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Effect of different planes of nutrition on urea molasses mineral block intake, nutrient utilization, rumen fermentation pattern and blood profile in Murrah buffaloes (*Bubalus bubalis*)

S.V. Hosamani[1], U.R. Mehra, R.S. Dass*

Nuclear Research Laboratory, Indian Veterinary Research Institute, Izatnagar, 243122, India

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Abstract

In order to investigate the effect of plane of nutrition on intake and nutrient utilization from urea molasses mineral block (UMMB), rumen fermentation pattern and blood biochemical constituents, 20 intact and 12 rumen fistulated male Murrah buffaloes aged about 3 years and weighing 320.3±13.11 kg were randomly distributed into four groups of eight animals in each, thus each group having five intact and three rumen fistulated buffaloes. All the animals were fed individually for 40 days. Animals in group I (control) were fed ad libitum wheat straw alone along with mineral mixture and common salt, group II, III and IV were given ad libitum wheat straw alongwith increasing levels of energy from UMMB alone (group II), UMMB+700 g concentrate mixture (group III) and UMMB+1400 g concentrate mixture (group IV). Crushed barley fortified with mineral mixture and common salt was the concentrate mixture used. At the end of feeding trial, a metabolism trial of 7 days duration was conducted on intact animals to determine the digestibility of nutrients. Rumen fermentation study was carried out on 12 rumen fistulated animals following the metabolism trial, blood was collected from intact animals to estimate the nitrogenous constituents in blood serum of animals fed on different planes of nutrition. The intake of total dry matter (DM) and total digestible nutrients (TDN) was non-significantly and intake of digestible crude protein (DCP) was significantly ($p<0.01$) higher in treatment groups over control group. Apparent digestibility of DM, organic matter (OM), and crude protein (CP) increased significantly ($p<0.01$) in group II to IV over group I, whereas, the digestibility of neutral detergent fibre (NDF), acid detergent fibre (ADF), cellulose and hemicellulose tended to be higher in UMMB fed groups. Nitrogen intake and its balance increased significantly ($p<0.01$) with the increase in plane of

* Corresponding author.
[1] Present address: Animal Science Department, University of Agricultural Science, Dharwad 580005, India.

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nutrition. Significantly (p<0.01) higher concentration of total volatile fatty acids (TVFA), total nitrogen (TN) and its fractions were observed due to increased plane of nutrition. The rumen pH reduced significantly (p<0.01) due to concentrate feeding in group III and IV, but rumen fluid volume and digesta flow rate were unaffected. The concentration of blood serum urea increased significantly (p<0.01) in experimental groups as compared to control but ammonia–N and total protein concentrations were unaffected due to feeding of animals on different plane of nutrition. Results indicated that additional energy supplied through concentrate in group III and IV, respectively, resulted in higher intake of protein and energy than the maintenance requirement (Kearl, L.C., 1982. Nutrient Requirements of Ruminants in Developing Countries. International Feed Stuffs Institute, Utah State University, Logan, UT, 82 pp), whereas wheat straw supplemented with UMMB was sufficient to meet the maintenance requirements of adult buffaloes. Higher plane of nutrition did not have any positive effect on intake of wheat straw and UMMB.

Keywords: Wheat straw; Buffaloes; UMMB; Rumen fermentation; Nutrient utilization

1. Introduction

Crop residues (straw and stovers), which form the backbone of livestock industry in India and other third world countries are deficient in nitrogen, minerals, vitamins and rich in antinutritional factors like lignin and silica (Leng and Preston, 1983; Jayasuriya, 1987; Van Soest, 1994) which leads to poor intake and reduced digestibility of various nutrients in ruminants. Supplementation of crop residues with urea molasses mineral block (UMMB) improved intake as well as digestibility of the fibrous residues (Madhu Mohini and Gupta, 1993; Mehra et al., 1993; Hosamani et al., 1995; Toppo et al., 1997). The major problem with the supplementation of the block lick is great diurnal variation in its consumption (Leng, 1984; Neric et al., 1985; Singh and Mehra, 1986; Singh and Mehra, 1990; Mehra et al., 1993) which may be due to the composition and degree of hardness of the block (Leng, 1984; Sudana and Leng, 1986; Hande, 1989). It is not only the texture of the block, the composition of the basal diet i.e. its protein and energy content, may also influence the daily block intake (Ali and Mirza, 1986). Therefore, present investigations were envisaged to find the effect of increasing levels of energy on the intake, nutrient utilisation, rumen fermentation pattern and blood biochemical constituents in adult male Murrah buffaloes fed UMMB alongwith wheat straw as a basal roughage.

