Effect of Graded Levels of Mustard Oil Cake Supplementation on Intake, Nutrient Digestibility, Microbial N Yield of Adult Cannulated Native (*Bos Indicus*) Bulls Fed Rice Straw

S. A. Chowdhury*
Bangladesh Livestock Research Institute, Savar, Dhaka 1341, Bangladesh

ABSTRACT : On a urea-molasses-straw (3:15:82, UMS) based diet, effect of graded levels of mustard oil cake (MOC) supplementation on the performances of native bulls has been studied. Four cannulated adult *Bos indicus* bulls of 415 (± 44.6) kg live weight and 80 months old, were given daily either of 0, 200, 400 or 800 g of MOC in four periods in a 4 ×4 latin square design. Besides, each animal also received 200 g of each of molasses and wheat bran and a mineral mixture. For unit (1 g) increase in MOC intake, total DM intake increased by 0.8 g/d (r^2=0.88) but no change in the straw DM intake. With the increasing levels of MOC, crude protein (CP) digestibility increased exponentially with an asymptotic value of 72%. However, MOC level had no effect on the digestibilities of DM, OM and ADF. Similarly, rumen degradability of rice straw was also not affected by the level of dietary MOC, and mean straw DM degradabilities were 15, 21, 28, 37, 47 and 51% at 8, 16, 24, 48, 72 and 96 hours of incubation respectively. Microbial N yield per kg digestible organic matter apparently fermented in the rumen were 7.46, 8.77, 6.88 and 5.96 g respectively for 0, 200, 400 or 800 g of dietary MOC. For each gram increase in dietary MOC, N intake and N balance increased by 0.054 g/d (r^2=0.998) and 0.59 mg N/kg $W^{0.75}$/d (r^2=0.99) respectively. Nitrogen balance was estimated to be attained at the N intakes of 246 mg N/kg $W^{0.75}$/d. Thus, on a UMS-based diet supplementation of MOC up to 800 g (10% of total intake) of the dietary intake had little or no effect on intake, digestibility, rumen parameters, and microbial N yield but slightly increased the N balance. However marginal response to MOC supplementation is probably due to the high degradability of MOC protein in the rumen. Thus, any substantial positive response of MOC supplementation on a UMS-based diet can probably be achieved by reducing its protein degradability in the rumen. (*Asian-Aus. J. Anim. Sci. 1999. Vol. 12, No. 5 : 715-722*)

Key Words : Urea, Molasses, Straw, Mustard Oil Cake, Native Bulls, Degradability

INTRODUCTION

Rice straw is essentially an energy feed, low in N, minerals and vitamins, which as such cannot meet the ATP, ammonia, amino acid, mineral or vitamins requirements for optimum microbial growth in the rumen or tissue development for the host animal. This imbalance in nutrient supply often results in only partial expression (as low as 10 per cent) of genetic potentiality of indigenous animals (Leng, 1995), However, this imbalance of straw can be corrected by different pretreatment and supplementation (Sundstøl and Owen, 1984), In a series of trials on supplementation of rice straw with graded levels of natural grasses (Chowdhury and Huque, 1997), *Leucaena* foliage (Chowdhury, 1996), rice mill feed (Chowdhury, 1997), wheat bran (Chowdhury, 1998) and urea-molasses (Chowdhury and Huque, 1998), have shown that dietary crude protein content is the first limiting factor in correcting nutrient imbalances of rice straw. The role of protein supplementation when feeding ruminants on unbalanced feeds like rice straw has been well defined by Preston and Leng (1987). Most common protein supplements in Bangladesh are mustard oil cake, sesame oil cake and different types of pulse bran. However, availability of these protein supplements is limited and often costly, it was necessary to determine the optimum economic level of oil cake need to be used in the diet. Dolberg and Finlayson (1995) have shown that benefit of supplementing cottonseed meal can be realised when quality of the basal diet was improved by treating rice straw with urea. Chowdhury and Huque (1998) have showed that rice straw when impregnated with 3% urea and 15% molasses (UMS) can apparently correct the imbalance of nutrients in rice straw. Therefore the objective of present research programme is to determine the effect of supplementing graded levels of mustard oil cake on the performances of native bulls fed urea-molasses-straw (UMS).

