The correlation of near infrared spectra to potential *in situ* and *in vitro* digestibility of grass silage

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Introduction

Digestibility is the most important quality parameter describing the production potential of silage in dairy cow feeding, which emphasises the importance of its accurate estimation. For extension purposes, the silage digestible organic matter in dry matter (DOMD) is generally estimated by near infrared (NIR) spectroscopy. Both *in vivo* apparent digestibility using sheep and several *in vitro* methods are used to calibrate NIR instruments. The aim of this work was to study the correlation of NIR spectra to potential *in situ* and *in vitro* digestibility of grass silage harvested at six maturity stages.

Material and methods

The silages were harvested from a Timothy–Meadow fescue (38 : 62) sward in Jokioinen, Finland (60.49°N) at six maturity stages (I: 4 June, II: 11 June, III: 19 June, IV: 25 June, V: 1 July and VI: 8 July in 1996) and preserved, unwilted, in 1000 kg experimental silos with formic acid (4 g kg^{-1}). The *in vivo* digestibility of the silages was determined with sheep and simultaneously separate samples were frozen for nylon bag incubations. For incubations, the samples were thawed, combined over periods and cut with scissors (1 cm). The samples (3 g DM in nylon bags, 6 × 12 cm, pore size 38 μm) were incubated in the rumen of three ruminally cannulated dairy cows receiving a grass silage-based diet for 0, 6, 12, 24, 36, 34, 96 and 144 h. The number of replicates was calculated individually for each feed and incubation time, to yield enough residue for subsequent analyses and varied from 4 to 30 bags per cow. After incubation, the bags were washed and dried at 60°C. The nylon bag residues were analysed for nitrogen with a LECO 428 nitrogen analyser for estimation of crude protein (CP) content. Neutral detergent fibre (NDF) and acid detergent lignin (ADL) were determined according to Robertson and Van Soest.[1] The potential *in situ* digestibility (OMDinsitu) of the residues was calculated by assuming the digestibility being zero after a very long incubation period (144 h). The cellulase solubility (OMDinvitro) of the residues was determined according to Friedel.[2] The samples were analysed separately for each cow. The residues were ground to pass a 1 mm screen and then scanned in the wavelength range 400–2500 nm with an NIRSystems 6500 spectrometer. Only the region 1100–2500 nm will be examined in this paper. WINISI II software was used for the data analysis.

Results and discussion

The amount of silage CP and ash decreased and that of NDF and lignin increased, typically, with progressing maturity (Table 1). As a result, *in vivo* digestible organic matter (DOMD) decreased 5.5

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Table 1. The chemical composition and fermentation quality of the silages used for the incubation study.

	Maturity[a]					
	I	II	III	IV	V	VI
Dry matter, g kg^{-1}	188	198	175	204	229	213
Ash, g kg^{-1} DM	87	84	70	74	74	66
Crude protein, g kg^{-1} DM	239	195	160	141	120	112
NDF, g kg^{-1} DM	402	513	584	608	647	669
Lignin, g kg^{-1} DM	20	25	32	34	47	55
Potential OMD (*in situ*)[b]	0.945	0.850	0.829	0.817	0.770	0.731
Potential OMD (*in vitro*)[c]	0.855	0.812	0.769	0.726	0.658	0.620
DOMD (*in vivo*), g kg^{-1} DM	752	718	697	656	604	564
DOMD (*in vitro*), g kg^{-1} DM	741	713	693	657	609	587

[a] For abbreviations see text
[b] 144 h *in situ* degradabiltity
[c] Cellulase solubility[2]

units per day. The difference between potential *in situ* and *in vitro* digestibility increased with increasing ruminal incubation time, obviously due to microbial contamination of the feed residues (Figure 1).

