Urea-Molasses-Mineral Block Licks Supplementation for Milk Production in Crossbred Cows

Bandla Srinivas[1] and B. N. Gupta
Division of Dairy Cattle Nutrition, National Dairy Research Institute, Karnal 132 001, India

ABSTRACT : Appropriation of partial substitution of concentrate mixture by urea-molasses-mineral block (UMMB) lick supplements for 20 lactating crossbred cows in 2nd and 3rd lactation was studied. Animals fed on wheat straw *ad lib.* and Berseem (*Trifolium alaxandrium*) fodder @ 1.5 kg/d on dry matter basis. Animals of control group were given concentrate supplement, while in treatment groups 10% of the concentrate requirement was substituted with 3 different types of UMMB lick type A (T_1), type B (T_2) and type C (T_3). CP content of the ration was 15%. Total dry matter intake (DMI) was about 1.0 kg /kg of fat corrected milk (FCM) yield and was not significantly different between control and treatment groups. Digestibility of neither proximate principles nor cell wall constituents were deviated on UMMB licks partial supplementation. FCM yield was increased by 140, 410 and 460 g/d, in T_1, T_2 and T_3, respectively, in comparision to control group but differences were statistically invalid. Though fat per cent was reduced, fat yields were remain constant among treatments. Milk composition was unaltered except significant difference ($p < 0.01$) in non-protein nitrogen (NPN) content. Gross-N and digestible-N conversion efficiency into milk-N were similar among control and treatment groups but, metabolizable-N conversion was significantly higher ($p < 0.01$) with T_1, T_2 and T_3 than control group. Energy utilization efficiency for milk production was only 36%. Result demonstrated that UMMB licks could be partial supplemented upto 10% of the concentrate requirement of crossbred cows yielding on an average 14 kg/d without any adverse effect on feed intake, nutrient utilization and milk production. Comparatively, UMMB lick type B and C was proved better than type A and also economically viable.

(**Key Words** : Urea-molasses-mineral Block Lick, Supplementation, Milk Production)

INTRODUCTION

Many of the South-Asian countries are suffering with chronic annual feed deficits. Increasing growth of animal population and combination of factors like natural calamities and export of agricultural commodities further accentuate the problem. Concentrate availability is insufficient to meet potential requirement of lactating animals. Efforts are diverted for using non-conventional feed resources to combat feed deficits by exploiting inherent ability of rumen microflora in using non-protein nitrogen (NPN) as source of ammonia. Some workers opinioned that urea-N utilization could be poor on diets containing more than 12% CP and sustaining milk yields greater than 12 kg/d (Roffler & Satter, 1975; Roffler et al., 1976). In contrary, Rys (1967) indicated that the responce of high yielding cows has been positive on partial supplementation of non-protein nitrogen (NPN) in their ration.

It has been proved that urea supplementation as free choice solid block lick has many more advantagous than amorphous urea addition in the diet (Neric et al., 1985; Sudana and Ueng, 1986). Feasibility of introducing UMMB licks in the ration containig less than 10% CP of low yielding lactating cows (less than 6 kg milk/day) was reported (Kunju, 1988; Srinivas and Verma, 1996). In moderate to high yielding cows invariably ration CP content goes beyond 12%. In such diets compatibility of urea addition is diametric. Based on existing information and studies conducted at our laboratory three types of UMMB licks were fabricated and evaluated for partial supplementation in the ration of dairy cows with the following objectives 1. To study the DM intake and efficiency of milk production and, 2. Quantitative and qualitative changes in milk.

[1] Address reprint requests to Bandla Srinivas; National Institute of Animal Nutrition and Physiology, Adugodi, Bangalore 560030 India.

