DEVELOPMENT OF UREA MOLASSES BLOCK AND ITS FIELD APPLICATION IN INDIA (A REVIEW)

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Summary

The base of Indian milk production is the millions of nondescript cows and buffaloes in rural areas, fed mainly on crop residues and agro-industrial wastes. The mainstay of the feeding system is straws and stovers. Therefore the approach to increase the fibrous residues utilisation for animal production was ideal and useful. The methods available for the above purpose were not found acceptable in rural areas owing to certain practical problems. The development of urea molasses block was, therefore aimed at solving the practical field problems. Urea Molasses Block has been developed as a feed supplement that can bring forth an effect of rumen manipulation thereby increase the conversion rate of feeds. The formula and process technology were thus developed. Before starting the mass production and popularisation the product was tested in controlled condition in farms and also in villages. Encouraged with the results the feed is now commercially manufactured under Indian Patent No. 156047.
(**Key Words:** Urea Molasses Block, Rumen Manipulation, Lactating Buffaloes, Crop Residue Utilisation).

Introduction

The mainstay of the feeding system for ruminants in India is fibrous feeds. These feeds are imbalanced as far as essential nutrients are concerned, poorly palatable and less digestible. Because of these characteristics both intake and utilisation are seen low. The nutritional requirements of ruminants in India are best understood by considering first the need for an efficient rumen fermentation, which may increase the efficiency of low cost feed utilization to increase the productivity of the animal (Leng, 1981). Therefore the manipulation of rumen fermentation is the cardinal point for increasing the utilisation of fibrous feeds.

The need

The ruminant has the unique ability to convert non-edible fibre to human food — milk, fat and meat. However, this conversion of fibre to human food through the ruminant is a rather wasteful process, if allowed to proceed unaided by human manipulation. Talking of milk alone, the cows and buffaloes in India convert annually some 400-500 million tonnes, of crude fibre into some 46 million tonnes of milk. This conversion takes place in nature unaided by human intervention and is therefore in itself an efficient process; though wasteful in the sense that human manipulation of the rumen fermentation system would have resulted in substantially larger outputs from the same amount of fibrous substrates.

We have a known deficit of feed nutrients and limited supply of feed concentrates. National priorities would emphasise land utilization, essentially for food production for several decades to come. When we reach self sufficiency and possible surplus in cereal production the emphasis will shift to production of more pulses, more oil seeds, and so on. Therefore, it is unlikely that the country can afford to devote large area of land for fodder and animal feed production in the fore seeable future.

Nevertheless milk production and production of other animal products must increase to satisfy the basic dietary need of the increasing population, as well as to meet the increasing demands arising from increased individual and national income. The need therefore, exists, for this country, to maximise the utilization of in-edible crop residues, which is increasingly being made available in the wake of the green revolution.

Development of least cost techniques for rumen

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manipulation, for a more efficient utilization of crop residues by the ruminant, for producing more of milk and other animal products thus becomes a matter of national priority.

Technique

The ruminant is designed to forage immense quantities of natural fibre and then to convert it to assimilable nutrients necessary for its various physiological functions. But in nature, levels of efficiency of this conversion is not critical, except that it should meet the animals requirements for life, growth and reproduction.

The crude fibre that ruminants ingest comprises of cellulose, and hemi-cellulose, the substrates for rumen fermentation, bound by indigestible lignin. Therefore, the natural process of rumen fermentation becomes slow and wasteful. The breaking of the cellulose lignin bond by different mechanical processes is economically infeasible and impractical at present. But it is possible to increase the digestibility of the fibre by the colonisation of rumen flora and their healthy survival. Many research studies have shown that this could be possible by supplying adequate levels of nutrients to the ruminant microflora. The nutrients identified for microbial multiplication are soluble nitrogen, soluble carbohydrates, minerals, amino acids, vitamines and energy (in the form of ATP). The feed stuffs identified for this purpose are urea, molasses, minerals, oil cakes and cereals.

The feeding of urea posed several problems because the ammonia released from urea was toxic to animals if the level increased beyond limits in the rumen liquor. Urea utilization could be increased provided soluble carbohydrate is supplied in proportionately increased quantities. Where the objective of the feeding strategy is the production of meat, milk, wool etc. then the crop residue should be converted into microbial protein and volatile fatty acids. To increase this output the supply of urea, molasses, minerals and amino acids in proportion to the increase of crop residues dry matter intake, shall be carefully controlled and fed. Under field this creates logistic, legal and economic problems. Therefore, the biological control on the intake particularly urea was the only solution found feasible.

