

RUMEN FERMENTATION IN HEREFORD STEERS GRAZING RYEGRASS AND SUPPLEMENTED WITH WHOLE OR GROUND MAIZE

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SUMMARY

The experiment investigated rumen fermentation in Hereford steers grazing high quality pastures, supplemented daily with whole or ground maize grain (1% of body weight), or grazing without supplementation, during autumn. Six rumen cannulated steers were allotted at random, to 1 of the 3 treatments. Grain was offered each morning. Dry matter degradability was measured using the nylon bag technique. Samples of rumen fluid were collected for analysis of pH, volatile fatty acids (VFA) and ammonia. Supplementation with maize did not affect ($P>0.05$) degradation rate of forage in the rumen, rumen pH, or rumen VFA concentration. It was concluded that neither grain supplement adversely affected the rumen environment of cattle grazing lush pastures during autumn.

Keywords: cattle, fermentation, degradability, pH, volatile fatty acids, grain, pastures.

INTRODUCTION

Ryegrass pasture is frequently used for intensive beef cattle production systems during autumn and winter, and is characterised by high crude protein and low water-soluble carbohydrate content (Fulkerson *et al.* 1998). High crude protein degradability in the rumen (Rearte 1999) can pose a problem as excess ammonia is excreted as urea in urine, with a negative effect on energy balance (Rearte 1999). One method of overcoming this problem is to supplement grazing steers with sources of fermentable energy to maximise microbial protein synthesis and capture of nitrogen from rumen degraded forage protein. However, high inputs of rapidly fermentable starch can decrease rumen pH, resulting in a lower rate of forage dry matter digestion, and consequently less forage intake (Van Soest 1994). Starch fermentation may be accelerated by grinding and may be reduced by feeding whole grain (Rowe *et al.* 1999). The objective of this study was to determine the effects of ground and whole maize, fed to steers grazing ryegrass, in terms of dry matter degradability in the rumen and fermentation characteristics.

MATERIALS AND METHODS

The experiment was conducted at the Experimental Station "Dr. M.A. Cassinoni" (EEMAC), of the Agronomy Faculty, in Paysandu, Uruguay, over the period 5th June to 1st August 2002. An area of 8.7 ha of annual ryegrass (*Lolium multiflorum*) was used. The ryegrass was grown from the residual seed accumulated in the soil from the year before, following an application of glyphosate (100 g/L, 3 L/ha) on 10th April 2002. On May 10th, the pasture was fertilised with 80 kg/ha of urea.

Six Hereford steers (450 ±30 kg) surgically fitted with rumen cannula were randomly allocated to 1 of 3 treatments: supplemented daily with 1) whole (WM) or 2) ground (GM) maize grain at a rate of 1% of liveweight (LW), or 3) grazing without supplementation (C). During the whole experimental period, the 2 cannulated animals in each treatment grazed with 6 other steers that were being evaluated for liveweight gain and forage intake (data not presented in this paper; see Simeone *et al.* 2003 and Beretta *et al.* 2003). Each treatment group grazed separate paddocks set up with electric fence grazing strips allocated each day to provide 5 kg forage dry matter per 100 kg liveweight. Animals were treated with Ivermectin 1 week before the start of the trial. Maize grain was offered daily around 0800 h in individual pens located near the paddocks. Cattle were moved to a new strip around 0900 h after finishing their supplement.

Pre-grazing pasture biomass was measured weekly using a double sampling method (Gardner 1967), and cutting the forage close to the ground level. Forage allowance was adjusted by varying the strip area for each treatment. Pasture height was measured weekly, on random points of the pasture plot, using a ruler and recording the undisturbed height of the plants adjacent to the ruler. Weekly samples of fresh pasture and 1 sample of the grain were analysed for ash, crude protein (CP), acid detergent

fibre (ADF) and neutral detergent fibre (NDF). Dry matter content (DM), ash and CP were determined by procedures described by AOAC (1984). Neutral detergent fibre and ADF were analysed by methods of Goering and Van Soest (1970). Forage digestible dry matter (DDM) was estimated using the equation $DDM = 92.51 - (ADF \% \times 0.7965)$, reported by Grant *et al.* (1997).

