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paper

FEED SUPPLEMENTATION BLOCKS

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Urea-molasses multinutrient blocks: simple and effective feed supplement technology for ruminant agriculture

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FOREWORD

In facing ever more limited resources and changing market conditions and in the attempt to enhance productivity for strengthening livelihoods, many technologies have been used to improve feed use and animal performance at the farm level. A particularly successful example, in terms of both geographic range of use and relative simplicity in formulation and preparation, is the urea-molasses multi-nutrient block technology.

The Animal Production and Health Division of FAO and the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture have actively promoted this block technology over the last two decades in a large number of countries. From the technical and scientific points of view, the block technology works reliably in improving livestock productivity. However, economic viability and practical and commercial sustainability depend on many factors, including prices and availability of main ingredients, entrepreneurial initiative, transport costs, investment capital, operational cash flow.

This book summarizes a wide range of experiences with the use of the block technology in countries around the world. The contribution from some countries could not be included due to the lack of reliable information sources. The book constitutes the most comprehensive source of information on this technology. This compilation of experiences provides ample evidence that the block technology has contributed significantly to enhancing animal productivity at the field level, and has generated considerable additional income for farmers.

The blocks have been used mainly to supply nitrogen to improve rumen function, but have also been the means of delivering other nutrients, minerals or therapeutic substances to improve animal performance. There are certainly also other supplemental compounds that could be delivered using this lick block technology.

We hope that this publication will help students, researchers, extension and development workers and farmers to better understand the block technology with respect to its potential and limitations, and to consider it as an option in improving animal productivity and farmers' incomes.

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Contents

LIST OF Abbreviations AND ACRONYMS

ACIAR	Australian Centre for International Agricultural Research
ADF	acid-detergent fibre
BCS	body condition score
BW	body weight
CF	crude fibre
CP	crude protein
CP	crude protein
CRD	continuous release device
DM	dry matter
DMI	dry matter intake
DOMI	digestible organic matter intake
FAO	Food and Agriculture Organization of the United Nations
FBZ	fenbendazole
IAEA	International Atomic Energy Agency
LWG	liveweight gain
MCC	Milk Collection Centre
MUMMB	medicated urea-molasses mineral block
NDF	neutral-detergent fibre
NE	net energy
NFE	nitrogen-free extract
NPN	non-protein nitrogen
OM	organic matter
OPF	oil-palm fronds
ppm	parts per million
TVFA	total volatile fatty acid
UMB	molasses-urea block
UMMB	urea-molasses mineral block
VFA	volatile fatty acid

Feed supplementation block technology – past, present and future

Harinder P.S. Makkar[1]

Introduction

Livestock production in developing countries is largely dependent on fibrous feeds – mainly crop residues and low quality pasture – that are deficient in nitrogen, minerals and vitamins. As protein supplements such as oil cakes are only availability at a very high price in developing countries, if available at all, this has led to the use of non-protein-nitrogen sources, such as urea, to compensate for the nitrogen deficiency in fibrous feeds, thus enhancing their digestibility, intake and nutrient availability through optimization of rumen fermentation. The use of solid feed supplementation blocks, i.e. urea-molasses blocks or multinutrient blocks, to provide the nitrogen, minerals and vitamins lacking in fibrous feeds offers several advantages: ease of transport, storage and use, and reduced risks compared with other approaches, such as giving a small amount of urea in drinking water, sprinkling of urea solution on fibrous feeds before feeding, or urea-ammonization of crop residues. These advantages, together with enhanced productivity in terms of increased milk and meat production and higher reproductive efficiency in ruminant animal species, that include cattle, buffalo, sheep, goats and yak, as a result of supplementation with the blocks have resulted in their adoption in over 60 countries. Many international organizations, including the Joint FAO/IAEA Division (Vienna), FAO, UNDP, ACIAR and SAREC-SIDA, have played important roles in dissemination of this technology to such a large number of countries. This chapter presents a synthesis of the information presented in this book by different groups. Further information can be obtained from the individual chapters.

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Past and present

Block development and the technology transfer phases

Although the first systematic trial on the use of blocks appears to have been conducted in South Africa in 1960 (Sansoucy and Hassoun, 2003), the use of blocks has been recorded from as early as the 1930s (Ben Salem, Nefzaoui and Makkar, this volume). During the early periods, the blocks included only urea and salts. Later, addition of molasses and minerals occurred. Till the 1970s, the blocks were produced mostly by feed manufacturing companies, were expensive, and their use in developing countries was negligible. In the early 1980s, with the realization of the significance of the blocks for smallholders in developing countries, work on simplification of the block production technology gained momentum through the efforts of the Joint FAO/IAEA Division, Professor Leng from Armidale University, Australia, and the National Dairy Development Board, Gujarat, India. The Joint FAO/IAEA Division, FAO and UNDP promoted block technology in many Asian, African and Latin American countries. During the initial phase, up to the mid-1980s, the "hot process" of block production was promoted, despite the high cost of the heating process. In 1986, the FAO Feed Resources Group modified the process to one that did not require heating of the ingredients, and this became known as the "cold process". The cold process used solidifying agents such as calcium and magnesium oxide, calcium hydroxide, di-ammonium phosphate, cement or bentonite. Although the cold process was available, the use of the hot process continued into the mid-1990s in India. However, use of the hot process could not be sustained because of increasing energy costs, and interest in block technology diminished. In the late 1990s, with the promotion of the cold process through FAO/IAEA Regional Technical Cooperation (TC) Projects RAF/5/041, RAS/5/030 and RAS/5/035, the use of the block technology picked up in many Asian and African countries. Pakistan was another country that started with the hot process and then shifted to the cold process for block production.

Manufacturing process and method of offering the blocks

Urea levels in typical urea-molasses multinutrient blocks (UMMBs) vary from 4 to 10 percent, and those of molasses and the binder vary from 30 to 45 percent and 6 to 15 percent, respectively. The manufacturing process differs substantially from country to country, depending on the scale of operation. To mix the ingredients, various approaches have been used, ranging from use of a shovel or even bare hands, to mechanical mixing using a dough mixer or concrete mixer. Similarly, moulds made up from metal, wood, cardboard and plastic, with square, rectangular or cylindroid shape, have been used, and in some countries, car and truck tyres and buckets have been used to give shape to the blocks. Depending on the composition of the blocks, in particularly the concentration of the binder, blocks have been hardened without or with the use of pressure. If used, pressure is generally applied either by foot by standing on the moulds, or through mechanical devices such as a car jack, screw-driven press or lever. Electrical, steam or diesel motors have also been used in countries such as Viet Nam, Malaysia and Mongolia to compress the blocks.

To avoid losses due to rats, birds, insects and fungal growth in high humidity areas, polyethylene packing has been the most used method when it is necessary to store blocks for a long period. In most countries, when the farmers have to buy the blocks, a smooth surface and good quality packing are preferred.

The blocks have been offered to animals in a wooden box or bucket of dimensions slightly larger than that of the block, which restricts biting of the block by animals. The hanging of blocks in front of the animal using a wire passing through the centre of the block has been another approach. In Venezuela, blocks weighing as large as 25 kg have been offered to animals in rangelands. These blocks are kept under shade and near the water source. The daily consumption of UMMBs per animal varies: 500 to 800 g for cattle and buffaloes, 60 to 125 g for sheep and goats, and 400 to 600 g for yak.

The block should be hard enough to ensure that the animal gets a slow release of nutrients through the licking process. This slow release of nutrients, particularly of nitrogen and carbohydrates, increases the efficiency of utilization of these nutrients. However, in Indonesia, a variation to produce soft blocks has also been found to be popular and effective in increasing milk production. The soft block, weighing about 500 g, is broken into two or three pieces and given to cattle at different times of the day. Soft blocks have also been used in China by some workers (Liu, Long and Zhang, this volume).

Benefits of block supplementation

The use of the blocks as a supplement has resulted in economic benefits to the farmers (Table.1). Block supplementation with crop-residue-based diets has resulted in increased milk production, with a favourable cost–benefit ratio, varying from 1:2 to 1:5, depending on the purchase price of ingredients and selling price of milk. Invariably, an increase in milk fat content by 0.2 to 0.8 percentage units on feeding the blocks also brought a higher price for the milk. Increase in lactation length has also been observed. Decreases in inter-calving days and in the age at first calving are additional beneficial effects of feeding the blocks. Feeding of crop residues with UMMBs can sustain a milk yield of up to 4 or 5 litres per day in cattle. For high production animals, blocks containing 'rumen undegradable protein' sources ("by-pass" protein sources), such as fishmeal, cottonseed meal, etc., have been developed and used in India, Venezuela and Pakistan.

In some situations, supplementation of the blocks has allowed a reduction of up to 50 percent in green fodder or a substantial reduction in concentrate mixture (as up to 30 percent of total crude protein requirement can come from the blocks) without sacrificing milk yield or liveweight gain, giving additional benefit to farmers through reduced input costs (Table 1).

Uptake of the block technology has been easier and faster for dairy cattle compared with beef cattle because of an immediate increase in milk yield from the third or fourth day of feeding the blocks, giving additional profit to the farmers. An increase in milk yield of the order of 1 to 1.5 litre per day on giving about 500 g of block has been recorded. Factors such as animal species and basal diet influence the beneficial effects of feeding the blocks. In general, the effects are most pronounced in cattle, then buffalo, yak and sheep (in that order), and least in goats. The greater ability of goats to browse different trees and browses containing leaves with high protein content could be responsible for the apparent lower efficiency of nitrogen utilization from blocks in this species. Similarly, supplementation of the blocks with diets of good composition has also resulted in poor response in cattle, buffalo and sheep. In such a situation, an attractive option is to decrease the costs of inputs by replacing concentrate mixture or green fodder with the block, and getting the same milk yield. This approach has been used in practical situations in countries such as Bangladesh, India, Indonesia and Sri Lanka for animals of medium milk yield. Maximum gains from supplementing with UMMBs are achieved during the dry period in tropical countries, when the farmers have nothing except crop residues and poor quality grasses and weeds.

Substantial enhancement of reproductive performance has been obtained in buffaloes following pre- and postpartum block supplementation. In most countries, the extension of the block technology to farmers has been through demonstration of increased milk yield, or better body weight gain and hence greater meat production. However, in India for buffaloes, the adoption of the block technology was through demonstration of the impact on reproductive performance, with a spillover effect being enhanced milk yield. This was due to widespread reproductive problems in buffaloes in the region, attributed to poor nutrition, that the farmers wished to overcome through an appropriate, low cost and simple technology (Brar and Nanda, this volume).

Use of blocks in emergency situations

In the recent past, a unique role for UMMBs as a supplement to the basal diet during the severe winter periods in Mongolia and upland regions of China has emerged. This has decreased the number of deaths in cattle and yak. The blocks have also prevented deaths during the drought periods and after floods in countries that have included India, the Sudan and Zimbabwe. During drought periods, only crop residues and other highly lignified fibrous materials are available for feed. Through blocks, the supply of nitrogen, minerals and vitamins to rumen microbes enhances the availability of energy supply to the animal from fibrous materials. The simplicity of the method of block production and compact nature of the blocks, and hence their fast production and ease in transport from non-emergency to emergency situations, are some of the advantages of this technology in disaster situations.

Block variants

The development and use of blocks has been a very popular area of research amongst animal nutritionists. Thousands of research and popular articles and books have been written on the subject, and interesting developments are still taking place in this field.

In the recent past, some variations in the blocks have been the incorporation of polyethylene glycol (PEG) as a tannin-inactivating agent, which has increased the utilization of tannin-rich browses and trees (Ben Salem, Nefzaoui and Makkar, this volume). For enhancing the utilization of tannin-rich tree leaves and by-products, the inclusion of high level of urea in the PEG-containing blocks is not necessary, because PEG dissociates the tannin-protein complex and enhances nitrogen availability to animals.

Medicated blocks containing anthelmintic agents such as fenbendazole (0.5 g/kg block; intake of 60 g/day for sheep), nematophagous fungi (*Duddingtonia flagrans* and *Arthrobototrys oligospora*) and tannins to control internal parasites (Wan Zahari *et al.*, this volume; Knox, this volume) have also been used in Malaysia and Australia.

