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164

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paper

FEED SUPPLEMENTATION BLOCKS

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164

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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).

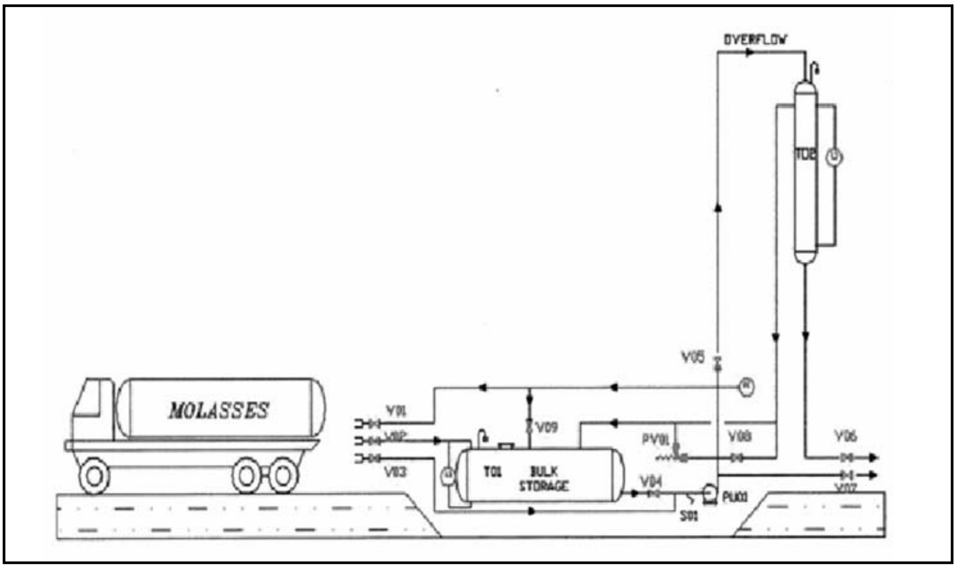

Figure 8 Process flow diagram for molasses storage and distribution at Kuku (Sudan).

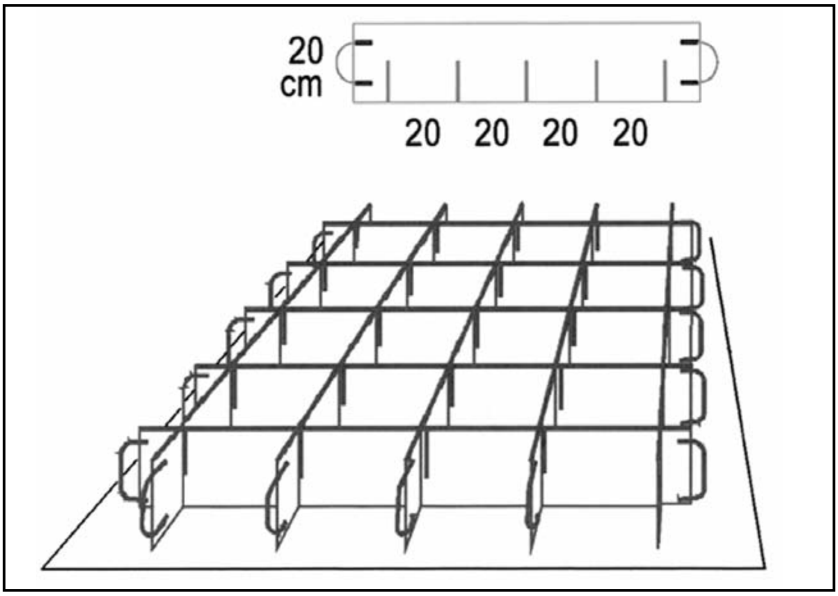

Figure 9 Mould design and construction.

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.

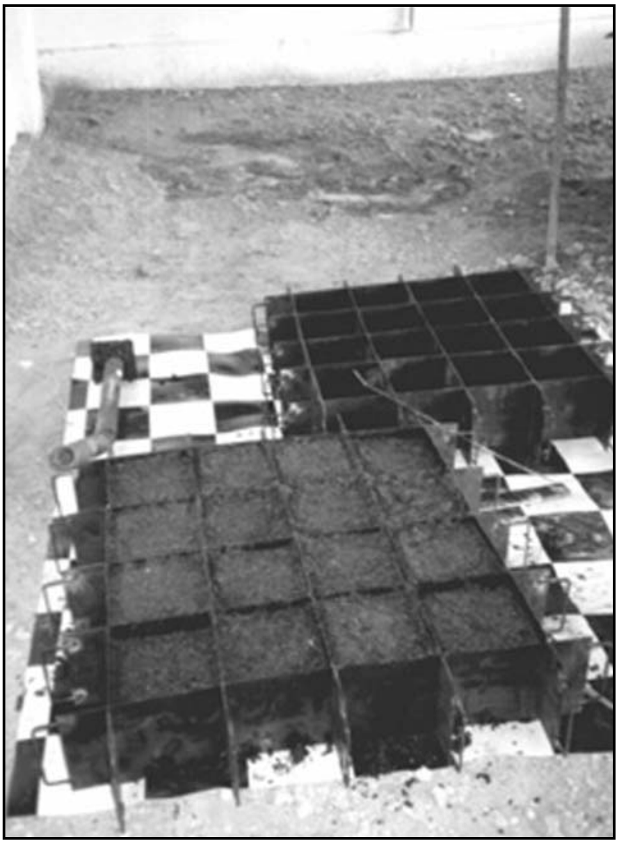

Figure 10 Moulds on a plastic sheet (Somalia).

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.

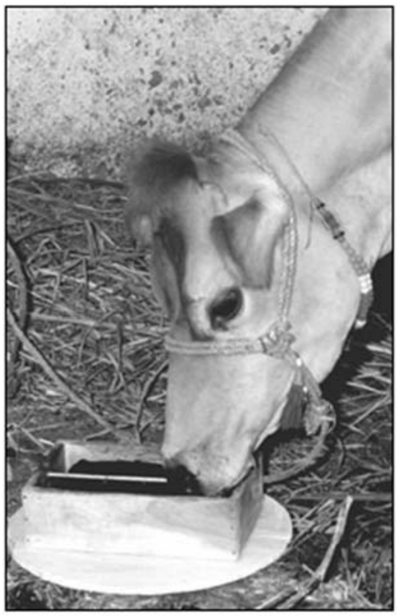
By using various organic acids – citric, tartaric, boric, etc. – it was possible to reduce the pH from 11.5 to 8.5, but the cost was prohibitive. Phosphoric acid also reduced the pH when incorporated at greater than 2 percent in the formulation, but it affected the solidification of blocks, especially 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.

