Catalytic Supplementation of Urea-molasses on Nutritional Performance of Male Buffalo (*Bubalus bubalis*) Calves

A. Sahoo*, A. V. Elangovan[2], U. R. Mehra[1] and U. B. Singh[1]

Indian Veterinary Research Institute, Regional Station, Palampur-176 061 (HP), India

ABSTRACT : Twenty male buffalo calves of 6-9 months of age (average body weight, 97 kg) were randomly allocated into two main groups of four (control) and sixteen (supplemented) calves. The supplemented group was further divided in to four equal sub-groups, with the two groups supplemented with a liquid preparation of urea-molasses, UML1, containing fish meal and UML2, containing formaldehyde treated deoiled mustard cake (FDMC) and the other two, with a semi-solid preparation, UMC1 with FDMC and deoiled rice bran (DORB) contributing similar level of CP as in UML2 and UMC2 with double the level of FDMC to that in UMC1. The control group was fed with DORB along with *ad libitum* wheat straw at 40:60 ratios. The rest of the groups were fed on the above diet supplemented with 500 g (as fed basis) of urea-molasses preparations. The experimental feeding was carried out for 24 weeks including a metabolism trial towards the end of experimental feeding. Daily feed intake and fortnightly change in live weight were also recorded during the study. Catalytic supplementation of 500 g urea-molasses induced 8-25% higher voluntary feed intake of wheat straw, resulting in 15-25% higher DM and OM intake. The digestibility of DM, OM, total carbohydrate, NDF, ADF, hemicellulose and cellulose in all the dietary groups were comparable. The CP digestibility of calves in supplemented groups were higher ($p<0.05$) than the control group. The balance of nutrients, viz. N, Ca and P, was also higher in the supplemented groups. Significantly higher intake of digestible CP coupled with other digestible nutrients attributed to higher TDN (1.67-1.78 vs. 1.37 kg) and ME (5.94-6.31 vs. 4.87 Mcal) intake in urea-molasses supplemented groups which resulted in higher live weight gain compared to that in control group ($p<0.01$). Between the supplements, UML2 and UMC2 faired non-significantly, indicating formalin treated mustard cake as a suitable replacement to fishmeal in the supplement. The overall ranking based on intake and digestibility of nutrients, live weight gain, economic evaluation and input-output relationship revealed that the rations with UML2 and UMC1 to be of greater value compared to other types. From the study it can be concluded that young ruminants can be reared successfully on a basal diet of deoiled rice bran and wheat straw supplemented with cheaper urea-molasses-mineral mix. ***(Asian-Aust. J. Anim. Sci. 2004. Vol 17, No. 5 : 621-628)***

Key Words : Urea-molasses, Nutrition, Performance, Buffalo Calves

INTRODUCTION

Even though crop residues and other cellulosic materials are the staple feed for ruminants in India and other tropical and sub-tropical countries, temporary shortages do occur during natural calamities like drought, cyclone and flood situation, which has an adverse impact on animal production. In these situations, urea-molasses feeding practice came in to existence as early as 1967 in Cuba by Preston and co-workers and in India by Pathak and Ranjhan (1973). Urea in combination with readily available energy sources (such as, molasses) was found promising when either fed with or sprayed over poor quality roughages, or used as urea-molasses supplement (Johri and Ranjhan, 1982; Preston and Leng, 1984; Kunju, 1986; Dass et al., 1996; Mehra et al., 1998). Preston and Leng (1987) advocated the supplementation of deficit nutrients, namely nitrogen (N), energy, minerals and vitamins for better utilization of poor quality roughages. On the other hand the deficit supply of conventional intact protein can be made good by its judicious supply as rumen undegradable protein (RUP) and by providing supplements containing non-protein nitrogen compounds (urea) with easily available carbohydrates (molasses) and minerals in the diet of ruminant animals. Various efforts to popularize urea-molasses mix at farmer's door did not succeed because of toxicity due to accidental overdosage of urea or incomplete mixing with crop residues. The present experiment was based on the observations made on the principles and practices of feeding and local feeding problems by livestock owners in some adopted villages of the Institute (Indian Veterinary Research Institute, Izatnagar, India). In the present study, the feeding practice of roughages offered chaffed and sprinkled (sometimes mixed) with available concentrates (preferably soaked) and/or family food wastes designated as 'Sani' was adopted to evaluate a constant supply of degradable N and soluble carbohydrate through urea-molasses supplement in order to overcome the drawbacks encountered in earlier feeding practices. Efforts were also made to study the effect of providing RUP in the supplement on growth performance of buffalo calves.

