RUMEN FERMENTATION KINETICS OF GRASS MEASURED IN SACCO AND WITH THE GAS PRODUCTION TECHNIQUE

J.W. Cone and H. Valk

DLO-Institute for Animal Science and Health (ID-DLO), Department of Ruminant Nutrition, P.O.box 65, NL-8200 AB Lelystad, The Netherlands.

ABSTRACT

Rumen fermentation kinetics of grass and silage, differing in age and yield (1500 -7900 kg DM ha^{-1}), were studied in sacco and in vitro, using the gas production test and the Tilley and Terry technique. An increasing yield increased the content of NDF and lignin in grass and decreased protein content, in vitro degradability measured by the Tilley and Terry method, and rate of fermentation measured with the gas production technique and the nylon bag method. The same ranking in fermentation characteristics was observed using the gas production test, the nylon bag method and the Tilley and Terry method. The gas production test proved an accurate, reliable and cheap alternative for the in sacco technique to determine differences in fermentation characteristics between different grass and silage samples in the rumen.

KEYWORDS

Fermentation, gas production, grass, kinetics, nylon bag, rumen, silage, vitro

INTRODUCTION

Fermentation kinetics of feedstuffs in rumen fluid can be studied determining the undegraded residue after different periods of incubation in rumen fluid (Tilley & Terry, 1963) or using the nylon bag technique (Ørskov & McDonald, 1979). However, both these methods are laborious and expensive. Fermentation can also be studied measuring gas production in a CO_2 saturated buffered rumen fluid. Although this technique was described in 1979 by Menke et al. (1979), still manual systems to record gas production over time are used widely. Since cheap, sensitive and reliable pressure transducers became available different groups developed automated gas production equipment. Recently Cone et al. (1996) presented a fully automated gas production apparatus with sensitive pressure transducers and electric micro gas valves to release over pressure. The obtained accurate cumulative gas production profiles could be fitted with a 3-phasic model (Cone et al., 1996; Groot et al., 1996), representing the fermentation of the soluble fraction, the non-soluble fraction and microbial turnover.

The aim of this study was to compare the different techniques to determine rumen fermentation characteristics of grass and grass silage, and to see whether the gas production technique can replace the nylon bag technique.

EXPERIMENTAL

Grass was cut on 8 different days on May 17 and 27, June 2, 7, 17, 23 and 30 and July 7 1993 after a pre-cut on April 27. Fresh samples were stored at - 20½C. Silages of the pre-wilted grass were made in 30 l buckets. Grass and silage samples were freeze dried and ground to pass a 1 mm screen for analysis. In vitro degradability in rumen fluid was determined by the method of Tilley & Terry (1963) using rumen fluid from two fistulated sheep, 2 h after the morning feeding, while the nylon bag technique described by Ørskov & McDonald (1979) was used. Rumen fermentation kinetics were determined with the gas production technique as described by Cone et al. (1996). Gas production profiles were fitted with a multiphasic model (Cone et al., 1996; Groot et al., 1996).

$$\text{ml gas} = a_1/(1+(b_1/t)^{c1}) + ... + a_n/(1+(b_n/t)^{cn})$$

a = maximal gas production (ml g^{-1} OM), b = time (h) at which half a is reached, c = parameter determining the shape of the curve, t = time (h).

Gas production profiles generally can be divided into 3 phases (Cone et al., 1996; 1997). Phase 1 represents the fermentation of the soluble fraction, phase 2 of the non soluble fraction and gas production in phase 3 is caused by microbial turnover (Cone et al., 1997).

RESULTS AND DISCUSSION

Table 1 shows that the yield of grass varied from 1500 to 7900 kg DM ha^{-1}. Ageing and an increasing yield of grass and of silage increased the content of NDF and lignin and decreased the protein content and the in vitro degradability, measured by the Tilley and Terry method (T&T). Table 1 also shows that the degradation rate (kd) of the organic matter, as measured by the nylon bag technique, was fastest for the youngest samples and lowest for the oldest samples.