Phosphorus-containing blocks to overcome the deficiency of phosphorus in savannahs in Venezuela (Herrera *et al.*, this volume), and copper- or zinc-containing blocks to mitigate their deficiency and improve reproduction in cattle, ewes and rams have also been developed (Liu, Long and Zhang, this volume; Ben Salem, Nefzaoui and Makkar, this volume). Nitrogen supplementation in the blocks through incorporation of tree leaves has lead to enhanced productivity, mainly through provision of minerals and maintenance of the nitrogen level in the rumen over a prolonged period. Unconventional by-products, such as olive cake (Ben Salem, Nefzaoui and Makkar, this volume), kenaf (*Hibiscus cannabinus*) (Wan Zahari *et al.*, this volume), *Vigna unguiculata* beans, cassava (*Manihot esculenta*) powder, *Cassia moschata* fruits, *Albizia saman* and *Gliricidia sepium* leaves (Herrrera *et al.*, this volume) have also been incorporated in place of conventional by-products. This has enlarged the prospect of strategic incorporation of local resources in the blocks. Replacement of molasses in the blocks by wasted mulberry fruits, thereby decreasing the cost of the blocks, has also been an interesting development in the recent past. In the northern mountainous belt of Pakistan, drying of mulberry fruit for human consumption is a centuries-old practice. The harvesting period of these fruits is just two months, July and August, during which it is not possible to collect all the mulberry fruits, and more than a third of both the fresh and sun-dried fruits go to waste (Habib, this volume). In some parts of China, Indonesia and Tunisia, blocks have also been prepared and used without molasses, because molasses was not available or was expensive. Wheat flour was used in place of molasses, and preparation of blocks containing wheat flour required the use of pressure to make the blocks, and in addition greater proportion of water was needed to make blocks of the right hardness and to avoid cracking during storage and transport.

Future research and development

Although research on urea-molasses blocks has a long history, considerable additional research is still needed in order to fully exploit the benefits of incorporating various nutrients, minerals, additives and drugs in the blocks.

Formulation of blocks based on low cost and locally available feed resources that do not compete with human food should be one of the thrust areas for future work. Some regions are deficient in specific minerals. These regions should be properly mapped and blocks tailored to meet the requirements for specific minerals.

Plant secondary metabolites, at high levels of intake, can produce adverse effects on livestock. The polyethylene glycol (PEG)-containing blocks for enhancing the efficiency of utilization of tanniniferous tree leaves, shrubs and some agro-industrial by-products have been developed, tested and found beneficial. There is a need to develop a model based on the activity of tannins in the diet and their intake so as to be able to determine the optimal level of PEG in a block to realize high benefits at low costs.

The use of bentonite has been suggested as a binding agent that reduces protozoal loads and decreases aflatoxins, alkaloids and fungal toxins (R. Leng, *pers. comm.*). There is a need to study the mechanism of action of this binder and those of other agents such as clay, charcoal, resins, etc., in decreasing antinutritional and toxic factors likely to be present in unconventional feeds.

Fenbendazole-containing blocks have been found to be highly successful in controlling nematodes. Their strategic use before or during, or both, the peak periods of infestation should be widely advocated and promoted. Commercial anthelmintic preparations are expensive. The strategic use of medicated blocks, in addition to enhancing the effectiveness of the drug, decreases the cost of controlling the parasites and works against drug resistance. In many developing countries, herbal drugs are widely used for controlling internal parasites and some of them have been found to be highly effective. These are widely available at a price much lower than synthetic drugs such as fenbendazole or its derivatives, mebendazole, albendazole, etc. In addition, herbal drugs are more eco-friendly. Some work on the use of blocks as a carrier for herbal digestive stimulants, herbal galactagouges, herbal ecbolics (e.g. Replanta, a polyherbal drug) has been initiated in India, with good results (P.S. Brar and A.S. Nanda, *pers. comm.*). Systematic studies on the incorporation of herbal drugs or additives in the blocks and their evaluation for effectiveness and cost–benefit are needed. Fresh neem and dried pineapple leaves are also promising anthelmintic agents. Under an IAEA Regional Asia Project (RAS/5/035), technically supported by the Joint FAO/IAEA Division, emphasis has been placed on the development and use of herbal-based blocks for controlling helminth parasitism and enhancing rumen fermentation. Similarly, additives such as saponin-containing plants could also be added to blocks to decrease protozoal number in the rumen, thus enhancing the efficiency of rumen microbial metabolism and microbial protein supply post-ruminally.

The development and use of the blocks as a carrier of various additives, drugs, natural plant products, etc., should be conducted through participatory research by involving all stakeholders, and in particularly the farmers. The participatory research will enhance the success rate for adoption of a technology since the technology developed through this approach is more relevant and appropriate.

Although the urea-molasses multinutrient technology is well developed and in use in a large number of countries, there is a need to disseminate this technology more widely through the involvement of NGOs, local government extension departments, and veterinarians. In some situations, the involvement of the private sector could play a vital role in making the technology sustainable, and their role should be recognized by the government sector and universities. Sugar mills producing molasses as a by-product could produce a value-added product by manufacturing the UMMBs. However, a quality control system must be put in place so that blocks of sub-standard quality are not sold to farmers. Farmer associations and cooperatives could also have a pivotal role in sustaining the technology through the setting up of revolving funds.

It is well established that the benefit of using UMMBs is through enhancing the efficiency of rumen fermentation, which increases the digestibility and intake of forages, leading to greater supply of microbial protein for production purposes. There is another dimension to supplementing poor quality forage-based diets with the blocks, and that is lower emission of methane per unit of forage digested or per unit of meat or milk produced when supplementing with the blocks, because of better rumen fermentation. However, quantitative data on methane emission and microbial protein supply post-ruminally with use of these blocks are not available. Research on generation of this data is also suggested.

References

References quoted in this section are all from this book.

Table 1
Responses and cost–benefit ratios of use of feed supplementation blocks for different animal species

Animal species and type	Remarks on productivity responses and cost–benefit ratio	Reference
Urea-molasses multinutrient blocks (UMMB) supplementation		
Crossbred cows	– No change in liveweight gains on replacing concentrate mixture with UMMB up to 30% of total crude protein requirement, thereby reducing feed cost	Garg, Sanyal and Bhanderi, this volume
Jersey and their crosses	– No change in milk production and loss of body weight at 50% reduction of green fodder dry matter with UMMB, thereby reducing cost of the feed and increasing net return of Rs 2.42/day/animal	Garg, Sanyal and Bhanderi, this volume
Buffaloes and cows (field study in 6 villages)	– Increase in milk yield and fat content of milk, improvement in general health, and an extra profit of Rs 2 to 3/day/ animal	Garg, Sanyal and Bhanderi, this volume
Cows	– Increase in milk yield by 1.1 to 1.5 litre/day/animal – Increase in conception rate by 12.2%, decrease in occurrence of diseases by 22.5% – Improvement in body condition, income increase of ¥736/year/animal	Liu, Long and Zhang, this volume
Yak	– Prevention of weight loss of yak cows during hard times in severe winter – Increase in milk yield by 0.21 litre/day/animal – Improvement in reproductive performance, with 8.8% and 30.9% increase in pregnancy rate and newborn weight respectively – Cost:benefit ratio of 1:1.4–1.8	Liu, Long and Zhang, this volume
Cows	– Increased milk yield, lower rate of decline in milk yield in UMMB supplemented animals, additional profit of Baht 4.5/day/animal estimated, taking into account cost of the feed and sale price of milk. – Conception at first service improved by 15.3%, significant decline in services per conception, reduction from 8.6 to 3.2% in culling rate due to infertility, reduction in calving-to-conception interval from 127.2 to 92.4 days, reduction in calving to first service interval from 77.5 to 65.9 days, reduction in calving interval from 405.4 to 365.1 days, increase in conception rate at 120 days from 62.6 to 76.7%	Wongnen, this volume

Animal species and type	Remarks on productivity responses and cost–benefit ratio	Reference
Cows	– Increase in milk yield by 1.5 litre/day/animal and in fat content by 0.1% unit – Decrease in interval between calving and onset of ovarian activity and first oestrus by 18 and 25 days respectively, decrease in calving to conception by 31 days and in calving interval by 30 days, increase in conception rate at first service by 10% to 70%.	Vu, this volume
Cows and buffaloes	– Increase in milk yield by 1.6 litre/day in cows and by 0.4 to 0.8 litre/day in buffaloes – Ovarian activity started 88–102 days after parturition in the supplemented animals compared with 138–172 days without supplementation, resulting in shorter calving interval	Habib, this volume
Goats	– Weight gain increased by 11.3 g/day – Active grazing and higher consumption of water noticed	Habib, this volume
Cows	– Milk yield increased by 20 to 32% – No abnormalities in internal organs	Khidir, this volume
Indigenous cows	– Milk production increased by 0.4 litre/day/animal, better body condition score, parturition to first calving interval 64 days less, and intercalving interval reduced by 37 days	Khan et al., this volume
Crossbred cows	– Milk yield increased by 1–1.5 litre/day/animal and longer lactation period – Increase in reproductive efficiency (reduction in calving interval by 64 days), leading to an extra calf produced and an additional lactation from a 10-year reproductive life – Cost–benefit ratio of 1:3 based on cost of the feed and selling price of milk	Khan et al., this volume
Heifers (indigenous)	– Increase in live weight by 4.8% after calving, earlier initiation of ovarian cyclicity	Khan et al., this volume
Buffaloes	– Daily rice straw dry matter intake increased from 1.3 to 2.9 as a percentage of body weight (an increase of 110%); generally, intake of UMMB is lower in buffaloes than cattle, which may be due to better recycling efficiency of nitrogen of the former – Increase in growth rate by 143 g/d, better body condition score – Increase in milk yield by 11%, increase in lactation length and overall 18% higher milk production – Reduction in daily supplementary feed cost of 77% by replacing concentrate with UMMB without decrease in milk yield	Perera, Perera and Abeygunawardane, this volume

Animal species and type	Remarks on productivity responses and cost–benefit ratio	Reference
Crossbred cows	– Reduction in period between parturition to first oestrus from 120 to 90 days, reduction in number of inseminations per conception and improvement in rate of conception, increase in milk yield by 12% and in fat content of milk by 0.8% units, improvement in fat content gave an additional profit of Rs 2 per litre, daily economic gain of Rs 8 per cow due to increase in milk yield – Reduction in cost of supplementary feeding of 100% for animals yielding up to 5 litre milk/day, and of 45 to 60% for animals yielding between 5 and 10 litre/day	Perera, Perera and Abeygunawardane, this volume
Sahiwal cows	– Increase in growth rate by 166 g/day, better body condition score – Overall cost–benefit ratio of 1:3.5	Perera, Perera and Abeygunawardane, this volume
Crossbred cows	– Increase in milk production by 1.3 litre/day/animal and in fat content of milk by 0.8% units, reduction in calving interval by 60 days, higher body weight of suckling calves and of cows – Cost–benefit ratio taking into consideration cost of the feed, which was lower on replacing concentrate with UMMB, increase in milk yield, and increase in weight of calves and cows was 1:5. This was higher than 1:3.5 observed for the concentrate-fed group	Khan et al., this volume
Buffaloes	Pre-partum UMMB supplementation: – Silent heat in lower proportion of animals (11 vs 75%) and fewer days taken to first ovulatory heat (34 vs 48 days) – Higher conception rate in first 70 days postpartum (30 vs 0%) – Higher percentage of fertile oestrus within 60 days postpartum (70 vs 14%) Postpartum UMMB supplementation: – Lower average percent body weight loss (0.02–3% vs 0.53–3.9%) – Animals started gaining weight earlier (5th vs 7th week postpartum) – Higher percent of animals displayed oestrus within 50 days postpartum (71 vs 14%) – 88 kg more milk per head during first 60 days, 8% increase in milk yield postpartum and 0.5 percent unit increase in milk fat – Longer duration of peak milk yield (4 vs 2 weeks)	Brar and Nanda, this volume