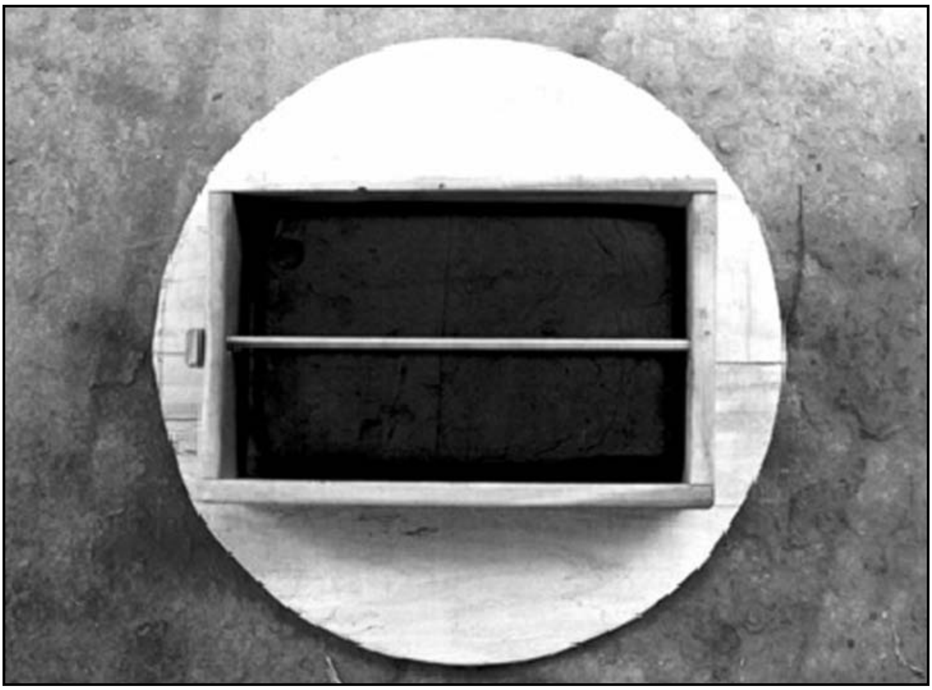


Figure 4.5 A wooden dispenser for UMMB feeding to animals.

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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Experiences with urea-molasses multinutrient blocks in buffalo production and reproduction in smallholder dairy farming, Punjab, India

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Introduction

Dairy farming plays an important role in the economic development of rural India, and about 80 percent of the trade in this sector is in the hands of small-scale and marginal farmers having 1 to 20 animals each. The ever-increasing shortage of good quality feed and green fodder is one of the major factors limiting profitable dairy farming. Green fodder deficiency increased from 29 percent in 1970 to 32 percent in 2000. In contrast, India produces about 360 million tons of agricultural by-products, which have poor digestibility and little nutritive value without further processing. To put these into effective use there is thus a need to improve their nutritive value.

Use of urea as a non-conventional source of non-protein nitrogen for ruminal micro-organisms is well known. In India, urea has been fed to cows and buffaloes in the form of *uromol* (Chopra *et al*., 1974), urea-molasses liquid supplement (Kaur, 1993) and urea-treated straw (Bakshi, Gupta and Langer, 1986). However, the labour and other costs involved in the preservation, transport and feeding of the end product made some of these methods unpopular and precluded their wider adoption by farmers. Urea-molasses multinutrient blocks (UMMB) are relatively free from these constraints, have the merit of providing nitrogen over a longer period of time than any other urea source, and are generally more widely accepted. This paper considers the development, adoption, merits and limitations of

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UMMB technology in India. The focus is on the "cold process' of UMMB preparation, and its application in boosting production and reproduction in dairy buffaloes in Punjab, India.

Formulation and Preparation of UMMB

UMMB use in India dates back to its introduction in 1983 by the National Dairy Development Board (NDDB), Anand. Initially, it was produced by a "hot process', using various formulations, equipment and procedures (Ahuja, Makkar and Kakkar, 1986; Gupta and Malik, 1991; Malik, Makkar and Kakkar, 1993; Garg, Mehta and Singh, 1998). Despite the reasonably evident scientific merits of UMMB application from the above studies, the technology did not match the requirements of farmers and its use remained limited to scientific and teaching institutes. The high initial costs, cumbersome procedures, significant labour requirements and poor cost–benefit ratio rendered it an unpopular proposition for field-level adoption. Subsequently, the "cold process' for UMMB preparation was introduced (Tripathi,1997; Garg, Mehta and Singh, 1998), and later modified to be a sustainable, cost-effective and overwhelmingly acceptable procedure, especially for smallholder dairy farmers (Brar and Nanda, 2002, 2003). This later process has the advantages of being simple, inexpensive and easily adopted by farmers.

Comparative evaluation of the "hot" and "cold" processes for UMMB preparation

For some time, controversy prevailed vis-à-vis the usefulness of the two procedures for UMMB production, which warranted their comparative assessment. The authors' laboratory undertook studies on the comparative merits and demerits of both UMMB preparation procedures, from the point of view of their usefulness under smallholder farming system conditions in India.

UMMB preparation by the cold process

Five formulations (I–V) were tested for the production of blocks using locally-available agro-industrial by-products in Punjab, India (Table 1). Urea was added to molasses, stirred and left standing overnight. Next morning, the rest of the ingredients were mixed together on a polythene sheet or in an iron pan. To obtain a uniform distribution in the whole premix, common salt, being the smaller quantity, was mixed with the cement, before mixing with the other dry ingredients. The urea-molasses mixture was poured into this premix and mixed thoroughly by hand or with a spade (for larger quantities). A known amount of this semi-solid mixture (1.0 or 2.0 kg) was put in an iron frame (9×3×3 in (≈23×8×8 cm); Figure 5.1), covered with a wooden sheet tightly fitting the frame and pressed for

20–30 seconds using the foot pressure of one person (Figure 5.2). The iron frame was then removed, leaving a UMMB block on the polythene sheet. These frames are simple to construct, are used routinely for making earthen bricks, and readily available in the local market. The blocks were left at room temperature to air-dry so as to be hard enough for handling, transport and feeding. The time taken to harden off and other physical characteristics of these blocks are shown in Table 5.2.

Table 5.1
Formulations used for preparing UMMB (percentage by weight).

Ingredients (on a percentage basis)	**Formulation**				
	I	II	III	IV	V
Molasses	40	40	35	35	35
Urea	10	10	10	10	10
De-oiled rice bran	–	26	–	33	17
Oiled rice bran	26	–	33	–	16
Ground-nut cake	10	10	10	10	10
Common salt	4	4	2	2	2
Cement	10	10	10	10	10

Table 5.2
Physical characteristics of UMMBs prepared by the cold process(1)

Characteristics	**Formulation**				
	I	II	III	IV	V(2)
Hardness	+	+	+++	+++	+++
Days to dry at ambient temperature(3)	–	–	8–10	2–4	3–6
Brittleness	–	–	+	++	+
Cost (Rs./Kg)	–	–	4.22	4.02	4.11
Acceptability to animals	Not tried	Not tried	100%	100%	100%

Notes: (1) The blocks were prepared during September–October (average daily room temperature = 20–24°C; humidity = 60–70%). (2) Easy to prepare, as it does not stick to pans. (3) The blocks took a little longer to harden on cloudy days with high humidity.