* Corresponding Author: A. Sahoo. Tel: +91-1894-230526, Fax: 91-1894-233063, E-mail: ivriplp@sancharnet.in

[1] Animal Nutrition Division, Indian Veterinary Research Institute, Izatnagar (U.P.), -243 122, India.

[2] Nutrition and Feed Technology, Central Avian Research Institute, Izatnagar-243 122 (UP), India.

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Table 1. Ingredient composition of urea-molasses supplement

Ingredients (%)	Urea-molasses liquid (UML)		Urea-molasses cake (UMC)	
	UML1	UML2	UMC1	UMC2
Molasses	72	66	46	46
Urea	7	7	7	7
Deoiled rice bran	-	-	32	24
Fishmeal	14	-	-	-
Formaldehyde treated deoiled mustard cake	-	20	8	16
Vitamins[1] and mineral mixture[2]	4	4	4	4
Common salt	3	3	3	3
Cost* (Rs/pack[#])	2.02	1.88	1.93	2.03

[1] Vitablend (Vit. A, D3) added @ 20 g/100 kg of urea-molasses supplement.

[2] Calcium carbonate 18.80, dicalcium phosphate 58.70, magnesium oxide 10.32, manganese sulphate 3.53, ferrous sulphate 2.26, zinc sulphate 0.86, copper sulphate 0.28, cobalt sulphate 0.039, potasium iodide 0.033, sodium fluoride 0.136 (% by wt basis).

* Relative price of ingredients (Rs/kg): molasses 1.50, urea 5.00, deoiled rice bran 3.50, fish meal 10.00, formaldehyde treated deoiled mustard cake 6.00, mineral mixture 15.00, common salt 1.00, vitablend 450.00. [#] Cost of preparation, Rs 50 per 100 kg.

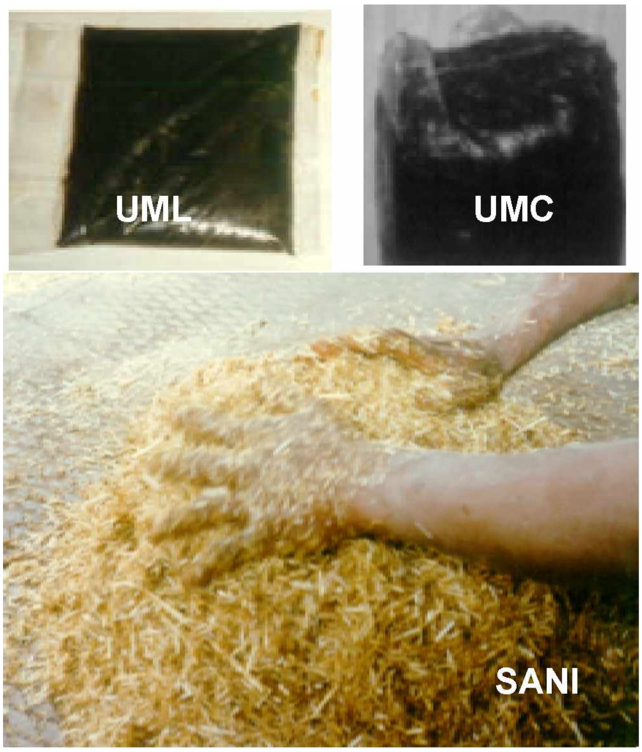

Figure 1. Urea molasses supplement, UML-liquid preparation, UMC-Semi-solid preparation (cake) and Sani-mixture of UML/UMC and wheat straw.