Animal species and type	Remarks on productivity responses and cost–benefit ratio	Reference
Buffaloes (true deep anoestrus)	– Higher percent of animals came into heat and conceived within one month (90 vs 28%) in spring season of higher feed availability – Higher percent of animals came into heat and conceived within one month (40 vs 10%) on UMMB supplementation for 30 days and another 30 days of the supplementation induced behavioural oestrus in 85% animals with 100% first service conception, in dry season of lower feed availability – Greater response to equine chorionic gonadotrophin treatment in terms of behavioural and ovulatory responses	Brar and Nanda, this volume
Buffaloes	– Blood urea, plasma protein, insulin and creatinine within physiological range, blood glucose did not differ between the supplemented and unsupplemented groups – Based on milk production alone, cost–benefit ratio varied from 1:2.3 to 1:4	Brar and Nanda, this volume
UMMB containing fenbendazole (FBZ) – anti-nematode block supplementation		
Cows	– Higher decrease in percentage of animals infested by parasites compared to UMMB without FBZ – Increase in body weight gain of about 7 litre/month/animal with UMMB containing FBZ compared to 3 litre/month/animal with UMMB fed animals	Vu, this volume
Heifers (crosses)	– Zero faecal egg count and no reinfection of nematodes, higher packed cell volume	Wongnen, this volume
Buffaloes	– One litre more milk/day/animal with UMMB and an additional 0.5 to 0.57 litre milk/day/animal with UMMB containing FBZ – improvement in health and hair coat	Garg, Sanyal and Bhanderi, this volume
Sheep (on station)	– Reduction in faecal egg count by 84 to 90%	Wan Zahari *et al.* this volume
Sheep (grazing)	– No significant difference in faecal egg count and in average daily body gain between animals fed UMMB with and without FBZ, presumably due to higher challenge to infection and lower intake of medicated blocks compared to penned animals on-station – Lower faecal egg counts in medicated block animals when existing worm burden was removed using a single injection of ivermectin, but no change in average daily weight gain	Wan Zahari *et al.* this volume
Calves	– Worm-free calves experimentally infected with 10 000 infective *Haemonchus* spp. larvae. After four days of giving medicated blocks, egg counts declined to zero while the UMMB-only group had 400 eggs per gram – At slaughter after 46 days, no adult worms or larvae in the group with medicated blocks; medicated block also prevented infection from daily parasite challenge	Knox, this volume

Animal species and type	Remarks on productivity responses and cost–benefit ratio	Reference
Heifers	– Zero faecal egg counts and 18% increase in body weight gain over 5-month period	Knox, this volume
Buffalo	– Zero faecal egg counts, increase in milk yield by 1.2 litre/day compared to the group fed only UMMB	Knox, this volume
Cross bred cattle	– Zero faecal egg counts, increase in milk yield by 0.6 litre/day compared to the group fed only UMMB	Knox, this volume
Buffalo and Cattle (large scale field trial)	– Lower faecal egg counts, better health, 5% improvement in milk yield compared to group given UMMB alone	Knox, this volume
UMMB containing pineapple leaves (150 g/kg) – anti-nematode block supplementation		
Heifers	– Significant decrease in faecal egg counts, levamisole injection and UMMB containing pineapple leaves were equally effective in controlling nematodes	Vu, this volume
UMMB containing triclabendazole –anti-fluke block supplementation [to give a daily dose of 0.5 mg and 1.5 mg /kg body weight for cattle and buffalo respectively]		
Buffaloes and cows	– Efficacy proven against experimental bovine and bubaline fasciolosis	Garg, Sanyal and Bhanderi, this volume
Blocks containing mulberry fruits (in place of molasses) supplementation		
Cows	– Increase in milk yield by 0.4 to 0.8 litre/day/ animal, improvement in health of animals and in fertility	Habib, this volume
Blocks containing polyethylene glycol		
Sheep	– For diet based on *Acacia cyanophylla* leaf, increase in organic matter and crude protein digestibilities by 10 and 22 percentiles, respectively, positive nitrogen retention of 2.5 g/day, increase in microbial nitrogen production of 6.6 g/kg digestible organic matter intake and 47 g/day increase in daily weight gain – Increase in meat redness, decrease in tenderness and increase in intensity of flavour, but no overall change in meat acceptability	Ben Salem, Nefzaoui and Makkar, this volume
UMMB containing phosphorus		
Heifers (grazing) in well-drained savannahs where phosphorus deficiency is common	– Improvement in weight gain, mating at a lower age and first calving 300 days earlier than the unsupplemented animals – Ovarian activity increased from 17 to 45%	Herrera *et al.*, this volume
Dual-purpose cows	– No significant increase in milk yield	Herrera *et al.*, this volume

For additional information on cost–benefit analyses of use of block technology, see:

– Asian countries, refer to http://www.iaea.org/programmes/nafa/d3/mtc/ras035-report.pdf; and

– African countries, refer to http://www.iaea.org/programmes/nafa/d3/mtc/cairo-nov2000.pdf

The block story

René Sansoucy[2] and Philippe Hassoun[3]

The problem

In most developing countries, particularly in tropical regions, the basal diet of ruminants, particularly large ruminants, consists of fibrous feeds, mainly from mature pastures (particularly at the end of the dry season) and crop residues (e.g. wheat and rice straw, maize and maize stover, sugar cane tops and trash). These roughages are unbalanced in terms of nitrogen (N), mineral and vitamin content, and they are also highly lignified. Consequently, their dry matter (DM) digestibility is reduced. These characteristics keep voluntary dry matter intake (DMI) and productivity low, and consequently the quantity of animal products (meat, milk, draught power, wool) is limited or nil. Animals may sometimes barely survive, or even die during, times of feed scarcity.

To remedy this situation it is necessary to supply the rumen microbes with the elements (mainly soluble N) that are deficient in the diet. One problem is that protein supplements (such as oil cakes) are in many cases not available in the country, are exported in order to get foreign exchange or are too expensive for the small-scale farmer to buy. The same occurs with mineral and vitamin supplements.

The availability of fodder trees, particularly legumes, with leaves rich in good quality protein, which could be a cheap and suitable solution, is insufficient to cover needs (Speedy and Pugliese, 1992). Planting and growing such trees is a long-term objective, and should be encouraged wherever possible.

A shorter-term solution is to provide supplements containing N, essential minerals and vitamins as part of the diet. One of the cheapest sources of non-protein N is urea. As a common fertilizer, it is widely available at reasonable prices in most countries around the world. Beames (1963) showed that cattle could survive for a long time on low quality roughage with only urea and molasses supplements.

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The principles for improving the efficiency of the diet of ruminants

Classical principles based on "feeding standards" – such as those used with controlled diets based on "good quality" feeds – are of little help in these situations. Preston and Leng (1987) and Preston (1995) proposed that the ruminant animal be considered to comprise two subsystems:

- the rumen; and
- the animal itself.

First, it is essential to take advantage of the rumen's ability to make use of fibrous feeds and of non-protein N (both inexpensive nutrient sources that are not usable by monogastric animals, including humans). For this to succeed, it is necessary to feed the rumen microbes in order to develop an efficient ruminal ecosystem, ensure efficient fermentation of fibre and increase the production of microbial protein. There are two basic requirements.

- The first requirement to satisfy is that of ammonia supply, which can be supplied from non-protein N (usually urea).
- The second requirement is for minerals (sodium, phosphorus, sulphur) and vitamins.

Thus, provided that the animal receives sufficient fibrous feeds, the diet will allow survival or may even cover maintenance requirements. However, if some production (growth, pregnancy, meat, milk or wool) is expected, supplementary 'bypass' protein and energy will be necessary in addition to the products of fermentative digestion.

Why the blocks?

Urea is a good and cheap source of N for ruminants. However, if eaten in excess, it could be very toxic, rapidly causing death. In order to supply urea in a safe way, several methods have been tried.

Ranchers in Australia, South Africa and elsewhere have for decades successfully used molasses-urea liquid mixtures given in troughs (Beames, 1963). However, there are several constraints to be overcome in using liquid molasses at farm level: transport, requiring expensive tanker-trucks; storage in fixed tanks; difficult handling of a highly viscous liquid; and distribution needing troughs or other receptacles (Sansoucy, 1986). Mixing urea with drinking water is another solution, but it is difficult and dangerous under small-scale farm conditions.

Other techniques have been tried in order to solve the above problems, in particular by "solidifying" the molasses. The solid form presents many advantages, as it makes transport, storage and distribution easy, and reduces risks.

The development of urea-molasses blocks

The first trials of providing urea through feed supplementation blocks were done in South Africa by Altona *et al.* (1960), cited by Beames (1963). The block, which included common salt and urea, gave satisfactory results. Later on, other experiments using molasses, urea and salt confirmed these results (Beames, 1963; Beames and Morris, 1965; Alexander, 1972). Feed manufacturing companies also developed urea-molasses blocks, but the blocks made by industrial processes were relatively expensive and not affordable to those who needed this product the most: the small-scale farmers in developing countries.

In the early 1980s, the work of Professor Leng from Armidale University in Australia, in cooperation with the Joint FAO/IAEA Division (Vienna) and the National Dairy Development Board (NDDB) (India), renewed interest in this technology, particularly in developing countries (Leng, 1984, 1986; Kunju, 1986).

It appeared that the technology could be extremely useful for Sahelian countries with sugar industries suffering from severe droughts, such as Senegal. Unfortunately, the manufacture of urea-molasses blocks as studied in Australia used a "hot process," which required the pre-heating of the molasses. The procedure needed heavy and expensive equipment (such as a double-jacket boiler) and foreign exchange to cover energy needs, usually imported as fossil fuel. This was a serious impediment for African countries.

It was for these reasons that the FAO Feed Resources Group (Sansoucy, 1986) tried to modify the technology to make it much simpler. The first trials were made at facilities provided by the Senegalese Agricultural Research Institute, in Dakar-Hahn. The idea was to develop a "cold process" that incorporated the molasses into the mixture without any heating, and to test various binding agents and ingredients. The original formula was based on the work of an FAO project in Egypt (Barker, *pers. comm.*). It consisted of: molasses, 50%; wheat bran, 25%; urea, 10%; quick lime, 10%; and common salt, 5%. More than 70 different formulas were tested for final block quality. Several, using locally available ingredients, were found satisfactory and selected for field trials. The new technology could be applied by mixing the ingredients manually or with concrete or horizontal feed mixers, depending on the scale. This improvement was a real breakthrough, since it allowed the application of the technology at low cost and at small scale, at village level by the farmers themselves or by a local artisan.

The Feed Resources Group then received strong support from the FAO Technical Cooperation Programme (TCP) through various projects in Africa (initially in Burkina Faso, Mali and Senegal). In addition, the first TCP projects coincided with the severe drought of 1983–1984 in Africa, which was a further incentive for developing the technology. In addition, specific trials with urea-molasses blocks manufacture and utilization were undertaken in UNDP projects (Bhutan, Egypt, India, Mauritius, Pakistan, the Philippines). Cooperation was maintained between the Feed Resources Group and the Joint FAO/IAEA Division to spread the technology in developing countries.

The Feed Resources Group also organized Regional Task Force Meetings in Africa (English- and French-speaking countries) and in Latin America (Spanish-speaking countries). These meetings aimed to describe and share experiences in the manufacturing and utilization of urea-molasses blocks.

At the request of governments, several missions were made using trained Task Force members in Africa or Latin America in order to demonstrate the technique and to prepare new TCP projects.

Many countries rapidly adopted the new technology because there was a need for the product and the simplicity and low cost of the process made it easy to apply without heavy investment. However, a constraint appeared in several countries, particularly in some African countries, namely a lack of molasses.

The development of blocks without molasses

In February 1989, in response to requests from some countries having feeding problems during the dry season, but not in position to produce urea-molasses blocks because molasses was not available or too expensive, the FAO Feed Resources Group attempted to manufacture blocks without molasses or with only a low level of molasses. This work was realized in Tunisia, in cooperation with Professor Kayouli (National Institute of Agronomy), the Livestock Bureau (Office de l'elevage et des pâturages (OEP)) and the Central Cooperative for Cereals (Coopérative centrale des grandes cultures (CCGC)). The first results were encouraging (Hassoun and Ba, 1990) and several formulas were successfully tested in Tunisia, Cambodia and Niger (Kayouli 1994a, b; Kayouli and Buldgen, 2001).

Although it is usually preferable to include some molasses – because it makes the block easier to manufacture, improves the palatability and supplies some useful elements, such as sulphur – this alternative was readily adopted, helping to solve the problem in various countries. More water needs to be added to the mixture and greater pressure must be applied to the moulds to make the block solid.

Soft cakes versus hard blocks?

Some research workers have observed low block intake and have tried to replace the hard blocks with a softer cake (Ho Quang Do, Vo Van Son and Preston, 2002). They reported greater intake. This problem has been well known from the beginning of the block experience.