Figure 1 shows the gas production rate of 5 of the 7 grass samples. It is shown that the gas production profiles can easily be divided into three different phases. The first phase is the gas production during the first 3-4 h of incubation, representing the fermentation of the soluble fraction. It is shown that gas productions rates in this first phase were lowest for the youngest samples and highest for the older samples. This was not caused by differences in the content of soluble fraction, but by differences in protein content, which was highest in the younger samples (Table 1). Fermentation of protein causes ammonia production which inhibits the CO_2 release from the carbonate buffer.

The second phase of gas production from approximately 4 to 12 h, representing the fermentation of the non-soluble fraction, showed that the youngest samples had the highest gas production and the oldest the lowest, suggesting that the cell wall fraction of young grass samples are more easy degraded than that of the older samples. Table 1 shows the fitted parameters of the second phase of the cumulative gas production profiles. Upon ageing b2 increased and c2 decreased. There was a good relationship between b2 and the T&T technique ($R^2 = 0.94$, $p = 0.00$, $n = 15$). Also between b2 and kd, measured in sacco, there was a good relationship for the silage samples ($R^2 = 0.77$, $p = 0.004$, $n = 8$) and a poor relationship for the grass samples ($R^2 = 0.38$, $p = 0.141$, $n = 7$). Including c2 increased the relationship for the silages ($R^2 = 0.91$, $p = 0.003$), but did not for the grass samples. We should keep in mind that only a limited number of samples were investigated and that there are big methodological differences between both techniques. Nevertheless, the gas production test proved an accurate, reliable and cheap technique to determine differences in fermentation characteristics between different grass and silage samples in the rumen. However, the value of any technique can only be established by comparison with in vivo data. Future research should be focused on comparison of the gas production technique with in vivo data and on the use of the gas production technique in routine ruminant feed evaluation.

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Table 1
Yield (kg DM ha^{-1}), chemical composition (g kg^{-1} OM), in vitro degradability (%) using the Tilley and Terry method (T&T) and in situ degradation rate (kd, % h^{-1}) using the nylon bag technique of grass and silage harvested at different days after a pre-cut on 27-04. CP = crude protein, NDF = neutral detergent fibre, ADL = acid detergent lignin. Curve fit parameters of gas production curves of the non-soluble fraction (phase 2) are shown. a2 = maximum gas production (ml g^{-1} OM), b2 = time (h) at which a = 50 %, c2 = parameter determining the shape of the curve.

	Yield	CP	NDF	ADL	T&T	kd	a2	b2	c2
grass									
17-05	1500	-	-	-	-	-	-	-	-
27-05	3900	239	514	16	77.1	7.2	124	7.3	2.72
02-06	5000	187	551	24	75.0	7.2	150	8.0	2.26
07-06	5200	179	526	21	76.3	4.8	116	8.8	2.42
17-06	5300	145	566	26	72.4	6.0	164	10.1	1.78
23-06	6300	140	541	29	72.7	5.4	159	10.9	1.76
30-06	6300	118	576	37	67.8	4.8	159	13.5	1.67
07-07	7900	130	600	43	62.8	5.4	136	15.9	1.65
silage									
17-05		277	377	10	75.3	6.0	110	7.4	3.23
27-05		267	538	17	72.1	4.6	108	9.2	2.86
02-06		216	535	21	72.1	4.3	127	8.7	2.10
07-06		189	549	21	71.3	4.6	143	10.8	2.29
17-06		163	565	29	67.9	3.7	146	11.3	1.84
23-06		152	583	30	66.0	3.4	142	13.3	2.06
30-06		135	596	35	62.3	3.0	135	14.6	1.97
07-07		135	606	44	55.9	2.7	135	19.5	1.65

Figure 1
Rate of gas production in buffered rumen fluid of grass samples, harvested at different dates after a pre-cut on April 27.