* Address reprint request to S. A. Chowdhury.
Received April 21, 1998; Accepted September 1, 1998

MATERIALS AND METHODS

Experimental design, animals and diets

The experiment was conducted during November, 1996 to March, 1997. Four adult cannulated native (Bos indicus) bulls of 415 (±44.6) kg live weight and 80 months old were randomly allocated to four treatments, in four different periods in a 4×4 Latin Square Design. The treatments were 0, 200, 400 and 800 g of mustard oil cake in addition to the other feed ingredients as shown in table 1. Each period continued for 4 weeks, having an initial adjustment

period of 3 weeks followed by one week collection of faeces and urine. Animals were offered *ad libitum* (approximately 15% in excess of requirement) chopped rice straw (82%) enriched with molasses (15%) and urea (3%, see Huque and Chowdhury, 1995) as the basal diet. Chemical composition of different feed ingredients are shown in table 2. Rice straw was available throughout the day, but the concentrate was fed twice (08:00 and 17:00 h) daily. In accordance with farmer's tradition, mustard oil cake was soaked overnight in water before being fed.

Table 1. Feed ingredients used for different treatments (Amounts in g/head/d)

Feed ingredients	Levels of Mustared Oil Cake (g/d)			
	0	200	400	800
Urea-molasses-straw*	*Ad lib.*	*Ad lib.*	*Ad lib.*	*Ad lib.*
Mustard oil cake	0	200	400	800
Wheat bran	200	200	200	200
Molasses	200	200	200	200
Oyestershell	40	40	40	40
salt	70	70	70	70

* Urea-molasses-straw (UMS): 82% rice straw, 15% molasses and 3% urea (on DM basis).

Table 2. Chemical composition of feed ingredients used in the experiment.

Feed ingredients	Dry matter (g/100 of fresh substances)	g per 100 g of dry matter		
		Organic matter	Crude protein	ADF
UMS*	78	87	5	43
Wheat bran	88	95	16	18
Mustard oil cake	93	80	34	26
Molasses	76	78	5	-

* Urea-molasses-straw : 82% rice straw, 15% molasses and 3% urea (on DM basis).

Experimental techniques

(a) Rumen Parameters : *In sacco* nylon bag (17× 9.5 cm, pore size 20-45 μm) studies (Ørskov md McDonald, 1979) were conducted by incubating 2 g of washed, dried & hammer milled (4 mm) rice straw for 8, 16, 24, 48, 72 and 96 hours in duplicate. Straw sample was incubated in flour different rumen environments created by four different diets. Following incubation. the bags were washed under running tap water until water obtained by gently squeezing the bags was clear. The bags and the contents were then dried at 60 ℃ in a forced-draught oven. The data of DM degradability of the test straw and grass were analyzed by the NAWAY computer programme of the exponential model $p=a+b(1-e^{-ct})$ described by McDonald (1981), where p is the actual degradation in time t and a, b and c are constants. Constant 'a', represents the intercept. 'b' is potentially degradable fraction in given enough time and 'c' is the rate constant of degradation of b. Rumen biochemical studies were conducted by using strained rumen liquor (SRL) collected at 0, 2, 5, 9 and 12 h after the morning meal. Immediately after collection, the pH of the SRL was measured by a digital pH meter and the sample was then stored at -20 ℃ with few drops of 6N H_2SO_4: before NH_3-N analysis. Rumen NH_3-N concentration was measured by steam distillation the SRL using the method described by Tareque (1991).

(b) Cnemical analysis : Samples of feeds, refusals and faeces were analysed for dry matter (DM), organic matter (OM) and N according to AOAC (1984). Urinary N also measured in the same way. The acid detergent fibre (ADF) was determined according to Goering and van Soest (1970).

(c) Estimation of rumen microbial N yield : Urine samples were analysed for determining purine derivatives (from allantoin + 15% correction for uric acid) to quantify microbial N (MN) yields in the rumen following the method described by Chen and Gomes (1992). Here microbial N absorbed in the intestine was estimated from the knowledge of the purine-N : protein-N in the microbial biomass.

(d) Estimation of metabolizable energy (ME) : Dietary ME contribution was estimated from the digestible organic matter (DOM) intake as DOM kg× 15.56 (ARC, 1980).

(e) Statistical analysis : The response to four different diets on the intake, digestibiliy, nutritive value, N balance, MN yield and rumen parameters were analyzed by an ANOVA of a 4×4 latin square design. A linear regression model of the form y=a+bx was used where appropriate. Statistical methods of Snedecor and Cochan (1967) used for the analysis.