A block must be hard enough to oblige the animals to lick it and not to bite it. However, if the block is too hard, the intake may be restricted, preventing any effect on the animal. In contrast, if the block is too soft, the animal may consume it too fast and in excess, and there may be a risk of urea toxicity. The hardness can be controlled by changing the proportions of the ingredients, such as increasing the percentage of molasses, or reducing the percentage of the gelling agent or binder. Although the concept of the block is based on sound science, block manufacture is an "art" that has to be learned by doing.

A "soft cake" is, by its nature, different from a block. The block is designed to safely provide the urea to the animal and to control the intake so that urea will be progressively ingested over the day, maintaining a more or less constant level of ammonia in the rumen. With a soft cake, the total intake might be controlled by the amount offered, but it is rapidly ingested, leading to a peak in ammonia concentration.

The utilization of blocks as feed supplement

Feed supplementation blocks that provide various nutrients – N, some carbohydrates, minerals and vitamins – are now more commonly called *multinutrient blocks*. Several hundred formulas, with or without molasses, have been developed and tested according to the local availability, quality and price of ingredients. This demonstrates the adaptability of the technology. Although designed mainly for dairy and beef cattle, the concept has been used for buffaloes (Nguyen Van Thu, 2000), small ruminants (Osuna, Ventura and Casanova, 1996; Salman, 1997; Houmani and Tisserand, 1999), and even rabbits (Perez, 1990; Dinh Van Binh, Bui Van Chin and Preston, 1991; Filippi, Amici and Machin, 1992).

Excellent results have been obtained with different types of production: growth, meat, milk, work or wool (Sansoucy, 1995), but one of the greatest effects seems to be obtained on reproductive animals (Hendratno, Nolan and Leng, 1991; Ghosh, Alam and Akbar, 1993; Vargas and Rivera, 1994; Doan Duc Vu *et al.,* 1999).

At present, the technology of the cold process has been well mastered by many people in developing countries. Blocks are now commercially produced on a large scale in many countries (India, Mexico, Niger, Pakistan, Sudan, Venezuela, etc.), using various kinds of equipment, from a simple shovel to sophisticated industrial equipment. In Australia, the success of the blocks is tremendous and growing from year to year (R.A. Leng, *pers. comm.*).

The possibility of using blocks as carriers of anthelmintic medicines was investigated at an early stage (McBeath, Preston and Thompson, 1979). However, in Asia, it has been successfully investigated more recently, in particular by the Australian Centre for International Agricultural Research (ACIAR). Other research has been conducted in Venezuela (Araque and Rosos, 1993), India (Sanyal *et al.*, 1995) and Ethiopia (Anindo *et al.*, 1997). The technology appears attractive, but the manufacture of such medicated blocks is only applicable at an industrial scale, not at village level.

The impact of block technology

Block technology has been very popular among teachers and students at Agricultural Universities. The number of research experiments conducted in developing countries, although not exactly known, is quite impressive. It has lead to many scientific publications in various international journals. In one journal alone – the electronic journal *Livestock Research for Rural Development* – more than 30 articles have been published on the subject [see http://www.cipav.org.co/lrrd/index.ht ml]. In the framework of the International Foundation for Sciences (IFS) programme, various research grants have been for studies on blocks. Strong interest from individuals and research institutes has led to all kinds of investigations. Studies have been conducted on the feeding value of multinutrient blocks and their effects on the nutritional status and animal production (milk, meat, growth), physiology (reproduction) and health (when anthelmintics were added in the blocks). Also, experiments have been done to test the manufacture of blocks using new local ingredients or binders. All experimental work has shown positive effects on production, health and reproductive parameters.

International and national meetings on multinutrient blocks have been organized by various organizations (FAO, IAEA, Guanare University in Venezuela (see Cardozo and Birbe, 1994)). The meetings have helped to spread the technology and its results among research and extension workers.

Multinutrient blocks have been a tremendous tool for extension of knowledge on feeding principles and practices for ruminant animals, and particularly regarding supplementation of the unbalanced diets that are common in developing countries. For this purpose, extension material documents have been prepared in most countries and in local languages for teaching farmers and small-scale manufacturers (Garcia and Restrepo, 1995) concerning manufacture and use of the blocks.

It is difficult to evaluate the global impact of the block technology on livestock production as the number of manufacturing units and of farmers feeding multinutrient blocks to their animals is not exactly known. However, it is certain that the technology been a great success. Efforts are ongoing and will continue. This book presents snapshots of aspects of the current state of knowledge, and should be of great help for both beginners and experienced people working on the subject.

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The technology used to make urea-molasses blocks

Michael Allen[4]

Introduction

This chapter considers the technology used to produce feed supplementation blocks based on urea and molasses (urea-molasses blocks – UMBs) in different parts of the world. It is not an exact prescription for making your own molasses blocks and it does not cover all the known locations and techniques that have been used. However, it should provide a sound introduction and a good overview of the state of the art.

Objectives in making blocks

UMBs are either made to test their efficacy with a target group of ruminants or to provide continuing nutritional support for them. The approach required to meet these requirements may be quite different, so it is therefore necessary to decide on clear objectives at the outset.

For *experimental production*, research centres may routinely mix animal rations in buckets. As a consequence, they may well choose a technology that uses a drum instead of buckets because it represents a simple scaling up of techniques with which they are already familiar. They will probably measure every component by weight. A farmer (or farmer cooperative) may similarly use buckets and drums, but would probably prefer to measure most components by volume. The cost of equipment to achieve this production is likely to be more critical for the farmer than it is for the research centre, with an overall preference for using hand power rather than machine power (Figure1).

For *commercial or semi-commercial production*, drums, tanks and mixers would be dedicated to the production of feed blocks, with reliability being an important factor. Amounts are measured in volumes wherever possible, and a greater rate of production is required.

In both cases, the technology used will probably be an extension of techniques already in use. For example, the commercial unit may use

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concrete-making equipment and special moulds to produce blocks, whereas a farmer may prefer to mix by hand and mould in a simple wooden mould of the form used for making earth bricks.

Overall process

The overall process of UMB making is conveniently broken into three stages, each of which has their own problems and their own solutions.

Raw material procurement and storage

UMBs manufactured by the cold process are made from some sort of bran (or a digestible filler), cement (or lime), water and common salt, as well as urea and molasses. All components (except the molasses and the water) are solids and can be transported and stored in sacks or drums (Figure 2). With care, even the molasses can be transported and stored in drums. These materials should be stored under cool conditions and the contents kept secure from pests and pilferage.

Figure 1 Adjusting rammed-earth brick mould for use with UMB in North China (Gansu Province).

Where water supplies are unreliable, water may need to be stored, but more often it is available with sufficient purity and in sufficient quantity from a tap connected by a pump to a local water supply. Molasses is usually much more difficult to procure and store.

Molasses is the material remaining after sugar had been crystallized from a mash of beet or cane in water. It contains numerous trace minerals and uncrystallizable sugars that are generally beneficial to ruminants. It is dark brown, viscous and sticky. It has a density of nearly 1 500 kg/m^3, which means that a 200-litre drum will hold about 300 kg of molasses.

Figure 2 Ingredient store.

So, while a utility vehicle may be able to carry four 200-litre drums of water, it may not be able to carry four 200-litre drums of molasses without damaging the suspension. Similarly, a 4 m^3 water tanker designed to carry 4 tonnes of water may not be able to handle 4 m^3 of molasses, which weighs 6 tonne (Figure 3). If there is any doubt, tanks and tankers designed for conveying water should be only half-filled with molasses. However, water storage tanks that are fixed can normally be filled with molasses without there being any serious problem (Figure 4), although it is still advisable to check that the foundations of the storage tank can bear the extra load (particularly if the molasses storage tank is suspended on girders or on a platform above the ground). As a safety precaution, it is a good idea to make a ditch around the molasses storage tank(s) to make sure that any leaks or spillages are collected away from the base and supports of the tank(s). Remember also that, in humid climates, spilled molasses will usually ferment and produce acids that weaken concrete. As a consequence, any molasses spilled on a concrete floor should be cleaned up quickly. Spilled molasses is also quite slippery and can cause accidents.

The size of the store necessary depends upon regularity of supplies: If, for example, molasses can only be obtained every three months, then the store should accommodate three months plus two weeks supply, where the extra two weeks is to allow for contingencies such as strikes or leakage!

Manufacturing process

Mixer

Depending on the scale of the operation, UMBs can be made on a concrete floor using a shovel (Figure 5), or the ingredients can be mixed together in a bucket or perhaps in a mechanical mixer (Figure 6).

Concrete mixers are very useful in this regard because they cost less than a purpose-built agricultural mixer and they can be sold when no longer needed. They can also be obtained easily in most countries. They certainly save a lot of hard work.

The exact order of mixing is probably not critical for the finished block, but most people mix the molasses with the urea as the first step. The cement powder is next introduced (although some prefer to make up a paste of cement with some water so as to stop dust nuisance and ensure that the cement is properly wetted). To this mix is then added the bran (such as peanut husks, or any other filler, such as earth). Finally, water (with the salt dissolved in it) is added in sufficient quantity to produce a dry mix. As a quick test, a handful should form a ball when squeezed in the hand and there should be no sign of free water on the surface of that ball. It is hard to predict how much water will be needed because the moisture content of the other ingredients and the fineness of the cement powder vary considerably. Therefore water should be added gradually until the correct dryish ball is produced. If one makes a note of the amount, it is much easier to make the next mix with those same ingredients.

As a general rule, dry ingredients should be added with the bran or filler (e.g. extra minerals), while water-soluble material should be dissolved first in water, and then added. Mixing, by whatever method, should continue until the mix is homogeneous. Note, however, that most helical-screw mixers intended for mixing dry feed ingredients on a farm do not make good block mixers.

Figure 3 Molasses road-tanker (Tanzania).

Figure 4 Molasses store (Cuba).

Figure 5 Hand mixing ingredients (Gansu, China).

Figure 6 Concrete mixer making UMB (Somalia).

Table 1
Basic FAO formula

Component	kg
Molasses	45
Cement	10
Bran	30
Urea	10
Salt	5
Water	4

A typical FAO formula (Table 1) for 100 kg of UMB mix would require that 45 kg of molasses would be mixed with 10 kg of urea, and then 5 kg of cement (or quicklime) added. About 35 kg of wheat bran will then be needed (or a proportional amount of any other filler) and up to 5 kg of common salt (sea salt or sodium chloride). Approximately 4 kg (4 litre) of water will be required to hydrate the cement or quicklime.

If the mix is being made manually, 100 kg will be too much, so a proportional amount will have to be made. Indeed, small mechanical mixers will also require smaller quantities. Obviously, a concrete mixer is designed to mix concrete so that its speed may be a little fast for making a good mix of molasses, cement, bran, water and salt. However, with a petrol-driven mixer, the idling screw can usually be set to make it run at a slightly slower speed so that the material tumbles in the mixer rather than just sliding round. A little experimentation may be necessary during the commissioning of any mechanical mixer.

Molasses handling

In a small-scale operation (up to 100 tonne per year), the molasses can be weighed for each batch. However, some molasses will stick to the container in which it is weighed. Strictly the weight of this molasses should be subtracted from the amount added. However, unless the formulation is being constantly changed, it is much easier to add a known volume of molasses to the mix rather than a known weight, and the amount sticking to the measuring container is more or less constant between batches so there is no need to clean the container before making the next batch. The same is true for the water, and it may even be possible to add an amount of bran/filler based on volume rather than on weight. Figure 7 shows the use of a large bucket and a winch to lift it in Sudan – an arrangement that had been in daily use for over ten years for the measurement and transfer of molasses.

A process flow diagram of the molasses storage and distribution system for a 1 000 tonne/year plant at Kuku, Sudan, is presented as Figure 8.

Moulding

Moulds can be made from a wide range of materials. Plastic pails or buckets, wooden troughs, or even cardboard boxes. However, if it is intended that these items be re-used, they should be of a shape and material that is readily separated from the blocks. Plastic sheet has been used to line cardboard boxes and wooden moulds; holes have been made in the base of plastic pails to assist with de-moulding. While smaller blocks are useful with smaller ruminants, blocks weighing between 5 and 10 kg are most suitable for cattle. Such a mass is difficult to remove from a mould and generally it is easier to remove the mould from the block.