In a straw based ration the microbial cell synthesis is around 8 g per 1 mole of ATP (Y-ATP 8). This means 1 g microbial protein would be synthesised against ATP availability of 0.07 Mole. Other requirements for biosynthesis include minerals and amino acids. For every 80 g NH_3-N, 20 g amino N and peptides is required for 100 g microbial protein synthesis. The correct requirement for mineral calculations for microbial synthesis is not yet clearly known.

The urea molasses block – the animal lick developed, contains the nutrients in necessary proportion. The requirement of nutrients for 100 g of microbial protein synthesis is given below:

Nutrients	Available from 250 g UMB	Requirement for 100 g microbial protein synthesis (Y ATP 14)
Protein from NH_3-N (g)	107	80
Protein from amino acid and peptides (g)	10	20
Polysaccharide (g)	66	32

Since the nutrients availability from the other feeds is also to be considered the formulation of UMB would supply the required nutrients for increased rumen fermentation, if the animal is allowed to lick the block freely.

The manipulation of rumen fermentation

The main aspects of rumen fermentation are to increase the microbial cell production in rumen. The requirements for that are:

1) Supply enough nitrogen
2) Supply enough ATP
3) Supply enough minerals and monomers.

TABLE 1. STOICHIOMETRY OF RUMEN FERMENTATION

	Mole	MJ	ATP (Mole)
Carbohydrate fermented to			
1) VFA	10	4.48	7.5
2) Microbial cells	5	2.25	3.7
Nitrogen available (g)			14.0
Microbial cells produced (g)			90.0
Y ATP			8.0

The microbial fermentation of straw in the rumen of a bullock weighing 400 kg and consuming 6 kg straw can be worked out stoichiometrically as follows. The digestible organic matter (DOM) will be 2.4 kg or 15 moles of unhydroglucose (CHO).

Rumen ammonia

The primary limiting factor in the above example to produce microbial cells is nitrogen (ammonia). The straw which is deficient in nitrogen fails to supply required levels of ammonia in rumen liquor.

The higher ammonia concentration needed for maximum cell growth suggests that the rumen micro-organisms probably have similar mechanisms for incorporating ammonia to those in soil.

TABLE 2. THE OPTIMUM LEVEL OF NH_3-N LEVEL IN RUMEN SUGGESTED BY DIFFERENT WORKERS

NH_3-N/L Rumen Liquor	Author
150 – 240	Miller, 1973
50 – 80	Satter & Slyter, 1974
195	Mehrez et al., 1977
160	Falmy et al., 1984
210	Dulphy et al., 1984
275	Leibholz & Kallaway, 1980
150 – 200	Leng & Nolan, 1984
200 – 300	Perdock, 1987

ATP generation

The rumen fermentation of CHO generates less ATP. 1 mole of glucose can generate only 4 moles of ATP when fermented in rumen. The ATP generation in rumen on fibrous feeds will be lower than glucose. So also the Y_{ATP} utilization depends on the VFA pattern in rumen. Generally one third of the fermentable organic matter is utilised for microbial cell production and two third for VFA production in rumen (Refer table 3).

Example is for a steer consuming 4 kg FOM (Leng, 1981).

Technology

Based on the above principles a suitable formula was worked out which is given below:

Ingredients	Percent
Molasses	45
Urea	15
Mineral mixture	15
Salt	8
Calcite powder	4
Bentonite	3
Cotton seed meal	10

Chemical analysis	
Moisture	3.0
Soluble nitrogen	6.9
Ether extract	0.5
Crude fibre	1.5
Insoluble ash	2.5
Calcium	6.0
Phosphorous	2.0
Natural protein	4.0

Molasses used for block manufacture should be having 75 percent dry matter with 59 percent total reducing sugars. The bentonite used may be sodium or calcium based. However the grinding

TABLE 3. THE EFFECT OF DIFFERENT EFFICIENCIES OF MICROBIAL GROWTH ON RATIO OF PROTEIN TO VFA ENERGY (P.E) AVAILABLE TO RUMINANTS

Y_{ATP}	Microbial Protein (g/d)	VFA energy (MJ)	Meth(A) energy (MJ)	Heat(B) (MJ)	Total energy loss (A+B)	Energy cost (% Dig. energy)	P.E (g/MJ)
8	498	55.5	9.4	6.4	15.8	22	9
14	798	46.8	8.5	5.1	13.6	19	17
19	1008	46.8	8.0	4.3	12.3	17	24
25	1212	34.9	7.6	3.1	10.7	15	34

fitness should be 0.01 micron urea can be fertilizer or technical grade with 46% nitrogen. The mineral mixture should have 32 percent calcium, 12% phosphorous and all micro nutrients. Mineral mixture, salt and calcite powder should be in fine powder form (0.01 micron size).