2. Materials and methods

2.1. Animals and feeding

The study was conducted on 32 adult male Murrah buffaloes (*Bubalus bubalis*) of about 3 years of age, weighing 320.3±13.11 kg, divided randomly into four groups of eight animals in each. Out of these 32 animals, 12 were operated upon to make a permanent rumen fistula. Thus, each group was having five intact and three rumen fistulated animals. Animals were given only wheat straw (group I, control), wheat straw supplemented with UMMB (group II), wheat straw+UMMB+700 g concentrate mixture (group III) and wheat straw+UMMB+1400 g concentrate mixture (group IV). Wheat straw was given ad libitum to all the animals in four groups. In addition animals in group I were given mineral mixture (30 g) and salt (15 g) to meet out their mineral requirement. The ingredient composition of UMMB was urea 15%, molasses 45%, mineral mixture 15%, cotton seed meal 10%, common salt 8%, calcite powder 4% and sodium bentonite 3%. Concentrate mixture consisted of crushed barley grain fortified with 2% mineral mixture and 1% common salt. During the experimental feeding period the animals were kept in sheds with cement floors and with individual feeding arrangements and during the digestion trial they were kept in metabolic crates. Clean drinking water was offered to the animals at 09.00 and 15.00 h daily. The animals were weighed at the start and after every fortnight to assess the change in body weight. The feeding practice continued for a period of 40 days, at the end of which a metabolism trial of 7 days duration was conducted on intact animals to know the digestibility of nutrients. During the collection period, feed intake and leftover were measured, samples of feeds offered and residues left over were taken in separate polythene bags for each animal daily for chemical analysis. 24 h collection of faeces and urine was recorded at 10.00 h and a suitable aliquot of the thoroughly mixed faecal samples were taken for dry matter (DM) and nitrogen (N) estimation, similarly, a suitable aliquot of urine was preserved in sulphuric acid for N excretion through urine. For chemical analysis, faecal material was dried at 60°C and ground to pass through a 1 mm screen in a Wiley mill and preserved in air tight bottles. Feeds were also processed similarly for analysis. All the intact animals were bled by puncturing the jugular vein before feeding and watering the animals after metabolism trial, serum was separated and stored frozen till analysis. Strained rumen liquor (SRL) was drawn for three consecutive days before feeding (0 h) and at different intervals of time postprandially (2, 4, 6, 8 h) with the help of metallic probes whose multiple holes were wrapped with nylon cloth and located at four different sites in the rumen after adapting the animals on this diet for 40 days. After 3 days sampling of SRL for rumen fermentation studies, polyethylene glycol (PEG) 6000 (60 g in 200 ml water) was infused into the rumen of all the fistulated animals with the help of a hard PVC rubber tubing having a funnel at the outer end and rumen liquor samples were collected at an hourly interval upto 8 h after infusion to determine the rumen fluid volume (Smith and McAllan, 1970). After measuring pH with a digital pH meter, SRL samples were acidified and frozen for further analysis.

2.2. *Chemical analysis*

Chemical composition of biological samples was determined using methods recommended by Association of Official Analytical Chemists (1985) and cell wall constituents (Van Soest et al., 1991). Hemicellulose and cellulose were calculated as NDF–ADF and ADF–ADL, respectively. Total-N and its fractions in rumen liquor were estimated by micro-kjeldhal technique (Association of Official Analytical Chemists, 1985) and total volatile fatty acids (TVFA) as per the method of Barnett and Reid (1957). Ammonia–N (NH_3–N) in rumen liquor and blood serum was estimated (Conway, 1957). Blood serum urea (Rahmatullah and Boyde, 1980) and total protein (Annino, 1976) were also estimated. The metabolizable energy (ME) values of the feeds were calculated (Ministry of Agric. Fisheries and Foods, 1975) by the following equation:

$$\mathrm{ME(MJ)kg^{-1}DM) = 0.15X\%DOMD}\ \text{(digestible organic matter in dry matter)}$$

DOMD (%) was calculated by the following formulae:

$$\mathrm{DOMD}(\%)\,\frac{\text{Percent OM Digestibility}(100 - \text{total ash})}{100}$$

Total digestible nutrients (TDN) was calculated as per the method as described by McDonald et al. (1987).