Received March 29, 1996; Accepted September 13, 1996

MATERIALS AND METHODS

Treatments and diet

Twenty Karanfries (Holstein friesian × Sahiwal) crossbred cows in 2nd and 3rd lactation were distributed randomly into 4 groups of 5 each based on their previous lactation yield (2,964-3,479 kg/305 d) and present lactation milk yield for initial one month (13.2-20.1 kg/d). All animals were fed on wheat straw *ad lib.* and green Berseem (*Trifolium alaxandrinum*) fodder @ 1.5 kg/d on DM basis. Animals of control treatment (C) were given concentrate supplement comprising groundnut extractions 32, cottonseed cake 5, barley 30, wheat bran 30, mineral mixture 2 and common salt 1 part, to meet requirement. Animals in other treatment groups such as T_1, T_2 and T_3 were given only 90% of total concentrate requirement and rest 10% was substituted with 3 different types of UMMB lick type A, B and C, respectively. Total concentrate requirement was divided into 3 equal parts and offered to animals before milking as stimuli for milk let down. Fresh water was offered to all the animals before and immediately after milking thrice daily. UMMB licks were placed in a specially designed trough and kept in a slant position adjoining the manger for free accessability.

Formulation of UMMB licks

All three types of UMMB licks contained equal parts of urea (table 1). Molasses (as source of easily fermentable energy) and urea (as source of rumen degradable nitrogen) were incorporated at a ratio 1:3 for optimum rumen fermentation (ARC, 1980). However, molasses content in UMMB lick type B and C was reduced by 5% on account of energy compensation from groundnut extractions. Groundnut extractions which is more soluble in rumen was added in UMMB lick type B and C to provide preformed amino acid and peptides to augument rumen fermentation (Argyle and Baldwin, 1989). Higher proportion of mineral mixture was added in the UMMB licks owing to their deficiency in low quality roughage and to improve the reproduction. Common salt was incorporated to enhance rapid turnover of feed in rumen. Sodium bentonite and Calcite powder were used as gelling agents for better setting of block. Though numerous gelling agents have been available in the market, sodium bentonite was chosen for its positive affect on nitrogen utilization in ruminants (Britton et al., 1978). It was observed that reducing molasses content and including groundnut extractions helped to attain a better consistency in UMMB lick type B and C (Srinivas et al., 1996).

Table 1. Ingredient composition of different UMMB licks

Ingredient (%)	Type		
	A	B	C
Urea	15	15	15
Molasses	45	40	40
Mineral mixture	15	10	8
Sodium bentonite	3	3	3
Calcite powder	4	4	3
Common salt	8	2	3
Groundnut extractions	Nil	10	14
Cottonseed extractions	10	16	14

Lactation study

After an adjustment period of two weeks, a lactation study was conducted for 150 d. Milk weights were recorded daily at each milking. Composite milk samples of thrice milking were taken at fortnightly intervals for estimating milk fat, total protein, total ash, total solids and NPN contents (BSI, 1984). Daily feed intakes were measured throughout the study.

Metabolism trial

A metabolism trial for 7 d was conducted between 90 to 120 days of lactation study. Daily collection of feces and urine were weighed, mixed thoroughly and 1% sub sample was taken. Feces and urine collections were kept acid by adding 4M H_2SO_4. During this period milk samples were collected daily and composition was analysed. Feed and feces samples were analyzed for proximate principles as per the method of AOAC (1984). Samples were also analyzed for neutral detergent fiber (NDF), acid detergent fiber (ADF), hemicellulose, cellulose and lignin (Goering and VanSoest, 1970). Urine samples were analyzed for nitrogen (AOAC, 1984).

Efficiency of milk production

Nitrogen utilization efficiency for milk production was calculated as per Pathak et al., (1976). Energy efficiency of milk production was calculated by considering heat of combustion of milk as 3.1 MJ/kg and 1 kg TDN as 18.41 MJ of digestibile energy (DE) and 15.15 MJ of metabolizable energy (ME) according to ARC (1980).

Economics of the ration

Cost of the feed was calculated based on the present cost of ration components and milk sale value. The cost of ration components; Wheat straw, fresh berseem fodder, concentrate and UMMB licks were 140, 60, 500 and 550 Rs/100 kg (1 US$ = Rs. 35.70), Respectively. The cost of 4% FCM was taken as 700 Rs/100 kg.