Process

In order to get a hard solid block molasses should be heated along with the ingrediants up to 120°C. Heating is done in a specially designed scraped surface heat exchanger. This equipment will have

1) High speed agitator
2) Deaerator
3) Slow speed surface scraper.

The heat is applied indirectly using steam jacketed vessel. One batch of 500 kg material will be processed within 2.5 hours. During the process the moisture content of the mixture will be reduced from 14 percent to 3 percent. The viscosity of the mixture will be brought to 25 degree C. At this stage the hot mixture which is ready for solidification will be filled in specially made moulds and kept for cooling. The blocks will start solidifying at a temperature of 60 degree C. The cooling at room temperature (35 degree C.) will be completed by 3 hours. The cooled blocks will be hard (20 kg/mm^2) which is tested with a penetrometer. Such blocks are wrapped with a plastic cover and brown paper 10 such blocks will be packed in a jute bag.

The blocks thus manufactured can be stored for 6 months in good condition provided that the packing is intact. Even the packing is removed blocks should be fed to cattle/buffaloes. Properly prepared blocks will not liquefy in manger. It may soften maximum one m.m. thickness while exposing to normal atmosphere, 35°C with 40% humidity. Usually this will help in licking by the animals. In India the cost of production will vary from 30 to 40% of the raw material cost for urea molasses blocks when the production units are attached to a feed milling plant.

The animals bio-system also limits the intake as the tendancy to lick deminishes in proportion to increased ammonia content of the rumen liquor. The texture of the block which is hard and solid would exercise some control on the intake. This natural control of block intake by the animal itself, is the break through.

The UMB feed supplement resulted in.

1. Intake of straw dry matter increased.

The intake of dry matter depends on the rate of fermentation and breaking down of particle size of feed fibre and its rate of passage through reticulo ruminal orifice. The natural slow fermentation retains the feed for long period of time in the rumen thus restricting further intake. UMB supplement increase the rumen fermentation and rumen turnover rate, thus increasing the intake of straw dry matter.

The primary limiting factor of dry matter intake for fibrous feed is its digestibility and the rate at which it is broken down to particle sizes that can pass through the reticulo-omasal orifice (Orskov; Preston, 1982). The fine grinding of fibrous feeds would facilitate its passage into the lower tract. However, its digestibility at the lower tract is doubtful. Therefore, it is ideal if the fibrous feeds are fermented in the rumen and broken

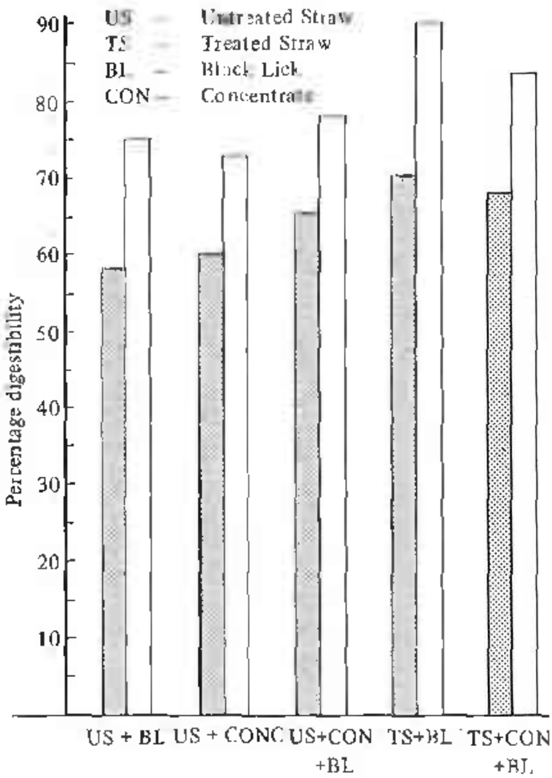

Figure 1. Effect of fibre digestibility and DOM of rice straw with supplementation of block licks.

down to particle size that can facilitate the flow and also facilitate it's digestibility at the lower tract. This way if the rumen turnover rate is increased there is every possibility to increase the dry matter intake of fibrous feeds. The parameter of digestibility and dry matter intake were considered as criteria to establish the effect of block lick supplementation on straw based ration.

