ASSOCIATIVE EFFECT OF MOLASSES-UREA BLOCK AND FORAGE QUALITY ON NUTRIENT DIGESTION AND NITROGEN RETENTION IN SHEEP

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ABSTRACT

A study was conducted in a 4x4 Latin square design involving four adult crossbred (Kaghani x Rambouillet) wethers kept in individual metabolic crates and four experimental diets viz: maize stovers (Diet A), maize stovers with 150 g/d molasses-urea block (Diet B), lucerne hay (Diet C) and lucerne hay with 150 g/d molasses-urea block (Diet D). The forage intake was restricted to 2% of body weight. Each experimental period consisted 10 days of adaptation followed by five days of data collection. Total dry matter intake on molasses-urea block (MUB) supplemented diets was higher ($P<0.05$) than unsupplemented diets. The daily quantity of total dry matter and water consumed by wethers was higher ($P < 0.001$) on MUB supplemented diets. Water consumption was positively co-related to nitrogen intake ($r^2 = 0.66$; $P < 0.001$) and varied due to diets ($P < 0.001$). *In vivo* dry matter digestibility (DMD) and organic matter digestibility (OMD) of lucerne hay-based diets were greater ($P < 0.05$) than those containing maize stovers. Supplementation of MUB did not affect the DMD or OMD of the diets. The interaction of MUB and forage ($P = 0.06$) revealed that MUB was effective in increasing ($P < 0.05$) the nitrogen digestibility of maize stovers from 30.59% on diet A to 51.33% on diet B but did not affect the nitrogen digestibility in animals fed lucerne hay. The wethers receiving lucerne hay-based diets retained more nitrogen ($P < 0.001$) than those given maize stovers (8.50 Vs 3.12 g/d). Molasses-urea block supplementation on both forages increased ($P < 0.05$) the nitrogen retention. Mean nitrogen retention was 1.82, 4.41, 7.19 and 9.82 g/d in wethers receiving diets A, B, C and D, respectively. Mean rumen ammonia concentration (mg N/100 ml) in wethers receiving maize stovers, was 10.52, which increased ($P < 0.05$) to 17.87 in response to MUB supplementation. On lucerne hay, the rumen ammonia concentrations did not change due to MUB and the mean values on diets C and D were 24.24 and 29.88 mg N/100 ml, respectively. It was concluded that MUB supplementation did not affect *in vivo* dry matter or organic matter digestibility of the experimental diets, but was effective in supporting higher nitrogen retention. Diets based on lucerne hay supported higher nitrogen retention in wethers than those fed maize stovers. Feeding of MUB increased the demand for drinking water.

Keywords: Sheep, molasses-urea block, nutrient digestion, nitrogen retention

INTRODUCTION

The majority of livestock in our country is fed on poor quality forages for a considerable part of a year. The type, availability and methods of utilization of these feed resources vary greatly in different seasons and in different agro-ecological zones. In most cases feeding crop residues and grazing cannot meet the requirements of the animals which result in low producing, structurally weak and emaciated animals. This situation demands the supplementation of deficient nutrients.

Conventional feed supplements are usually very expensive and most of our farmers cannot afford to feed these adequately to their livestock. Therefore, there is a need for using alternative feed supplements, which are economical, less labor intensive and compatible with the existing managemental practices of small farm holdings.

Molasses urea blocks (MUB) has been demonstrated as a useful supplement which provides critical nutrients for optimizing rumen fermentation in animals fed poor quality roughages (Habib *et al.*, 1991). Molasses-urea block provides fermentable nitrogen in the form of urea along with readily available energy and minerals, which improve the microbial activity in the rumen. Molasses-urea block is a convenient and inexpensive method of providing a range of nutrients required by both the rumen microbes and the animal, which may be deficient in the diet. The main justification for using MUB is their convenience for packaging, storage, transportation and feeding.

Research conducted both on private and public farms have demonstrated that MUB supplementation has increased feed intake, growth rate and milk production in ruminant livestock fed low quality roughages (Habib *et al.*, 1991). However, the composition of MUB suggests that it may not be equally beneficial in animals fed good quality forages. Inconsistent responses in animal performance to MUB feeding under different feeding situations reported in the literature has put doubts on the relevancy of the strategy to different periods of fodder availability. The present study was, therefore, planned to elucidate the associative effect of MUB and forage quality on nutrient digestibility and N utilization in sheep to asses the need for MUB supplementation in ruminants fed different quality forages.