2.3. Statistical analysis

The data were subjected to test of significance between the different plane of nutrition groups using the analysis of variance technique (Snedecor and Cochran, 1967) and treatment means were compared using Duncan's multiple range test (Steel and Torrie, 1980).

3. Results and discussion

3.1. Dietary chemical composition and feed intake

The chemical composition of UMMB, barley and wheat straw is given in Table 1. Change in body weight, intake of UMMB, wheat straw and concentrate is given in Table 2. The gain in body weight was negative in group I, just maintained in group II and significantly (p<0.01) higher in group III and IV, thus, indicating that supplementation of UMMB alongwith wheat straw could maintain the body weights of the animals. Similar results were reported earlier in buffaloes (Mehra et al., 1991). UMMB intake was similar in group II and III, but it tended to be lower in group IV, may be due to higher level of concentrate intake in this group. Similarly, an insignificant reduction in UMMB intake was observed when dietary concentrate was increased in cattle (Garg and Gupta, 1992) and buffaloes (Madhu Mohini and Gupta, 1993) fed on paddy straw.

Table 1
Chemical composition of feeds fed to experimental animals (% on dry matter basis)

Particulars	UMMB	Barley	Wheat straw
Organic matter	67.10	95.92	91.44
Crude protein	50.21	10.75	3.45
Ether extract	0.42	1.83	1.07
Crude fibre	1.52	6.88	35.51
Neutral detergent fibre	6.01	41.14	79.91
Acid detergent fibre	4.40	17.06	49.92
Cellulose	2.06	14.80	38.92
Total ash	32.90	4.08	8.56

Table 2
Change in body weight and daily feed intake in experimental animals

Attribute	Group				SEM
	I	II	III	IV	
Body weight (Kg)					
Initial	323.3	317.0	324.0	316.7	13.11
Final	320.0	317.0	329.3	326.0	15.64
Gain in body weight (g day^{-1})**	−83.3[a]	0.0[a]	133.3[b]	233.3[b]	37.27
Wheat straw intake (kg day^{-1})	4.50	4.96	4.79	4.63	0.42
Concentrate intake (kg day^{-1})	–	–	0.70	1.40	0.06
UMMB intake (g day^{-1})	–	598.0	576.0	530.0	36.7
Total DM intake (kg day^{-1})	4.24	5.25	5.69	6.11	0.46

[a, b, c] Values bearing different superscript in a row differ significantly.
** p<0.01.

3.2. Digestibility of nutrients

Apparent digestibility of DM, OM and CP increased significantly (p<0.01) in group II–group IV over group I (Table 3). Improved digestibility of OM indicated the availability of fermentable N and readily available carbohydrates supplied through UMMB (group II) and UMMB+concentrate (group III and IV) which might have resulted in better utilization of wheat straw (Leng, 1984; Schiere et al., 1989). Increased CP digestibility in UMMB supplemented group was directly proportional to its level in the diet. This was expected since apparent digestibility of feed protein is directly related to percentage of protein in the diet (Sahlu et al., 1993). The digestibility of NDF, ADF and cellulose tended to be higher in group II over group I, but it depressed non-significantly in group III and IV, probably due to the shift of fermentation pattern, because of the availability of easily fermentable carbohydrates through UMMB as well as concentrate to the microbes in the rumen. Similar trends of nutrient digestibility in cattle (Singh et al., 1991; Garg and Gupta, 1992) and buffaloes (Hande, 1989; Madhu Mohini and Gupta, 1991) was reported.