The digestibility of dry matter and crude fibre for untreated and ammonia treated straw with block lick supplementation for lactating Surti buffaloes are shown in figure 1. The DDM percentage and crude fibre digestibility for urea treated straw was recorded as 51% and 65% respectively by M Saadullah et al.(1982).When untreated straw supplemented with block lick the figures were 51% and 74%. However, the value for ammonia treated straw with block lick supplementation was 64.95% and 91.33% respectively. Another study by using nylon bag technique has shown that the digestibility of untreated straw is more. The half 't' value calculated was 16.137 hours. In the case of straw dry matter intake and increase of 30 to 50% is noticed in different experiments. The details are given in table 4.

TABLE 4. EFFECT OF BLOCK LICK SUPPLEMENTATION ON STRAW INTAKE IN DIFFERENT ANIMALS

Type of animal	Straw intake kg/day		% Increase
	Without block lick	With block	
Sheep(Avg. 30 kg B.W)	0.540	1.10	103.7
Jersey Bulls (Avg. 300 kg B.W)	4.400	5.70	29.5
Lactating Surti Buffaloes	5.400	6.70	24.0

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2. The digestibility of straw day matter and fibre increased

The digestibility is increased due to increased rate of rumen fermentation by immensely larger population of microflora and mostly increased cellulolytic activity. The digestibility for straw organic matter and crude fibre is around 40% and 60% under the un-manipulated condition. With UMB supplement the digestibility increases to 50% respectively.

3. The requirement of concentrate was minimised

Generally the proteins are degraded in rumen to evolve ammonia for the microbial requirements. The efficiency of microbial synthesis of protein in rumen is very poor. [The 100g amino acid if fermented in rumen, the microbial protein synthesised would be 10 g and the available protein for production would be 5 g.] If the protein is bypassed the available protein would be around 40 g. Therefore if the microbial requirement is made available from the NPN source dietary protein would bypass the ruminal degradation. Therefore, UMB satisfies the microbial requirement and helps bypass dietary protein, thus increasing the available protein from a given quantity of feed. This reduces the concentrate requirement of the animal. The ruminal ammonia level and TVFA level in the rumen liquor are the visible indications. It is calculated that for 100 mg ammonia per L of rumen liquor the level of TVFA should be around 25 m M/L. On the basis that 1 MJ ME is required for 14 g bacterial cells and 1 mole TVFA would provide 2.8 MJ ME. When UMB was fed the level of ammonia was 112 mg to 195 mg/L and TVFA was 48 m M/L to 54 m M/L. This supports the observation that giving the UMB supplements 40% reduction of concentrate feeding could maintain the milk production.

This has been proved by a feeding trial with 24 lactating buffaloes under controlled feeding and observations at NDDB, Anand. The summary results of the trials is shown in table 5. The trial was essentially designed to evaluate economic response. A comparison of group 1 (straw based diet + higher level of concentrate to meet requirement) and group IV (with lick and bypass protein but 40% less concentrates) shows an additional profit of Rs. 2.64 which would be an increase in daily income by about 50%. Group IV consumed 15% more straw than Group I. Though the milk production is not varied significantly because of the computed nutrients fed to all groups, the net income is increased in group IV because of low feed cost. Health and reproduction have been found normal in these animals even on prolonged feeding of a diet supplemented with block but no greens.

After successful completion and evaluation of the product, the test trial was conducted in two villages of Kaira milk shed namely Mogri and Dallapura. The result of the village trials are shown in table 6.

TABLE 5. FARM LEVEL TRIAL WITH ANIMAL LICKS

Group[2]	Balanced cattle feed (kg)	Paddy straw (kg)	Animal lick (kg)	By-pass protein (kg)	Milk production (kg)	Fat yield (kg)	FCM[1] (kg)	Feed cost (Rs.)	Net return (Rs.)
1.	6.18	5.4	–		5.26	0.346	7.38	8.03	5.20
2.	6.23	5.4	0.35	–	4.87	0.408	8.07	8.64	7.67
3.	4.45	6.5	0.57	–	4.68	0.341	6.99	6.72	6.93
4.	3.45	6.7	0.37	0.42	5.33	0.344	7.19	5.94	7.84

[1]FCM – Fat Corrected Milk (4% fat).
[2]Group I – Balanced cattle feed (computed) + Paddy straw ad lib.
Group II – Balanced cattle feed as group I + Animal lick + Paddy straw ad lib.
Group III – Balanced cattle feed 20% less than group I + Animal lick + Paddy straw ad lib.
Group IV – Balanced cattle feed 40% less than group I + Animal lick + Bypass protein (Computed + Paddy straw ad lib).

