Journal of Animal and Feed Sciences, 13, Suppl. 1, 2004, 79–82

Comparison of the *in situ* technique and the gas production technique in mimicking rumen dry matter degradation

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ABSTRACT

The objective of this study was to compare the dry matter degradability of forages as determined with the *in situ* nylon bag technique and the gas production technique. The effective degradable DM measured with the *in situ* technique (situ DDM) was well related with the gas production after 20 h, when situ DDM was calculated with a passage rate equal to the degradation rate. The degradation rate obtained with the *in situ* technique was moderately related with the time at which 50% of the maximal gas production was reached in the second phase of the gas production technique.

KEY WORDS: nylon bag, gas production, dynamic, degradation, organic matter

INTRODUCTION

In the past 40 years great efforts were done to develop techniques to mimic rumen fermentation, as *in vivo* measurements are expensive and laborious and reduce animal welfare. Using these techniques, the rumen degradation of OM (DOM) can be predicted. DOM is a good measure for energy production in the rumen and an important factor for determining the potential synthesis of microbial protein in the rumen (Vérité et al., 1987; Tamminga et al., 1994).

The most frequently used alternative techniques are the *in situ* technique and the gas production technique. Comparisons of these techniques in measuring rumen degradation of feed and other parameters of rumen fermentation are

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scarce. Rymer and Givens (2002) studied relationships between patterns of rumen fermentation, the *in situ* degradability and gas production profiles.

In this study the results of dry matter degradation of forages were compared for the *in situ* technique (Michalet-Doreau et al., 1987) and the gas production technique (Cone et al., 1996).

MATERIAL AND METHODS

Forages

Twelve forages, used in this study, were investigated in the fresh form, as silage or hay. The forages were lucerne (*Medicago sativa*), red clover (*Trifolium pratense*), orchard grass (*Dactylis glomerata*) and perennial ryegrass (*Lolium perenne*). Red clover haylage, a wilted forage wrapped in bales and with a dry matter content of about 500 g kg^{-1}, was made in stead of hay because of wet harvest conditions.

In situ technique

The method of sample preparation for measuring DM degradation (DDM) with the *in situ* technique was as described by Dulphy et al. (1999). The procedure of the measurement was according to Michalet-Doreau et al. (1987) and the data were fitted according to the method of Ørskov and McDonald (1979). Effective degradable DM was calculated using a passage rate (kp) of 0.06 h^{-1} (situ-6-DDM) and by using a more dynamic feed dependant kp rate equal to rumen degradation rate (situ-kd-DDM) (Van Vuuren, 1993). Each forage was incubated in two series for each incubation period in three cows, receiving a ration with 70% hay and 30% concentrate.

Gas production technique

The forages were incubated in quadruplicate in the gas production technique, as described by Cone et al. (1996). Gas production profiles were described with a three-phasic model (Groot et al., 1996), describing the gas production assumed to be caused by fermentation of the soluble components (phase 1), the non-soluble components (phase 2) and microbial turnover (phase 3) (Cone et al., 1997). Each phase is described by three parameters: A (maximum gas production, ml/g OM), B (time at which 50% of the maximal gas production is reached in h) and C (parameter determining the shape of the curve, without dimension). The gas production after 20 h of incubation (GP20) was used in the comparisons.

Chemical analysis

DM contents of feed and residues in nylon bags were determined after drying at 80°C for 48 h and ash content was determined after 6 h at 550°C. N was determined using the Kjehldahl method (AOAC, 1980). Neutral detergent fibre

(NDF) was determined in the samples dried at 60°C without the use of sodium sulphite and alpha amylase, using the method described by Van Soest et al. (1991), but the results were expressed with residual ash.

RESULTS

The variation in quality of the 12 forages resulted in large ranges of parameters measured with the *in situ* technique and the gas production technique (Table 1). GP20 was well related with situ-kd-DDM ($R^2 = 0.53$) and not related with situ-6-DDM ($R^2=0.22$). The relationship between kd and B from the second phase of the gas production profile (B2) was moderate ($R^2 = 0.37$). This relationship was better ($R^2=0.49$, n=75) with the forages from the database used in Gosselink et al. (2004).

Table 1. Dry matter (DM, g kg^{-1}) and chemical composition (g kg^{-1} DM) of the 12 forages. The soluble DM fraction (a), degradable DM fraction (b) and the degradation rate (kd, h^{-1}) of the 12 forages measured with the *in situ* technique. The parameters B2, C2 and the gas production after 20 h of incubation (GP20) were derived from incubation of the 12 forages with the gas production technique

Forage	Method of conservation	DM	Ash	CP	NDF	*In situ* technique			Gas production technique		
						A	B	kd	B2	C2	GP20
Lucerne	Fresh	162	138	198	498	32.0	41.0	0.114	8.04	2.50	164
	Silage	212	98	182	438	38.0	37.8	0.077	7.56	2.51	182
	Hay	861	99	171	560	21.2	49.1	0.074	8.24	2.46	159
Red clover	Fresh	127	120	168	492	48.5	35.2	0.106	6.94	2.70	218
	Silage	171	92	166	478	35.2	45.7	0.101	6.48	2.31	203
	Haylage	524	108	128	475	35.4	46.3	0.059	6.87	2.40	209
Orchard grass	Fresh	193	80	116	676	22.4	58.4	0.051	8.77	2.77	183
	Silage	217	71	126	614	26.8	59.3	0.037	8.39	2.89	188
	Hay	852	70	110	697	16.4	66.5	0.035	10.0	2.81	165
Lolium perenne	Fresh	182	98	91	620	27.1	55.0	0.054	7.84	2.48	222
	Silage	191	92	101	578	32.4	49.7	0.051	8.30	2.77	210
	Hay	873	96	91	632	24.8	55.0	0.053	8.71	2.65	192

DISCUSSION

The results showed that rates of degradation and passage in the rumen are important when comparing the gas production technique and the *in situ* technique. The relationship between kd from the *in situ* technique and B2 from the gas production technique was also observed by Cone et al. (1998) with OM

degradation of grass. Rymer and Givens (2002) showed also that the dynamic parameters from these techniques are related.

This study showed the importance of a dynamic kp, because effective degradable DM calculated with the in situ technique was related with the gas production when kp was expressed as function of kd. The reason for this is that in roughage with a slower rate of degradation the increase in functional specific gravity will be more gradual, and thus, the slower rate of degradation is compensated by a slower kp (Van Vuuren, 1993).

CONCLUSIONS

The *in situ* technique and the gas production technique showed similarity in mimicking the dynamics of rumen DM degradation of forages.

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