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Near infrared reflectance spectroscopy (NIRS) to predict biological parameters of maize silage: effects of particle comminution, oven drying temperature and the presence of residual moisture

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Abstract

Maize silage nutritive quality is routinely determined by near infrared reflectance spectroscopy (NIRS). However, little is known about the impact of sample preparation on the accuracy of the calibration to predict biological traits. A sample population of 48 maize silages representing a wide range of physiological maturities was used in a study to determine the impact of different sample preparation procedures (i.e., drying regimes; the presence or absence of residual moisture; the degree of particle comminution) on resultant NIR prediction statistics. All silages were scanned using a total of 12 combinations of sample pre-treatments. Each sample preparation combination was subjected to three multivariate regression techniques to give a total of 36 predictions per biological trait. Increased sample preparations procedure, relative to scanning the unprocessed whole plant (WP) material, always resulted in a numerical minimisation of model statistics. However, the ability of each of the treatments to significantly minimise the model statistics differed. Particle comminution was the most

Abbreviations: DM, dry matter; DOMD, digestibility of organic matter within the DM; MPLS, modified partial least squares; NIR, near infrared reflectance; NIRS, near infrared reflectance spectroscopy; PCA, principle least squares; PLS, partial least squares; SNV, standard normal variate; SEC, standard error of calibration; SECV, standard error of cross validation

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important factor, oven-drying regime was intermediate, and residual moisture presence was the least important. Models to predict various biological parameters of maize silage will be improved if material is subjected to a high degree of particle comminution (i.e., having been passed through a 1 mm screen) and developed on plant material previously dried at 60 °C. The extra effort in terms of time and cost required to remove sample residual moisture cannot be justified.

Keywords: Maize silage; Near infrared reflectance spectroscopy; Residual moisture; Drying temperature; Particle comminution

1. Introduction

Maize silage is an important forage crop in ruminant production systems in Northern Europe. A simple assessment of the digestible energy content of maize silage is inadequate when predicting nutritive value as it fails to assess the kinetics of nutrient supply to the ruminant (Givens et al., 1995), however it is frequently the only assessment made. Near-infrared spectroscopy (NIR) using the reflectance mode, has been demonstrated to be a successful predictor of various biological parameters of maize silage, particularly digestibility (De Boever et al., 1997) and the in vitro fermentability of DM (Lovett et al., 2004). However, such calibrations have been developed on previously oven dried plant materials. The potential of NIR to predict nutritional traits using fresh samples is increasingly recognised, as it both reduces the cost of analysis and eliminates potential impacts of oven drying upon the estimation of some nutrients (Givens and Deaville, 1999). Although successful NIR calibrations have been developed to predict grass silage digestibility using undried samples (Gordon et al., 1998; Park et al., 1998) earlier work with maize silage (Lovett, 2000) for a variety of biological parameters demonstrated limited potential, presumably because of the interaction between the high moisture content and the highly heterogeneous physical structure of the plant. Most NIR calibrations developed on dried plant material have used oven temperatures of 100 °C, despite such temperatures being known to negatively impact herbage chemical composition (Deinum and Maassen, 1994).

This study was conducted to determine effects of maize silage oven-drying temperature on the calibration statistics of NIR. In addition, the effect of particle comminution and the presence of residual moisture were also investigated, in order to determine the optimum sample preparation procedures to predict a variety of maize silage biological parameters from oven dried samples.

2. Materials and methods

2.1. Maize silage samples and sample pre-treatment

The harvesting and ensiling process employed to produce the 48 maize silages used in this study have been previously described (Lovett et al., 2004). The experimental silos were opened after 120 days, the maize silage was thoroughly mixed on a plastic sheet and two representative sub-samples, each of approximately 0.5 kg fresh weight, was