before the chemical analysis is completed. Even in the best conditions the analysis is not returned to the nutritionist before a few days, and in practice it may take even a few weeks. The time delay may actually affect the effectiveness of the diet change. As dairy farms consolidated in larger herds, lots of feed are consumed quickly and the analytical results may arrive after the feed is already consumed. In forages like silages there are changes overtime. A single sample and analysis cannot represent the entire silo. Accurate description of chemical and nutritional properties of forages requires frequent sampling and analysis, but at costs that are not well accepted by farmers. In the past few years, near infrared (NIR) methods has been accepted as accurate method for feed analysis (N.F.T.A, 2002). It is rapid and inexpensive, all characteristics that fit the needs for farm analysis. Normally wet feeds must be dried and ground before NIR analysis. Analysis of undried, unground feed has also been used in NIR (Park, 1998), which offer the possibility to reduce labour and time of analysis. The improvement and evolution of NIR instrument has brought to the market a new kind of instruments based on diode array detectors. This technology allows to build instruments with no moving part, with reduced size and weight that can be easily transported without affecting their functionality. The study evaluated the use of a diode

Table 1. Regression statistics of the calibration data set.

Constituent		n.	Mean	SD	SEC[1]	RSQC[2]	SECV[3]	RSQCV[4]
DM	%	330	32.20	2.79	0.87	0.90	0.97	0.88
CP	% As Is	329	2.12	0.24	0.11	0.79	0.12	0.76
NDF	"	327	15.23	1.12	0.36	0.90	0.40	0.87

[1] SEC= Standard error of calibration; [2] RSQC= R square of calibration; [3] SECV= standard error of cross validation; [4] RSQCV= R square of cross validation.

array instrument for the analysis of maize silage without any sample preparation.

Material and methods

Samples (num=388) of maize silage were collected from Italian cattle farm from the year 2000 until 2004. The samples were stored at -20°C until analysis. Sample were thawed overnight and allow to reach at least 10°C. They were scanned on Zeiss Corona 45 (Helma Italia, Milano) equipped with a turnstep accessory, placing the samples on a large (diameter 180mm) Petri dish that allows scanning over large sampling area. Spectral data were collected between 960 and 1700nm. Scanning time (integration time) was approximately 20ms and each scan lasted for 10s with the acquisition of about 500 scan per samples that were averaged to obtain one spectrum per sample. Samples were then dried at 60°C for 48 h, then ground with a hammer mill fitted with a 1mm screen. Laboratory determination included residual DM (105°C), NDF (Mertens, 2002) and CP. Chemical and spectral data were combined into a file. In order to evaluate performances, 48 samples were kept for validation and the remaining samples (num=340) were used for calibration development. Original spectra were interpolated every 2nm and prediction equations were developed with modified partial least square (MPLS) regression method using WinISI 1.5 (Infrasoft International, USA), with math treatments that included standard normal variate and detrening for scatter correction, first derivative calculated over 4 data point. Evaluation of performances were based on the standard error (SE) of calibration, SE of cross validation and on the validation file on the basis of SE of prediction and bias.

Results and conclusions

The data set comprised a large variability due to sampling over a large geographic area of Italy and the inclusion different growing years. Dry matter averaged 32.3% (SD=2.9), CP 2.1% As Is (SD=0.25), NDF 15.2% As Is (SD=1.2). The validation set had very similar chemical composition to calibration data set.

Estimated prediction errors as indicated by the SE of cross validation (SECV) were small and indicated good accuracy of prediction (Table 1). For DM and NDF, R2 of cross validation (RSQCV)

Table 2. Performance of the calibration equation used to predict a validation data set.

Constituent		n.	Mean	SD	SEP[1]	Bias[2]	RSQ[3]
DM	%	49	32.82	2.86	1.05	0.11	0.86
CP	% As Is	49	2.16	0.26	0.14	0.01	0.71
NDF	"	49	15.50	1.21	0.52	0.08	0.82

[1] SEP= Standard error of prediction; [2] Bias= Average difference between reference and predicted values; [3] RSQ= R square.

Figure 1. NIR prediction *vs* Reference method (LAB) for DM in validation.

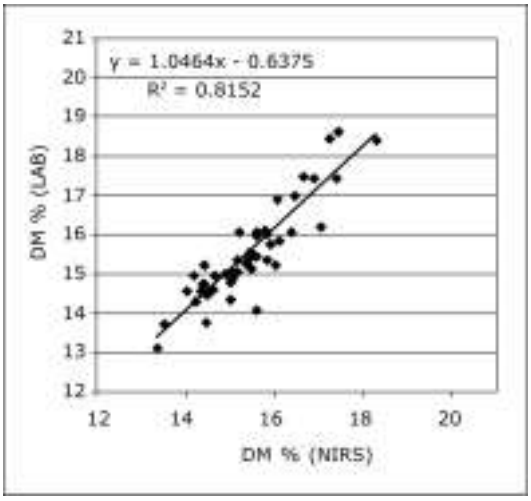
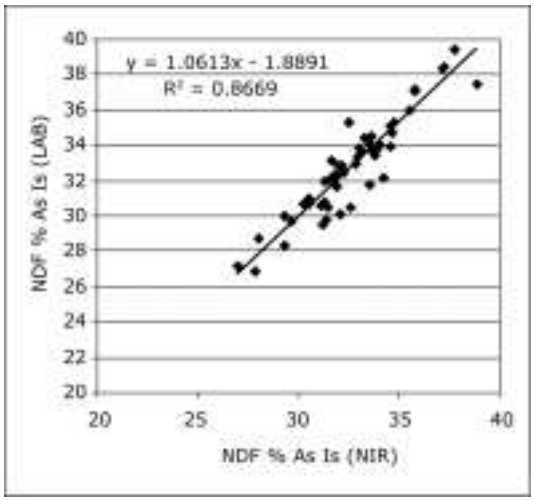


Figure 2. NIR prediction *vs* Reference method (LAB) for NDF in validation.



were around 0.87-0.88. Despite the smallest SECV CP had a RSQCV below 0.80, but this is due to the limited variability of this constituent in maize silage.

The performance of the calibration equation were confirmed in the validation test predicting samples not included in the calibration data set. The SEP values for all three constituents (Table 2) were slightly greater than the SECV of Table 1, but practically very similar. The level of accuracy is practically identical to what reported by Park (1998) on undried unground grass silage that used a laboratory NIR instrument, and similar to prediction accuracy of maize silage predicted, as it is common in NIR, on dried ground samples (Boever, 1997) . The calibration with this portable diode array has proofed to be accurate over the entire range of variation of the data set. The good accuracy along with the competitive cost of the instruments based on diode array can allow to analyze maize silage without any sample processing (drying and grinding) and extent the application of NIR analysis bringing the analytical process directly at farm level.

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