RESULTS AND DISCUSSION

Intake

Intake of diets having urea-molasses-straw (UMS) and concentrate with different levels of mustard oil cake (MOC), are shown in table 3. Supplementation of 0, 200, 400 and 800 g of MOC constituted 0, 2.67, 5.23 and 10 per cent of total DM intake. As expected, increasing levels of MOC supplementation significantly ($p<0.05$) increasee by total DM intake. For unit (1 g) increase in MOC intake, total DM intake increased by 0.8 g/d ($r^2=0.88$; $n=4$; $p<0.01$) but no change in the

Table 3. Intake of straw and concentrate at different level of mustrard oil cake supplementation in adult bulls

Parameters	Level of oil cake (g/head/d)				SED (residual df=6)	Significance
	0	200	400	800		
Straw DM intkae (kg/d)	6.57	6.31	6.45	6.38	0.227	NS
Straw DM intkae (g/kg $W^{0.75}$/d)	71	69	71	71	2.03	NS
Contration DM intake (kg/d)	0.328	0.517	0.704	1.076	-	-
Total DM intake (kg/d)	6.90	6.83	7.15	7.46	0.149	p<0.05
Oil cake DM intake (kg/d)	0	0.187	0.374	0.748	-	-
Oil cake as % of DM intake	-	2.67	5.23	10	-	-
Substitution rate (%)	-	3.95	1.83	2.89	-	-

NS: Not significant.

straw DM intake (b=-0.15 g/d; r^2=0.21; n=4; p=0.63). Dietary crude protein content below 7%, known to decrease the DM intake (Poppi and McLenan, 1995). In the present trial, straw was enriched with urea (3%) and molasses (15%) maintained sufficiently high rumen NH_3-N concentration (>150 mg/l, see table 5) and maintain over 8% dietary crude protein content (Huque and Chowdhury, 1995). Therefore, increasing rumen fermentable N supply with MOC supplementation cannot be expected to increase the straw DM intake. This is different from the observation that intake of ammonia teated straw decreased with the increasing levels of cottonseed meal (Dolberg and Finlayson, 1995). One possible reason could be that dietary MOC content was much lower in the present trial (only up to 10%) than that used for the mentioned cottonseed meal trial (Dolberg and Finlayson, 1995).

Digestibility

Whole gut digestibilities for different nutrients are shown in table 4. Digestibilities of DM, OM and ADF were not affected by the levels of supplementation of MOC. However, N digestibilities increased (p<0.05 from 48% at 0 g dietary MOC to 59, 64 and 69%, at 200, 400 and 800 g of dietary MOC level respectively.

Table 4. Whole gut digestibility (%) of diets containing different levels of mustard oil cake supplementation

Parameters	Levels of oil cake (g/head/d)				SED (Residual df=6)	Signifi-cance
	0	200	400	800		
Dry matter	56	58	58	59	3.29	NS
Organic matter	60	62	62	61	3.92	NS
Nitrogen	48^a	59^b	64^{ab}	69^a	3.46	p<0.05
ADF	65	68	65	67	4.25	NS

NS: Not significant.

Similar results was also observed by Chowdhury (1996) where inclusion of leucaena foliage up to 27% of diet linearly increased N digestibility but bad no effect on the digestibilities of DM, OM or ADF. This is probably due to increase in the ratio of higher digestible N, from MOC than to lower digestible straw N. When N digestibility data was fitted to the exponential model of : $\Delta CP=A+B(1-e^{-\rho P})$; where Δ CP is the change in CP digestibility, A and B are constants and ρ is the fractional crude protein digestibility at the dietary oil cake (%) level P. The fitted equation was $Y=48+24(1-e^{-21P})$, with the residual standard deviation of 0.44. It can be estimated from the equation that the highest possible crude protein digestibility would be 72% which is close to the observed CP digestibility (69%) at 800 g (i.e., 10% of the total diet) dietary MOC level. This means that farther increase in dietary MOC level will achieve little improvement in CP digestibility.

Absence of any effects on the digestibilities of DM, OM and ADF is probably because MOC contribute very small fraction of these nutrients in the diet. For example, MOC contribute only 0, 2.5, 7.5 and 9.3% of the total dietary OM intake at 0, 200, 400 and 800 g of dietary MOC supplementation respectively. Lack of response in digestibility can also be due to protein adequacy of UMS based diet where rumen ammonia N concentration found to be maintained in the range of 100-200 mg/l (Huque and Chowdhury, 1995; also in the present trial, figure 1), which is optimum for maximum digestibility of fibrous material (Leng, 1990). Therefore, the extent of MOC supplementation used here will probably have little or no influence on the digestibility of non-protein energy yielding substrate but will probably increase total nutrient supply to the host animal.