MATERIALS AND METHODS

Experimental design

Twenty male buffalo (*Bubalus bubalis*) calves of 6 to 9 months of age (average body weight, 97±6.8 kg) were randomly distributed into two main groups of control (four calves) and supplemented (16 calves) with the later being further sub-grouped into four equal groups on the basis of their live weight. Two of the supplemented groups received liquid preparations of urea-molasses, UML1 containing fish meal as RUP and UML2, containing formaldehyde treated deoiled mustard cake (FDMC). The other two groups received a semi-solid (cake) preparation. UMC1 containing FDMC and additional deoiled rice bran (DORB) for solidfication having CP at similar level as that in UML2 and UMC2, where the FDMC level was doubled (Table 1). All the calves were offered a basal diet of DORB (1.5 kg as fed basis) and *ad libitum* wheat straw (WS) at an approximately 40:60 concentrate to roughage ratio.

Preparation of urea molasses supplement and storage

The compositions of urea-molasses supplements are presented in Table 1. All the ingredients were mixed uniformly in the following sequence, urea-common salt-mineral mixture and salt, in molasses and the whole mixture was further mixed with fishmeal or FDMC, which represented the urea-molasses liquid (UML) and then, 500 g of the preparation was packed in polyethylene pack (Figure 1) and stored for future feeding. In the preparation of urea-molasses cake (UMC), 500 g of the above mixture (devoid of fishmeal) was further solidified to form a cake by mixing with deoiled rice bran and then wrapped in polyethylene pack (Figure 1) to store for future feeding. The polyethylene-packed supplements were kept one above the other, a minimum of 5 packs, in small plastic craits to accommodate 60-80 packs and were stored in dark at room temperature.

Assessment of keeping quality

The keeping quality of urea-molasses supplement (UML/UMC) was assessed in terms of spillage of UML from the pack, weight threshold of number of packs layered one after another, stickiness, flies and growth of molds etc.

Feeding and metabolism trial

The urea-molasses supplement dissolved in 1 L of drinking water was offered as 'Sani' (Figure 1) by mixing it with WS. For control animals, the same amount of water was mixed with WS and offered for feeding. All the calves were provided with clean drinking water for *ad libitum* intake. The experimental feeding was continued for a period

Table 2. Nutrient composition (% DM) of basal diet and urea-molasses supplements

Nutrients	Oil extracted rice bran	Wheat straw	UML1	UML2	UMC1	UMC2
DM%	90.2	92.2	72.9	75.0	80.2	80.0
OM	85.8	90.5	81.5	85.5	81.7	82.3
CP	16.3	3.3	42.1	41.0	38.5	40.0
EE	1.5	0.9	0.9	0.8	1.0	0.9
T-CHO	68.0	86.3	38.5	43.7	42.2	41.4
NDF	52.5	74.8	9.5	13.8	26.1	30.5
ADF	23.5	49.6	6.8	8.1	12.3	12.9
Lignin	5.3	6.2	3.5	3.6	3.5	3.8
Cellulose	18.2	43.4	3.3	4.5	8.8	9.1
Hemicellulose	29.0	25.2	2.7	5.7	13.8	17.6
Calcium	0.14	0.38	2.89	2.45	1.95	2.16
Phosphorous	1.01	0.06	0.81	0.77	0.93	0.85

UML: urea-molasses liquid, UMC: urea-molasses cake, T-CHO: Total carbohydrate.

of 24 weeks.

A metabolism trial of seven days collection of faeces and urine was conducted towards the end of feeding trial. Amounts of faeces and urine excreted by individual calves were recorded on 24 h basis at 0900 h daily. Faeces pooled in pre-weighed plastic buckets were mixed thoroughly and representative samples were taken for aliquoting and analysis. Urine collected through a tray kept under each metabolism cage was stored in a plastic bottle layered by a thin film of toluene. Samples of feed offered, orts and faeces aliquot were pooled over the period of 7 days after drying (100±5°C) overnight in a hot air oven for further chemical analysis. Aliquot of faeces and urine were also preserved with sulphuric acid for the analysis of nitrogen.

Feed intake and live weight gain

Voluntary feed intake was measured daily by substracting the DM in feed refusals from the DM offered. The animals were weighed at fortnightly intervals on two consecutive days in the morning before offering feed and water.

