The Kinetics of Fibre Digestion, Nutrient Digestibility and Nitrogen Utilization of Low Quality Roughages As Influenced By Supplementation with Urea-mineral Lick Blocks

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Introduction

It has been recognized that when animals are offered a low-nitrogen, high fibre roughage such as rice straw (RS), one of the critical nutrients is fermentable nitrogen (N) available to rumen microbes (ARC, 1984). The use of urea/molasses blocks is a convenient way of avoiding an excessive intake of urea, and will ensure an almost continuous supply of ammonia-N (Preston, 1986).

Urea/molasses block feeding has given positive results in many parts of the world (Kunju 1986; Hadjipanayiotou et al 1993b, Chen et al 1993). The blocks which contain molasses are highly palatable, but are unlikely to be widely applied in many countries because of unavailability of molasses. Therefore some workers have attempted to manufacture blocks with reduced quantities of molasses (Hadjipanayiotou et al 1993a, Liu et al 1990).

The objective of this study was to evaluate the effect of a urea-mineral lick block (ULB) without molasses on rumen fibre digestion kinetics and on the nutrient digestion and nitrogen utilization of rice straw (RS), ammonia bicarbonate treated RS (ABRS) and hay prepared from natural pasture.

Materials and Methods

Animals and their management

Three yearling lambs each equipped with a rumen cannula and weighing about 30 kg were dosed with anthelminthic and housed individually in metabolism crates. Feeds were offered in two equal meals per day at 0900 and 1800 h, and the daily amounts were calculated to exceed that eaten on the previous day by about 10 % to avoid selective feed intake. All animals had free access to drinking water.

EXPERIMENTAL FEEDS

The RS (Japonica, cv. 'Zhenongda 40') was obtained from the Experimental Farm, Zhejiang Agricultural University. The ABRS was prepared by the stack method: one ton of RS was treated with 100 kg ammonia bicarbonate and 250 kg water for 30 days at an ambient temperature of 15-20°C (Liu et al 1991). Hay was prepared from natural pasture which is the main roughage source for ruminants in our region. The composition of the experimental feeds are presented in Table 1.

TABLE 1: Chemical composition of the experimental feeds

Feed	DM (%)	OM (%DM)	CP (%DM)	NDF (%DM)
Rice straw (RS)	81.8	86.0	8.8	69.9
AB-treated RS	80.7	85.2	12.5	61.8
Hay	83.1	78.0	10.6	60.0

The ULB was prepared without molasses, and contained 4 % N with all minerals. The composition of the ULB used were the same as described in previous study (Liu et al 1996: these proceedings).

Experimental design and procedures

The experimental design was two 3x3 Latin square designs, one for roughage with ULB and one without ULB. Each period consisted of 21 days, the first 10 days of which were for adaptation followed by

11 days of measurements. A digestibility and N balance trial was conducted over 5 days (from day 11 to day 15), while the rate of passage of digesta through the rumen (kp) was determined. The degradation of crude protein (CP) and dry matter (DM), and digestion of neutral detergent fibre (NDF) in the rumen were measured from day 16 to day 21.

The digestibility of nutrients and N balance were determined by total collection of faeces and urine. Feed and faeces were analyzed for DM, organic matter (OM), CP (Association of Official Agricultural Chemists, 1990) and NDF (Goering and Van Soest, 1970). The N content in urine was analyzed by the Kjeldahl method.

The procedures determining the kp were the same as described previously (Liu et al 1995b), where the model of Grovum and Williams (1973) was used.

Rumen digestion of NDF and ruminal degradation of CP and DM were determined in sacco (Ørskov, 1985) and details of procedures are as described previously (Liu et al 1995b). The parameters of digestion kinetics of NDF in the rumen were estimated using the model of Mertens and Loften (1980). The nonlinear iterative least square procedure was used to fit the equation:

$$R=PED*\exp(-kd(t-LT))+U$$

where R is the percentage of NDF recovered at time t (h), PED is the potential extent of digestion at fractional rate kd (kd>0), LT is the discrete lag time of digestion, and U is the indigestible fraction (U=100-PED).

