Development of reliable tools to predict at the farm level the quality of forages using Near Infrared (NIR) spectroscopy

N. Chamberland, Ph. Vermeulen, B. Lecler, O. Minet, V. Decruyenaere, E. Froidmont, V. Baeten
Walloon Agricultural Research Center – CRA-W (Belgium)
EAAP, Ghent- Belgium, 26-30 August 2019
n.chamberland@cra.wallonie.be, foodfeedquality@cra.wallonie.be

Aim

Development of reliable, rapid and non-destructive analytical methods for predicting quality parameters such as dry matter (DM), chemical composition (Starch, Crude Protein, ADF, NDF, Ash and Fat) and digestibility of wet forages directly at the farm level (specifically for maize silage, grass silage, fresh grass and hay).

Methodology

Fresh forages from twenty dairy farms have been collected in Wallonia (Belgium) between 2018 and 2019. NIR spectra were measured directly on site with two portable NIR spectrometers : the FieldSpec 4 from ASD (350-2500 nm) and the Micronir 1700 from VIAVI (950-1650 nm). Twenty NIR spectra were acquired for each sample with the handheld instruments. Moreover, samples were also measured with a benchtop FOSS XDS instrument (400-2498 nm) using the rectangular full cup in the NIR laboratory of the CRA-W.

Reference values of these samples were obtained by prediction using a FOSS DS2500 but on the same dried and ground material.

All spectra have been reduced to the common range of all instruments.

Models of prediction were built using the Winisi Software with SNV detrend and first derivative on 1100-1650 nm of range.

Handheld instruments

Micronir 1700

- Diffuse Reflectance scanning
- Contact probe
- Wavelength range: 950-1650 nm

FieldSpec 4

- Diffuse Reflectance scanning
- Contact probe
- Wavelength range: 350-2500 nm

Global Models with benchtop instrument (FOSS XDS)

Foss XDS models for grass silage

Constituents	n	Mean	SD	Factors	SECV	R²	RPD
Dry Matter	132	49.83	13.31	9	2.14	0.97	6.22
Protein	141	16.41	2.73	9	1.21	0.80	2.26

Foss XDS models for maize silage

Constituents	n	Mean	SD	Factors	SECV	R²	RPD
Dry Matter	226	34.57	3.56	9	1.41	0.87	2.52
Protein	236	7.05	0.66	12	0.39	0.65	1.69

n: effectif, SD: Standard Deviation, SECV: Standard Error of Cross-Validation, Factors: number of component for PLS regression , R²: Coefficient of determination, RPD (SD/SECV): Residual predictive deviation

To assess the performance of the prediction models, two parameters are taking into account:

- **Coefficient of determination (R²)**: vary between 0 and 1, higher R², better predictions

- **Residual predictive deviation (RPD = SD/SECV)**: higher the RPD better the predictions, RPD between 2 and 3 is considered to be as a good model

Global Models with handheld instruments (Micronir 1700 and FieldSpec)

Micronir (Viavi) models for grass silage

Constituents	n	Mean	SD	Factors	SECV	R²	RPD
Dry Matter	119	49.97	13.20	8	3.19	0.95	4.14
Protein	130	16.47	2.76	9	2.04	0.45	1.35

Micronir (Viavi) models for maize silage

Constituents	n	Mean	SD	Factors	SECV	R²	RPD
Dry Matter	156	35.22	3.61	7	3.03	0.29	1.19
Protein	154	7.07	0.69	7	0.55	0.36	1.25

FieldSpec (ASD) models for grass silage

Constituents	n	Mean	SD	Factors	SECV	R²	RPD
Dry Matter	73	46.64	15.85	6	6.99	0.8	2.27
Protein	74	17.81	3.01	6	2.49	0.31	1.21

FieldSpec (ASD) models for maize silage

Constituents	n	Mean	SD	Factors	SECV	R²	RPD
Dry Matter	189	34.02	3.01	11	2.22	0.45	1.36
Protein	196	7.01	0.61	2	0.53	0.24	1.15

Discussion

Regarding the R² and RPD parameters, models of prediction for handheld instruments are not so accurate compared to those obtained with the benchtop instrument. This is mainly due to the high heterogeneity of the products analyzed and because the handeld devices operate in difficult environment (at farm).

In order to improve these models, two steps are proposed:
1) Inscreasing the number of scans over the surface of the sample to be analyzed; for instance collecting 30 spots/spectra in order to take into account the heterogenity of the products.
2) Collecting samples with higher variability in terms of dry matter and protein in order to increase the standard deviation (SD).

Expected outcomes

These results are the first step to develop an user-friendly tool for dairy farmers to predict on site the composition of their forage by enabling the calculation of their nutritionnal value and the adaptation of animal's feeding for a better sustainability.

Acknowledgments

Wallonie recherche CRA-W

Walloon Agricultural Research Centre
To address today's questions and to prepare tomorrow's challenges
www.cra.wallonie.be

€FFORT