MATERIALS AND METHODS

Experimental design

The experiment was conducted in a 4x4 Latin square design (Steel and Torrie, 1981) involving four wethers and four diets fed in four periods. Each period was consisted 10 days of adaptation followed by 5 days of data collection. Four adult Rambuillet cross (Kaghani x Rambouillet) study. The wethers were kept in individual metabolic crates equipped with feeding and water troughs and arrangements for separate collection of feces and urine.

Diets and feeding

The wethers were fed four experimental diets viz. chopped maize stovers (Diet A), chopped maize stovers with 150 g/d molasses-urea block (Diet B), chopped lucerne hay (Diet C) and chopped lucerne hay with 150 g/d molasses-urea block (Diet D). The daily intake of the basal diet was restricted to 2% of body weight. The diets were offered once a day at 9.00 a.m. All the diets were weighed before feeding. The quantity of feed refused, if any, was recorded daily before offering fresh feed. Clean drinking water was made available to the wethers all the time. During first ten days of each experimental period, wethers were gradually adopted to their allotted diets. This was followed by a five days data collection period.

Preparation of molasses-urea block

Molasses-urea blocks prepared for the present study were composed of molasses 38%, urea 7%, calcium hydroxide 10%, NaCl 5%, minerals mixture 5%, rice bran 10% and wheat bran 25%.

Collection of samples and chemical analysis

During the last five days of each experimental (data collection period) period, feces voided and urine excreted by the individual wether and feed offered and refused was recorded daily. Samples of feed offered, feces voided and urine excreted were also collected daily. Each of these was mixed and representative samples were pooled separately for each individual wether and stored at -20°C until analyzed.

At the end of the feeding trial, the pooled feed (offered and refused) and fecal samples were thawed and about 50 g of each sample (in duplicate) was taken for dry matter estimation and the remaining samples were air dried in an electric oven at 60°C for 72 hours, ground in a laboratory mill to 1 mm particle size and analyzed for dry matter (DM), ash, and total nitrogen (N) according to the procedures of A.O.A.C. (1990). Organic matter contents were calculated by subtracting ash from dry matter. Urine samples after thawing and mixing were analyzed for nitrogen contents.

Collection of rumen fluid and estimation of ammonia concentration in the rumen fluid

Rumen fluid samples (50 ml) were collected from the wethers on the last day of each collection period with the help of a stomach tube before feed was offered and then after two hours of feed offered. The samples were acidified, centrifuged and supernatant was analyzed for ammonia-N (A.O.A.C., 1990).

Nutrients digestibility and nitrogen retention

After chemical analysis of feed and fecal samples the digestibility of dry matter (DMD), organic matter (OMD) and nitrogen (ND) was calculated using following equation:

$$\text{Digestibility \%} = \frac{A-B \times 100}{A}$$

Where A represents the quantity of a nutrient (DM, OM or N) consumed by the wethers (g/d) and B as quantity of the same nutrient excreted in feces (g/d). Nitrogen retention (g/d) was calculated by subtracting the total nitrogen excreted in feces and urine (g/d) from the total dietary nitrogen (g/d) consumed by the wethers.

Statistics

The data was analyzed by using analysis of variance procedure (SAS, 1998). The means of different parameters were compared with the Duncan Multiple Range Test or LSD (Steel and Torrie, 1981). Interaction effect between forage type and MUB was introduced in the model for dry matter intake, nitrogen digestibility and nitrogen retention etc.

RESULTS AND DISCUSSION

Feed and water intake

The absence of difference ($P > 0.05$) in forage dry matter intake (DMI) among the wethers (Table 2) was expected because daily forage intake was restricted to 90% of the voluntary intake of the animals and at all times wethers consumed the offered forage in full quantity. The total DMI on diets containing MUB supplement was higher ($P < 0.05$) than un-supplemented diets (Table 2). The high total DMI with MUB on both maize stovers and lucerne hay-based diets suggested absence of substitution effect of the supplement on the basal diet. Preston and Leng (1987) reported that dietary supplements with no substitution effect are always desired in ruminant rations. Tiwari *et al.* (1990), Mehra *et al.* (1991) and Badurdeen *et al.* (1994) also reported higher DMI in cattle, buffaloes and buffalo calves when MUB was supplemented with straw-based diets.