Chemical analysis

The feed, residue and faecal samples were analysed for its proximate principles as per AOAC (1984), and the fiber fractions as per the method described by Van Soest et al. (1991). Nitrogen in feed, faeces and urine samples were analysed by the standard Kjeldahl method using Tecator digestion unit and Kjeltek Auto 1026 distillation unit (Tecator, Sweden). Calcium (Ca) was estimated as per the method of Talpatra et al. (1940) and that of phosphorous (P) by the method described in AOAC (1975).

Statistical analysis

The data were subjected to test of significance in different orthogonal contrasts (control vs. other treatment groups; liquid vs. cake supplements) using ANOVA as per the methods described in Snedecor and Cochran (1989).

RESULTS AND DISCUSSION

Nutrient composition

The chemical composition of basal diet and urea-molasses supplements is presented in Table 2. Both UML and UMC constituted for major protein concentrate (about 40% CP) in the feeding of experimental calves. The variation in fiber fraction was due to compositional variation of ingredients used in the preparation of urea-molasses supplement. Because rice bran is rich in P (Ranjhan, 1998), variation in the content of Ca and P in the supplement was observed. UMC2 with double the level of FDMC concentrated 1.5% more CP than UMC1 and the variations with regards to the liquid preparations was due to the difference in the DM content of the products as the supply of CP through UML1, UML2 and UMC1 was kept at similar level.

Intake and digestibility of nutrients

Intake and digestibility of nutrients are presented in Table 3. There was considerable increase in voluntary feed DM intake (15 to 25%) due to supplementation of urea-molasses fed as 'Sani' by mixing uniformly with WS. The increase in DM intake from WS in supplemented groups, after subtracting the UML/UMC contribution (0.37-0.40 kg) to the total, revealed improvement in palatability. Chowdhury and Huque (1997) also observed higher intake of straw DM in urea-molasses straw diet and attributed the reasons to higher rate and extent of straw DM degradability. The contributory effect was being an increase ($p<0.05$) in intake of other nutrients (OM, CP and EE). An increased CP intake in the supplemented groups compared to control ($p<0.01$) was mainly due to supplementary feeding of urea and other proteinous feed through urea-molasses supplement.

The digestibility of nutrients except that of CP was comparable among the dietary groups. Supplementation of urea-molasses revealed a marginal improvement in DM digestibility (46.3 vs. 48.0-49.6%) but the values for other

Table 3. Intake and digestibility of nutrients in different dietary groups during metabolism trial

Attributes	Dietary groups						Main effect	
	Control	UML1	UML2	UMC1	UMC2	SEM	Between supplements	Pooled supplement
Nutrient intake								
DM (kg)	3.16[b]	3.76[ab]	3.88[a]	3.94[a]	3.59[ab]	0.21	NS	*
OM (kg)	2.79[b]	3.31[a]	3.41[a]	3.47[a]	3.16[a]	0.15	NS	*
CP (g)	280[b]	442[a]	445[a]	447[a]	441[a]	17.32	NS	**
EE (g)	36.5	41.9	42.5	43.9	40.4	2.54	NS	*
T-CHO (kg)	2.47	2.83	2.93	2.98	2.68	0.18	NS	NS
NDF (kg)	2.08	2.28	2.36	2.45	2.21	0.15	NS	NS
ADF (kg)	1.21	1.36	1.41	1.45	1.28	0.11	NS	NS
Hemicellulose (kg)	0.85	0.92	0.95	1.00	0.93	0.06	NS	NS
Cellulose (kg)	1.03	1.15	1.19	1.23	1.08	0.09	NS	NS
Digestibility (%)								
DM	46.3	48.0	49.6	48.6	48.7	1.20	NS	NS
OM	49.2	50.3	50.4	50.8	52.1	1.35	NS	NS
CP	25.4[b]	49.1[a]	48.1[a]	50.2[a]	47.2[a]	1.63	NS	**
EE	61.2	55.0	57.2	57.5	60.1	2.19	NS	NS
T-CHO	52.3	51.1	51.3	50.8	52.7	1.40	NS	NS
NDF	40.5	40.2	43.1	42.3	43.6	1.68	NS	NS
ADF	29.8	26.7	29.0	28.8	29.0	1.71	NS	NS
Hemicellulose	59.0	58.6	62.5	62.7	64.8	2.07	NS	NS
Cellulose	34.5	32.6	35.2	35.9	36.1	1.91	NS	NS
Nutritive value of diet								
ADP%	2.25[b]	5.77[a]	5.52[a]	5.70[a]	5.80[a]	0.09	NS	**
TDN%	44.72	45.61	45.67	45.56	46.66	1.23	NS	NS
ME* (Mcal/kg DM)	1.592	1.624	1.626	1.622	1.661	0.04	NS	NS