Rumen environment

Rumen ammonia N concentration of different dietary treatments at different hours after the morning meal are shown in figure 1. There was no significant (p>0.05) effect of levels of MOC on the rumen ammonia N concentration at any given hour of collection. Mean rumen NH_3-N concentrations were 42, 128, 135, 154 and 88 mg/l respectively at the 0, 2, 5, 9 and 12 h after the morning meal. Generally, the

trend was for a sharp rise in rumen NH_3-N concentration after the morning meal and a slight depression Except at 200 g of dietary MOC intake (due % unknown reason), all treatments had elevated NH_3-N concentration after the afternoon meal. Irrespective of levels of MOC inclusion, rumen NH_3-N concentration ranged between 40-190 mg/l, which is suggested to be within the range required for optimum digestibility (50-80 mg/l, Satter and Styler, 1974) but below the requirement for maximum intake (200 mg/l, Leng, 1990).

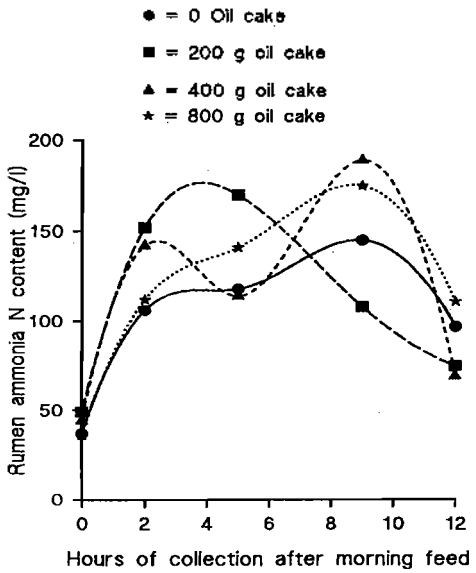

Figure 1. Effect of different levels of mustard oil cake supplementation on rumen ammonia N concentration (mg/l) at different hours of collection in adult bulls fed urea-molasses-straw as the basal diet. Each point represents the mean of four observations.

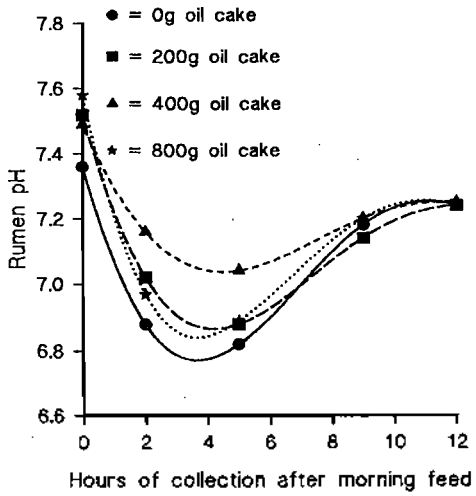

Figure 2. Effect of different levels of mustard oil cake supplementation on rumen pH at different hours of collection in adult bulls fed urea-molasses-straw as the basal diet. Each point represents the mean of four observations.

Rumen pH content of different dietary treatments at different hours after the morning meal are shown in figure 2. There were no significant ($p>0.05$) effect of MOC levels on the rumen pH at any given hour of collection. The mean rumen pH at the 0, 2, 5, 9 and 12h after the morning meal were 7.49, 7.00, 6.91, 7.18 and 7.24 respectively, which is reported to be optimum fur maximum cellulolytic activity (Ørskov, 1982).

Straw dry matter degradability

The DM degradability of the test straw incubated in rumen of flour different rumen environments is presented in table 5. There was no significant effect of levels of MOC on the degradability of rice straw at any given hour of incubation except for the 16 h.

Table 5. Straw DM degradability (%) in the rumen of animals fed rice straw supplemented with differrent levels of mustard oil cake.