The *in situ* procedure was used for determining forage and grain rumen DM degradability. The procedure was repeated 4 times during the experimental period (1 every 2 weeks). During and between sampling periods, animals remained grazing in the paddock of the corresponding treatment. Hand-clipped samples of forage from control and supplemented treatments were collected for incubation, before each sampling period. Samples of masticated whole grain were collected from the distal end of the oesophagus after rumen evacuation from 1 “extra” cannulated steer. There was only 1 collection of grain using this procedure and samples were kept frozen to use in the successive *in situ* studies. Duplicated samples of fresh forage, cut into 1 cm lengths with a knife, and of ground or masticated grain (depending on the treatment) were placed in nylon bags (40 µm pore size) in the rumen of steers. Each bag contained approximately 6 grams of fresh forage or 4 grams of maize and was attached to a 1 m cord with a 750 g weight tied to the end. They were all placed in the rumen at the same time, before supplementation, and removed in replicate pairs following 3, 6, 9, 12, 24, 36, 48, and 72 hours incubation. Two bags placed in warm water (39°C for 15 minutes) before incubation were not incubated and taken as “time 0” samples. After removal from the rumen, bags were immediately washed in cold water, dried at 60°C for 48 h and weighed. Data from the *in situ* studies, expressed as percentage of degraded DM, were fitted to the exponential equation described by Ørskov and McDonald (1979) to estimate parameters (a, b and kd). Results from duplicate bags were averaged for the calculations. The effective degradability (Edg) of DM was calculated assuming rumen outflow rates (kp) of 0.06 from the equation proposed by Galyean and Owens (1988).

Samples of rumen fluid (100 mL) were collected at 3-h intervals during 24 hours on the last day of each sampling period. A flexible plastic tube closed at the lower end, and a 1 L container attached to the other end, was used to extract samples, which were then strained through 2 layers of cheesecloth. Rumen pH was measured immediately with a portable pH meter, and a 30 mL sub-sample of rumen fluid was acidified with 2 mL of 0.5 N H₂SO₄/100 mL rumen fluid and kept frozen for subsequent analysis of volatile fatty acids (VFA) and ammonia (NH₃).

Parameters of the adjusted model for forage degradability were subjected to analysis of variance using a completely random design with repeated measurements. Data for rumen fluid parameters were subjected to analysis of variance using a split plot design with repeated measurements. The model used for both the *in situ* data and rumen fluid parameters included treatment (T), sampling date (SAM), and the interaction between these 2 factors. For all statistical analyses, SAS software was used.

RESULTS

Average pre-grazing biomass (2650 kg DM/ha) and height (20.3 cm) of the pasture did not differ between treatments ($P > 0.05$). Dry matter content of pasture averaged 20.1%. Ash, NDF, ADF, CP and DDM values were 11.6, 46.1, 24.9, 15.3 and 72.7% of forage DM, respectively. Maize grain had 93% DM and 18.6% NDF, 9.6% ADF and 8.2% CP, on a DM basis.

Table 1. Effect of supplementation with whole or ground maize grain on rumen fermentation in steers grazing ryegrass pasture (mean daily values).

	Control	Whole maize	Ground maize	T	T x SAM	SAM	s.e.
PH	6.2	6.0	6.1	ns	ns	**	0.12
Ammonia (mg/L)	96	95	55	ns	ns	**	12.4
Total VFA (mmo/L)	118	130	115	ns	ns	**	3.8
Acetate (molar %)	65	61	61	ns	ns	ns	1.8
Propionate (molar %)	21	23	23	ns	ns	ns	2.2
Butyrate (molar %)	12	12	12	ns	ns	ns	0.9