Statistical analysis

Differences within and between treatments were tested using an analysis of variance, randomized complete block design (Panse and Sukhatme, 1989).

RESULTS

Feed analysis and intake

Chemical composition of UMMB licks showed that type B and C contained more rumen degradable protein (RDP) and undegradable protein (UDP) than type A (table 2). There was no significant difference in straw or berseem dry matter intake (DMI) between control and treatment groups (table 3). UMMB lick intake was 30 and 38% higher in UMMB lick type B and C compared to type A. Total DMI (kg/100 kg body weight and g/$W^{0.75}$ kg) did not vary significantly among groups. DMI per kg of fat corrected milk (FCM) yield was about 1.0 kg in all groups.

Table 2. Chemical composition of feed components (% on dry matter basis)

Particulars	Conc. mixture	Wheat straw	Berseem	Type of UMMB lick		
				A	B	C
Organic matter	90.8	89.8	90.4	69.7	79.2	78.9
Nitrogen	3.6	0.5	2.7	9.3	10.2	10.3
Ether extract	4.6	0.8	1.3	0.6	1.0	1.1
Crude fibre	6.7	45.7	22.7	1.1	2.4	2.6
Nitrogen free extract	56.9	40.2	49.5	58.7	65.6	64.9
Neutral detergent fibre	40.0	82.2	40.2	7.4	10.6	11.3
Acid detergent fibre	22.7	54.7	22.8	2.3	3.2	3.9
Hemicellulose	17.4	27.5	17.4	5.1	7.4	7.4
Cellulose	15.1	39.2	14.6	0.9	1.6	1.8
Total ash	9.2	10.2	9.6	30.3	20.8	21.1
Rumen degradable protein	13.4	Nil	10.1	15.3	19.7	20.6
Rumen undegradable protein	9.7	Nil	6.7	1.9	4.5	5.0

Digestibility and nitrogen balances

Digestibility of proximate principles did not deviated on partial supplementation of UMMB licks. Although there was little depression in organic matter digestibility in treatment groups, statistically differences were not valid. Similarly, digestibility of cell wall constituents were also unaffected. N intake (g/d) was higher in treatment groups. Customarily a wide variation in lick consumption by the animals was noticed. N excretion as % intake in feces was similar among control and treatment groups but, excretion through urine was higher in treatment groups. N balances were lower in UMMB licks supplemented animals yet the differences were not significant.

Milk composition

No conspicuous change in milk yield was observed between groups (table 4). Fat % was significantly higher ($p < 0.01$) in control group than other treatment groups. Total solids, total protein and total ash content in milk were unaltered. However, NPN content in milk was significantly higher ($p < 0.01$) in UMMB licks partially supplemented animals.

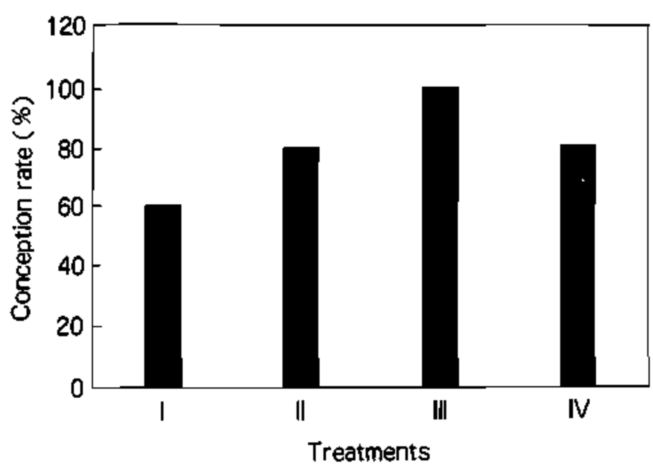

Figure 1. Conception rate in different treatments.