T-CHO: total carbohydrate, ADP: apparently digestible protein.

TDN=ADP+Digestible T-CHO+Digestible EE×2.25. ME=3.56×TDN (Blaxter, 1967).

Means in a row bearing different superscripts differ significantly. NS: nonsignificant ($p>0.05$); * $p<0.05$, ** $p<0.01$.

nutrients were similar in all the groups. Increase in CP digestibility in UML and UMC supplemented groups was directly proportional to its level in the diet as reported by various workers (Orskov and Fraser, 1970; Singh and Talapatra, 1971) and not uncommon on urea-molasses supplement feeding (Pathak and Ranjhan, 1976; Leng, 1984; Tiwari et al., 1990; Hosamani et al., 2003). This may be probably due to higher absorption of ammonia through the rumen wall coupled with higher availability of microbial protein and RUP at the intestinal level. According to NRC (2001) protein supplementation should be limited to high rumen RUP containing feedstuffs to avoid large excesses of rumen-degradable protein. No difference in CP digestibility between UML1 with fish meal and UML2, UMC1 and UMC2 with FDMC was seen. In an earlier experiment Sahoo and Pathak (1996a, b) successfully replaced animal protein with vegetable protein in milk fed calves and yearling bulls. Further, increasing the level of FDMC in UMC2 did not have any significant effect on digestibility parameters. A probable shift in fermentation pattern because of easily available fermentable N and energy could not significantly affect the digestibility of fiber constituents (NDF, ADF, cellulose, hemicellulose) in the present experiment. Hosamani et al. (2003) noted similar observation in buffalo calves fed on different energy sources supplemented with urea-molasses mineral block. However, depression in fiber digestibility was observed in *ad libitum* liquid urea-molasses feeding by earlier workers (Pathak and Ranjhan, 1976; Johri et al., 1982).

Nitrogen balance

The intake and balance of N is presented in Table 4, which revealed positive balances in all the dietary groups. Supplemental feeding of urea-molasses added to increased N intake, which coupled with higher digestibility (Table 3) resulted in higher N balances in the supplemented groups than the control ($p<0.01$). The N loss through faeces was least affected ($p>0.05$) by increased N intake. However, urinary excretion of N increased in the supplemented groups in direct proportion to higher N intake as indicated by a higher N balance as percent of N absorbed in the control group ($p<0.01$). A lower urinary N excretion in the control groups which may be referred as negative control in terms of N availability was indicative of N preservation against a reduced supply of N which recycled through saliva into the rumen as a means of economic N usage adopted by ruminant animals in N adversity (Jackson et al., 1990; Milward et al., 1991; Sahoo et al., 2002). However, the N balance was non-significantly higher in the supplemented groups (19.55-21.02) compared to that of

Table 4. Nitrogen, calcium and phosphorous balance in different dietary groups during metabolism trial