Hours of incubation	Levels of oil cake (g/head/d)				SED (Residual df=6)	Signifi-cance
	0	200	400	800		
8	14	15	15	16	3.19	NS[1]
16	23	19	22	20	0.68	$p<0.05$
24	30	28	27	27	2.39	NS
48	37	39	38	35	2.35	NS
72	46	48	47	47	1.78	NS
96	58	58	59	57	4.49	NS
Factors of the equation* $y=a+b(1-e^{-ct})$						
a (%)	11.55	8.85	NF[2]	NF	-	-
b (%)	81.5	76.62	NF	NF	-	-
a+b (%)	103.05	85.47	NF	NF	-	-
c (%)	0.83	1.04	NF	NF	-	-

* NAWAY computer programme of the exponential model described by McDonal (1981). Here, 'a' is the intercept (or readily solule fraction), 'b' is the insoluble but porentially degradable material in time 't' and 'c' is the constant of degradation of b.

[1] NS: not significant. [2] NF: not fitted.

When data were fitted to the exponential equation $y=a+b(1-e^{-ct})$, only data from first two levels (0 and 200 g) of MOC supplementation were fitted (see table 7) but not the data from 400 and 800 g of MOC supplementation. This is probably because straw DM degradabilities increased linearly with time in 400 g ($b=0.458$ g/h; $r^2=0.992$; $p<0.01$) and 800 g ($b=0.475$ g/h; $r^2=0.995$; $p<0.01$) of MOC supplementation. Mean straw DM degradabilities for all four treatments were 15, 21, 28, 37, 47 and 58% respectively at 8, 16, 24, 48, 72 and 96 hours of incubation. Absence of any effect of the incremental increase of oil cake

Table 6. Nitrogen utilization by different groups of animals fed different levels of oil cake

Parameters	Levels of oil cake (g/head/d)				SED (Residual df=6)	Significance
	0	200	400	800		
N intake (g/d)	58.29	67.33	79.64	101.29	1.797	p<0.01
N intake (mg/kg W0.75/d)	635	734	868	1104	19.59	p<0.01
Faecal N excretion (g/d)	30.66	28.22	29.33	31.56	2.856	NS
Urinary N excretion (g/d)	21.26	31.04	36.34	41.00	3.659	p<0.05
Total N excretion (g/d)	51.92	59.25	64.86	75.05	4.537	p<0.01
N balance (mg/kg $W^{0.75}$/d)	72	90	158	287	79.61	p<0.05
Efficiency of N utilization*	0.51	0.46	0.47	0.48	0.063	NS

* Efficiency of N utilization=(N retention+basal N excretion)/N intake; here basal N excretion is 246 mg/kg $W^{0.75}$/d (see the text).

Table 7. Purine derivatives excretion and estimated microbial N yield by different groups of animals fed different levels of oil

Parameters	Levels of oil cake (g/head/d)				SED (Residual df=6)	Significance
	0	200	400	800		
Total purine excretion (mmol/d)	56.29	59.50	56.42	54.08	5.42	NS
Microbial N yield (g/d)	17.97	20.63	17.98	15.98	4.61	NS
Microbial N yield (g/kg DOMR)	7.46	8.77	6.88	5.96	0.68	NS

NS: Not significance.

supplementation on straw DM degradability in the rumen is probably due to the fact that maximum nylon bag digestibility of straw is attained at rumen ammonia-N concentration at around 120 mg/l (Perdok et al., 1988) which is commonly observed in UMS based diet. Therefore, with the levels studied here, MOC inclusion had no effect on the improvement of rumen condition.

Nitrogen utilization

Nitrogen utilization by different groups of animals are shown in table 6. An obvious effect of increasing levels of dietary MOC was a linearly increase the N intake such that, for each gram increase in dietary MOC, N intake increased by 0.054 g/d (r^2=0.998; p<0.01). Although faecal N excretion was similar across the treatment groups, but the urinary N excretion increased by 0.023 g/d (r^2=0.88; p<0.05) and the N balance increased by 0.59 mg/kg $W^{0.75}$/d (r^2=0.99; p<0.05) for each gram increase in dietary MOC. However, considering the rumen degradability of MOC protein of 75% (at 5% fractional outflow rate; Khandakar and Tareque, 1997) and intestinal digestibility of rumen undegradable MOC protein of 85% (Walli et al., 1993), the amount of MOC N available at the tissue level estimated to be 0, 24, 47 and 94 mg/kg $W^{0.75}$/d at the tissue level at 0, 200, 400 and 800 g of dietary MOC supplementation respectively, which is not even enough to meet the maintenance N requirement (350 mg/kg $W^{0.75}$/d, ARC, 1984) of an animal. This means that animals in the present trial should have been in negative N balance although they showed positive balance. One possible reason could be that above assumptions underestimate the actual amount of available N at the tissue level of host animal. Another possible reason could be that N balance overestimate the N status of animal by a level of 0-40% (Chowdhury, 1992). This has also been observed in growing bulls fed rice straw alone, where, animals lost body weight despite their positive N balance (Chowdhury and Huque, 1998).