Figure 9 shows the design of a mould to make 16 blocks – a design that has found wide acceptance. It is easily fabricated from steel sheet and the unit can be put together in about a minute. Its main advantage is that it can be stripped from the 16 blocks within minutes of moulding. It need only be lightly washed (and not dried) before it is reassembled for the next batch of blocks. By changing slot spacing, this design of mould has been used to make smaller blocks more suitable for use with goats or sheep.

Figure 7 Molasses bucket on winch (Kuku, Sudan).

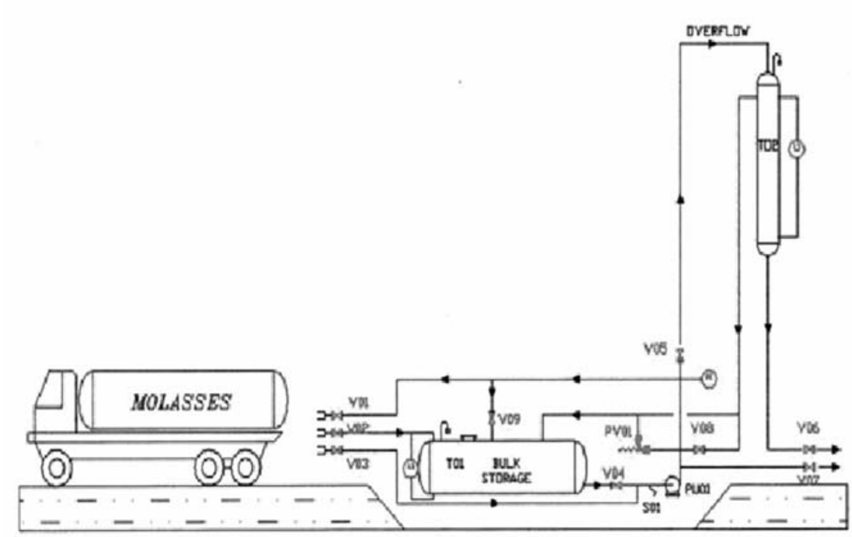

Figure 8 Process flow diagram for molasses storage and distribution at Kuku (Sudan).

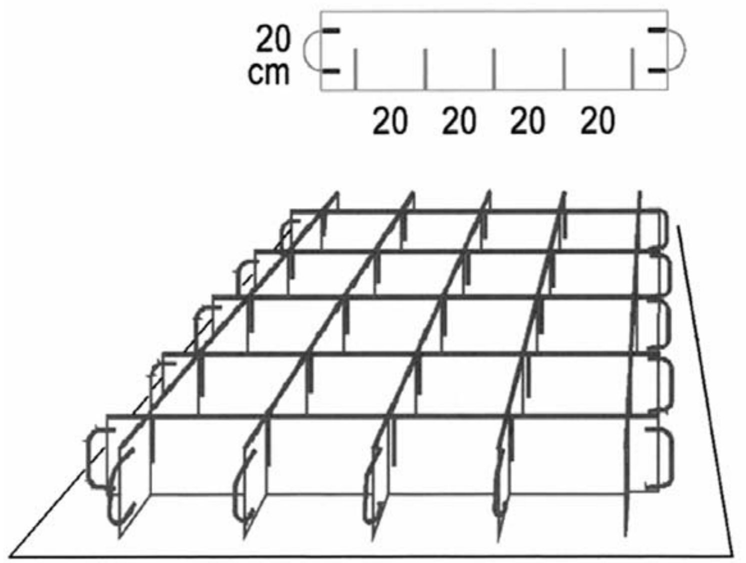

Figure 9 Mould design and construction.

The floor of the moulding room usually provides the base on which the blocks are made. With a beaten earth or new concrete floor, it is recommended that a thick plastic sheet be placed on the floor to assist in moulding. This sheet does not need to be much larger in size than the area the moulds occupy (ca 1 m × 1 m). Figure 10 shows such a plastic sheet in use in Somalia.

The moulding room should be light and airy with protection from the sun and rain. A simple roof over a level floor is adequate. An ideal location is adjacent to the raw material and the product stores so that handling is minimized.

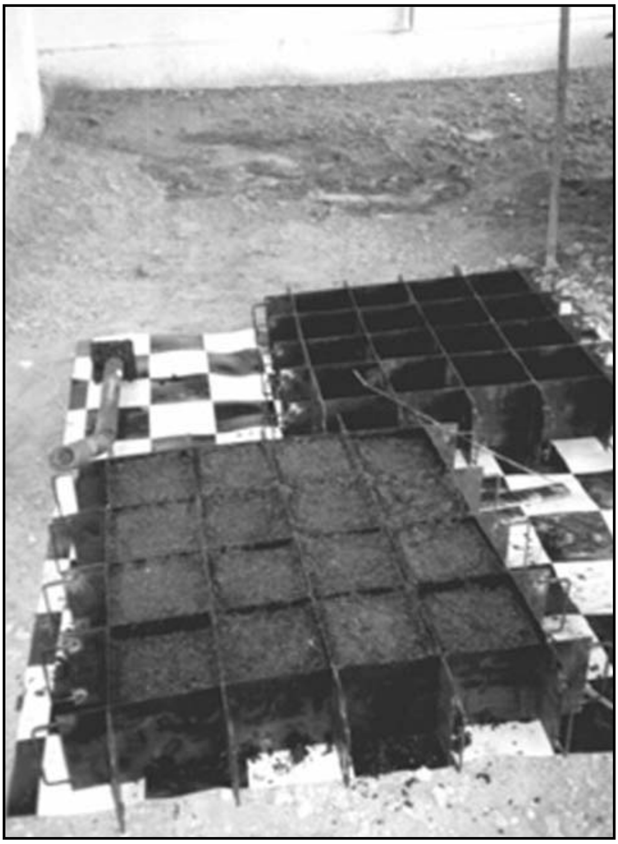

Figure 10 Moulds on a plastic sheet (Somalia).

Blocks can be moved from the floor and put into storage as soon as they are hard enough to handle (after 3 to 8 hours). However, the block needs to be much harder if the animal is to lick it rather than chew off the corners. Blocks also need to be quite hard if they are to be loaded into the back of a vehicle and transported for any distance over unsealed roads.

The rate of drying and hardening depends on local temperature and humidity, so it is not possible to give a reliable estimate of the time needed. In sub-Saharan conditions of high temperature and low humidity, blocks can be put in store within minutes of de-moulding; and transported for use some three days later. In the winter of northern China or the monsoon of Java, blocks may not harden adequately at all. Obviously some experimentation will be needed.

Product storage and distribution

Storage is best in a well-ventilated shed where the blocks are kept out of direct sunlight. Indeed, only a roof is necessary in most places, unless security is a problem. Only the wettest of climates will give problems of mould or fungal growth, but rats, mice and birds seem to be a universal problem.

Provided blocks are sufficiently hard, they may be transported singly on a bicycle or in loads of several tonnes on 4-wheel drive trucks, or, of course, anything in between.

Feeding out may be as simple as presenting the block directly to an animal (or herd), or fitting the block into a special holder or box so that the animal has only limited access to one surface of the block. This is often the situation where a block has been directly moulded into a plastic lined container or a cardboard box where the wrapper remains attached to the block. This technique can be useful if presentation and the circulation of information about the block and its use are considered to be important. They do, however, present a significant proportion of the total cost of distributed blocks.

Further information on how to estimate the cost of blocks based on the capital cost of equipment and running costs will be found in Allen, 1997.

Summary

The technology used to make urea-molasses feed-blocks is extremely simple and relatively straightforward. The process and equipment described in this chapter has formed the basis for a strategy to improve yields and quality of stock in several countries. The process has been adapted to make just a few blocks or used by industrial dairy companies (e.g. Butana Dairy Company, Khartoum, Sudan) to make many tonnes of blocks. Figure 11 shows 25 concrete mixers being assembled at Kuku, Sudan, for use in that country's continuing strategy to reduce the effect of extended droughts on livestock.

Figure 11 Sudanese concrete mixers awaiting assignment.

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Urea-molasses mineral block supplementation in the ration of dairy animals – Indian experiences

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Introduction

Milk production in India was estimated at 84 million tonnes per annum at the end of 2002, and growth in production has been about 4 percent. Indian milk production comes from buffalo milk (ca 54 percent), cow milk (ca 42 percent) and the balance (4 percent) is from small ruminants (sheep and goats). The basis for Indian milk production is the millions of non-descript cows and buffaloes in rural areas, fed mainly on crop residues and agro-industrial by-products. The mainstay of the feeding system in India is fibrous feed, which forms the bulk of ruminant diets. These fibrous feeds are deficient in protein, energy and minerals, with poor palatability and digestibility. Without additional supplements, such feeds can not support even body maintenance of the animals. One of the methods of increasing utilization of straws is the supplementation of deficient nutrients in the form of fermentable N, energy and minerals, ensuring thereby enhanced microbial growth in the rumen, which in turn enables the ruminants to consume more straw. Several workers have shown increased intake or digestibility, or both, of straw when the straw is supplemented with urea, molasses and minerals (Pathak and Ranjhan, 1976; McLennan, Wright and Blight, 1981; Deniel, Hassan and Nath, 1986). Spraying of these additives on the straw is not a viable option due to the risk of urea toxicity and problems of distribution, handling and storage of molasses under field conditions. Various treatments – physical, chemical, physiochemical and biological – have also been tried to improve intake and utilization of nutrients from poor quality roughages. Physical – wafering, chopping, grinding, milling, steaming under pressure, irradiation, soaking, boiling,

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etc. – and chemical treatments – alkali, ammonia, acids and gases – to break down lignocellulosic compound have been tried, but with variable success.

All these treatments have some drawbacks. Improper use may cause severe economic loss, especially in the case of urea. An excessive amount of urea or faulty treatment of roughages treated with it may harm, or even kill, animals due to ammonia toxicity.

To obtain appropriate use of urea, various methods have been tried worldwide. The problem of feeding urea to animals has been overcome in India by the introduction of feed supplementation blocks in the form of urea-molasses mineral block (UMMB) licks developed at the National Dairy Development Board (NDDB), Anand, India (Kunju, 1986a, b). Several researchers had previously reported on the use of UMMB licks for supplementing crop residue-based diets for large and small ruminants (Leng, 1983; Sansoucy, 1986, 1995). The slow ingestion of urea provided through such licks ensures its efficient, non-toxic utilization. However, the formulation, packaging and feeding of UMMB licks require critical attention to ensure their regular and proper use by farmers.

NDDB first introduced farmers to UMMBs in 1983, when they were prepared by using a "hot process" technique. However, because of the high costs of the production process and its inefficiency, these licks were not very popular with farmers. This was exacerbated by cost increases, which resulted in a rise from Rs 5 to Rs 22 for a 3-kg block between 1983 and 1994.

This stimulated further research and development work to improve the production technology. This chapter describes some of the benefits of using UMMBs and gives a brief introductory description of the "hot process" used for UMMB production. It then summarizes the research undertaken at NDDB for standardizing the formulation of UMMBs and for developing means for their large-scale production by the "cold process". It also deals with UMMB packaging, quality control and long-term storage, and examines the licking behaviour of animals presented with these blocks under field conditions.

Effect of UMMB feeding on dry matter intake

When considering the dry matter intake (DMI) of fibrous feed, the primary limiting factors are its digestibility and the rate at which it is broken down to particle sizes that can pass through the reticulo-omasal orifice (Preston and Leng, 1984). The fine grinding of fibrous feeds would facilitate its passage into the lower tract, but its digestibility in the lower tract is decreased. Hence it is ideal if the fibrous feeds are fermented in the rumen and broken down to particle sizes that can facilitate the flow and also facilitate its digestibility. Increase in intakes of dry matter (DM), organic matter (OM), crude protein (CP), neutral-detergent fibre (NDF) and acid-detergent fibre (ADF) with UMMB lick supplementation has also been supported by several researchers (Manget Ram, 1989; Mohini, 1991; Gupta and Malik, 1991) (Tables 1 and 2). With UMMB supplementation, straw DMI increased by 30 to 50 percent in different experiments.

Effect of UMMB feeding on digestibility and nutrient balances

Digestibility increased (Table 2) due to increased rates of rumen fermentation, mediated through a larger population of microflora and increased cellulolytic activity. Straw OM digestibility was around 40 to 45 percent under unmanipulated conditions. With UMMB supplementation, digestibility increased to 50 percent (Manget Ram and Gupta, 1988).

