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Protein degradability of silages in the rumen estimated by NIRS*

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ABSTRACT

The feasibility of estimating *in situ* ruminal protein degradability parameters (A, B, C, ERD) of silages by NIRS was investigated. *In situ* protein degradability of maize (n=12), whole-crop cereal (n=18) and lucerne (n=24) silages was determined using two ruminally cannulated Holstein heifers. The NIRS measurements were conduced using a 19-filter spectrophotometer, InfraAlyzer 450R, in the range of 1445-2348 nm. Calibration equations based on 5 terms for all (n=54) and for 3 subsets of different kinds of silages were calculated. The NIRS method can be successfully used to estimate the ERD of silages. By using small, homogenous files, the precision of estimation can be increased and the standard error of estimation decreased.

KEY WORDS: silage, protein, degradability, *in situ*, estimation, NIRS

INTRODUCTION

Several methods are used to estimate protein ruminal degradability (Hvelplund and Weisbjerg, 1998; Schwab et. al., 2003). All of them are time consuming, hence the continued need for a new method. Previously conducted studies (Antoniewicz et al., 1995, Hoffman et. al., 1999) showed the feasibility of using near infrared reflectance spectroscopy (NIRS) in predicting forage dry matter or protein degradability in the rumen, determined by an *in situ* method. The applicability of NIRS must still be proved on a wide range of feedstuffs, including silages. The aim of present study was to determine the practicability of estimating ruminal protein degradability of different silages by NIRS.

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MATERIAL AND METHODS

The ruminal protein degradability of lucerne (LS), whole-crop (WCCS, made fromoats, triticale, barley, rye), and maize silages (MS) was determined. Maize was ensiled at full maturity, whole-crop cereal silages were made of herbages cut at different stages of maturity, and lucerne silage was made from I, II and III cuts. The plants were chopped and ensiled with microbial inoculants (WCCS silages, Microsil) or a microbial-enzymatic inoculant (LS - Feedtech). All silages were dried in a air-forced oven at 50°C for 48 h and ground to pass through a 1.5 mm screen. Chemical composition was determined using standard methods. *In situ* CP rumen degradability measurements were carried out on two ruminally cannulated Holstein heifers (420±20 kg). The standard diet was balanced to keep the meadow hay-to-concentrate ratio at 80:20. Approximately 3 g of dried samples were placed in 6 × 11 cm nylon bags of 50 (±10) μm pore size (Ankom Co, Fairport, NY). Incubations were carried out at 2, 4, 8, 16, 24, 48 and 72 h. Washing losses from the bags (0 h) were determined by incubation in water at 39°C for 15 min. The effective CP rumen degradability (ERD) and the degradability rate constants (A, B, C) were calculated according to Ørskov and McDonald (1979) at a ruminal outflow rate of 0.06 h^{-1}, using the NLIN SAS procedure.

In the NIRS measurements, the original samples (reground to 1 mm) were scanned twice with a 19 filter spectrophotometer InfraAlyzer 450R (Technicon), using the range of 1445-2348 nm. Spectral data were recorded as log 1/R (R-reflectance) with IDAS PC software. One calibration set: ALL (n=54) and 3 small subsets: LS (n=24), WCCS (n=18) and MS (n=12) were studied. In the ALL set, one sample was recognized as an outlier and deleted from further calculations. Statistical calculations were performed using 5 best terms (spectral waves) in calibration equations. The predicted values were related to the corresponding data determined *in situ* by means of regression analysis, multiple correlation coefficient (R) and standard error of calibration (SEC).