Ruminal degradation of CP and DM was calculated from the disappearance rate from dacron bags incubated in the rumen. The data were fitted to the model of Ørskov (1985):

$$p=a+b(1-\exp(-ct))$$

where p is disappearance rate at time (t), a is the rapidly digestible fraction in the rumen, and b is the fraction slowly digested at rate c (c>0).

The effective degradability (dg) of CP and DM was calculated using the equation presented by Ørskov (1985):

$$dg=a+bc(c+kp)$$

Statistical analyses

The results were analyzed as a two-way factorial design(Steel and Torrie, 1960), in which square was considered as a factor.

Results and Discussion

The results of the digestion trial are presented in Table 2. The dry matter intake of all three roughages slightly decreased with ULB supplementation but the differences were not significant. Intake of ULB was estimated to be about 10 grams per day, which was similar to that obtained for goats (Liu et al 1996: these proceedings).

The digestibility of DM and OM of RS was increased by 13.1 and 12.7 % ($P<0.05$) and approached to that of ABRS, indicating that the effect of ULB on digestibility of RS is similar to that of treatment with AB. The hay used in this study was of low quality as shown by its digestibility, which was the same as that of RS. The digestibility of hay was significantly increased by ULB supplementation ($P<0.05$). When ABRS was supplemented with ULB, the digestibility of all nutrients was improved.

TABLE 2 The effects of using a urea-mineral block lick on the intake and digestibility of experimental diets offered to lambs.

Roughage	Rice straw		ABRS		Hay		Significance #		
Block supplement	-	+	-	+	-	+	R	B	RxB
Intake (gDM/d)	576	534	683	591	735	705	*	NS	NS
Digestibility (%)									
Dry matter	48.9	55.3	54.4	57.1	49.1	55.0	*	**	NS
Organic matter	51.8	58.4	57.6	60.2	53.0	58.5	*	*	NS
N * 6.25	39.5	45.7	60.1	61.0	35.2	48.8	**	*	NS
N D F	62.6	66.8	65.6	68.5	66.2	69.4	*	*	NS

R, roughage effect; B, block effect; RxB, interaction effect between roughage and block; *, different significantly $P<0.05$; **, $P<0.01$; NS, not significant.

The results of N balance are shown in Table 3. Nitrogen intake was lower in lambs given the RS ($P<0.05$) evenwith ULB. When RS or hay was given alone the faecal N loss was above 60 %. Ammonia treatment and ULB supplementation were able to decrease the faecal

N loss on RS diets. The lambs fed on ABRS with or without ULB had the highest urinary N loss, while the lowest urine N losses were from those animals on hay. The ULB increased the N losses from urine on all roughages, regardless of the amount and the proportion to N intake. Without the ULB, N retention (NR) was highest in lambs on ABRS, followed that on hay, with the lowest in animals on RS. While the feeding of ULB increased the NR in lambs on hay, the NR in animals on ABRS decreased due to the ULB supplementation. No difference was found in the NR from animals on RS with or without ULB.

TABLE 3 The nitrogen utilization of lambs fed on experimental diets with or without a urea mineral lick block

Roughage	Rice straw		ABRS		Hay		Significance #		
Block supplement	-	+	-	+	-	+	R	B	RxB
Grams per day									
Nitrogen intake	8.1	8.1	13.2	12.3	12.5	12.5	**	NS	NS
Faecal loss	4.9	4.4	5.4	4.8	8.1	6.4	**	*	NS
Urine loss	1.6	2.2	2.3	3.1	1.2	1.6	*	*	NS
Retention	1.6	1.5	5.5	4.4	3.2	4.5	**	NS	NS
Percent of intake									
Faecal loss	60.5	54.3	40.9	39.0	64.8	51.2	**	*	NS
Urine loss	19.8	27.2	17.4	25.2	9.6	12.8	*	*	NS
Retention	19.7	18.5	41.7	35.8	25.6	36.0	*	*	NS
N Retained/N Digested (%)	50.0	40.5	70.5	58.7	72.7	73.8	**	*	NS

See footnote in Table 2.

The proportion of N retained to N digested decreased with ULB supplementation in lambs on RS or ABRS, but there was little change in animals on hay. This may be associated with an unbalanced supply of N and energy to the rumen microbes when straw diet was supplemented only with ULB, resulting in the inefficient use of N.