Blocks from formulations I and II, with 40 percent molasses, were too soft to retain their block shape. The blocks prepared from formulations III, IV and V were acceptably hard, although a variable number of days were required for them to reach the desired hardness. The blocks from formulation IV (33 percent de-oiled rice bran) were relatively more brittle and had a high breakage percentage during transport, leading to wastage, while the blocks from formulation III (33 percent oiled rice bran) were sticky, difficult to prepare and took longer to harden off. Blocks from formulation V, with 16 percent oiled and 17 percent de-oiled rice bran, were relatively easier to prepare, sufficiently hard, less brittle and required only a moderate time (3–5 days) to harden. Blocks weighing one kilogram had a greater tendency to break than the two-kilogram blocks, so the latter were chosen for further studies and dissemination.

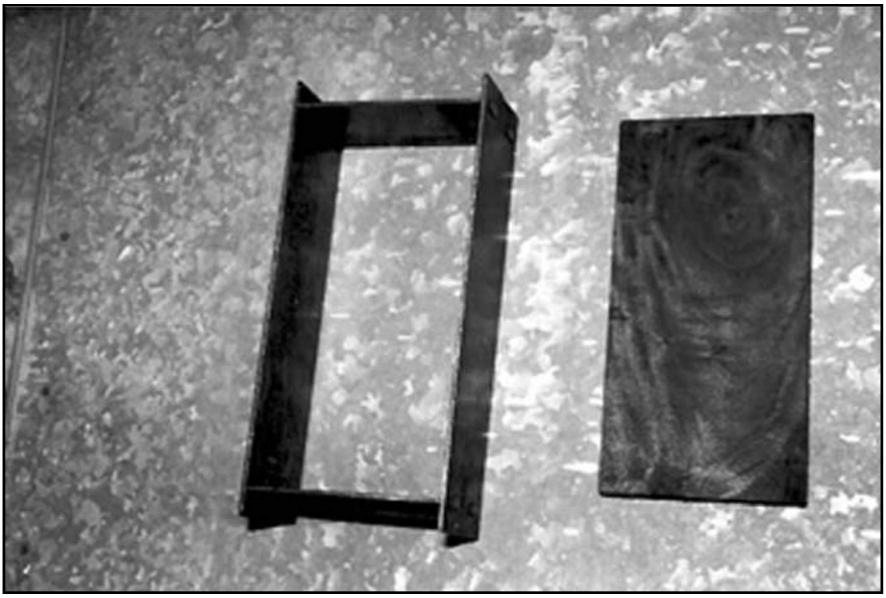

Figure 5.1 Metal mould used to produce UMMBs.

Figure 5.2 Compressing mixture into mould using foot pressure.

UMMB preparation by the hot process

Blocks were prepared using the process of Malik, Makkar and Kakker (1993), using the same five formulations as used in the cold process (Table 5.1). Urea and molasses were mixed together in an iron pan and heated for half an hour while being stirred slowly. Once hot, other ingredients were added and mixed thoroughly. Blocks were prepared by forming this mixture using a hydraulic press. The blocks produced using formulations III, IV and V had the required texture and animal acceptability. However, this method involves heating the ingredients, is labour intensive, takes a longer time and needs costly equipment, such as a hydraulic press. Further, the blocks so produced have been reported to be highly hygroscopic, leading to poor shelf life (Tripathi, 1997; Garg, Mehta and Singh, 1998). As the feed block technology was also being investigated for easy and reliable drug administration for several animal health conditions, the hot method might not be appropriate as it might adversely affect some of the active ingredients. Although the method was adopted by a few commercial firms, the high costs of equipment, infrastructure, additional energy required for heating, and cumbersome procedure militated against its acceptance by small-scale farmers. It could not be extended to the rural masses that own about 75 percent of the dairy buffaloes and contribute about 60 percent of the total milk in the state. The hot process was therefore dropped from further studies on nutrient blocks in the authors' laboratory.

The cold process had the merits of saving time, energy, labour and overall costs in comparison with the hot process. Due to the lower cost, good characteristics of the blocks produced, convenience of their preparation and use in the field, and excellent acceptability in the preliminary trials, this process was selected for further studies at the farmer level.

Nutritive value and block storage quality

The nutritive value (see Table 5.3 for proximate analysis) and keeping quality (shelf life) of formulations III, IV and V were observed over a period of 14 months. The nutritive value in terms of crude protein, neutral detergent fibre, cellulose, ether extract and ash were similar in all the formulations tested and did not vary much during storage (Table 5.3). Marginal differences in components, if any, could be the effect of the type and quantity of ingredients used by different workers (Kakkar and Makkar, 1995; Chauhan *et al.,* 1997). Further, no deterioration in colour, odour or texture was observed in storage, nor any apparent contamination with mould. Of the several lots of the blocks produced, only one lot developed surface mould within one month of storage. This could be due to improper drying or high water content, or both, or prior contamination of the molasses used. Malik, Makkar and Kakkar (1993) had suggested wrapping blocks in polythene sheets to avoid moisture contamination, especially during the rainy season. Based on these observations, it was inferred that the UMMB so prepared could be preserved in a dry environment at room temperature for a reasonable period.

Table 5.3
Proximate analysis of fresh and stored UMMB prepared using formulations III, IV and V (percentage of dry matter)

Components	Freshly prepared UMMB			14-month-old UMMB		
	III	IV	V	III	IV	V
Dry Matter (percent of UMMB)	85.0	84.0	86.5	84.4	81.8	83.5
Crude Protein	42.4	43.0	41.8	40.9	40.8	41.3
Neutral Detergent Fibre	26.7	25.9	26.5	26.0	26.0	27.0
Acid Detergent Fibre	–	–	–	21.0	14.5	17.5
Cellulose	3.6	6.4	4.1	5.0	7.0	5.5
Ether extract	1.4	0.5	0.8	2.5	0.5	1.0
Ash	28.3	26.4	27.5	35.1	22.8	26.5

Acceptance of the blocks by buffaloes

All the animals offered UMMBs accepted them readily. In the first week of the trial, more buffaloes (46 percent) tended to bite the blocks, but this decreased to 26 percent in the second and to about 5 percent in the third and fourth weeks of supplementation. The daily average UMMB consumption by each animal was calculated to be 627 ±34 g. In earlier studies, where bentonite was used as a binder, adult cows and buffaloes consumed 400–500 g of UMMB (Makkar and Saijpaul, 1996). The use of cement as a binder in the present study did not affect the intake of the blocks. The intake of UMMB also depended upon the basic diet being fed to the animals, and the quality and texture of the blocks. Calves kept on lower amounts of concentrate consumed more UMMB (695 vs 559 g/day; Kakkar, Malik and Makkar, 1997).

Studies on the Effect of UMMB Supplementary Feeding – Field trials

Several field studies were undertaken on boosting reproductive performance and milk production through UMMB supplementary feeding in buffaloes.

Effect of UMMB supplementation on reproduction

An efficient reproductive process is a prerequisite for profitable dairy farming. However, delayed onset of postpartum ovarian activity (90–180 days) and high incidence of deep anoestrus, especially during summer (50–75 percent) lead to prolonged inter-calving intervals (15–25 months) in Indian dairy cows and buffaloes, causing huge economic losses to the Indian dairy industry. The major limiting factor is a lack of sufficient good quality feed and fodder, coupled with the limited purchase capacity of smallholder and landless farmers. Several pilot projects were initiated to study the reproductive performance of buffaloes following UMMB supplementation at various stages of reproduction, the results of which are presented below.