3.3. Plane of nutrition

Plane of nutrition in animals of various groups is presented in Table 4. Total DM intake was low in group I, which tended to be higher in group II–IV. There was non-significant increase in DM intake due to block feeding in buffaloes in wheat straw (Hande, 1989) and rice straw (untreated or ammoniated) based ration (Schiere et al., 1989; Mangat Ram et al., 1990). On the contrary, Singh et al. (1991) observed a 24% increase in DM intake due to block feeding on wheat straw based diet in crossbred cattle. The DM intake (kg $W^{-0.75}$) was 55.5, 70.1, 73.4 and 79.7 g, respectively, in four groups against a recommended level of 77.69 g kg $W^{-0.75}$ (Kearl, 1982). Similarly, the DCP intake in the respective four groups was −0.03, 2.46, 3.18 and 3.81 g, against the recommended level of 2.53 g kg $W^{-0.75}$ (Kearl, 1982). Likewise, the total digestible nutrient (TDN) was 25.05, 33.86, 36.68 and 42.43 g against the recommended level of 34.54 g kg $W^{-0.75}$

Table 3
Nutrient digestibility in buffaloes fed on different plane of nutrition

Attribute	Group				SEM
	I	II	III	IV	
Dry matter					
Intake (g day^{-1})	4230.0	5240.0	5680.0	6110.0	460.0
Intake (g kg W$^{-0.75}$)	55.5	70.1	73.3	79.8	5.1
Digestible intake (g day^{-1})	1920.0	2600.0	2960.0	3320.0	252.1
Digestibility (%)*	44.8^{a}	49.8^{b}	52.0^{bc}	54.5	1.5
Organic matter					
Intake (g day^{-1})	3890.0	4690.0	5110.0	5530.0	420.0
Digestible intake (g day^{-1})	1880.0	2490.0	2800.0	3190.0	249.0
Digestibility (%)*	47.8^{a}	53.0^{b}	54.8^{bc}	57.7^{c}	1.5
Crude protein					
Intake (g day^{-1})**	126.9^{a}	413.6^{b}	492.6^{bc}	535.8^{c}	21.0
Intake (g kg W$^{-0.75}$)**	1.7^{a}	6.0^{b}	6.4^{bc}	7.0^{c}	0.8
Digestible intake (g day^{-1})**	−1.8^{a}	183.7^{b}	245.9^{c}	291.8^{c}	10.4
Digestibility (%)**	−2.50^{a}	44.5^{b}	50.0^{b}	55.2^{b}	4.2
Neutral detergent fibre					
Intake (g day^{-1})	5390.0	3790.0	3860.0	3990.0	360.0
Digestible intake (g day^{-1})	1620.0	1960.0	1960.0	2060.0	200.9
Digestibility (%)	47.3	51.6	50.7	51.8	3.8
Acid detergent fibre					
Intake (g day^{-1})	2110.0	2370.0	2360.0	2380.0	220.0
Digestibile intake (g day^{-1})	850.0	1230.0	1210.0	1170.0	129.4
Digestibility (%)	40.3	52.1	51.2	49.60	2.8
Cellulose					
Intake (g day^{-1})	1660.0	1860.0	1860.0	1890.0	180.0
Digestible intake (g day^{-1})	1010.0	1160.0	1160.0	1180.0	105.2
Digestibility (%)	60.6	63.1	62.0	62.6	1.9
Hemicellulose					
Intake (g day^{-1})	1280.0	1420.0	1510.0	1610.0	136.9
Digestible intake (g day^{-1})	760.0	760.0	820.0	890.0	113.0
Digestibility (%)	58.7	53.6	54.1	56.4	5.2

[a, b, c] Values bearing different superscript in a row differ significantly.
$^{*}p<0.05$.
$^{**}p<0.01$.

(Kearl, 1982). ME intake (Mcal day^{-1}) was 6.74, 8.93, 10.03 and 11.43 in four groups, respectively, against the recommended level of 9.01 Mcal day^{-1} (Kearl, 1982).

The ratio N/digestible organic matter (N/DOM) in the experimental groups were 0.011, 0.026, 0.028 and 0.026, respectively, while the optimum should be 0.032 g N g^{-1} DOM (Agricultural Research Council, 1980).