A noticeable effect of UMMB supplementation with wheat straw was that the negative N, Ca and P balances associated with feeding wheat straw alone became positive balances of 2.90, 2.85 and 0.50 for N, Ca and P, respectively (Table 3), which indicated that the blocks provided compensatory nutrients for those that are limiting with wheat straw alone (Manget Ram, 1989; Tiwari, Singh and Mehra, 1990; Mohini, 1991; Garg and Gupta, 1992). Mohini (1991) observed even significant enhancement in the digestibility of nitrogen-free extract (NFE) with UMMB lick supplementation in paddy-straw-based diets. Digestibility of ADF was enhanced from 37.4 percent to 41.3 percent with UMMB licks supplementation with wheat straw, while NDF digestibility increased much more than ADF, i.e. from 42.6 to 51.8 percent. DM and OM digestibilities increased from 44.0 and 45.22 percent to 50.0 and 53.0 percent, respectively, by UMMB licks supplementation (Tiwari, Singh and Mehra, 1990). Based on these observations, it can be safely concluded that supplementation with UMMB licks boosted the digestibility of basal diets based on low quality forages.

Table 1

Straw daily intake and straw DM digestibility in two groups of dairy cattle without (I) and with (II) UMMB.

Group	Body weight (kg)	UMMB intake (kg)	Straw intake**		Straw DM digestibility (%)	DOMI through straw** (kg/100 kg BW)
			kg/100 kg BW	g/$w^{0.75}$ (kg)		
I	224.0 ±14.2	–	1.27 ±0.08	48.8 ±2.43	48.5 ±1.06	0.619 ±0.03
II	228.4 ±12.4	0.44 ±0.04	1.95 ±0.06	75.6 ±1.79	48.7 ±1.20	0.986 ±0.05

NOTES: **$p < 0.01$; DOMI = digestible organic matter intake; BW = body weight.

Table 2
Digestibility of various nutrients in two groups without (I) and with (II) UMMB.

Group	DM*	OM*	CP**	EE	CF	NFE
I	48.54 ±1.06	48.98 ±1.21	--	48.91 ±1.56	42.96 ±0.94	62.54 ±1.80
II	53.35 ±1.05	53.85 ±1.39	50.30 ±1.62	49.22 ±0.82	43.28 ±0.71	64.15 ±2.61

NOTES: *p<0.05; **p<0.01; DM = dry matter; OM = organic matter; CP = crude protein; EE = ether extract; CF = crude fibre; NFE = nitrogen-free extract.

Table 3
Daily N, Ca and P balances (g) in two groups of dairy cattle without (I) and with (II) UMMB.

	Group I	Group II
Nitrogen		
Intake**	19.55 ±0.78	73.73 ±3.71
Excreted in faeces**	26.27 ±1.23	36.92 ±2.91
Excreted in urine**	21.25 ±0.06	33.92 ±0.08
Balance**	-27.97 ±0.61	2.90 ±1.07
Calcium		
Intake**	14.25 ±0.57	51.96 ±2.57
Excreted in faeces**	18.65 ±0.65	42.53 ±1.51
Excreted in urine**	1.97 ±0.07	6.58 ±0.64
Balance**	-6.37 ±4.80	2.85 ±0.74
Phosphorus		
Intake**	2.79 ±0.11	14.67 ±0.85
Excreted in faeces**	3.17 ±0.10	12.49 ±0.65
Excreted in urine**	1.01 ±0.07	1.68 ±0.16
Balance**	-1.39 ±0.12	0.50 ±0.11

NOTE: **p<0.01

Effect of UMMB feeding on rumen fermentation

The important feature in utilization of nutrients in ruminants is the anaerobic fermentative digestion. Therefore, to increase the efficiency of nutrient utilization or productivity, there is need for actions that maintain an environment conducive to better microbial activity in the rumen. The major requirements for obtaining better microbial activity and cell production in the rumen are:

- supply of enough nitrogen;
- supply of enough ATP; and
- supply of enough minerals and monomers.

The primary limiting factor with straws is N deficiency – insufficient N to ensure adequate ammonia in the rumen fluid (Kunju, 1988; Manget Ram, 1989; Srinivas and Gupta, 1991; Srinivas, 1991). When supplementation in the form of UMMB lick was provided, the ammonia-N (NH_3-N) in the rumen fluid increased to optimum (Manget Ram and Kunju, 1986; Kunju, 1988; Manget Ram, 1989; Mohini, 1991). NH_3-N concentration increased substantially from 76 mg/l to 239 mg/l after UMMB-lick supplementation with a paddy-straw-based diet. When NH_3-N in the rumen increases, the lick consumption diminishes proportionally (Garg, Tripathi and Kunju, 1990). The ammonia level is believed to be a biosystemic control of lick intake by the animal (Kunju, 1988). Manget Ram (1989) observed significant ($P<0.01$) difference in rumen NH_3-N level when wheat straw was supplemented with either concentrate mixture or UMMB lick. The NH_3-N levels in rumen fluid were 223 mg/l and 183 mg/l, respectively, for UMMB lick or concentrate supplementation. Even at this high level of rumen NH_3-N, blood NH_3-N rose only to 1.27 mg/100 ml, which indicated no toxic effect of urea through UMMB licks (Table 4). Total N and trichloracetic acid (TCA)-precipitable N did not differ significantly between concentrate and UMMB lick supplementation. Equal TCA-precipitable N for both the supplements indicated equal microbial yields (Gupta, Khan and Murthy, 1970; Manget Ram and Gupta, 1986, 1987; Manget Ram, 1989). When preformed amino acid sources increased in the UMMB block, the NH_3-N content was not significantly different from the concentrate-supplemented group, which indicated that NH_3 released from UMMB licks was used with the same efficiency as that from concentrate supplementation (Mohini, 1991).

Table 4.4

Different N constituents in blood plasma in two groups of dairy cattle without (I) and with (II) UMMB.

		Group I	Group II
Total N**	(g/100 ml)	1.822 ±0.02	2.165 ±0.02
of which:			
NH_3-N**	(mg/100 ml)	0.29 ±0.03	1.27 ±0.04
Urea-N**	(mg/100 ml)	4.29 ±0.21	17.56 ±0.36

NOTE: **p<0.01

With increased DMI, the volatile fatty acid (VFA) concentrations increased when lambs consumed UMMB supplement along with a basal diet of wheat straw. A small but insignificant shift in the VFA proportion towards higher propionate production was also observed (Sudana and Leng, 1986). It was calculated that for 100 mg ammonia per litre of rumen liquor, the total VFA (TVFA) level should be around 25 mM/l. When UMMB was fed, the level of ammonia was 112–195 mg/l and TVFA concentration was 48–54 mM/l (Kunju, 1988). TVFA production was significantly higher ($p<0.01$) with concentrate supplementation than with UMMB supplementation with paddy-straw-based diets, compared with feeding paddy straw alone (Mohini, 1991). Rumen turnover also increased with UMMB supplementation, which indicated rapid DM digestion due to effective colonization by the rumen microflora (Kunju, 1986a; Manget Ram and Gupta, 1988; Manget Ram, 1989; Mohini, 1991; Srinivas, 1991). Sixty percent of the straw DM disappearance was achieved in 48 hours by supplementing UMMB licks alone with straw-based rations (Kunju, 1986b). Bacterial production rate as g/day DOMI was considerably higher with UMMB supplementation compared with concentrate supplementation. Nevertheless, the percentage efficiencies of N incorporation in cattle were 30.83 and 29.54 for concentrate- and UMMB-supplemented groups, respectively (Manget Ram, 1989). In buffaloes, N incorporation efficiencies were only 23.31 and 17.78 percent for concentrate- and UMMB-supplemented groups, respectively (Mohini, 1991). In contrast, protozoan production rate was about halved in UMMB-supplemented groups when compared with concentrate-supplemented groups. This could be due to a partial defaunating effect of either UMMB lick ingredients in general, or sodium bentonite in particular (Manget Ram, 1989; Mohini, 1991).

The amino acid composition of ruminal bacteria showed higher serine, glycine, threonine, alanine and arginine, and lower lysine, while most of the amino acids were similar for protozoa, except for lysine, when animals were supplemented with either UMMB lick or concentrate mixture (Manget Ram, 1989). The overall conclusion, based on rumen parameters, was that the UMMB licks could invariably and effectively replace concentrate supplementation at maintenance level.

Effect of UMMB feeding on productivity of animals

Growth

Beames (1963) was the first to report that the provision of a salt-urea-molasses block for cattle fed a hay-based ration significantly reduced loss in body weight. In sheep as well, the UMMB licks supplemented group lost less weight than the un-supplemented group (Coombe and Mulholland, 1983). Schiere *et al.* (1989) fed urea-treated rice straw along with UMMB lick and obtained better growth and succeeded in obtaining 89 g/day weight gain, compared with wheat straw alone (-101 g/day) or urea-treated straw alone (76 g/day). Manget Ram (1989) did not find significant differences in liveweight gains when UMMB licks were used to replace up to 30 percent of total CP requirement previously obtained from concentrate mixture, and therefore affirmed that feeding practices can be made more economical by partially replacing concentrate mixture with UMMB licks.

Tiwari and co-workers (1990) attempted to determine the optimal proportion of fishmeal as a bypass protein source in support of UMMB licks that contained 38 parts molasses, 10 parts urea, 10 parts cement, 40 parts wheat bran, 1 part salt and 1 part mineral mixture (by weight). They provided fish meal at rates of 50, 100 and 150 g/day, and inferred that the calves provided with 100 g/day of fishmeal in addition to UMMB gained more weight than calves fed on UMMB alone or 50 g fishmeal + UMMB or 150 g fishmeal + UMMB. These liveweight gains were respectively 288, 90, 166, 179 and 275 g/day. When UMMB licks were prepared with 40% *subabul* (*Leucaena leucocephala*) leaves, the weight gain was much lower than in the concentrate-supplemented group. The weight gains were 587 and 185 g/head/day respectively for the concentrate group and the subabul leaf-based UMMB licks group (Gupta and Malik, 1991). In buffaloes, the weight gains were about 40 g/day higher than cattle (Mohini, 1991). By using anti-pyrine as indicator, the body composition of the animals fed on concentrate or UMMB supplementation was studied in cattle (Manget Ram, 1989) and in buffaloes (Mohini, 1991), and they observed no difference in body composition in cattle and buffalo calves after supplementation with UMMB licks. It could be concluded from these observations that UMMB licks can partly replace concentrate mixture and provide a fairly good growth rate in ruminants without any adverse effect on body composition.

Milk production

In India, the effect of feeding UMMB lick on milk production was studied extensively at NDDB, both in buffaloes and crossbred cattle. Twenty Surti buffaloes in their second and third lactation were divided into four groups of five animals each. The first group was fed on rice straw and cattle feed. The second group received the same ration plus UMMB. The third group was given cattle feed equal to 80 percent of that given to first group, with UMMB lick. The fourth group was given cattle feed equal to 60 percent of the first group, along with UMMB and 1.0 kg bypass protein. It was observed that the economic gains in the fourth group were remarkable. The animals on an average licked 350, 570 and 370 g/day UMMB lick in the second, third and fourth groups, respectively. The fat-corrected milk yields were 7.38, 8.07, 6.99 and 7.19 kg over 120 days, respectively, for groups 1 to 4 (Kunju, 1986a, b; 1988).

In lactating Jersey and crossbred Jersey cows, milk yields were tested by substituting 50 percent of green fodder with rice straw (Tripathi, Garg and Kukreja, 1986). Animals in group I were fed green fodder ad lib and concentrate at 40 percent of milk production. Animals in groups II and III were fed half the green fodder of group I, but with concentrate similar to group I. In addition, group II was offered rice straw ad lib, while group III was provided free choice of UMMB lick along with ad lib rice straw. Fat-corrected milk production was 10.45, 10.00 and 10.84 kg/day for groups I, II and III, respectively, with body weight changes of +0.187, -0.245, +0.035 kg/day. Thus, the block lick supplementation could maintain milk production in both Jersey and their crosses in group III without loss of body weight with 50 percent reduction of green fodder DM and ad lib feeding of rice straw. It was noticed that the supplementation increased the net return over feed cost by Rs 2.42 per day per animal (1985 values).