Efficiency of milk production

Gross-N and digestible-N conversion efficiency into

Table 3. Dry matter intake and nutrient digestibility

Parameter	Control	T_1	T_2	T_3	SE_m
Source of dry matter intake :					
Straw	4.87	5.06	5.11	5.16	0.20
Berseem (kg/d)	1.50	1.50	1.50	1.50	–
Concentrate (kg/d)	7.95	7.75	7.71	7.72	0.81
UMMB lick (g/d)	Nil	261	339	361	10.00
Total dry matter consumption :					
kg/d	14.32	14.56	14.56	14.74	0.96
kg/100 kg B. Wt	3.38	3.42	3.24	3.37	0.30
g/kg $W^{0.75}$	155.75	155.14	149.29	153.81	12.59
kg/kg FCM yield	1.01	0.99	1.01	1.00	0.04
Digestibility coefficients :					
Dry matter	62.03	61.79	62.53	62.30	0.86
Oraganic matter	66.03	65.01	65.29	65.18	0.87
Crude protein	61.95	61.73	62.00	62.15	0.88
Ether extract	49.42	49.16	50.38	49.24	1.05
Crude fibre	58.43	58.61	59.08	59.16	0.77
Nitrogen free extract	55.84	56.12	55.66	56.24	0.61
Neutral Detergent fibre	58.09	58.52	58.69	58.97	0.65
Acid detergent fibre	51.54	51.83	51.58	51.89	0.56
Hemicellulose	64.13	64.64	64.87	64.56	0.60
Cellulose	56.82	57.16	57.44	57.83	0.65
CP (%)	15.36	15.97	15.21	15.27	0.81
DCP (%)	8.81	8.60	8.58	8.52	0.23
TDN (%)	53.28	53.76	55.97	53.43	1.25
ME (MJ/kg DM)	8.07	8.15	8.48	8.10	0.19
Nutritive ratio	1:5.08	1:5.26	1:5.53	1:5.28	0.16

Table 4. Average milk production per day and milk composition

Parameter	Control	T_1	T_2	T_3	SE_m
Milk yield (kg/d)	13.23	13.58	14.33	14.40	1.29
Fat corrected milk yield (kg/d)	14.45	14.59	14.86	14.91	1.40
Total solids (g/100 ml)	12.71	12.69	12.83	12.79	0.59
Fat** (g/100 ml)	4.62^a	4.49^a	4.26^b	4.22^b	0.07
Protein (g/100 ml)	3.34	3.40	3.39	3.35	0.04
Total ash (g/100 ml)	0.79	0.78	0.78	0.77	0.02
Non-protein nitrogen** (mg/100 ml)	43.15^a	51.83^a	52.80^b	52.91^b	0.44
Fat yield (g/d)	611.62	610.76	612.72	610.35	59.20

[a,b] Values bearing different superscripts in a row differ significantly; ** $p < 0.01$.

milk-N were similar among control and treatment groups but, metabolizable-N conversion was significantly higher ($p < 0.01$) with UMMB licks partially supplemented animals (table 5). Although feed energy (MJ) and milk energy (NJ) were higher with treatment groups, efficiency of either DE or ME utilization was same as control animals. ME utilization efficiency for milk production was around 36% only.

Economics

The cost of feed was presented in table 6. Total feed cost in the treatment groups was higher than the control group, however, simultaneously net return on milk sale was also higher in corresponding groups.

Table 5. Nitrogen balance, efficiency of utilization of dietary nitrogen and energy for milk production