The quantity of water consumed by the wethers highly varied ($P < 0.001$) among the diets and ranged from 1.2 to 2.5 liters/day (Table 2). The higher water consumption on MUB supplemented diets irrespective of forage type suggested high requirement of drinking water with MUB feeding. MUB contained 7% urea, which increased the mean daily nitrogen consumption of the wethers from 8.50 to 14.50 g/d on maize stover diets and from 18.50 to 24.50 g/d on lucerne hay diets. The high water consumption associated with high N intake in the wethers is evident by a significant correlation of the two parameters in the present study. The regression equation derived is given below:

Water consumption liter/d: 0.28+0.88 (N intake g/d); $r=0.81$, $P < 0.01$

The above relationship also explained the higher water consumption by the wethers on nitrogen rich lucerne hay than maize stover based diets (2.1 Vs 1.4 l/d). These observations agree with Church (1984) who suggested that greater consumption of protein might lead to increase water requirements due to increased urinary nitrogen excretion. Excessive N absorbed from rumen is metabolized to urea in the liver that partly excreted in urine (Gans and Mercer, 1984) and would therefore simultaneously more water is required for excretion.

***In vivo* digestibility of nutrients**

In vivo digestibility measurements (Table 3) revealed that diet composition influenced both DMD ($P < 0.05$) and OMD ($P = 0.09$), which were higher ($P < 0.01$) in wethers receiving lucerne hay than maize stovers. Gohl (1981) also reported high DMD of lucerne hay than maize stovers in ruminant animals. However, supplementation of MUB did not improve the DMD of maize stovers and lucerne hay in the wethers. In contrast to the present findings, Tiwari *et al.* (1990) reported that MUB supplement increased DMD in buffaloes fed a basal diet of wheat straw..

The absence of MUB affect on DMD and OMD in the present study could be related to ammonia concentrations in the rumen of the wethers which was optimum even on the un-supplemented lucerne hay and maize stover diets (Table 7). Satter and Slyter (1974) reported the ammonia concentration of 3-5 mg N/100 ml of rumen fluid as optimum for microbial activity in the rumen. In the present study mean ammonia-N concentrations were 10.52 and 24.24-mg/100 ml on un-supplemented maize stovers and lucerne hay diets, respectively. Therefore, it could be argued that in response to MUB feeding further increase in ammonia concentration to 17.87 and 29.88 mg-N/100 ml of rumen fluid on maize stovers and lucerne hay, respectively was not effective to further enhance the microbial digestion in the rumen. However, Jalal-ud-Din (1991) showed that in buffalo steers fed wheat straw, the rumen ammonia concentration was increased from sub optimum level to 8.80 mg N/100 ml in response to MUB feeding which significantly increased the DM digestibility.

Effect of MUB supplementation on ND was not consistent on both forage diets (Table 3) as suggested by interaction of MUB x forages ($P = 0.06$). Nitrogen digestibility in wethers receiving maize stovers was increased ($P < 0.05$) from 30.59 to 51.53% when MUB was given as a supplement. However, no change in ND was observed when MUB was supplemented with lucerne hay. If ND determines the bio-availability of N in a ruminant animal then the present results suggested that MUB supplementation would markedly increased the availability of N on forages which are low in digestibility.

Nitrogen retention:

The nitrogen retention parameters studied in the present study (Table 4) showed that N excretion in urine was proportional to the quantity of N consumed by the wethers and this may explain the higher urinary N excretion on nitrogen rich lucerne hay and MUB supplemented diets. However, fecal N excretion did not vary due to forage type (Table 5) despite clear difference in the N content of the two forages fed in the present study (Table 1). Irrespective of MUB supplementation, mean N excreted in feces on diets containing maize stovers (Diets A and B) and lucerne hay (Diets C and D) were 6.46 and 6.61 g/d, respectively, which accounted for 56.17 and 30.74% of the total N consumed on the two forges, respectively. The high proportion of total N excretion in feces on maize stovers diets suggested that relatively large fraction of N was presumably bound to fiber as ADF-N which according to Van Soest (1982) may have reduced its bio-availability in the rumen and caused greater escape of the dietary N in the feces.

Mean N retained (g/d) in the body of the wethers was higher ($P < 0.001$) on lucerne hay than maize stovers. Molasses-urea block supplementation was also effective ($P < 0.001$) in stimulating N retention on both forages. A positive linear relationship of N intake (g/d) and N retention (g/d) was found ($r = 0.83$) which suggested that daily N consumed determined N retention in the body of the wethers. These observations support the findings of Boorman (1980). Irrespective of MUB supplement, the lower ($P < 0.05$) mean N retention on maize stovers (3.12 g/d) than lucerne hay (8.50 g/d) was expected due to clear difference in the nutrient composition (Table 1) and digestibility (Table 4) between the two forages. Response of wethers to MUB supplement was same on both the forages and no forage x MUB interaction was found. Molasses-urea block feeding increased the N retention only by 2.59 and 2.63 g/d on maize stovers and lucerne hay diets, respectively. It is interesting to note that supplementation of maize stovers with MUB improved the N status of the wether and brought it close to that recorded on lucerne.