The fitted linear regression between the N intake (X, mg/kg $W^{0.75}$/d) & N balance (Y, mg/kg $W^{0.75}$/d) are as follows.

$$Y=0.476(\pm 0.0473)X-246;$$
$$(r^2=0.98,\ n=4,\ t=10.06,\ p<0.01)$$

From the equation, it can be estimated that N intake at zero N balance (i.e., the basal N excretion) was 246 mg/kg $W^{0.75}$/d, which is much lower than the ARC (Agricultural Research Council, UK) adopted value of 350 mg/kg $W^{0.75}$/d (ARC, 1984). Lower estimated basal N excretion of indigenous *Bos indicus* cattle has also been observed in previous trials in this laboratory (Chowdhury, 1997, 1998), which is probably a natural adaptation to undernourished condition (Fattet et al., 1984) presumably through reduction of

Table 8. Energy utilization by different groups of animals fed different levels of oil cake

Parameters	Levels of oil cake (g/head/d)				SED (Residual df=6)	Significance
	0	200	400	800		
Digestible OM intake (kg/d)	3.56	3.63	3.84	3.92	0.249	NS
ME (MJ/d)*	55.39	56.56	59.79	61.08	3.891	NS
MEI (kJ/kg $W^{0.75}$/d)	609	625	644	679	48.36	NS
Energy concentration (M/D;MJ/kg DM)	8.14	8.12	8.33	8.16	0.494	NS

* Estimated from the digestible OM apparently fermented in the rumen (DOMR=DOMI×0.65, ARC, 1980) and ME was estimated as 15.58×DOMR (kg/d;ARC,1980).

glutamate dehydrogenase and other enzymes that fed amino groups to the urea cycle (Waterlow, 1986).

Efficiency of N utilization (estimated as (N balance+basal N excretion)/N intake), were 0.51, 0.46, 0.47 and 0.48 respectively for 0, 200, 400 and 800 g of dietary MOC. Here basal N excretion was taken to be 246 mg/kg $W^{0.75}$/d (see above). The efficiency of N utilization in animals depends on its availability of amino acids and energy yielding substrate at the tissue level (Chowdhury and Ørskov, 1997). Provided energy supply is adequate, lower the amount of N available at the tissue level higher will be the efficiency of N utilization. In this trial, efficiency of N utilization were o.46, 0.47 and 0.48 respectively at 200, 400 and 800 g of dietary MOC supplementation, which are very similar to the N utilization efficiency of 0.46-0.49 when sheep were infused with maintenance amounts of casein into the abomasum (Chowdhury et al., 1997). This means that irrespective of amounts of dietary MOC levels, animals were receiving very low level (probably at around the maintenance level) of N at the tissue level. Low N availability at the tissue level is probably due to a) lower microbial N yield. b) lower levels of dietary MOC and c) high degradability of the MOC protein in the rumen. Thus, in order to achieve any substantial response to N balance or growth rate, tissue amigo acid N availability must be increases either by decreasing the N degradability of MOC in the rumen and/or by increasing the dietary MOC level. However, these data does not provide any indication that what should be the minimum quantity of MOC needed to achieve any substantial N balance/growth response on a UMS based diet. Microbial N yield: Urinary purine derivatives excretion and microbial N yield in response to incremental increase in MOC supplementation are shown in table 7. Urinary purine derivatives excretion and hence the microbial N yield was not affected ($p>0.05$) by the levels of MOC supplemented. Microbial N yields per kg digestible organic matter apparently fermented in the rumen (DOMR=DOM intake×0.65; ARC, 1980) were 7.46, 8.77, 6.88 and 5.96 g respectively for 0, 200, 400 ana 800 g of dietary MOC. Increasing levels of MOC expected to increase the microbial N yield by providing additional amino acids (Maeng et al., 1976) and other microbial monomers. Present result are therefore different from the observations that protein added to poor quality diets increases microbial growth efficiency (Ben-Ghedalia and Yosef, 1989; Argyle and Baldwin, 1989). As mentioned earlier UMS based diet maintain rumen ammonia-N level over 100 mg/1 which is well above the concentration required for maximum microbial growth of 50-80 mg/1 (Satter and Slyter, 1974). Therefore further increase in fermentable N supply from MOC can not expected to improve the microbial N yield. Another possibility is that, MOC was soaked overnight before feeding, which might have resulted very rapid fermentation of the MOC N in the rumen and excreted through urine without being used for microbial growth. Thus, MOC supply to a urea molasses straw based diet had no effect on the microbial N yield.