Kunju (1988) reported on successful village trials with UMMB supplementation for milk production. It was observed under field conditions that each 3 kg block lick lasted for one week per animal. At six villages (situated in Kaira District Cooperative Milk Producers Union Ltd, Anand, Gujarat, India) the milk yields were enhanced in animals when given free access to UMMB licks. Not only milk yields, but also fat percentages were enhanced. Increased straw intake and fat yield (Table 5) were reported by most of the farmers. On average, each farmer benefited by Rs 2–3 per day. Many farmers reported improvement in the general health of animals on supplementation with block licks compared with feeding straw alone. Increased straw intake was reported by all farmers, with simultaneous improvement in milk yield and fat percentages (Dave and Choudhary, 1986).

Table 5
Effect of using UMMB licks in villages.

Site	Village	CF intake (kg/day)	UMMB (g/day)	Milk yield (kg/day)		Fat yield (g/day)	
				Pre-lick	With lick	Pre-lick	With lick
1.	Alwa	2.0	410	4.8	5.9	330	450
2.	Punadhara	2.0	352	4.0	4.8	270	340
3.	Fulgenamuwada	1.0	382	2.4	3.5	160	280
4.	Hirapura	2.0	300	4.2	5.2	350	480
5.	Bamroli	2.0	320	3.6	4.2	270	380
6.	Dehgam	2.0	285	4.3	4.7	310	350

SOURCE: Kunju, 1988.

UMMB lick feeding during droughts

Shortage of feeds and fodders, in terms of both quantity and quality, is a major problem for developing countries like India in meeting the nutritional requirement of livestock. The unpredictable pattern of rainfall and recurring droughts also adversely affect agronomy and livestock. Droughts occur in India at regular intervals in various states, including Rajasthan, Gujarat, Madhya Pradesh, Uttar Pradesh, Karnataka, Tamil Nadu, Andhra Pradesh and Bihar. Despite the increased reliability of long-term weather forecasting, droughts lead to large economic losses among animal-rearing communities. During such prolonged dry periods, there is often considerable animal suffering, which may lead to their loss through lack of affordable or available feeds. Such loss is especially significant for landless labourers and small-scale and marginal farmers.

During drought conditions, the only feed resources available are crop residues and highly lignified fibrous materials. The feeding of such material is energetically wasteful. The supply of the essential nutrients required for growth of microflora by supplementation with UMMB licks increases the digestibility of fibre. In 2002, UMMBs were instrumental in saving animals in the state of Rajasthan, which was severely affected by drought.

Impact of UMMB licks

In India, dairying as an industry took a giant leap forward in the 1980s. The industry within the cooperative sector tries to provide milk at a reasonable price for every Indian. However, increasing feed costs and the entry of multinationals into the dairying sector threatened the industry. The advent of UMMBs could certainly reduce feed cost. Rural milk producers could save around Rs 3 per animal per day in feed costs without affecting the health of the animal or the level of production of animals fed crop residue-based diets.

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

Due to increasing human population, the total availability of land for fodder production in India is shrinking daily, in part as result of diversion of land to oilseed and pulse production, with feeding of crop residues to low producing animals to obtain human food and to produce more milk at low cost. In addition, if the available crop residues are not utilized properly, it may cause ecological problems. Use of UMMBs not only increases the utilization of crop residues and productivity of low producers, but also spares good quality feeds and fodder for higher producing animals. In view of this, the arrival of UMMBs is considered a revolution in ruminant nutrition, and a real boon to rural milk producers, providing growth and milk production and life-saving product during drought conditions.

Advantages of feeding UMMB licks to animals

- Stimulates rumen fermentation, thereby, increases straw intake by animals.
- Increases microbial protein synthesis and supply at abomasum level, giving higher productivity.
- Improves daily milk (by 0.5–1.0 kg) and fat (by 0.3–0.5 percent) yields.
- Increases lactation length.

- Maintains health and reproductive functions.
- Improves growth rate of animals on straw-based diets.
- No risk of urea toxicity.

Factors affecting UMMB licking by animals

- Level and type of concentrate supplementation.
- Level and type of basal ration, which includes leguminous and non-leguminous green fodder and dry fodder such as crop residues or hay.
- Type of animal (species and breed.
- Physiological stage, such as growth, lactation or non-lactation (dry).
- Method of dispensing UMMBs.
- Extent of availability of UMMBs.
- UMMB hardness.

Points to be remembered for maximizing gain from UMMB feeding

- Dispense the UMMB in front of the animal in a proper way.
- Initially, the licking of UMMB by Zebu cattle and buffalo will be slow.
- Needs an adaptation period of 1–2 weeks.
- Do not discontinue the block.
- Use the block as a lick only.
- Do not spray water on the block for licking.

The UMMB lick should be protected from dung, urine, fodder and rain.

Production aspects of UMMB technology

Acceptance of any product greatly depends upon its manufacturing process, cost of production, shelf life, convenience of use, etc. Various problems in production were encountered when UMMB technology was first introduced, affecting acceptance by farmers. NDDB spent a substantial amount of time and money in standardizing UMMB production technology, to ensure that the product is in presentable form. For the benefit of institutions and individuals engaged in the production of UMMB, experiences with UMMB production at different times and stages is described below.

Table 4.6
Composition of hot-process UMMB lick blocks (by weight).

Ingredients	Percentage
Urea	15
Molasses	45
Mineral mixture	10
Calcite powder	8
Sodium bentonite	3
Cottonseed meal	15
Common salt	4

SOURCE: Garg, Mehta and Singh, 1998.

The hot process

The ingredients used for the production of blocks by the hot process are given in Table 6. These were produced by steam heating molasses mixed with other ingredients, in a double-jacketed insulated vessel. After heating for 150 to 180 minutes at 130°C, the material was removed from the vessel, weighed in aliquots of 3 kg, put into moulds and allowed to harden. Although these hot process blocks were distributed to farmers for nearly ten years, they were never used regularly. This was probably due to inefficient extension and marketing, coupled with costs, which quadrupled between 1983 and 1993, in contrast to the price of feed concentrates, which only doubled over the same period.

Other related problems included the high cost of plant maintenance and fuel, unreliable equipment with frequent breakdowns, high labour demands and the difficulties of manually weighing the hot material. The blocks were also highly hygroscopic: at 60 percent relative humidity, blocks would deliquesce in storage and form a liquid mass.

The cold process formulation

As an alternative to steam heating the ingredients, adding gelling agents such as calcium and magnesium oxide, calcium hydroxide, cement, di-ammonium phosphate, etc., helps to solidify the block material (Sansoucy, 1986; Sansoucy, Aarts and Leng, 1988; Tiwari, Singh and Mehra, 1990). This technique is referred to as the "cold process". Initially, four formulations were tried by incorporating minor changes in ingredients suggested by Sansoucy (1986). Molasses, to which common salt and urea were added, was mixed in a vertical mixer for five minutes, after which calcium oxide was added and the ingredients were mixed thoroughly for a further ten minutes. The material was then transferred to the moulds to solidify overnight. After storage for one week, the blocks were offered to animals that were fed a crop-residue-based diet. Each animal licked 250 to 350 g of block per day. Encouraged by these observations, the evaluation of UMMB licks was extended to cooperative dairies. However, it was noted that by four to six weeks after production the blocks had become very hard and were only licked sporadically. The production of blocks using this formulation was thus discontinued.

To overcome this hardness problem, the proportion of bran was increased to 30 percent and calcium oxide was reduced to 6 percent during winter (maximum temperature, 22°C; minimum temperature, 8°C; relative humidity, 40 to 60 percent). Based on temperature and humidity data, formulations for summer, winter and rainy seasons were standardized. Blocks were produced in different seasons using the respective formulation and stored for four weeks before being fed to animals in the different agro-climatic zones.

After conducting rumen studies, feeding trials on growing and lactating animals were conducted for four to six weeks under controlled conditions at various farms where the level of animal production was medium to high. Before distribution of the product, farmers were given an explanation and demonstration of its use. Different animals were selected at random in various villages. Initial and final milk yield and fat yield were recorded after two weeks of preliminary feeding. Results of some of these field trials are shown in Table 5. Increased straw intake and fat yield were reported by most of the farmers. It was observed in field trials that the animals licked the blocks in sizable quantities, depending on the composition of their basal diet. In general, each 3-kg block lasted for one week per animal.

Following the farm trials, block licks were offered to individually kept village animals in different areas, and the level of acceptance ranged from 30 to 60 percent. It was felt that some of the village animals, because of their low to medium levels of production and access to sufficient green forage (e.g. lucerne), might not be tempted to lick the UMMB.

It appeared that the animals' poor acceptance of the blocks could be due to high pH and an unpleasant taste. The pH was between 10.5 and 11.5 when the level of calcium oxide was between 6 and 7 percent. In view of this, further investigations were carried out to vary and improve block formulation.

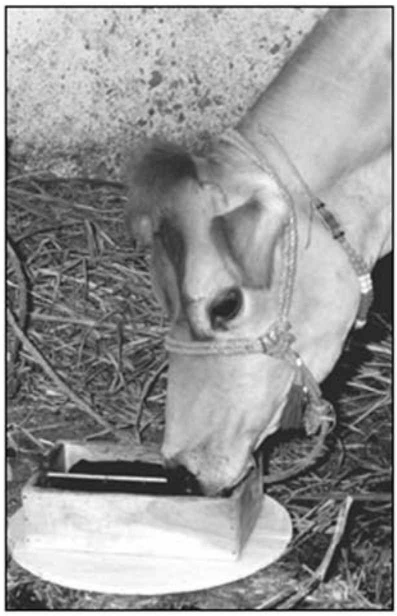
By using various organic acids – citric, tartaric, boric, etc. – it was possible to reduce the pH from 11.5 to 8.5, but the cost was prohibitive. Phosphoric acid also reduced the pH when incorporated at greater than 2 percent in the formulation, but it affected the solidification of blocks, especially during summer. When the blocks were too soft they were licked rapidly and had to be removed to avoid urea intoxication in the animals.

On studying the reaction of different gelling agents with molasses, it was felt that the gelling action of calcium oxide involved two steps. First, its reaction with moisture from the molasses, and, second, its reaction with the carboxylic group of organic acids present in molasses (predominantly aconitic acid). Apparently, the latter reaction was primarily responsible for block solidification.

Table 4.7
Cold process UMMB lick formulation.

Ingredient	percentage
Urea	6
Molasses	45
Mineral mixture	6
De-oiled rice bran	14
Rice pollard (fine)	13
Calcite oxide	4
Magnesium oxide	2
Phosphate buffer	10

Based on the above observations, moisture content in the moisture-contributing ingredients (molasses, urea, salt, etc.) was partially bound by brans, clays and mineral mixture at the first mixing and calcium oxide was added later. A smaller amount of calcium oxide was then required for solidification. By using guar meal powder along with the brans and clays, it was possible to reduce the proportion of calcium oxide to 4 percent. Subsequently, the pH was brought down to between 7.5 and 8.0 by adding phosphoric acid and sodium di-hydrogen phosphate. Using the latter two ingredients, several other formulations were developed that had pH of between 7.5 and 8.0. The blocks produced in this way were readily licked by 95 percent of village animals in Gujarat, Rajasthan and Karnataka (Figure 4.1 and 4.2). At present, UMMB licks are manufactured without using guar gums. Instead, calcium and magnesium oxides are added in the formulation at 4 and 2 percent, respectively. At the end, phosphate buffer is added to bring the pH down to between 8 and 8.5 (Table 7).

Figures 4.1 and 4.2. UMMB licking under field conditions.

Manufacturing methods and tools

Hand mixing

Where molasses is readily available to farmers, blocks have been made by hand mixing. However, owing to insufficient mixing of the calcium oxide, solidification may be low. This may not be a significant factor when blocks are made on demand at the farmer level, but may be considered a greater constraint in larger-scale commercial operations.

Extruder

It has been reported (Barry, 1993) that an extruder ensures thorough mixing of viscous materials and also speeds up the gelling process. In our investigations, all the UMMB ingredients were mixed in a vertical mixer and later passed through a screw-type extruder. The mixing was found to be thorough and homogenous and the blocks solidified within six to eight hours. However, using an extruder involved an additional cost of Rs 2.50 per block for electricity. Moreover, the process was more complicated, requiring both a mixer and an extruder, which increased costs and production time. It was therefore felt that using an extruder might not be commercially viable.

Concrete mixer

Among others, Avilla *et al.* (1993) advocated the use of a concrete mixer for the manufacture of UMMBs. When this method was tested, it was observed that the mixing of viscous ingredients was not homogenous, and, as a result, some of the blocks were hard while others remained soft. Moreover, about 25 percent of the mixture remained stuck in the container and had to be removed manually. This increased batch processing time and reduced turnover; hence the idea of using a concrete mixer was discarded.