T: treatment, SAM: sampling date. ns: not significant; ** $P < 0.01$

Rumen pH, ammonia-n and VFA mean daily concentrations are summarised in Table 1. Mean daily pH was not affected by grain supplementation and no differences ($P > 0.05$) were observed in daily pH patterns between treatments. The pH for all treatments decreased after feeding time reaching the lowest values between 6 and 9 hours after feeding (6.0, 5.7 and 5.7 for C, WM and GM, respectively),

and gradually increasing thereafter. Mean daily rumen ammonia concentration for steers fed whole grain did not differ from the control, while there was a tendency ($P=0.103$) for steers fed ground maize have a lower value (Table 1). Between 3 and 6 hours after cattle started grazing a new pasture strip, there was a large increase in rumen ammonia concentration for animals with no supplementation (136 mg/L). Supplementing with ground maize reduced the peak (72 mg/L, $P<0.05$). Mean daily total VFA concentration, and molar proportions of propionate, acetate and butyrate, were not affected by treatment. There was only a significant effect of SAM on total VFA concentration. The daily pattern of total VFA concentration did not differ between treatments ($P>0.05$).

Table 2. The effect of supplementation with whole or ground maize on forage and grain dry matter degradability.

Treatment	Control	Whole maize	Ground maize
Forage dry matter			
Kd: Degradation rate of insoluble fraction (%/ h)	8.6	9.6	7.6
a: Instantly degradable fraction (%DM)	9.6	14.3	14.3
b: Total degradable fraction (%DM)	73.7	66.1	69.8
Effective degradability (%DM) ^A	52.8	54.9	52.6
Grain dry matter^B			
Kd: Degradation rate of insoluble fraction (%/ h)	--	5.3	4.6
a: Instantly degradable fraction (%DM)	--	9.9 ^a	19.3 ^b
b: Total degradable fraction (%DM)	--	81.5	71.8
Effective degradability (%DM) ^A	--	35.4 ^a	53.3 ^b

^A Calculated assuming $k_p = 0.06$ per h

^B Corresponding to masticated maize grain and ground grain incubated samples in the "Whole maize" and "Ground maize" treatments, respectively

a, b: Means in the same row with different superscripts are significantly different ($P<0.05$)

Results from the *in situ* measurements for forage and grain DM degradation are presented in Table 2. There was no significant effect of treatments on any of the parameters of the model used for forage DM rumen degradability. Grinding grain increased the soluble fraction disappearance of the grain DM. The effective degradability of ground grain was higher than that of whole maize. Day of sampling was not a significant source of variation in these analyses.

DISCUSSION

Mean daily ruminal pH values measured in our study, were less than considered optimal for fibre digestion, cellulolytic bacteria or for microbial protein synthesis (Van Soest 1994). Although rate of forage DM degradation might have been reduced by low rumen pH, there was no significant difference in rumen pH between treatments, and similar rates of DM degradation were observed.

In our experiment, ruminal pH and VFA concentrations were influenced more by time of the day, than by treatments. Natural ruminant daily grazing pattern was probably accentuated by grazing management in our experiment. As cattle grazed in daily strips, the pasture on offer was gradually depleted during the day. Animals showed higher grazing activity when entering a new pasture strip in the morning. This variation during the day in pasture intake, together with morning supplementation, would be the main reason explaining daily pH changes. These results are consistent with those reported by Simeone *et al.* (2002), who studied similar treatments in cattle grazing fresh oats and mixed perennial pasture, where a diurnal pattern of rumen pH was observed, with the lowest values occurring between 6 and 12 hours after the morning meal.

A lower peak concentration of ammonia 3 hours post feeding when steers were fed with ground maize may be associated to the higher instantly rumen degradable fraction observed for this supplement. Whole maize showed a lag phase of 3 hours before active fermentation started, which may have reduced its potential benefit as an energy source to synchronise with rapid nitrogen liberation from pasture crude protein. Although bacterial protein synthesis was not measured in our study, it is likely that more rapidly available carbohydrates from ground maize resulted in a greater uptake of ammonia N by the micro-organisms and, consequently, in a faster depletion of ammonia N (Elizalde *et al.* 1992).

It is concluded that supplementation with maize grain at 1% of body weight does not have an adverse effect on rumen pH, VFA concentration or forage degradation rates in steers grazing ryegrass. Grinding the maize reduced peak rumen ammonium concentration, probably improving

synchronisation between energy and N, offering potential to enhance the output of microbial protein from the rumen and animal performance.

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