Nitrogen retention as percent of total N consumed by the wethers was also calculated to estimate the efficiency of N retention (Table 5). The efficiency of N retention was not affected by MUB but affected ($P < 0.001$) by forage type and was greater on lucerne hay than maize stover based diets (38.97 Vs 28.27%). This could be attributed to better energy/protein ratio in lucerne hay (Boorman, 1980).

Concentration of ammonia in the rumen fluid

Ammonia in the rumen primarily results from the degradation of dietary nitrogen in the rumen. Mean rumen ammonia concentrations were found positively related ($r = 0.81$) to the quantity of dietary N consumed by the wethers.

Mean ammonia concentration (mg N/100 ml rumen fluid) across the four diets increased ($P < 0.001$) from 13.36, before feeding to 26.08 at 2 hours after feeding. Although ammonia concentration was significantly affected by diet composition ($P < 0.001$), the variation was not consistent at both sampling times as revealed by a significant interaction of diet x time ($P < 0.01$). The comparison also indicated that the MUB supplementation after 2 hours of feeding increased ($P < 0.05$) the rumen ammonia concentration on maize stovers but could not change the rumen ammonia concentration when supplemented with lucerne hay. Molasses-urea block contained 7% urea and contributed major part of the N contents in the block.

Table 1: Nutrient composition of the experimental feeds.

Feed samples	Dry matter % (as fed)	Percent in dry matter				
		Ash	Crude protein	Crude fiber	Ether extract	Nitrogen Free extract
Molasses-urea block	82.02	32.48	28.75	5.43	1.59	31.75
Lucerne hay	88.06	10.88	16.08	33.22	1.80	38.02
Maize Stovers	87.22	10.73	6.84	35.85	1.42	45.16

Table 2: Dry matter intake and water consumption by the wethers (Mean±SE).

Diets	Forage dry matter (g/d)	Total dry matter (g/d)	Water consumption (l/d)
Maize stovers	768.00±59.52	768.00^{b}±59.52	1.20^{c}
Maize stovers + MUB	760.75±55.95	893.75^{a}±61.92	1.60^{b}
Lucerne hay	771.75±56.60	771.75^{b}±56.60	1.71^{b}
Lucerne hay + MUB	768.75±56.09	904.00^{a}±54.40	2.50^{a}
LSD (0.05)	29.141	36.995	0.331

Means in the same column with different superscripts are different ($P < 0.05$).

Table 3: In vivo digestibility of nutrients in wethers fed different experimental diets (Mean ± SE).

Diets	Dry matter digestibility (%)	Organic matter digestibility (%)	Nitrogen digestibility (%)
Maize stovers	$50.69^{b} \pm 1.61$	$54.85^{b} \pm 1.53$	$30.59^{c} \pm 7.58$
Maize stovers + MUB	$51.32^{b} \pm 0.61$	$55.30^{ab} \pm 0.60$	$51.33^{b} \pm 3.48$
Lucerne hay	$55.96^{a} \pm 2.35$	$58.53^{ab} \pm 2.09$	$67.12^{a} \pm 2.08$
Lucerne hay+ MUB	$57.05^{a} \pm 0.84$	$59.68^{a} \pm 1.02$	$70.03^{a} \pm 1.95$
LSD (0.05)	4.313	4.450	10.319

Means in the same column with different superscripts are different ($P < 0.05$).

Table 4. Nitrogen intake and retention in wethers fed different experimental diets with or without molasses-urea block (Mean ± SE).