RESULTS

In the calculation of calibration equations for predicting degradability parameters A, B, C and ERD of silages, based on 5 best fitted filters, the important regions of infrared were: 1722-1759, 2100-2190, 2230 and 2336-2346 nm. The best correlation between *in situ* parameters and those predicted by NIRS was found for subsets MS and LS (Table 1), being over 0.92 for A, B and ERD and over 0.86 for C. On the other hand, the lowest R values were observed for parameters A and B (0.69 and 0.79, respectively) for the WCCS subset. The correlation between *in situ* parameters and those predicted by NIRS for ALL set was the highest for A

and ERD (R=0.90 and R=0.88, respectively) but the lowest for B and C (0.64 and 0.53, respectively). The standard errors of calibration (SEC) were much higher when the ALL file was considered.

Table 1. *In situ* protein degradability parameters[1] (A, B, as % of CP, C as % h^{-1}) and effective rumen degradability (ERD) of silages estimated by NIRS

	A	B	C	ERD
		ALL[2]		
n	54	54	50	54
Range *(in situ)*	59.85 - 91.28	2.04 - 25.29	0.01 - 0.89	64.94 - 97.69
R[3]	0.90	0.64	0.53	0.88
SEC[4]	3.57	4.79	0.08	3.50
		MS		
n	12	12	12	12
Range *(in situ)*	66.69 - 91.28	2.04 - 24.31	0.01 - 0.05	72.34 - 92.23
R	0.99	0.99	0.88	0.99
SEC	0.47	0.59	0.008	0.34
		LS		
n	23	23	24	24
Range *(in situ)*	59.85 - 82.20	8.00 - 25.29	0.03 - 0.40	64.94 - 88.50
R	0.94	0.92	0.86	0.97
SEC	1.90	2.37	0.06	1.67
		WCCS		
n	18	18	18	18
Range *(in situ)*	77.4 - 89.34	5.2 - 19.47	0.01 - 2.58	83.5 - 97.69
R	0.69	0.79	0.91	0.86
SEC	2.86	2.92	0.40	2.38

[1]A-rapidly degraded protein, B-slowly degraded protein, C-degradability rate constant of B, [2]for abbrev. see in the text, [3]R - multiple correlation coefficient, [4]SEC - standard error of calibration

DISCUSSION

The study showed that NIRS can be effectively used for predicting rumen degradability of protein, which is in agreement with the results obtained by Antoniewicz et al. (1995) and Hoffman et al. (1999). The precision of prediction based on smaller subsets was better due to higher homogeneity. On the other hand, the subsets of maize and lucerne silages seem to be more homogeneous than WCCS. Moreover, whole crop cereal silages are characterized by very rapidly degradable protein (77-89% of fraction A). Thus, the variation in *in situ* protein degradability was lower in this subset than in the others. It is noteworthy that the predicted protein degradability (ERD) estimated by NIRS was less variable than the measured *in situ* value, which is in agreement with the results of Hoffman et al. (1999).

CONCLUSIONS

The results confirm that NIRS can be an alternative method for *in situ* determination of protein degradability in the rumen. The homogeneity of samples is one of the most important features of the calibration set.

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STRESZCZENIE

Szacowanie rozkładu białka kiszonek w żwaczu metodą NIRS

Badania dotyczyły możliwości szacowania metodą NIRS rozkładu białka kiszonek w żwaczu. Parametry A, B, C oraz efektywną degradację białka (ERD) kiszonek z kukurydzy (n=12), całych roślin zbożowych (n=18) oraz lucerny (n=24) określono na 2 przetokowanych jałówkach. Pomiary NIRS przeprowadzono na 19 filtrowym spektrofotometrze InfraAlyzer 450R (zakres widma 1445-2348 nm). Wyliczono równania kalibracyjne z udziałem 5 długości fal dla zbioru wszystkich kiszonek (n=54) oraz poszczególnych podzbiorów. Na podstawie uzyskanych wyników można stwierdzić, że metoda NIRS może być z powodzeniem zastosowana do szacowania ERD w kiszonkach. Użycie kalibracji wyliczonej dla osobnych zbiorów kiszonek może zwiększyć (R>90%) dokładność szacowania oraz zmniejszać błąd analizy (SEC).