The above data on plane of nutrition indicated that animals in group I were short of energy and protein which increased on supplementation of UMMB and concentrate. Though the DM intake was 89.55% of the Kearl requirement in group II, but the

Table 4
Effect of plane of nutrition on nutrient intake in experimental buffaloes

Attribute	Group				SEM
	I	II	III	IV	
Average body weight (kg)	323.3	315.0	330.0	325.7	14.2
Metabolic body size ($W^{0.75}$ kg)	76.24	74.73	77.43	76.59	2.5
Crude protein					
Intake (g day^{-1})**	126.9^{a}	413.6^{b}	492.6^{bc}	535.8^{c}	20.95
Intake (g 100 kg BW^{-1})**	39.3^{a}	131.3^{b}	149.1^{bc}	164.5^{c}	5.43
Intake (g kg W$^{-0.75}$)**	1.66^{a}	5.95^{b}	6.36^{bc}	6.99^{c}	0.75
DCP					
Intake(g day^{-1})**	−1.8^{a}	183.7^{b}	245.9^{c}	291.8^{c}	10.40
Intake (g 100 kg BW^{-1})**	−0.16^{a}	58.3^{b}	74.4^{c}	89.50^{c}	3.16
Intake (g kg W$^{-0.75}$)**	−0.03^{a}	2.46^{b}	3.18^{c}	3.81^{c}	0.33
TDN					
Intake (g day^{-1})**	1910.0	2530.0	2840.0	3250.0	362.9
Intake (g 100 kg BW^{-1})**	590.0	800.0	870.0	1000.0	87.5
Intake (g kg W$^{-0.75}$)**	25.0	33.9	36.7	42.4	3.7
ME intake (Mcal day^{-1})	6.74	8.93	10.03	11.43	
N intake (g day^{-1})	20.30	66.20	78.80	85.70	3.35
DOM intake	1880	2490	2800	3190	249.0
N/DOM	0.011	0.026	0.028	0.026	–

[a, b, c] Values bearing different superscript in a row differ significantly.
[*] $p<0.05$.
[**] $p<0.01$.

supplementation of wheat straw with UMMB alone could meet out the 98.4% and 97.2% requirement of DCP and TDN, respectively, indicating that there was no need to supply concentrate for the maintenance of these animals. With higher plane of nutrition, there was a decrease in wheat straw and block intake, though non-significantly.

3.4. Nitrogen balance

Data on nitrogen intake, its losses through faeces and urine are shown in Table 5. The total nitrogen intake increased significantly ($p<0.01$) with UMMB and concentrate supplementation. Loss of N through faeces and urine was minimum in group I, increased significantly ($p<0.05$) with increase in N intake. The N balance which was negative in wheat straw fed group turned to positive side by supplementation of straw with UMMB or UMMB plus concentrate. Similar results were observed earlier when UMMB was supplemented to wheat straw in cattle (Garg and Gupta, 1992) and sheep (Coombe and Mullholland, 1983; Mirza et al., 1988).

3.5. Blood profile

Total protein (g 100 ml^{-1}), ammonia–N (mg 100 ml^{-1}) and urea–N (mg 100 ml^{-1}) given in Table 5, which are indicative of the adequacy or the inadequacy of the nitrogen

Table 5
Nitrogen intake, balance and concentration of blood biochemical constituents in experimental animals

Attribute	Group				SEM
	I	II	III	IV	
N intake (g day^{-1})**	20.30[a]	66.20[b]	78.80[bc]	85.70[c]	3.35
N outgo through					
Faeces (g day^{-1})*	20.59[a]	36.68[b]	39.46[b]	39.03[b]	4.01
Urine (g day^{-1})*	6.52[a]	22.59[b]	23.97[b]	21.03[b]	2.63
N Balance (g day^{-1})**	−6.81[a]	6.83[b]	15.37[bc]	25.64[c]	2.79
Serum NH_3–N (mg 100 ml^{-1})	1.59	1.91	1.87	1.87	0.19
Serum urea (mg 100 ml^{-1})*	2.46[a]	30.08[b]	22.37[bc]	16.75[c]	2.21
Serum total protein (g 100 ml^{-1})	6.30	7.05	7.06	7.12	0.39