Effect of pre-partum UMMB supplementation on postpartum reproduction in buffaloes

High milk production, and therefore excessive drainage of body reserves, in the immediate postpartum period leads to excessive weight loss, which, in turn, suppresses ovarian activity. It is therefore preferable that a dairy animal should have appropriate body reserves before parturition, and sufficient feed intake after parturition to meet its energy demands (Gearhart *et al.*, 1990; Staples, Thatcher and Clark, 1990). The animals are, however, unable to increase dry matter intake, owing to limited rumen capacity and delayed ruminal microfloral adjustment to new, energy-rich diets that are fed conventionally (Goff and Horst, 1997; Roche, Mackey and Diskin, 2000). Hence, good quality feeding pre-partum is needed to develop sufficient body reserves and also to attain timely adjustment of ruminal microflora to the probable postpartum diet (Domecq *et al.*, 1997; Goff and Horst, 1997). The study reported here was undertaken to assess the effect of pre-partum UMMB supplementary feeding on postpartum reproductive performance in water buffaloes.

Thirty-two closely observed buffaloes were provided with UMMB during the last trimester of gestation, and their postpartum onset of ovarian activity was compared with that of unsupplemented controls. Buffaloes in both the groups exhibited first behavioural oestrus between 15 and 45 days (average 24) postpartum. However, plasma progesterone concentrations studied in a limited number of animals revealed that none had ovulated (absence of a rise >1.0 ng/ml). UMMB supplementation did not appear to affect the onset of first behavioural oestrus, which could probably be related to factors other than nutritional status of an animal (Beam and Butler, 1997; Butler, 2000). Ovulatory heat was recorded (plasma progesterone concentration >1.0 ng/ml) in 90 percent of the supplemented and 80 percent of the control buffaloes on average at 48 (range: 34–57) and 34 (range: 23–49) days postpartum, respectively. Incidence of silent heat in the respective groups was 11 percent and 75 percent. The days taken to first ovulatory heat (34 vs 48 days) and the proportion of silent heat (11 vs 75 percent) was noticeably lower in the supplemented than in the control buffaloes. Further, the conception rate during the first 70 days postpartum was noticeably higher in supplemented than in controls (30 percent vs 0 percent). Wider observations involving more buffaloes under field conditions showed that 70 percent of the pre-partum UMMB supplemented buffaloes exhibited fertile oestrus within 60 days postpartum, compared with only 14 percent in control animals.

Effect of postpartum UMMB supplementation on reproduction in buffaloes

Good quality nutrition is a necessity for proper puerperal and postpartum production and reproductive events, which, however, remain constrained by limitations in concentrates and green fodder availability, especially among poor farmers. UMMB supplementation to 14 freshly calved buffaloes belonging to small-scale rural farmers proved beneficial. The average percent body weight loss was greater (0.53 to 3.9 percent) in unsupplemented than in supplemented (0.02 to 3.0 percent) buffaloes. Further, the supplemented buffaloes started gaining body weight earlier (5^{th} week postpartum) than did the unsupplemented controls (7^{th} week postpartum). A higher proportion (71 percent) of the supplemented buffaloes displayed oestrus within 50 days postpartum, compared with only 14 percent in the controls (Randhawa, 2002). Similar benefits, however, could not be seen from UMMB supplementation of buffaloes on larger-scale organized urban dairy farms (Kumar, 2001), probably due to the already better nutritional status of buffaloes (Makkar and Saijpaul, 1996).

Effects of UMMB supplementation in true anoestrus buffaloes

Fifty-four rural buffaloes suffering from true deep anoestrus, as confirmed from history, per-rectal examination of genitalia and circulatory progesterone concentrations, were supplemented with UMMB during September–October. Of these, 90 percent came into heat and conceived within one month of supplementary feeding, compared with only 28 percent in the control group (Brar and Nanda, 2002). In another, similar, trial during May–June – a period with minimal breeding activity in buffaloes (Nanda, Brar and Prabhakar, 2003) – UMMB supplementation for 30 days induced behavioural oestrus in 40 percent of the buffaloes, compared with only 10 percent in the control group. Extended UMMB supplementation for another 30 days (total 60 days) induced behavioural oestrus in 85 percent of buffaloes, with a 100 percent first-service conception rate (Kang *et al.*, 2002). These studies suggested that malnutrition is a major cause of anoestrus, and that it could be ameliorated through UMMB supplementation, although the response was poorer during the hot, dry summer than in spring.

Potentiation of reproductive hormonal therapy through UMMB supplementation

Certain hormones are employed to induce fertility in anoestrus animals. Variable responses, however, have been reported in buffaloes, probably due to the variable nutritional status of treated animals. Therapeutic efficacy of certain hormonal interventions was evaluated following UMMB supplementary feeding in buffaloes. Groups of progesterone-primed anoestrus buffaloes were treated with equine chorionic gonadotrophin (eCG), with or without concomitant UMMB supplementation. Behavioural oestrus was induced in 80 percent of the supplemented and 67 percent of the unsupplemented buffaloes, of which 75 percent and 50 percent ovulated. It is thus evident that UMMB supplementation affected behavioural as well as ovulatory responses of the hormone-treated buffaloes (Kang *et al*., 2003; Randhawa *et al*., 2003a).

From the foregoing, it appears that prevention and treatment of anoestrus through UMMB supplementation strategy is better than eCG treatment, taking into account the total time taken to conceive, requirement for veterinary intervention, costs involved and loss of milk yield.

Effect of UMMB supplementation on milk production in buffaloes

UMMB-supplemented buffaloes showed increased milk yield and higher milk fat values at almost all stages of reproduction. Pre-partum UMMB supplemented buffaloes on average yielded 88 kg more milk per head during the first 60 days of subsequent lactation than did their unsupplemented counterparts. Similarly, an average increase of 8 percent milk yield and 0.5 percentage unit milk fat was recorded following UMMB supplementation postpartum (Brar and Nanda, 2002). Supplemented buffaloes sustained peak milk yield for longer (4 vs 2 weeks) than their unsupplemented counterparts (Randhawa, 2002). UMMB feeding during late lactation led to a 4 percent increase in milk yield and 0.7 percent unit increase in milk fat, whereas the unsupplemented controls experienced a decline in milk yield (Kang, 2002).

Buffaloes treated with eCG for induction of oestrus experienced a drop in milk yield, which persisted for about 5 to 7 days. This drop, however, was reduced by 40 percent in buffaloes supplemented with UMMB before and during hormonal treatment.

Earlier studies by other workers in India (Makkar and Saijpaul, 1996) also reported 6–8 percent increase in milk production in cows consuming 400–500 g UMMB daily. This could replace up to 20 percent of the concentrate in the diet without affecting the quality and quantity of milk produced and body weight in buffaloes fed with 30–35 kg green fodder (Chauhan *et al*., 1997).