Attributes	Dietary groups						Main effect	
	Control	UML1	UML2	UMC1	UMC2	SEM	Between supplements	Pooled supplement
Nitrogen (g/day)								
Intake (NI)	44.86[b]	70.65[a]	71.16[a]	71.58[a]	70.50[a]	1.17	NS	**
Faecal excretion	33.45	36.01	36.99	35.59	37.20	1.90	NS	NS
Urinary excretion	3.52[b]	20.09[a]	19.23[a]	21.04[a]	19.74[a]	2.02	NS	**
Balance (NB)	7.89[b]	14.55[a]	14.94[a]	14.95[a]	13.76[a]	1.20	NS	**
% of intake	17.53	20.56	21.02	20.93	19.55	1.74	NS	NS
% of absorbed	69.10[a]	42.03[b]	43.70[b]	41.60[b]	41.34[b]	3.43	NS	**
Calcium (g/day)								
Intake	8.75[b]	19.95[a]	19.01[a]	17.90[a]	17.40[a]	0.74	NS	**
Faecal excretion	6.67[b]	14.37[a]	13.25[a]	12.65[a]	12.27[a]	0.78	NS	**
Urinary excretion	0.21[b]	0.53[a]	0.49[a]	0.48[a]	0.50[a]	0.03	NS	**
Balance	1.86[b]	5.05[a]	5.27[a]	5.37[a]	5.09[a]	0.25	NS	**
% of intake	21.32[b]	25.41[a]	27.64[a]	28.88[a]	28.58[a]	1.21	NS	*
% of absorbed	89.28	90.42	91.38	91.41	91.30	1.08	NS	NS
Phosphorous (g/day)								
Intake	14.75[b]	17.81[a]	17.80[a]	18.71[a]	18.17[a]	0.50	NS	*
Faecal excretion	13.13	13.88	13.77	14.48	14.05	0.52	NS	NS
Urinary excretion	0.27[b]	0.48[a]	0.45[a]	0.51[a]	0.49[a]	0.03	NS	**
Balance (g/d)	1.35[b]	3.45[a]	3.58[a]	3.72[a]	3.63[a]	0.17	NS	**
% of intake	9.25[b]	19.32[a]	20.05[a]	19.98[a]	19.95[a]	1.07	NS	**
% of absorbed	83.26	87.72	88.77	87.98	88.05	2.13	NS	NS

Means in a row bearing different superscripts differ significantly. NS: nonsignificant ($p>0.05$), * $p<0.05$, ** $p<0.01$.

control (17.53) when expressed in proportion to its intake. Similar observations were also made in earlier studies (Tyagi and JaiKishan, 1983; Mehra et al., 1998; Giri et al., 2000).

Calcium and phosphorous balance

The calves of all the groups were in positive Ca and P balance (Table 4). The P intake in control animals was at higher side than that of Ca (14.75 vs. 8.75 g/d) and was chiefly contributed by P rich DORB (Ranjhan, 1998). In the supplemented groups Ca rich molasses (Ranjhan, 1998) and the supplemental mineral mixture corrected this imbalances and also resulted in reasonably higher intake ($p<0.01$) and thus, higher balances of these minerals. According to NRC (1989), with sufficient dietary P, wide ranges of the ratio can be tolerated within the recommended level of intake and the efficiency of absorption remained relatively constant (Challa et al., 1989). In the same line, Ca and P balance in our study as percent of absorbed amount was similar in all the groups, although it was higher as percent of intake in the supplemented groups. Both excretion of Ca and P was higher in the supplemented groups in response to higher intake. Similar trend in Ca and P balances in response to rice bran and roughage based ration was also observed by Moran (1983) and Giri et al. (2000).

Nutritional performance

The basal diet consisting of DORB and wheat straw became more palatable due to the incorporation of urea-molasses as evidenced from increase in wheat straw DM intake of calves in the supplemented groups, since the former was kept constant in all the calves (Table 5). In the control group DM intake per unit body weight was able to supply nutrients to maintain an average daily gain of 200 g, which is considered sub-optimal in buffalo calves. Therefore, they need additional nutrients to sustain minimum growth potential (>300 g, average daily gain, Kearl, 1982) for future animal productivity. The TDN intake was observed to be 20-30% higher in UML and UMC supplemented groups that maintained an average daily gain of about 350 g, which was higher ($p<0.01$) than the control group. The relative intake of TDN was comparatively less to that recommended by Kearl (1982) for buffalo calves growing even at a low average daily live weight gain (250 g). However, the requirements of apparently digestible protein (ADP) and energy (TDN or ME) delineated by NRC (2001) for growing cattle closely related to their intake in the present experiment. Ranjhan (1998) also recommended a similar level of nutrients for growing buffalo calves. The animals under control group were underfed with ADP but relatively better N utilization efficiency (Table 4) might have taken care of the deficit during the 24 weeks of feeding trial. Similar observations on N economy were also made in another experiment on growing crossbred calves exposed to experimental protein restriction (Sahoo et al., 2002). The CP intake in supplemented groups was little higher which in association with lower digestibility (47-50%) may probably meet the