A new method for manufacturing UMMB licks

NDDB, in association with an industry partner, has developed a device for manufacturing UMMBs (Figure 4.3) that is capable of mixing the ingredients thoroughly and efficiently. It is mobile and comprises a 300-litre stainless steel vessel with a diameter of 150 cm. It has a rotor in the centre on which specially designed scrapers and mixing worms are fixed at an angle to ensure thorough mixing of the materials (Garg, Mehta and Gupta, 1998). The speed of the rotor can be adjusted to suit the scale of operations. A sliding door is provided at the bottom of the vessel. After mixing, the material is discharged into a stainless steel tray for transfer into moulds or a pressing device. Using this method, it is possible to produce approximately 500 blocks in one eight-hour shift. In view of its mixing efficiency, micronutrients, deworming agent and vitamins may also be added as desired. The cost of this new equipment is only Rs 800 000, compared with the Rs 5 million needed for plant for the 'hot process'.

A pressing device for UMMB licks

Originally, the UMMB mixture was filled into moulds or egg crates and left overnight to solidify. To produce 500 blocks per day required 500 moulds, at a cost of approximately Rs 250 000. To reduce this cost, a rotary, pneumatically controlled pressing device (Figure 4.3) was developed, that cost approximately Rs 200 000. After mixing, the material was weighed in aliquots of 3 kg and pressed in a rectangular stainless steel die. The blocks pressed in this manner (Figure 4.4) maintained their shape and solidified without the need for moulds or egg crates.

Packaging of Blocks

Since block licks are hygroscopic, proper packaging is very important and should be moisture proof to maintain the quality of the blocks. Bags made of different materials were evaluated; they included polythene sheet, multifilm (low density/high density), PET laminate film (aluminium foil/PET film/polythene sheet) and high molecular weight high density (HMHD) sheet. Considering their cost, sturdiness and impermeability, HMHD bags were found be the most reliable.

A wooden dispenser for UMMB licking

Since most of the animals in developing countries are underfed, they tend to bite blocks, which might lead to over-ingestion and result in inefficient utilization or urea toxicity. To avoid this problem, a specially designed wooden dispenser (Figure 4.5) was developed for this product to facilitate licking. It can be kept in front of the animals or fixed on the wall of mangers at a convenient point for easy access by the animal. Since the product is in the form of a hard block and the biological system of the animal helps in regulating the intake, no case has so far been reported of urea toxicity under farm or field conditions, in spite of its wide use in different States. At present, for manufacturing UMMBs by the cold process, ten commercial plants in the dairy cooperative sector and two in the private sector have been established in different states. The blocks are supplied well packed in HMHD bags. Annual production has been between 300 000 and 400 000 UMMBs.

Figure 4.3 The new device developed by the National Dairy Development Board.

Figure 4.4. Block licks after pressing.

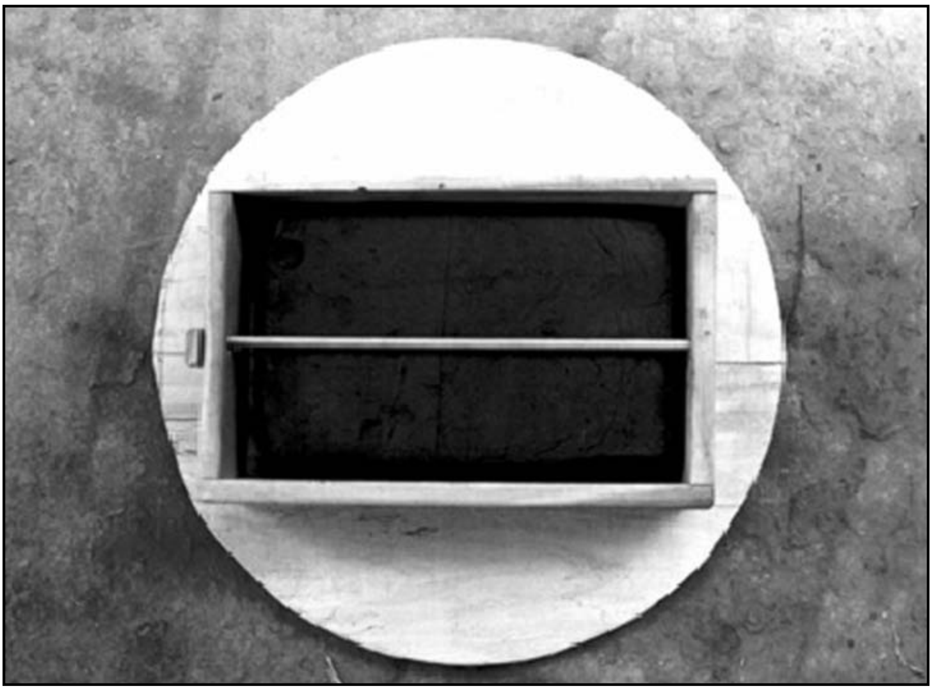


Figure 4.5 A wooden dispenser for UMMB feeding to animals.

Medicated urea-molasses block

Following the successful formulation and production of UMMB licks, collaborative research projects were initiated in 1990 by NDDB and Commonwealth Scientific and Industrial Research Organization (CSIRO), under the auspices of the Australian Centre for International Agricultural Research (ACIAR). The projects aimed to develop a self-medication device for prolonged low-level administration of anthelmintics, using UMMBs as the carrier.

Anthelmintic pharmacokinetics studies undertaken in dairy cattle and buffaloes provided the dosage needed for the anthelmintic selected for use in UMMBs, so that the animals could receive the desired dose of the drug on a daily basis. Following successful formulation and demonstration of effective nematode parasite control in dairy animals, nationwide data on parasite epidemiology were generated for formulating region-based strategic nematode parasite control programmes using medicated UMMBs (MUMMBs). Outside the collaborative umbrella, technology for the production of UMMBs incorporating flukicide was also developed to control liver flukes in dairy animals.

Anti-nematode MUMMB

Fenbendazole (FBZ) has been found most suitable for incorporation in UMMBs as the drug is stable in blocks, does not require a milk withholding period and has a safety index of 67 in cattle and 1000 in small ruminants. Moreover, as the drug is not patent protected it can be procured in bulk from the open market.

A series of studies on FBZ pharmacokinetics on single and continuous intraruminal dosing, confirm that effective concentration of oxfendazole (OFZ) – the anthelmintically active principal metabolite of FBZ in plasma – could be achieved by daily intraruminal administration of FBZ at 0.5 mg/kg body weight (Sanyal, 1994; Sanyal and Singh, 1992; Sanyal, 1993a). The effective level was reached between days 4 and 6 of drug administration and a plateau was maintained thereafter. The OFZ disposition profile reveals typical zero order absorption-elimination from day 4-6. In other words, by daily low level dosing, the parasites would be exposed to the toxic concentration of the drug for much longer periods without additional use of the drug. Successful incorporation of FBZ in UMMBs at 0.5 g/kg block material has been demonstrated by solid phase extraction and reverse phase high performance liquid chromatography (HPLC). The medicated blocks offered to the animals give sustained levels of the parent drug and its metabolites in the plasma, resulting in selection of drug doses to be incorporated in UMMBs that would ensure the desired plasma concentrations of the anthelmintic in cattle and buffalo (Sanyal and Singh, 1993a; Sanyal, 1993b).

Trials conducted in calves experimentally infected with *Haemonchus placei* for evaluating the efficacy of MUMMBs incorporating FBZ demonstrated that the medicated blocks could effectively remove established adult parasites and also prevent establishment of infection by killing incoming larvae (Sanyal and Singh, 1993b). The anthelmintic delivery device could thus be highly effective for the treatment as well as prevention of gastrointestinal nematodosis in cattle and buffaloes.

Farm and large-scale field trials conducted on replacement heifers and lactating crossbred cattle and buffaloes in Gujarat revealed improvement in animal productivity. Farm-bred heifers of 20–33 months of age and weighing 165–240 kg, licking MUMMB for 4 months, had consistent zero egg counts and a weight gain of 60 g/day (Sanyal and Singh, 1995a). On-farm lactating buffaloes offered MUMMB, produced more milk, with a net gain of 1.0 litre milk per buffalo per day (Sanyal and Singh, 1995b). Sustained parasite control could also be achieved in farm-bred lactating crossbred cattle with an average increase of 0.57 litre milk per animal per day (Sanyal *et al.*, 1995).

Field trials involving buffaloes and cattle in Surat and Ahmedabad Cooperative Milk Unions in Gujarat indicate that the animals with access to MUMMB could withstand parasite challenge even a month after MUMMB withdrawal. Farmers reported improvement in body coat texture and overall health of animals. A field trial conducted by Surat District Cooperative Milk Producers' Union Ltd, Surat, involving 2 000 dairy cattle and buffaloes, indicated an average block intake of 210 g/day. Farmers noted, *inter alia,* an increase in fodder consumption by animals following MUMMB offer, resulting in improved health and hair coat and an average increase of 0.5 litre milk per animal per day.

Studies on parasite epidemiology conducted in NDDB, together with 7 Veterinary Colleges, each representing a geographic zone, revealed greater infection intensity in the host and higher larval burden on pasture following the advent of monsoon rains. However, the date and duration of peak infection varied from zone to zone. Haematophagous abomasal nematodes are the predominant parasites encountered in all geographical and agroclimatic zones. The principal recommendation of an international workshop where these epidemiological findings were discussed was to use medicated blocks at the onset of monsoon rains for strategic and sustainable parasite control in dairy animals (Sanyal and Singh, 1995c).

Anti-fluke MUMMB

For developing MUMMBs incorporating flukicide exploiting the principle of prolonged low-level administration, triclabendazole (TCBZ; Fasinex™, Ciba-Geigy, Switzerland) is the drug of choice as this is the only drug available in India effective against early, immature liver flukes. Pharmacokinetic studies on TCBZ in dairy animals revealed very poor anthelmintic uptake in buffaloes compared with cattle (Sanyal, 1995). Critical efficacy of TCBZ against experimental bovine and bubaline fasciolosis reveal high efficacy of the drug against both immature and mature fasciolosis in cattle at the recommended dose rates of 12.0 mg/kg body weight (Sanyal, 1996), while buffaloes require 24.0 mg/kg body weight or more to control immature and mature fasciolosis (Sanyal and Gupta, 1996a). Daily low-level administration of TCBZ against experimental bovine and bubaline fasciolosis showed that daily dosing for 10 days is required to eliminate mature liver flukes in cattle and buffalo when ingested at a rate of 0.5 and 1.5 mg/kg body weight, respectively (Sanyal and Gupta, 1996b). Thus, different drug dose rates are required for TCBZ MUMMBs for cattle and for buffaloes to ensure delivery of the appropriate minimum daily dose for efficacy against experimental bovine and bubaline fasciolosis (Sanyal and Gupta, 1998).

Conclusion

Control of parasitic disease in India, at least in the foreseeable future, will depend primarily on the use of chemotherapeutic agents. In the event of escalating problems of anthelmintic resistance, food residues and environmental concerns, MUMMBs could become an effective tool for anthelmintic management. This is particularly important as sustained low level administration of benzimidazole anthelmintics has also been found efficacious against larvae of benzimidazole-resistant strains of nematode parasites (Barger, Steel and Rodden, 1993). Prolonged low level administration of anthelmintics through UMMBs would have the following benefits:

- Avoiding the labour needed for conventional oral drenching.
- Avoiding the spillage of medicines that occurs during conventional oral drenching.
- Low but prolonged administration of the drug would not only increase its efficacy against existing worms but also prevent reinfection.
- The urea, molasses and minerals incorporated in the blocks also greatly improve the nutritional status of the animals, which makes them more tolerant to parasites and in turn increases productivity.
- The emergence of anthelmintic-resistant parasites would probably be delayed and the larvae of already resistant parasite strains would be likely to be killed, thereby extending the effective life of existing anthelmintic drugs.
- Strategic application of MUMMBs would help in reduction of worm egg output in the faeces of the animals, resulting in reduced level of pasture contamination and, ultimately, a reduced level of parasitic challenge to young calves, which are highly susceptible to worm infestation.

Thus, MUMMBs could effectively be used as tools for integrated parasite management for sustainable development of dairy animals.

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