Biochemical changes after UMMB supplementation

High circulatory urea concentration, which may occur after consuming protein-rich diet, has been linked to an altered uterine environment and reduced fertility in dairy cattle (Beam and Butler, 1998). UMMB is a urea-based nutritional supplement and apprehensions about its possible ill effects on animal health are not totally unfounded. Laboratory studies were undertaken to assess biochemical changes, if any, following long-term UMMB consumption in buffaloes. The blood urea-nitrogen in all the studies cited above remained within physiological limits (<20 mg/dl). Blood glucose did not differ between the groups of buffaloes studied under field conditions. Total plasma proteins, insulin and creatinine, estimated at weekly intervals in various studies, remained within normal physiological limits. Blood concentration of free fatty acids, an indicator of fat mobilization in lactating animals, was relatively lower in UMMB supplemented than in unsupplemented buffaloes (42 vs 49 mg/dl). This suggested a superior nutritional status in the supplemented animals (Kang, 2002; Randhawa *et al.*, 2003b).

Cost–benefit analysis of UMMB supplementation in buffaloes

Use of UMMB supplementation proved economically beneficial. Taking into account milk production alone, the average cost–benefit ratio of feeding UMMB prepared by the cold process was 1:3. It was 1:2.3 during the summer months (Kang, 2002) and 1:2.9 during spring (Randhawa, 2002). The Highest economic gain (1:4; Brar, 2001) was recorded following UMMB supplementation during the last trimester pre-partum. Overall financial gains were better for relatively underfed animals on small, rural farms, compared with well fed animals in urban dairy units (Kumar, 2001; Randhawa, 2002).

Obviously, the economic returns are more appreciable after feeding UMMB prepared by the cold process than by the hot process because of the lower costs of the former (Malik *et al.*, 1997; Brar, 2001). The actual economic returns from UMMB supplementation are much more than reported in the preceding paragraphs because of the general improved reproductive performance in the supplemented buffaloes. Increased milk fat yield would also add to the benefits.

Extension of UMMB technology to the field

Extensive efforts have been made to transfer the technology to the end-user, the farmer. The process of extension adopted by the authors' team included:

(i) training trainers, namely Field Veterinary Officers, veterinary students, research scientists from various national veterinary and animal husbandry teaching and research institutes and state agricultural universities from 17 of the 27 states in India, and international visiting fellows from Indonesia and Bangladesh;

(ii) training farmers, through more than 50 field demonstrations given to rural dairy farmers at village-level centres and at animal welfare camps organized in collaboration with Punjab State Animal Husbandry Department. A UMMB Farmers' Club has been established, which at the time of writing had over 200 members;

(iii) implementing pilot projects in more than 20 villages to study and to demonstrate the benefits of UMMB supplementation. At first, the blocks were prepared and distributed free-of-cost to the enrolled farmers, while later on they were encouraged to produce blocks for themselves on a routine basis;

(iv) training private entrepreneurs in preparation of and supplementation with UMMB on a commercial scale. Several private UMMB production centres, organized mainly by the farmers, are now producing and selling UMMB in Punjab. Mass UMMB production has been initiated at some places after introducing minor changes in the procedures. Production of 1 200 blocks by one entrepreneur in about four hours has been recorded; and

(v) establishing 17 pilot farms in villages in the vicinity of Milk Collection Centres, which are frequently visited by the local dairy farmers. This proved highly effective in transfer of UMMB technology from farmer to farmer.

The UMMB extension procedures used by the team vary somewhat from the approach used by many earlier workers. The current emphasis has been more on improvement of animal reproductive performance, for which veterinary intervention is often needed. Training of field veterinarians has thus been of immense help in extension of UMMB technology to the end user. In addition, the UMMB club has worked well through farmer-to-farmer contacts.

Experiences with medicated blocks

Limited work on this aspect of UMMB use has been done in India. Incorporation of fenbendazole in blocks led to 13 percent increase in milk production in buffaloes (Knox, 1995; Sanyal and Singh, 1995). In the authors' laboratory, preliminary trials on medicated blocks carrying Replanta, a herbal drug, hastened uterine involution and postpartum ovarian activity. Further work is in progress.

Limitations of UMMB Production in India

India is a vast country, with varied agroclimatic conditions and agro-industrial by-product availability. Further, the climate changes a lot over the year. This variability implies that no single block formulation, or even process, may be valid at all times and in all places.

India has extreme fluctuations in green fodder availability over the year. While blocks would be in high demand during the two fodder lean periods (April–June and November–December), use of UMMB might not be beneficial during gluts of lush fodder. This may affect the interests of commercial UMMB firms, making it an unsustainable preposition. Nevertheless, this could be effectively handled through providing information on when and when not to use the feed supplementation blocks.

Blocks prepared by addition of tree leaves (Gupta and Malik, 1991) or other unconventional ingredients (Saijpaul and Makkar 1996) could not be popularized due to the limited area of their potential application.

Future Of UMMB technology in India

The fast increasing human population pressure is reducing the land available for fodder production. However, the increased cereal production leaves abundant agro-industrial by-products, and UMMB has a great role to play in the profitable utilization of these by-products, simultaneously reducing potential environmental pollution. Apart from the importance of UMMB in reproduction, as discussed earlier, there is a great potential role to play in meeting the nutritional needs of animals in drought-prone western states and in flood-affected eastern states of India. The use of medicated blocks for control of endoparasites should be exploited in small ruminants. The authors' have already started exploring the use of UMMB in solving the major problem of "delayed puberty" in buffaloes. The use of UMMB as carrier to deliver many herbal digestive stimulants, herbal galactagouges, herbal ecbolics, ionophores and anthelmintics is under consideration.

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Urea molasses multinutrient blocks technology – Bangladesh experiences

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Introduction

Bangladesh is an agricultural country, and livestock play an important role in the rural economy. There are about 24 million cattle, with an average milk production of 1.0 kg/day in local cow and about 3.0 kg/day in crossbred cow. About 1.62 million tonne of milk is produced for 140 million people, and per capita availability of milk was 30 ml in 1999-2000 (DLS, 2001). The average milk production of small-scale market-oriented dairy cows is 5 kg/day. Practically no grazing land is available for animals due to high pressure on land for cereal grain production for human consumption. Low productivity and poor reproductive performance in local and crossbred cows due to feeding with poor quality straw-based diets and improper management are common features of livestock husbandry in Bangladesh. There is a serious scarcity of green grass, and consequently agricultural crop residues or by-products are fed to the animals, together with only a limited amount of high-cost concentrate. As a result, smallholder farms face serious problems in feeding dairy animals for optimum production. For several years, attempts have been made to help the smallholder farmers make the best possible use of locally available feed resources so that crops and livestock can be produced more efficiently and profitably. Feed supplementation strategies have been developed to correct the nutrient

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deficiency of poor quality roughages. Urea-molasses multinutrient blocks (UMMBs) have been introduced at village level and on mini-dairy farms in some urban and peri-urban areas in Bangladesh.

Initially, the focus was on increasing straw utilization by ruminants, because straw is the major source of feed available. Although straw is available in large quantities, it is low in nutritive value due to its high lignocellulose content, with only small amounts of crude protein and essential minerals. It was possible to improve the feeding value of rice straw using chemical treatments (Saadullah, 1991), but this approach did not become popular among farmers because of the extra cost and extra work involved (Akbar, 1992). In order to find suitable supplements to optimize rumen fermentation to enhance production and improve reproductive performance, one approach used was to supplement the rice straw with more readily available materials to provide the energy and protein that were lacking in the basal diet.