[a, b, c] Values bearing different superscript in a row differ significantly.
* $p<0.05$.
** $p<0.01$.

in the diet of animals (Hammond, 1983). Concentration of ammonia–N and total protein were statistically alike in all the four groups, whereas urea–N was significantly ($p<0.05$) more in group II, III and IV than group I, but the values were within the normal physiological range i.e. 10–30 mg 100 ml^{-1} (Patel and Anaokar, 1971). Significantly ($p<0.05$) lower urea concentration in group IV than group II and III may be due to the more availability of energy from concentrate for the synthesis of amino acids (Dass et al., 1996), but less absorption of rumen ammonia from the rumen wall for urea synthesis in liver.

3.6. Rumen fermentation

The effect of different diets on rumen pH, total volatile fatty acids and various nitrogen fractions in strained rumen liquor at different hours of post feeding are presented in Fig. 1 and the means values are summarized in Table 6. Rumen pH reduced ($p<0.01$) significantly in group IV as compared to group I and II, which may be due to higher production of volatile fatty acids as a result of more availability of easily fermentable carbohydrates from molasses and concentrate (Barley) (Verma et al., 1996).

Ammonia–N concentration in SRL was significantly ($p<0.01$) more in group II, III and IV than group I. Maximum concentration of ammonia–N was observed at 2 h in group II, III and IV, which was maximum at 4 h in Group I.

Maximum concentration of total-N in SRL was observed at 4 h postprandial in groups III and IV, while peak value was obtained at 2 h in groups I and II. The differences in total-N level may be attributed to the different levels of concentrate and differences in UMMB consumed in different groups (Mangat Ram and Kunzu, 1986).

Values for TCA-precipitable-N were 19.96, 24.40, 28.07 and 28.40 mg 100 ml^{-1}, respectively, in four groups, indicating an increasing trend from group I–IV, but statistically the values were alike in groups II, III and IV and all different significantly ($p<0.01$) than group I. Concentration of NPN was significantly ($p<0.01$) more in group II, III and IV as compared to group I. Its concentration was maximum at 2 h in all the three