Table 5. Nutritional performance and input-output relationship in different dietary groups

Attributes	Dietary groups						Main effect	
	Control	UML1	UML2	UMC1	UMC2	SEM	Between supplements	Pooled supplement
Nutrient intake/day								
DM (g) deoiled rice bran	1,351	1351	1,351	1,351	1,351	0.00	NS	*
Urea-molasses supplement	000^{c}	365^{b}	374^{b}	401^{a}	400^{a}	10.07	*	**
Wheat straw	1,700	1,968	2,103	2,130	1,836	156.2	NS	*
Total	3,051^{b}	3,684^{a}	3,828^{a}	3,882^{a}	3,587^{ab}	209.4	NS	*
Intake level of roughage	100.0^{b}	115.8^{ab}	123.7^{a}	125.3^{a}	108.0^{ab}	5.51	NS	*
Catalytic effect on roughage intake	0.0	15.8	23.7	25.3	8.0	NA	NA	NA
TDN (g)	1,368^{b}	1,680^{a}	1,748^{a}	1,769^{a}	1,674^{a}	95.13	NS	*
ADP (g)	69^{b}	213^{a}	211^{a}	230^{a}	203^{a}	7.45	NS	**
ME* (Mcal)	4.87^{b}	5.98^{a}	6.22^{a}	6.30^{a}	5.96^{a}	0.34	NS	*
Nutrient intake/kg $W^{0.75}$ body weight								
DM (g)	86.1^{b}	98.2^{ab}	100.6^{a}	103.4^{a}	96.8^{ab}	4.37	NS	*
TDN (g)	38.8^{b}	44.8^{a}	45.9^{a}	47.0^{a}	45.2^{a}	1.76	NS	*
ADP (g)	2.00^{b}	5.71^{a}	5.57^{a}	6.18^{a}	5.51^{a}	0.22	NS	**
ME (kcal)	138^{b}	160^{a}	163^{a}	167^{a}	161^{a}	6.27	NS	*
Live weight (LW) gain								
Initial LW (kg)	98.2	96.5	98.2	97.2	97.0	9.63	NS	NS
Final LW (kg)	133.8	154.0	157.7	154.7	150.7	11.74	NS	NS
ADG (g)	213^{b}	341^{a}	356^{a}	347^{a}	323^{a}	27.5	NS	*
Feed conversion ratio (kg gain/unit nutrient intake)								
DM (kg)	0.070^{b}	0.093^{a}	0.093^{a}	0.090^{a}	0.090^{a}	0.005	NS	*
TDN (kg)	0.156^{b}	0.203^{a}	0.204^{a}	0.195^{a}	0.193^{a}	0.011	NS	*
ME (Mcal)	0.044^{b}	0.057^{a}	0.057^{a}	0.055^{a}	0.054^{a}	0.003	NS	*
Economic evaluation								
Feed cost* (Rs)	7.09	9.40	9.16	9.24	9.02	NA	NA	NA
Cost (Rs)/kg gain	33.29	27.49	25.73	26.63	27.93	NA	NA	NA
Input-output relationship								
Extra TDN (kg)/extra gain (kg)	0.00	2.44	2.66	2.99	2.78	NA	NA	NA
Extra ME (Mcal)/extra gain (kg)	0.00	8.68	9.46	10.66	9.90	NA	NA	NA
Extra cost (Rs)/extra gain (kg)	0.00	18.05	14.48	16.04	17.55	NA	NA	NA

* Relative feed cost (Rs): Wheat straw-100, Urea-molasses supplement-as in Table 1. Deoiled rice bran-350.