After studies on the nutritional status of the animals, the selected supplement was made into a UMMB that could be licked by the animal. UMMB was prepared with locally available feed ingredients that are cheap, and with some ingredients produced on-farm as agricultural by-products. Considering the nutritive value and cost of block constituents, the composition of a typical block was 39 percent sugar-cane molasses, 20 percent wheat bran, 20 percent rice polish, 10 percent urea, 6 percent lime powder and 5 percent common salt. Molasses from the sugar cane industry is available at low cost, although it is now also being used for various purposes in the food and pharmaceutical industries. Rice polish and other ingredients are also available at a reasonable low cost. The cold process was used for manufacturing block on a small scale (Sansoucy, 1995). This method is simple and does not require expensive equipment to make the blocks. Urea and salt are mixed in a bowl with the required amount of molasses, and kept overnight. Then lime powder, rice polish and wheat bran are mixed thoroughly (Figure 6.1). The previously mixed molasses, urea and salt is then poured onto the mixture of wheat bran, rice polish and lime powder. The mixture is then mixed thoroughly by hand or with a concrete mixer (for medium-scale production) and poured into a wooden or steel mould, typically about 9″ × 5″ × 6″ (≈23×13×15 cm) in size (Figure 6.2). The material is pressed into the mould using foot pressure or a simple press (Figure 6.3), and then released from the mould and set aside to harden on the floor (Figure 6.4). Pressure on the block in a mould can also be created with a ball press machine for easier operation and small-scale production. Hardening requires at least 15 hours at room temperature. The block is then ready for presentation to the animal (Figure 6.5).

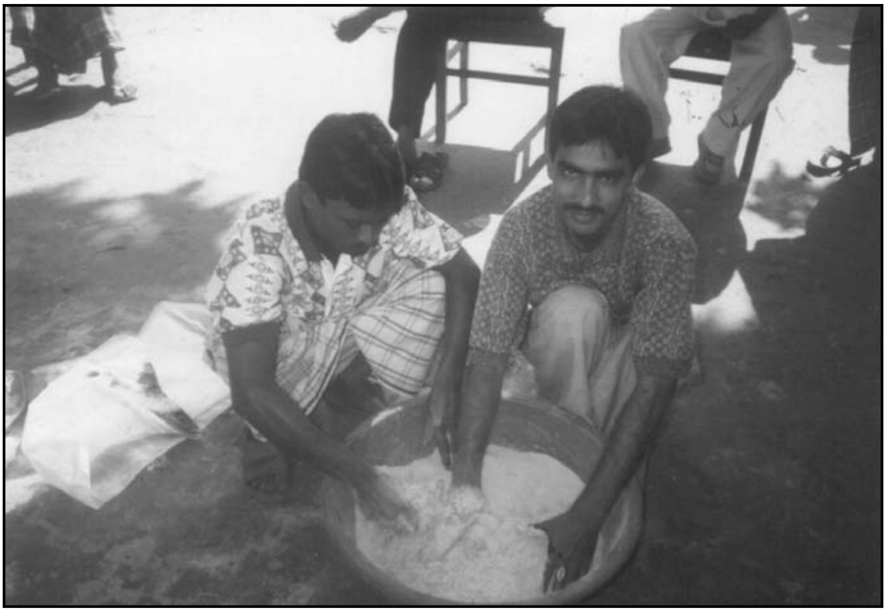

Figure 6.1 Mixing of wheat bran, rice polish and lime powder.

Figure 6.2 Placing the mixture into a mould.

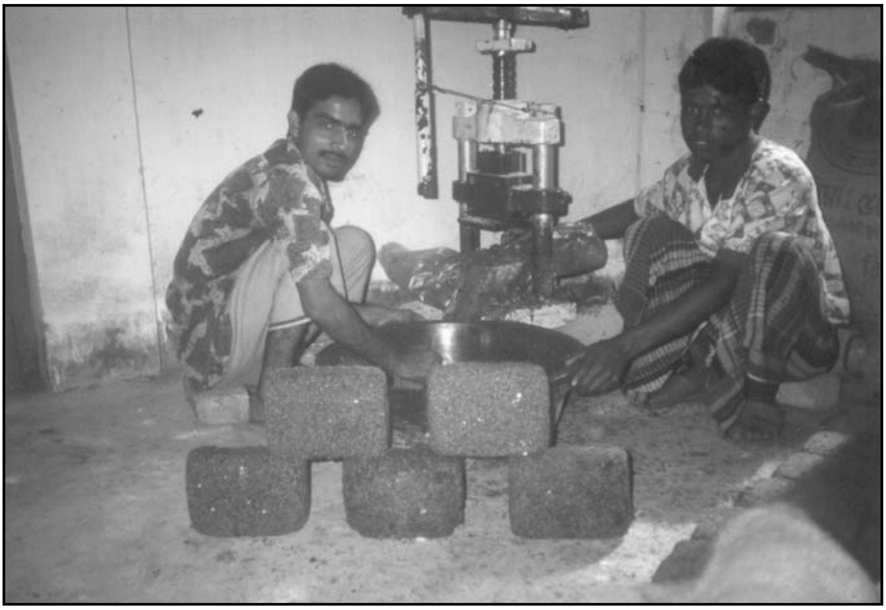

Figure 6.3 A mechanical device being used for making UMMB licks.

Figure 6.4 Removing a block from the mould.

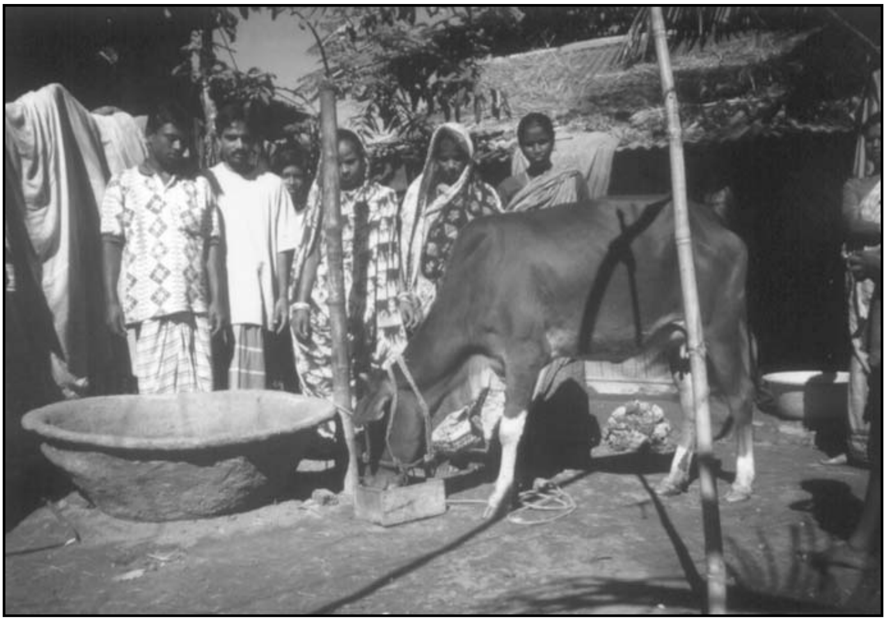

Figure 6.5 Block being licked by a cow.

