Analysis of Silage Fermentation Characteristics Using Transflectance Measurements by Near Infrared Spectroscopy

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The XX International Grassland Congress took place in Ireland and the UK in June-July 2005. The main congress took place in Dublin from 26 June to 1 July and was followed by post congress satellite workshops in Aberystwyth, Belfast, Cork, Glasgow and Oxford. The meeting was hosted by the Irish Grassland Association and the British Grassland Society.

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Introduction The fermentation end products as lactic acid, volatile fatty acids and ammonia-nitrogen, are important indicators of the efficiency of silage fermentation and are closely related to nutritive value of them (Jaster, 1995). Drying is problematic in the case of silage as many fermentation products are volatile and may get lost during the drying process. This may be a reason why NIR technology is being little used for the evaluation of silage fermentation characteristics. The feasibility of using near infrared transflectance spectroscopy to evaluate the content in fermentation end products of grass and maize fresh silage was investigated in this study.

Materials and methods One hundred and forty-seven representative grass and sixty maize silage samples were collected over a 24 month period. Each of the silage samples were pressed immediately to obtain the extract. After centrifugation (8500 rpm, 10 min) to clarify the extract, the spectra were taken directly on extract. Samples were scanned in transflectance mode over the range 1000 to 2500 nm in a FT-NIR Spectrum One from Perkin Elmer using IdentiCheck Reflectance Accessory (ICRA) liquids sampling accessory. To develop calibration and prediction models the Quant + software was employed. Reference data were determined on the extracts for lactic acid and total volatile fatty acids by HPLC using a WATERS Alliance 2690 instrument and ammonia-N by SPECTROQUANT ammonium test, (Merck).

Results Different mathematical pre-treatment and calibration models were developed using partial least squares (PLS) regression with internal full cross-validation. The optimum equation for each fermentation parameter was selected according to a low standard error of cross validation (SECV) and a large correlation coefficient in the calibration. R^2 values were acceptable on all fermentation parameters with R^2 >0.70, except for acetic acid in grass silage (Table 1). Therefore the results indicate a reliable relationship between chemical analysis and NIR predicted values determined directly on extract. According to ASTM (American Society for Testing and Materials) guidelines for the judgement of a model's validity for NIR calibration (ASTM, 1994) and Williams and Sobering, (1996), this study obtained acceptable values of RDP (ratio of the standard deviation of the reference data to the SECV) for screening purposes, except for ammonium-N in maize silage.

Table 1 Range and statistical parameters for prediction of fermentative characteristics on grass and maize silage by FT-NIR

Grass silage				Maize silage			
Parameter (g/dl)	Range	R^2	SECV	Parameter (g/dl)	Range	R^2	SECV
Lactic acid	0-8.08	0.71	0.506	Lactic acid	0.841-5.75	0.80	0.268
Acetic acid	0-1.27	0.61	0.138	Acetic acid	0-2.30	0.85	0.148
Butyric acid	0-4.15	0.78	0.379	Butyric acid	-	-	-
Ammonium-N	0-0.261	0.82	$299 *10^{-3}$	Ammonium-N	0-0.0012	0.71	$153 *10^{-3}$

Conclusions The results of this investigation indicated that silage fermentation characteristics can be predicted with a fair amount of accuracy by FT-NIR analysis using ICRA as liquids sampling accessory directly on silage extract, in order to avoid the volatilisation of fermentation end products. These results may be of great practical significance when silage is used as a roughage component in dairy rations.

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