Energy utilization

Estimated (as DOMR kg×15.56, ARC, 1980) metabolizable energy (ME) intake at different levels of dietary MOC are shown in table 8. For unit (1 g) increase in dietary MOC level, ME intake increased by approximately 0.09 kJ/kg $W^{0.75}$/d ($r^2=0.99$; $p<0.01$). However, incremental increase in MOC supplement had no effect ($p>0.05$) on dietary energy concentration which were 8.14, 8.12, 8.33 and 8.16 MJ/kg DM respectively for 0, 200, 400 and 800 of dietary MOC. Thus, incremental increase in MOC had no effect on the energy utilization of animals.

Up to 800 g (about 10% of total intake) of the dietary supplementation MOC had no effect on the intake, digestibility, rumen parameters and the microbial N yield, but slightly increased the N balances of adult bulls on a urea-molasses-straw based basal diet. High degradability of the MOC protein is probably responsible for the absence of any positive response. Traditionally, in Bangladesh, MOC is being soaked overnight before being fed, which probably further increase its protein degradability in the rumen. This may have some positive response on a straw diet

unsupplemented with readily fermentable energy and N but will probably have no effect on a diet like UMS which contain sufficient amount of fermentable energy and N. Thus, any substantial positive response of MOC supplementation on a UMS-based diet can probably be achieved by reducing its protein degradability in the rumen.

REFERENCES

AOAC. 1984. Official Methods of Analysis, Centennial Edition. Association of Official Analytical Chemist, Washington DC.

ARC. 1980. The Nutrient Requirements of Ruminant Livestock. Commonwealth Agricultural Bureaux. Slough England.

ARC. 1984. The Nutrient Requirements of Ruminant Livestock. Supplement No. 1. Commonwealth Agricultural Bureaux. Slough England.

Argyle, J. L. and R. L Baldwin. 1989. Effect of amino acids and peptides on rumen microbial growth yields. J. Dairy Sci. 72:2017-2027.

Ben-Ghedalia. D. and E. Yosef. 1989. SO_2-treated straw as a silage additive: fermentation data on lucerne with particular reference to protein degradation. Anim. Feed Sci. Technol. 22:247-254.

Chen, X. B. and M. J. Gomes. 1992. Estimation of microbial protein supply to sheep and cattle based on urinary excretion of purine derivatives - an overview of the technical details. An occasional publication of the Rowett Research Institute, Greenburn Road. Bocksburn, Aberdeen AB2 9SB, UK.

Chowdhury, S. A. 1992. Protein utilization during energy undernutrition in sheep. Ph.D. Thesis, University of Aberdeen, UK.

Chowdhury, S. A. 1996. Effect of low levels of leucaena (*Lucaena leucocephala*) foliage supplementation on intake, nutrient digestibility and microbial N in cattle fed rice straw alone. Asian-Aus. J. Anim. Sci. 10(3):265-273.

Chowdhury, S. A. 1997. Effect of graded levels of rice mill fed (RMF) supplementation on intake, nutrient digestibility, microbial N yield and growth rate of native (*Bos indicus*) bulls flea rice straw alone. Asian-Aus. J. Anim. Sci. 10(5):445-454.

Chowdhury, S. A. 1998. Effect of graded levels of wheat bran supplementation on intake digestibility, microbial N yield and growth rate of native bulls fed rice straw alone. Asian-Aus. J. Anim. Sci. 11(2):162-170.

Chowdhury, S. A. and K. S. Huque. 1997. Graded levels of green grass supplementation on nutrient digestibility, rumen fermentation and microbial nitrogen production in cattle fed rice straw alone. Asian-Aus. J. Anim. Sci. 10(5):460-470.

Chowdhury, S. A. and K. S. Huque. 1998. Effect of molasses or rice gruel inclusion to urea supplemented rice straw on its intake, nutrient digestibilities, microbial N yield, N balance and growth rate of native (*Bos indicus*) growing bulls. Asian-Aus. J. Anim. Sci. 11(2):145-151.