UMMB licks for improvement of milk yield and reproductive performance of indigenous cows

To test the effects on intake and productivity of cattle, as well to assess acceptance by farmers, UMMBs were distributed to farmers in selected villages in Mymensingh district who were rearing indigenous cows on straw-based diets. Milk yield, body weight gain, calf weight gain and body condition score increased on providing UMMB licks for cows (Table 6.1)

With UMMB supplementation, cows came into heat earlier after calving (Table 6.2). The first progesterone (P4) rise of a cow after calving, first detectable heat, calving-to-conception interval and calving interval were shorter in UMMB-supplemented cows compared with unsupplemented indigenous cows (Mazed, 1997). Positive effects on milk production and reproductive performance of indigenous cows were also reported by others workers (Maih *et al.*, 1999, 2000). They found that milk yield and body weight gain of cows and of suckling calves improved upon providing UMMB licks.

Table 6.1
Effect of feeding UMMB on productive performance of indigenous cows and calves.

Parameter	Treatment		Level of significance(1)
	-UMMB	+UMMB	
Milk yield (kg/day)	1.47	1.84	*
Body weight change of cow (g/day)	-33	-4	NS
Calf's weight gain (g/day)	66	110	**
Body condition score of cow on 1-5 scale	2.31	2.51	**

NOTE: (1) * P <0.05; ** P <0.01. SOURCE: Mazed, 1997.

Table 6.2
Effects of feeding UMMB on postpartum reproductive performance of indigenous cows (Mazed, 1997)

Indicators	Treatments		Level of significance
	-UMMB	+UMMB	
Interval from calving to:			
1st progesterone rise (days)	104	103	NS
1st oestrus (days)	194	130	**
Conception (days)	199	162	NS
Calving interval (days)	480	443	NS

NOTE: ** P <0.01

Optimum level of UMMB for crossbred cows

Further attempts were made to assess the effect of feeding UMMB on milk yield and reproductive performance of crossbred cows reared in commercially oriented small-scale dairy farms in peri-urban areas and villages, fed a rice-straw-based diet. UMMB was made using locally available feed ingredients: molasses (39 percent), wheat bran (20 percent), rice polish (20 percent), lime powder (CaO) (6 percent) and common salt (5 percent). The blocks were prepared using the cold process. Four levels of UMMB were fed to the cows (0; 350; 500; and 650 g/head/day of block (treatment groups T_0, T_1, T_2 and T_3, respectively) to establish the optimum amount of UMMB required for maximum production response in crossbred cows with an average of 300 kg body weight and fed 2.75 kg/head/day of homemade concentrate mixture, with an initial milk production of about 6 kg/day. In this context, it should be noted that long anoestrus periods and infertility are serious problems in rearing crossbred cows in Bangladesh. Results were encouraging. On feeding UMMB, milk yields of dairy cattle increased by 1 to 1.5 kg/day (Table 6.3). The optimum level of UMMB for crossbred cows to achieve higher milk production and better reproductive performance was 500 g/head/day.

Cows and calves with access to UMMB licks gained more body weight than their counterparts without access to UMMB. The intervals from calving to initiation of luteal activity, oestrus and conception were shorter in UMMB-fed lactating cows (Table 6.4).

The postpartum reproductive intervals of cow can be reduced by feeding UMMB (Hendratno, 1999), which is of economic significance. It was interesting that the difference between first progesterone rise and first detectable oestrus were 66 to 80 days in groups T_0 and T_3 (Table 6.4), which indicated that the farmers were unable to detect heat at its first occurrence, resulting in 3 to 4 heats lost without insemination. The calving interval of cows was reduced by 64 days in group T_2, which has an economic value as more calves are produced over the total reproductive life of a cow. Taking 10 years as a typical reproductive life of a cow, it is expected that a cow in the T_0 group will produce 7 calves in her total reproductive life, while cows in group T_2 group will produce 8 calves each. The additional calf and lactation from each cow earns more profit in the T_2 group of animals.

Table 6.3

Mean values for milk yield, body weight change in cows and calf weight gain.

Parameter	Diet(1)				SEM	Level of significance
	T_0	T_1	T_2	T_3		
Milk yield (kg/day)						
180 days average	5.42	5.49	6.81	6.83	0.009	*
Lactation average	3.33	3.38	4.19	4.20	0.055	*
3.5 percent FCM(2)	5.95	6.38	8.16	8.16	0.106	* *
Lactation yield (kg)	1115	1196	1527	1531	19.85	* *
Body weight change of cow (g/day)	9.4b	65.9ab	88.1a	88.4a	4.302	*
Calf weight gain (g/day)	159b	167b	215a	228a	2.717	* * *

NOTES: (1) The diets were: T_0 = Control (no UMMB); T_1= 350 g/head/day UMMB; T_2 = 500 g/head/day UMMB; T_3 = 650 g/head/day UMMB. (2) FCM = fat-corrected milk. a,b = means with different superscripts differ significantly (P <0.05).

Table 6.4
Effect of UMMB on postpartum reproductive intervals of cows

Indices	Diets(1)				SEM	Level of significance
	T_0	T_1	T_2	T_3		
Interval from calving to- (d)						
1st progesterone rise (days)	96	87	82	62	3.486	NS
1st oestrus (days)	162	132	123	142	4.555	NS
Conception (days)	234	187	170	170	5.702	NS
Next calving (days)	517	470	453	460	5.670	NS
Calving interval reduced (days)	–	47	64	57		* * *
Service per conception(2) (No.)	2.67^a	2.0^b	1.8^b	1.73^b	0.044	NS

NOTES: (1) Diets were: T_0 = Control (no UMMB); T_1 = 350 g/head/day UMMB; T_2 = 500 g/head/day UMMB; T_3 = 650 g/head/day UMMB. (2) Means with different superscripts differ significantly (P <0.05). NS = not significant.

Economic returns were calculated for the different groups of animals. The highest profit was earned from the T_2 group (US$ 2.11), fed 500 g of UMMB/head/day (Table 6.5).

Table 6.5
Economic benefit from UMMB supplementation in cows

Item	Diet(2)			
	T_0	T_1	T_2	T_3
Cost (Tk/day)(1)				
Cost of supplement [1]	0	2.52	3.60	4.68
Cost of basal diet [2]	29.71	32.94	34.13	34.16
Total feed cost [A = 1 + 2]	29.71	35.46	37.74	38.84
Income (Tk/cow/day)				
from milk sale [a]	119.00	127.60	136.20	136.60
from cow weight gain [b]	0.75	5.27	7.04	7.08
from calf weight gain [c]	12.72	13.28	17.20	18.56
Total income [B= a + b + c]	121.80	128.33	160.44	162.24
Profit [B –A] (Tk/cow/day)	92.09	92.87	122.70	123.40
Profit (US$/cow/day)	1.58	1.60	2.11	2.12
Cost:benefit ratio	1:3	1:2.7	1:3.3	1:3.2

Notes: (1) Calculated in taka (Tk). Exchange rate at the time of reporting: Tk 58 = US$ 1.
(2) Diets were: T_0 = Control (no UMMB); T_1 = 350 g/head/day UMMB; T_2 = 500 g/head/day UMMB; T_3 = 650 g/head/day UMMB.