The results obtained for DM and CP degradation in the rumen are shown in Table 4. Without ULB, the degradability of DM and CP

was significantly higher for ABRS than that for RS and hay, with little difference between RS and hay. The ULB had little effect on the rumen degradation of DM and CP in any of the three feeds.

TABLE 4 Constants of the equation p=a+b(1-exp(-ct)) for the degradation of dry matter and crude protein of experimental feeds in the rumen of lambs with or without a urea mineral lick block

Roughage	Rice straw		ABRS		Hay		Significance #		
Block supplement	-	+	-	+	-	+	R	B	RxB
DM degradation									
a (%)	16.0	12.4	15.9	16.1	19.5	20.0	**	NS	*
b (%)	52.8	58.0	55.1	53.8	49.2	56.1	NS	NS	*
c (%/h)	3.07	3.45	4.08	5.53	3.25	2.66	**	NS	*
kp (%/h)	2.96	2.88	3.14	2.71	3.54	3.00			
dg (%)	42.9	44.0	52.0	52.2	43.7	46.3	*	NS	NS
a+b (%)	68.8	70.4	71.0	69.9	68.7	76.1			
DM degradation									
a (%)	36.1	32.1	35.2	30.0	29.3	28.0	NS	NS	NS
b (%)	50.7	50.4	53.1	45.0	46.0	44.6	NS	NS	NS
c (%/h)	0.98	1.72	3.95	5.68	2.06	1.85	*	NS	NS
dg (%)	48.7	50.9	64.4	60.5	46.2	45.0	*	NS	NS

See footnote in Table 2.

The parameters of NDF digestion in the rumen are presented in Table 5. When given alone, the RS had a similar value for the potential extent of digestion (PED) and its digestion rate to hay, but the discrete lag time (LT) for RS was lower than that for hay. The AB treatment increased the PED ($P<0.05$) and kd ($P.0.05$). Neither the PED nor kd for RS and ABRS was influenced by the feeding of ULB, but the kd for hay was significantly increased. The product of PED*kd (NDF digested per hour) was, however, increased by 92 and 30.3 % for RS and hay respectively, though little effect was observed for ABRS. The LT for hay was shortened by ULB feeding.

TABLE 5 Parameters of the ruminal digestion kinetics of dietary fibre in lambs with or without a urea mineral lick block

Roughage	Rice straw		ABRS		Hay		Significance #		
Block supplement	-	+	-	+	-	+	R	B	RxB
PED (%)	59.2	59.6	62.3	63.1	59.6	55.2	*	NS	NS
kd (%/h)	3.29		3.58	5.68	5.19	3.32	4.67	*	NS *
PED*kd (%)	1.95	2.13	3.54	3.27	1.98	2.58			
LT (h)	5.4	5.4	5.6	5.1	6.3	5.0	NS	NS	NS
kp (%/h)	2.96		2.88	3.14	2.71	3.54	3.00		
EED (%)	26.6	28.2	33.6	36.1	23.1	28.9	**	*	NS

See footnote in Table 2.
EED is calculated as: PED*kd/(kd+kp)*exp(-kp*LT).

The effective extent of ruminal fibre digestion (EED) was estimated according to Huang and Xiong (1990) and is shown in Table 5. The RS had an EED value similar to that hay and treatment with AB improved the rumen fibre digestion and increased the EED of RS by 26 %. The ULB improved the EED for all roughages, suggesting that ULB can improve the integrated digestion of low quality roughage fibre in the rumen.

Conclusion

The ULB significantly increased the nutrient digestibility of RS and hay, and slightly improved the digestibility of ABRS, possibly as a result of an improved digestion of fibre in the rumen. Both the amount, and the proportion of N retention to intake were increased by ULB supplementation in lambs fed on hay. The proportion of N retained to N digested decreased with the feeding of ULB in animals on RS or ABRS, indicating that the effect of ULB on the efficiency of N utilization varied between different roughages. It was concluded that when low quality roughages high in fibre and low in N are supplemented with ULB containing urea and minerals, a synchronized supply of N and energy to rumen microbes should be considered to improve the utilization efficiency of N.

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