Chowdhury, S. A. and E. R. Ørskov. 1997. Protein energy relationship with paticular references to energy undernutrition : A review. Small Ruminant Research. 27:1-7.

Chowduuy, S. A., E. R. Ørskov, F. D. Deb. Hovell, J. R. Scaife, and G. Mollison. 1997. Protein utilization during energy undernutrition in sheep sustained by intragastric infusion: effects of protein infusion level, with or without sub-maintenance amounts of energy from volatile fatty acids, on energy and protein metabolism. Br. J. Nutr. 77:565-576.

Dolberg, F and P. Finlayson. 1995. Treated straw for beef production in China. World Animal Review. 82:14-24.

Fattet. I., F. D. Deb. Hovell, E.R. Ørskov, D. J. Kyle, K. Pennie, and R. I. Smart. 1984. Undernutrition in sheep: The effect of supplementation of protein on protein accretion Br. J. Nutr. 52:561-574.

Goerging. H. K. and P. J. van Soest. 1970. Forage Fibre Analysis. United States Department of Agriculture Handbook No. 379.

Huque, K. S. and S. A. Chowdhury. 1995. Study on the supplementing effects or feeding systems of molasses and urea on methane and microbial nitrogen production in the rumen and growth performances of bulls fed a straw diet. Asian-Aus. J. Anim. Sci. 10(2):206-209.

Khandkar, Z. H. and A. M. M. Tareque. 1997. Studies on protein degradabilities of feed stuffs in Bangladesh. Asian-Aus. J. Anim. Sci. 9(6):637-642.

Leng, R. A. 1990. Factors affecting the utilization of 'poor quality' forages by ruminants particularly under tropical condition. Nutr. Res. Rev. 3:277-303.

Leng, R. A. 1995. Trees-Their Role in Animal Nutrition in Developing Countries in the Humid Tropics. University of New England, Armidale, NSW 2351, Australia.

Maeng, W. J., C. van Nevel, R. L. Baldwin, R. L. and J. G. Morris. 1976. Rumen microbial growth rates ana yield: effects of amino acids and protein. J. Dairy Sci. 59:68-79.

Ørskov, E. R. 1982. Protein Nutrition in Ruminant. Academic Press, London.

Ørskov. E. R. and I. McDonald. 1979. The estimation of protein degradability in the rumen from incubation measurements weighed according to rate of passage. Journal of Agricultural Science. Cambridge. 92:499-503.

Perdok, H. B., R. A. Leng, S. H. Bird, G. Habib and M. Van Houtert. 1988. Increasing livestock production from straw-based diets. In: Increasing Small Ruminant Productivity in Semi-Arid Areas, 81-91. [E. F. Thomson and F. S. Thomson, Ed.]. Syria: International Centre for Agricultural Research in Dry Areas.

Poppi, D. P. and S. R. McLanan. 1995. Protein energy utilization by ruminants at pasture. J. Anim. Sci. 73:278-290.

Preston, T. R. and R. A. Leng. 1987. Matching Ruminant Production System with Available Resources in the Tropics and Sub-tropics. Panambul Books, Armidale, NSW, Australia.

Satter, L. D. and L. L. Slyter, 1974. Effect of ammonia concentration on rumen microbial protein production *in vitro*. Br. J. Nutr. 32:194-208.

Snedecor, G. W. and S. J. Cocharn. 1967. Statistical Methods. The Iowa State University Press, Ames, Iowa, USA.

Sundstøl, F. and E. Owen. 1984. Straw and other fibrous by-products as feed. Elsvier Science Publishers. B. V. Molenwerf. 1. P.O. Box 211, 1000 AE Amsterdam, The Netherlands.

Traque, A. M. M. 1991. Nutrition Laboratory Analytical and Research Methods for Domestic Animals. ADB, 2nd Livestock Research., TA No. 668-BAN.

Walli, T. K., K. T. Sampath, S. N. Rai and S. Tamminga. 1993. Relevance of the RDP/UDP system for feeding ruminants in the tropics with emphasis on straw based diet. In: Feeding of Ruminants on Fibrous Crop Residues. (Kiran Singh and J. B. Schere. Ed.) Indian Council of Agricultural Research, Krishi Bhavan, New Delhi, India. pp. 157-170.

Waterlow, A. J. F.1983. Metabolic adaptation to low intakes of energy and protein. Ann. Rev. Nutr. 6:495-526.