TABLE 6. VILLAGE TRIALS WITH LACTATING BUFFALOES – SUPPLEMENTED WITH ANIMAL LICKS

Village	No. of milk producers	No. of lactating buffaloes	Average milk yield/day(kg)		Average fat yield/day(kg)		Avg. daily milk price(Rs.)		Net return over feed(Rs.)		Net gain (Rs.)
			Initial	Final	Initial	Final	Initial	Final	Initial	Final	
Mogri	9	9	6.32	6.37	0.458	0.502	17.90	19.58	9.84	12.74	2.90
Dallapura	10	10	4.71	4.82	0.321	0.364	12.52	14.22	5.12	7.36	2.24

Field trials on feeding urea molasses block in lactating buffaloes

After conducting rumen studies, growth trials and lactation trials in buffaloes on feeding urea molasses block under farm condition, various field trials were undertaken in lactating buffaloes. Before distribution of the product, farmers were explained and demonstrated about its use. Different animals were selected at random in various villages. Initial and final milk yield and fat yield were recorded after a preliminary feeding of two weeks. Results of some of these field trials are shown in table 7. Increase in straw intake and fat yield was reported by most of the farmers. On an average, each farmer was benefited by Rs. 2/- to 3/- per day. It was observed under field trials that each block lasted for one week per animal which weighs 3 kg. A special type of dispenser has also been developed for this product to facilitate licking, which could be fixed on the wall of manger at a convenient site for easy access by the animal. Since product is in the form of a hard block and the biological system of the animal helps in regulating the intake, so far, no case of urea toxicity has been reported under farm or field conditions inspite of its wide use in different states. At present, seven commercial plants of 10 MT capacity each have been installed from where this product in well packed in polythene pouches and then in a card board carton to avoid exposure to atmospheric air and moisture are sold out. The product is available in 3 kg size.

TABLE 7. THE OBSERVATIONS ON RESPONSE OF FEEDING BLOCK LICK IN VILLAGES[1]

Sl. No.	Village	Milk (kg/day)		Fat (g/day)	
		Pre lick	With lick	Pre lick	Lick
1.	Alwa	4.8	5.9	330	450
2.	Punadhara	4.0	4.8	270	340
3.	Fulgenamuwada	2.4	3.5	160	280
4.	Hirapura	4.2	5.2	350	480
5.	Bamroli	3.6	4.2	270	380
6.	Dehgam	4.3	4.7	310	350

Source: Kaira District Co-op. Milk Producers' Union Ltd., Anand, India.

Purchase of urea molasses block by farmers

The purchase of UMB by different agencies during February 1985 to January 1988 is summarised in table 8.

TABLE 8. STATEMENT OF UMB SALE IN INDIA

Months	No. of blocks sold		
	1985-86	1986-87	1987-88
February-April	20,040	42,900	2,700
May-July	22,250	12,350	200
August-October	33,130	5,260	28,090
November-January	4,650	1,200	81,900
Total	80,070	61,710	112,890
	(240.21MT)	(185.13MT)	(338.67MT)

Impact

The most vital impact of UMB animal lick is its spectacular effect on reducing the feed cost for milk production. In India dairying as an industry took a gaint leap forward in the seventies and brought in its wake new problems. The industry under the cooperative ampit strived to distribute milk at a reasonable price to enable every Indian to drink milk. However, the escalation of feed cost posed fresh threat to the industry. The advent of Urea Molasses Block Animal Lick could certainly reduce the feed cost. Indications are that a rural milk producer could save around Rs. 2.50 per animal per day in feed costs without affecting the health of the animal or the level of production.

The low producing Indian animals would no longer need to depend on scarse concentrate feeding for expressing their low genetic potential. This reduces the pressure on the available concentrates and thus permits a differential feeding system for the high producing animals.

The total availability of land mass for fodder cultivation in India would be around 7 million hectares. This leaves only bare minimum of green fodder for the large livestock population. Nevertheless 46 million tonnes of milk is produced annually from 400 to 500 million tonnes of dry fodder including crop residues. Indications are that the availability of this material may go up further 50 percent in relation to the increased crop production in the country.

This may result in:

1. Feeding crop residue to low producing animals and convert into human food.
2. Production of more milk at low cost.
3. Diversion of land for oilseeds and pulses production.

Therefore we are left with no other alternative than to depend on crop residues feeding for milk production. If this mountain heaps of crop residues are not utilised it may cause ecological problems. The diversion of land for forage and feed production as it is in west, would befall adisaster to our economical and ecological system.

Urea molasses block is a recourse to this situation. It would not only increase the utilization of crop residues and productivity of low producers but also spares good quality fodder and feeds for high producing animals.

In view of the above facts the invention of Urea Molasses Block the animal lick is considered to be a break through in the ruminant nutrition and a real boon to the rural milk producers.

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