Components	Diets			
	Maize stoves	Maize stovers+MUB	Lucerne hay	Lucerne hay + MUB
N intake (g/d)	$8.50^{d} \pm 0.96$	$14.50^{c} \pm 1.26$	$18.50^{b} \pm 1.55$	$24.50^{a} \pm 0.87$
Fecal N excretion (g/d)	$5.98^{b} \pm 0.79$	6.93 ± 0.15	$6.06^{b} \pm 0.38$	$7.15^{a} \pm 0.61$
Urinary N excretion (g/d)	$1.01^{d} \pm 0.07$	$3.15^{c} \pm 0.34$	$5.96^{b} \pm 0.73$	$7.44^{a} \pm 1.12$
Total N excretion (g/d)	$7.03^{d} \pm 0.88$	$10.09^{c} \pm 0.47$	$12.03^{b} \pm 1.06$	$14.59^{a} \pm 1.18$
N Retention (g/d)	$1.82^{d} \pm 0.69$	$4.41^{c} \pm 0.98$	$7.19^{b} \pm 1.47$	$9.82^{a} \pm 1.51$
N Retention (% of total N intake)	$26.72^{b} \pm 4.43$	$29.43^{ab} \pm 4.64$	$37.99^{a} \pm 4.35$	39.[illegible]$5^{a} \pm 5.63$

Means in the same row with different superscripts are different ($P < 0.05$).

Table 5: Nitrogen intake, excretion and retention in wethers fed different forages irrespective of MUB supplementation.

Components	Maize Stovers	Lucerne hay
N intake (g/d)	$.50^{b}$	21.50^{a}
Fecal N excretion (g/d)	6.46^{a}	6.61^{a}
Urinary N excretion (g/d)	2.08^{b}	6.70^{a}
Total N excretion (g/d)	8.56^{b}	13.31^{a}
N Retention (g/d)	3.12^{b}	8.50^{a}
N Retention (% of total N intake	28.27^{a}	38.97^{a}

Table 6: Nitrogen intake, excretion and retention in wethers given MUB supplement irrespective of forage type

Components	Without MUB	With MUB
N intake (g/d)	13.15^{b}	19.50^{a}
Fecal N excretion (g/d)	6.02^{a}	7.04^{a}
Urinary N excretion (g/d)	3.49^{b}	5.30^{a}
Total N excretion (g/d)	9.53^{b}	12.34^{a}
N Retention (g/d)	4.50^{b}	7.11^{a}
N Retention (% of total N intake)	33.16^{a}	34.69^{a}

Means in the same row with different superscripts are different ($P < 0.05$

Table 7: Mean concentration of ammonia in the rumen fluid (mg-N/100 ml) of wethers before and two hours after feeding

Diets	Before Feeding	2 hours after feeding	Mean
Maize stovers	$10.27^{b} \pm 2.58$	$10.71^{c} \pm 2.87$	10.52
Maize stovers+MUB	$11.90^{b} \pm 3.03$	$22.35^{b} \pm 4.38$	17.87
Lucerne hay	$12.84^{b} \pm 0.67$	$32.80^{a} \pm 7.03$	24.24
Lucerne hay + MUB	$18.45^{a} \pm 2.38$	$38.45^{a} \pm 5.88$	29.88
Mean	13.36	26.08	19.72

Means in the same column with different superscripts are different ($P < 0.05$).

It was, therefore, expected that rumen ammonia levels on both forages would increase in response to MUB feeding. Nevertheless, failure to find significant increase in rumen ammonia concentration in the wethers fed lucerne hay may be attributed to efficient utilization of ammonia-N by the rumen microbes and or rapid absorption from the rumen. Ammonia absorption across the rumen wall is pH dependent. The rate at which a feed supplements is degraded also depends on rumen environment especially pH. This is particularly important for protein supplements of plant origin (Orskov, 1982). Although not measured in the present study, pH of the rumen fluid on lucerne hay would be expectedly high due to its high rumen degradable protein contents as compared to maize stovers, which may have increased the absorption of ammonia from the rumen. These observations are supported by greater excretion of N in the urine of wethers given lucerne hay supplemented with MUB (Table 4).

It can be concluded that MUB supplementation did not affect *in vivo* DMD and OMD of the diets, but was effective in supporting higher nitrogen retention in the wethers fed either maize stovers or lucerne hay. Diets based on lucerne hay were more digestible and caused higher nitrogen retention in wethers than those fed maize stovers.

Based on the present findings it can be recommended that MUB is an effective supplement for increasing the nitrogen status of ruminant animals fed poor quality or good quality forages. However, when animals are fed MUB, they should have free access to drinking water.

In the present study feed intake of the animals was restricted to 90% of their intake. Further studies are required to investigate the interaction of MUB and forage quality in ruminants fed ad libitum.

In addition to its use as a strategic feed supplement MUB can also serve as a carrier for rumen modifiers, growth promoters and therapeutic agents, which warrant further investigations.

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