Parameter	Control	T_1	T_2	T_3	SE_m
Surce of nitrogen intake (g/d)					
Wheat straw	25.38	26.37	26.67	26.91	1.06
Berseem fodder	40.46	40.46	40.46	40.46	–
Concentrate	288.89	288.42	281.11	281.48	29.87
UMMB lick	Nil	24.24	34.73	36.36	1.18
Total nitrogen intake	354.73	373.49	382.98	386.01	31.18
Nitrogen excretion (g/d)					
Faeces	135.30	140.55	146.73	147.56	13.34
Urine	112.31	124.71	128.43	131.98	10.39
Milk	70.62	73.89	77.64	76.76	6.74
Total out put	318.24	339.16	352.82	336.22	29.81
Nitrogen balance (g/d)	36.41	34.33	30.16	29.79	1.68
Nitrogen conversion efficiency (%)					
Gross	20.84	19.77	20.14	19.90	0.54
Digestible	32.20	31.48	32.54	33.07	1.02
Metabolizable*	66.11^{a}	68.28^{ab}	71.26^{bc}	71.96^{c}	1.39
Efficiency of energy utilization (%)					
Digestible	28.90	29.09	29.09	30.39	1.04
Metabolizable	35.16	35.37	35.37	36.95	1.27

abc Values bearing different superscripts in a row differ significantly;
* $p < 0.05$.

Table 6. Economics of the ration

Parameter	Control	T_1	T_2	T_3	SE_m
Cost of ration components (Rs/100 kg)					
Wheat straw	6.95	7.12	8.69	8.77	0.13
Fresh berseem fodder	7.20	7.20	7.20	7.20	–
Concetrate mixture	39.77	38.74	38.56	38.60	2.82
UMMB licks	–	1.47	1.87	1.98	0.03
Total cost of feed (Rs)	53.92	54.53	56.32	56.55	2.91
Return on milk sale (Rs)	101.32	102.13	104.04	104.36	5.15
Profit (Rs/day)	–	0.81	2.72	3.04	0.08

Exchange rate 1 US $ = Rs. 35.70.

DISCUSSIONS

CP, RDP and UDP content in concentrate mixture were within the specifications (ARC, 1980). RDP content in Berseem was considerd as 60% (Negi et al., 1988). UMMB lick type B and C intake were higher than type A. This might be due to better viscoelastic properties in former 2 types of block licks. The changes made in the composition of UMMB type B and C had conspicuous influence on the textural properties such as hardness, adhesiveness, cohesiveness, springiness etc., (Srinivas et al., 1996). Total DM intake ranged from 3.24 to 3.42 kg/ 100 kg body weight among treatment groups. Total DM intake in lactating cows varies with milk yield and size but generally range between 2-4 kg/100 kg body weight (NRC, 1978). The total DM intake was in accordance with the earlier reports (Huber and Kung, 1981; Belyea and Adams, 1990). Partial supplementation of UMMB licks had no adverse effect on digestibility of proximate principles. No alteration in cellulose and hemicellulose digestion also explained any adverse changes in anaerobic fermentation. ME availability in ration was same in all treatment groups. Digestible-N intake was higher in UMMB licks partially supplemented animals because ammonia-N might have been absorbed through rumen epithelium (Huber and Kung, 1981). Concomitantly nitrogen excretion in milk and urine were also higher in these animals.

There was marginal increase in milk production on partial substitution of UMMB licks. Milk yield (4% FCM) was increased by 140, 410 and 460 g/d, respectively on supplementation of UMMB lick type A, B and C respectively. Further, the existing distinction did not validate statistically. Improvement in the milk yield due to UMMB lick supplementation to paddy straw in low yielding cattle was reported (Kunju, 1988). Customarily depression in feed intake and milk yields is possible when urea intake exceeds 0.45 g/kg body wt. (Treacher et al., 1979). The amount of urea ingested by the treatment groups was about 0.15 g/kg body wt., which was fairly below than the illegetimate level suggested by Treacher and coworkers. NPN content in milk observed on UMMB partial supplemented animals was higher than normal volumes of 28 mg/100 ml (ARC, 1980). This could be attributed to more nitrogen intake as urea compared to control animals. Generally, protein intakes around normal level had little effect on protein content of milk conversely, extra protein or nitrogen intake may increase NPN content in milk (Roffler and Satter, 1975).