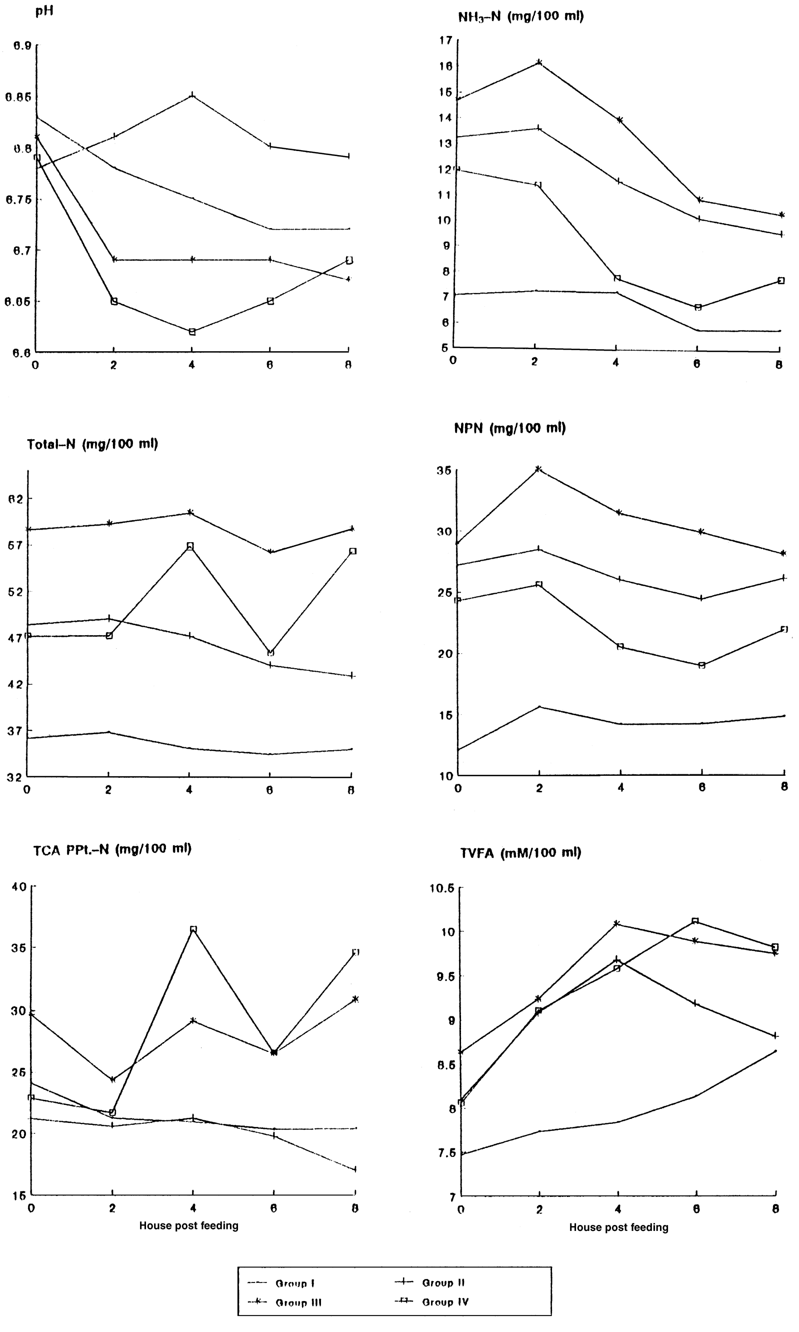

Fig. 1. Effect of different planes of nutrition on rumen fermentation pattern in buffaloes fed wheat straw supplemented with urea molasses mineral block

Table 6
Rumen fermentation pattern in experimental buffaloes

Attribute	Group				SEM
	I	II	III	IV	
Rumen fluid volume (l)	72.03	79.37	74.55	69.94	0.83
Rumen fluid volume (% of body weight)	26.36	26.77	26.54	25.97	0.83
Rumen fluid flow rate (l day^{-1})	3.63	3.83	4.07	4.15	0.45
pH**	6.76^{ab}	6.80^{a}	6.71^{bc}	6.68^{c}	0.02
NH_3–N (mg 100 ml^{-1} of SRL)**	6.63^{a}	13.20^{b}	11.63^{b}	9.13^{c}	0.66
Total N (mg 100 ml^{-1} of SRL)**	35.50^{a}	46.28^{b}	50.56^{b}	58.63^{c}	1.61
TCA-precipitable-N (mg 100 ml^{-1} of SRL)**	19.96^{a}	24.40^{b}	28.07^{b}	28.40^{b}	1.03
NPN (mg 100 ml^{-1} of SRL)**	15.54^{a}	21.88^{b}	22.49^{b}	30.56^{c}	1.33
TVFA (mM^{-1} 100 ml of SRL)**	7.96^{a}	8.96^{b}	9.51^{b}	9.33^{b}	0.23

a, b, c Values bearing different superscript in a row differ significantly.
** ($p<0.01$).

treatment groups, which may be due to the rapid hydrolysis of urea present in block. Concentration of TVFA was significantly ($p<0.01$) lower in group I as compared to other groups. This could be due to the difference in the content of carbohydrate and protein in the diet of group I from other groups (Pant and Roy, 1971). There was a progressive increase in the concentration of TVFA after feeding and attained a peak level at 4 h in UMMB supplemented groups. However, subsequent decline in the level of TVFA at 6 and 8 h after feeding may be either due to absorption through rumen wall into blood stream or decrease in availability of carbohydrate and protein for microbial fermentation. Rumen fluid volume and flow rate of liquid digesta were not significantly different amongst treatment groups, indicating that dietary feeding had no influence on these parameters. Similar observations have already been reported in cattle and buffalo (Mangat Ram and Gupta, 1987). In the present experiment the rumen fluid volume were between 25.97% and 26.77% of body weights of animals, which is similar to the values reported earlier (Toppo et al., 1997).

4. Conclusion

It could be concluded that wheat straw supplemented with UMMB could meet out the maintenance requirement of buffaloes. Supply of higher energy through concentrate in group III and IV did not increase the intake of UMMB or wheat straw.

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