Figure 2 shows the SNV and Detrend treated spectra of nylon bag residues after seven different incubation times and of the washed intact silage (0 h incubation) for early cut silage and silage cut at a late maturity stage. Clear differences, due to incubation time and maturity, can be seen in the regions

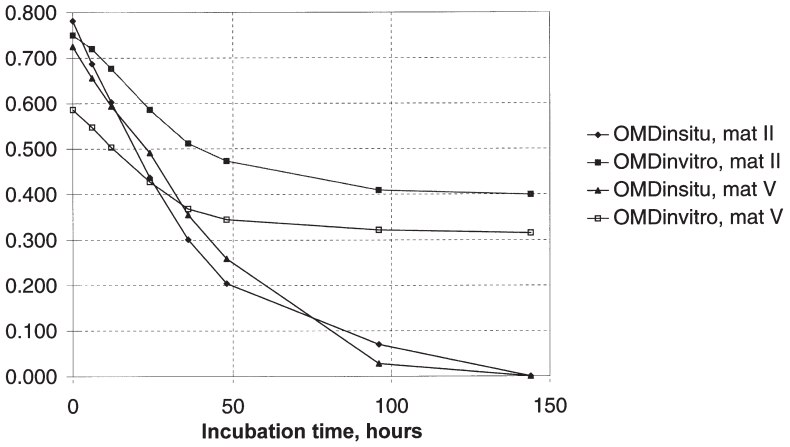

Figure 1. Potential digestibility *in situ* (OMDinsitu) and cellulase solubility (OMDinvitro) of the nylon bag residues.

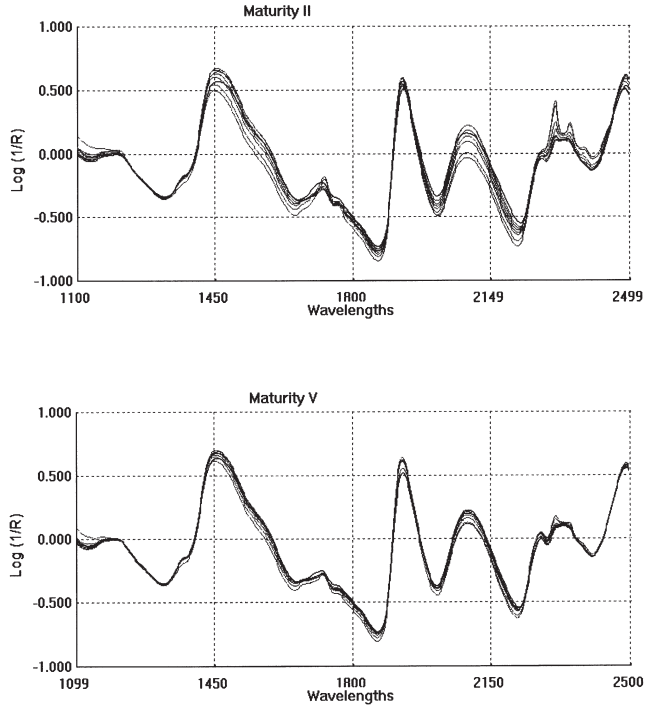

Figure 2. Comparison of NIR spectra (SNV and Detrend) of silage nylon bag residues of maturities II and V. (—) washed silage, (—) incubation times 6–144 h, average of three cows.

1650–1730 nm and 2270–2360 nm. Givens *et al.*[3] suggested that the areas around 1672 and 2254 nm relate to indigestible cell wall material.

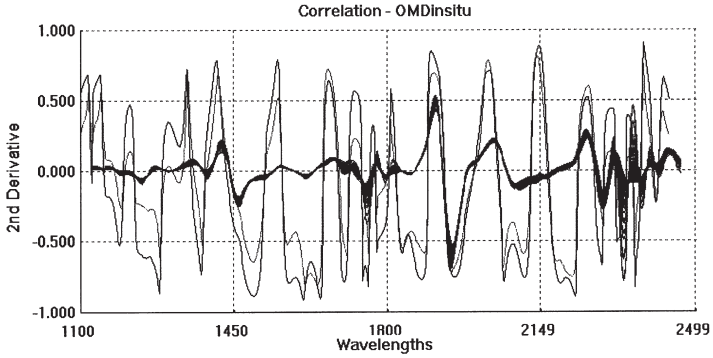

Figure 3. NIR 2nd derivative spectra (SNV and Detrend) of 132 samples including all maturity stages and incubation times (—) and correlation plot for OMD *in situ* (—) and OMD *in vitro* (----).

Conclusions

The spectral regions associated with OMD in this study are very similar to those reported earlier.[4] The correlations of potential *in situ* and *in vitro* OMD to the NIR spectra are very similar (Figure 3). The regions of high correlation are the same for both parameters. Before closer examination of the spectra, problems in the *in vitro* analyses, caused by micobial protein in the residues, have to be solved.

References

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