All animals were in positive nitrogen balance of about 30 g/d. High positive N balance in lactating animals were also recorded by other workers on liquid urea-molasses diets (Pathak et al., 1976; Belyea and Adams, 1990). It was not clear how high N balances were used in the body ? There might be one possibility of utilizing balances towards pregnancy since some of the animals were conceived during the trial period. Out of 5 animals in each group only 3 animals in control group, 4 animals each in T_1 and T_3, and all animals in T_2 were conceived. Although ME availability was similar in control and all the treatment groups, metabolizabl-N use efficiency was significantly higher ($p < 0.01$) in animals received UMMB licks as partial supplements. Difference in ME utilization efficiency at similar levels of energy supply may be assumed for improvement in fermentative end products. Sudana and Leng (1986) reported increased propionate production on UMMB licks supplementation. In such cases fermentative heat losses could be altered better on increased propionate production (Orskov, 1975). Nitrogen utilization efficiency on UMMB licks was little higher than the earlier observations on liquid urea-molasses feeding to crossbred cows (Pathak et al., 1976). Broster and Oldham (1981) suggests 75% efficiency of nitrogen utilization for the ration containing 15% CP with 60% degradability and ME concentration of 10.85 MJ/kg. In the present study, despite 15% CP with 60% degradability, but ME was only 8.5 MJ/kg, the nitrogen utilization efficiency was 70% only. It appears that the energy differences were obviously a cause for the efficiency of utilization of nitrogen (Roy et al., 1977; Satter and Roffler, 1975). In contrary, Cowan et al. (1981), inferred that a maximum nitrogen use efficiency for milk production was only 35%.

Energy utilization efficiency was more or less 36% in all the treatment groups and affirm with earlier report (Belyea and Adams, 1990). The amounts of energy that has been given as milk by animal depends primarily on two factors: 1. The amount of ME surplus to maintenance and, 2. The partial efficiency with which the surplus energy is converted into milk (Basamaeil and Clapperto, 1980). Moe et al. (1972), suggested a range of 45 to 56% efficiency and Blaxter and Wainmann (1966) suggested as low as 31% marginal energy efficiency for milk production.

The economics showed that marginally there was increase in the feed cost in treatment groups but it was profitable under consideration to milk sale. A profit of 247 (US $9), 830 (US $23) and 927 (US $26) Rs/305 days of lactation period was expected on UMMB licks partial supplementation.

In theorization, the results established that concentrate mixture could be partially substituted with UMMB licks in the ration of dairy cow up to 10% although CP content of the ration exceeds 12% and milk yield was ranged from 10-18 kg. Such substitution had no impact on intake, nutrient use and milk production. It was also an economically feasible practice. Indeed urea supplementation in the form of solidified block licks allow animal to ingest urea at different frequencies and augment its efficiency of utilization.

REFERENCES

ARC. 1980 and 1984. The nutrient requirement of livestock, Fomham Royal, common Wealth Agricultural bureau, England.

AOAC. 1984. Official analytical methods, Association of Analytical Chemists, Washington, D.C.

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

Basamaeil, S., and J. L. Clapperton. 1980. The effect of chloro form introduced into the rumen of the lactating goat on the yield and composition of the milk. J. of Dairy Res. 47:51-60.

Belyea, R. L., and M. W. Adams. 1990. Energy and nitrogen utilization of high versus low producing dairy cows. J. Dairy Sci. 73:1023-1030.

Blaxter, K. L., and F. W. Wainmann. 1966. The fasting metabolism of cattle. Brit. J. Nutr. 20:103-108.

Britton, R. A., Colling, D. P. and Klopenstein, T. J. 1978. Effect of complexing sodium bentonite with soybean meal or urea *in vitro* ruminal ammonia release and nitrogen utilization in ruminants. J. Anim. Sci. 46:1738-1747.

Broster, W. H., and J. D. Oldham. 1981. In: Recent developments in ruminant nutrition. (Ed., W. Haresign & D. J. A. Cole), Butterworths, London.

BSI. 1984. Standard methods for foods. Bureau of standards for India, New Delhi, India.