ADP: Apparently digestible protewin, ADG: Average daily gain, NA: Not applicable.

Means in a row bearing different superscripts differ significantly. NS: Nonsignificant ($p>0.05$). * $p<0.05$, ** $p<0.01$.

ADP requirement of growing animals (Kearl, 1982; NRC, 2001). Increasing the level of FDMC in UMC2 did not have any advantage over other supplemented groups. A wider energy: protein ratio in association with poor degradable source of N (wheat straw and deoiled rice bran) was thus found to be deficient for maintaining the growth potential of animals in control group. However, in supplemented groups, readily fermentable N and energy from urea-molasses supplement might have enhanced the proliferation and growth of microbes (Preston and Leng, 1984; Jayasuriya, 1987), which along with the RUP from fish meal or FDMC provided increased non-ammonia N at duodenal level for higher animal productivity (Leng, 1984; Kunju, 1986).

Catalytic effect of urea-molasses supplement

While studying the voluntary consumption of straw as against total dry matter, there was 8-25% higher intake of wheat straw in supplemented groups compared to control (Table 5). Molasses as sweetener adds to palatability and hence might have increased the DM intake in supplemented groups (3.59-3.88 vs. 3.05 kg). The catalytic effect on DM intake coupled with higher CP digestibility added into comparatively higher nutritional performance (increased nutrient intake, efficiency and growth) in supplemented groups. Chaudhary et al. (2002) observed comparable intake and performance in milking cow on DORB plus molasses based ration with that of wheat bran. It is further suggested that availability of fermentable N (urea) and soluble carbohydrate (molasses) supplied through urea-molasses supplement facilitates the growth of cellulolytic population in the rumen which might have resulted in better utilisation of wheat straw and increase in DM intake (Leng, 1984).

Economic evaluation and input-output relationship

The price of urea-molasses supplement (Table 1) was observed to be cheap (approximately, Rs 2.00 per pack of 500 g), with UML2 being the cheapest (Rs 1.88). The ration with fish meal incorporated urea-molasses supplement (UML1) was found to be more expensive as compared to other types (Table 5). The input of feed cost per kg gain was found lowest for the ration with UML2 (Rs 25.73). The unit feed (DM) conversion for live weight gain (kg) was lowest for control (0.070 kg) and was higher ($p<0.05$) in the supplemented groups (0.090-0.093 kg). Similar trend was also observed for unit conversion of TDN and ME intake. The economics was also evaluated based on input-output ratio which revealed an extra input of Rs 18.05, 14.48, 16.04, 17.55 for an extra one kg live weight gain in UML1, UML2, UMC1 and UMC2 supplemented groups, respectively. Although, the input in terms of energy (TDN/ME per kg gain) was lowest for UML1, the cost involved was at the higher side.

The overall ranking based on intake and digestibility of nutrients, live weight gain, economic evaluation and input-output relationship revealed that the rations with UML2 and UMC1 to be of greater value compared to other types.

Applicability of the method

The laboratory preparation of UML or UMC in small scale seemed to be quite feasible and economic. The moisture content of molasses was sufficient enough to dissolve urea, salt, vitamin and mineral mixture, which helps in uniform mixing and constant supply of soluble nutrients for increased efficiency of utilization. Flies were not a problem and the supplement did not grow moldy even after 3 months of storage. Sporadic spillage was seen in UML pack, which seemed to be due to faulty sealing. Transportation to nearby villages in small craits was quite handy and feasible. In another exploratory study (personal communication) it was observed that farmers inclined to adopt the technology due to its low cost and feasibility.

CONCLUSION

Results indicated that under economic compulsions or during a scarcity period under natural calamities, feeding of urea-molasses supplement can very well sustain minimum growth potential in animals to meet future animal productivity. Further, FDMC can be substituted for costly fish meal to meet the RUP requirement of animals. The supplement packed in polyethylene pack seemed quite handy for transportation and additionally, due to its low cost, may be able to supply a multi-nutrient supplement at farmers' door. The method of feeding was also quite convenient in overcoming the accidental urea toxicity in animals.

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