Cowan, R. T., G. W. Reid, J. F. D. Greenhalgh and C. G. A. Tait. 1981. Effects of feeding level in late pregnancy and dietary protein concentration during early lactation on food intake, milk yield, live weight change and nitrogen balance of cows. J. Dairy Res. 48:201-212.

Goering, H. K. and P. J. Vansoest. 1970. Forage fiber analysis (apparatus, reagent, procedures and some applications), Agricultural Research Council, U.S. Department of Agriculture, Handbook no. 379, Washington, D.C.

Huber, J. T. and Limin Kung, Jr. 1981. Protein and non-protein nitrogen utilization in dairy cattle. J. Anim. Sci. 64:1170-1195.

Kunju, P. J. G. 1988. Urea molasses block lick: A future animal feed supplement. Asian-Austra. J. Anim. Sci. 1:233-239.

Moe, P. W., W. P. Flatt and H. F. Tyrrell. 1972. Net energy value of feed for lactation. J. Dairy Sci. 55:945-958.

NRC. 1978. In: Nutrient requirement of Dairy Cattle. 5th edition. National academy of Science, Washington, D.C.

Negi, S. S., B. Singh, and H. P. S. Makkar. 1988. Rumen degradability of nitrogen in typical cultivated grasses and leguminous fodders. Anim. Feed Sci. Tech. 22:77-83.

Neric, S. P., D. L. Aquino, P. C. Dala Cruz and S. K. Ranjhan. 1985. Effect of urea molasses mineral block lick on the performance of cara cows. Indian J. Anim. Nutr. 2:84-88.

Orskov, E. R. 1975. Manipulation of rumen fermentation for maximum food utilization. World Rev. Nutr. Dietet. 22:152-182.

Panse, V. B. and P. V. Sukahtme. 1989. Statistical methods for agriculture workers, Indian Council of Agricultural Research, New Delhi.

Pathak, N. N., D. V. G. Krishnamohan, S. K. Ranjhan, R. C. Katiyar and P. N. Bhat. 1976. Utilization of urea-molasses liqvid diets alonwith limited amounts of intact protein and cereal forage for milk production in crossbred cows. Indian J. Anim. Sci. 46:396-402.

Roffler, R. E. and L. D. Satter. 1975. Relationship between ruminal ammonia and non-protein nitrogen utilization by ruminants. I. Development of model for predicting non-protein utilization by cattle. J. Dairy Sci. 58:1880-1898.

Roffler, R. E., C. G. Schwarb and L. D. Satter. 1976. Relationship between ruminal ammonia and non-protein nitrogen utilization by ruminants. II. Influence of intraruminal urea infusion on ruminal ammonia concentration. J. Dairy Sci. 59:80-84.

Roy, J. H. B., C. G. Balch, E. L. Miller, E. R. Orskov and R. H. Smith. 1977. Proceedings of 2nd International symposium on protein metabolism and nutrition, Flevohof, The Netherlands (Publications, European Association of Animal Production, no. 22).

Rys, R. 1967. In: Urea as a protein supplement. (Ed. Michael H. Briggs), 1st edition, Pregmon press, New York.

Satter, L. D., and R. E. Roffler. 1975. Nitrogen requirement and utilization in dairy cattle. J. of Dairy Sci. 58:1219-1237.

Srinivas Bandla, B. N. Gupta, and G. P. Singh. 1996. Factors affecting textural properties of UMMB licks. Indian J. Anim. Sci. 66:279-284.

Srinivas Bandla, and N. C. Verma. 1996. Substitution of concentrate mixture with UMMB licks for milk production in crossbred cows. Indian J. Dairy Sci. (in press).

Sudana, I. B. and R. A. Leng. 1986. Effects of supplementing a wheat straw based diet with urea or a urea-molasses block and/or cottonseed meal on intake and live weight change of lambs. Anim. Feed Sci. Tech. 16:25-35.

Treacher, J. R., A. J. Stark, and K. A. Collis. 1979. The health and performance of cows fed large anounts of urea. J. Dairy Res. 46:1-14.