A number of studies in villages and peri-urban areas of Bangladesh have demonstrated the benefits of using UMMB as a supplement with cut-and-carry forages offered to dairy cattle on smallholder farms.

Replacement of concentrate by UMMB

Efforts have been made to replace concentrate by UMMB and to study performance under village farming condition. Concentrate feeds are costly and not available throughout the year. Moreover, smallholder farmers are reluctant to purchase concentrate ingredients when milk production goes down at the end of the lactation. Many farmers rear cows on very small amount of concentrate to minimize feed cost. To study the effect of replacing concentrate by UMMB, 60 multiparous crossbred dairy cows reared on straw-based diets were selected. Three diets, comprising a daily ration per head of 2.75 kg concentrate (T_0), 2.45 kg concentrate + 0.30 kg UMMB (T_1) or 2.25 kg concentrate + 0.50 kg UMMB (T_2), were fed to three groups of 20 lactating cows each. Rice straw was fed as roughage, with a very small amount of cut-and-carry grass (1.4 kg/head/day) under zero grazing conditions for 180 days. The results are presented in Table 6.6. Animals in group T_2 had significantly (P <0.001) higher roughage intake, and milk yield was also improved significantly (P <0.05) (6.94 kg/head/day). The fat content of milk increased in T_1 (45.8 g/kg) and T_2 (48.4 g/kg) groups compared with the control, T_0 (40.4 g/kg). The highest content of fat was in the T_2 group, which resulted in higher economic return. Body weight gain of calves was improved significantly (P <0.05). Calving interval was also reduced by 60 days. The highest profit was in the T_2 group (US$ 2.70/head/day), and derived mostly from replacing concentrate by 500 g UMMB/head/day.

Protein content of milk increased with increasing amounts of UMMB, and non-fat milk solids (SNF) and total solids (TS) also increased when concentrate was replaced with 300 g and 500 g UMMB in groups T_1 and T_2, respectively (Table 6.7). Supplementation with UMMB resulted in improved milk quality.

Table 6.6

Effect of UMMB supplementation on intake, milk yield and body weight change of cows and calves.

Parameters	Diet$^{(2)}$ T_0	T_1	T_2	SEM	Level of significance$^{(1)}$
Roughage intake (kg DM/day)	6.9	8.0	9.2	0.177	* *
Total DM intake (kg/day)	9.4	10.5	11.3	0.29	NS
Milk yield (kg/day)	5.6^b	5.8^b	6.9^a	0.07	* * *
3.5% FCM (kg/day)	6.1^b	6.9^b	8.5^a	0.09	* * *
Body weight change of cow (g/day)	6.1	13.7	42.9	5.46	NS
Calf weight gain (g/day)	160^b	181^b	248^a	4.74	*
Calving interval (days)	485	483	425	10.48	NS

Notes: (1) * * * = P<0.001; NS = not significant (P >0.05). (2) T_0 =2.75 kg concentrate per day, no UMMB; T_1 = 2.45 kg/day concentrate + 0.30 kg/day UMMB; T_2 = 2.25 kg/day concentrate + 0.50 kg/day UMMB. Means with different superscripts differ significantly (P <0.05). DM = dry matter

Table 6.7
Effect of UMMB supplementation on milk composition of crossbred cows

Components		Diet(1) T_0	T_1	T_2	SEM	Level of significance
Milk fat	(g /100 g)	4.04	4.58	4.84	0.15	NS
Milk protein	(g /100 g)	3.5	3.56	3.62	0.05	NS
Lactose	(g /100 g)	3.95	3.93	4.10	0.04	NS
SNF	(g /100 g)	8.12	8.17	8.42	0.08	NS
TS	(g /100 g)	12.16	12.77	13.26	0.19	NS

KEY: SNF = non-fat milk solids. TS = total [milk] solids.

NOTES: (1) T_0 = 2.75 kg/day concentrate, no UMMB; T_1 = 2.45 kg/day concentrate + 0.30 kg/day UMMB; T_2 = 2.25 kg/day concentrate + 0.50 kg/day UMMB.

Table 6.8
Economic benefit from UMMB supplementation with different amount of concentrate in crossbred cows.

Item	Diet(2) T_0	T_1	T_2
Cost (1) (Tk/day)			
Cost of supplement [1]	0	2.16	3.60
Cost of basal diet [2]	29.70	29.48	29.75
Total feed cost [A= 1 + 2]	29.70	31.64	33.35
Income (1) (Tk/day)			
Income from milk sales [a]	122.0	138.2	169.0
income from cow weight gain [b]	0.48	1.09	3.43
Income from calf weight gain [c]	12.80	14.48	14.72
Total income [B= a + b + c]	135.28	153.77	187.15
Profit [B -A] (Tk/day)	105.58	122.13	153.80
Profit from UMMB supplement (US$/day)*	1.85	2.14	2.70
Cost:benefit ratio	1:3.5	1:4	1:5

NOTES: (1) Calculated in taka (Tk). Exchange rate at the time of reporting: Tk 58 = US$ 1. Milk price = Tk. 20.00/kg, Concentrate = Tk 7.40/kg; UMMB = Tk 7.20/kg. (2) Diets: T_0 = 2.75 kg concentrate, no UMMB; T_1 = 2.45 kg concentrate + 0.30 kg UMMB/day; T_2 = 2.25 kg concentrate + 0.50 kg UMMB/day.

Economic benefits of partial replacement of concentrate with equal amount of UMMB were assessed. Replacing concentrate by 300 g or 500 g UMMB per day resulted in more earnings than feeding concentrate alone (Table 6.8). The benefits of replacement of concentrate were due to the lower cost of UMMB compared with concentrate mixture, and improved milk yield and quality, especially higher fat content. It was observed that the body weight gain of suckling calves was higher in groups T_1 and T_2 (181 g/day and 248 g/day, respectively) than in the non-replacement group (160 g/day), which also has an economic value. Similarly, early postpartum weight gain of a cow has a positive effect on the next pregnancy and calving. It was observed that the cost-benefit ratio was highest in group T_2 group (1:5), with a total profit of US$ 2.70/day (Table 6.8).

Feeding UMMB to animals for growth

In Bangladesh, animals frequently suffer from stunted growth because of poor nutrition. The only feeds are rice straw and small quantities of cut and carried forage, which is seasonally available., Attempts were therefore made to supplement their diets using UMMB licks. The results were encouraging. Use of UMMB increased liveweight gain of buffalo heifers (Akbar, Islam and Moldak, 1991). UMMB supplementation with straw-based diets for indigenous cows resulted in 4.8 percent increased liveweight gain after calving, and it also stimulated initiation of ovarian cyclicity earlier than in counterpart unsupplemented animals (Ghosh, Alam and Akbar, 1993).

UMMB supplementation in dry season

The principal animal feed resource in Bangladesh is rice straw (90 percent of roughages), and rice by-products, such as rice polish. Farmers also feed their cattle with mixed green fodder (grass and forbs) cut from roadsides, but during the dry season – November to April – such mixed green fodder is not available and the animals are completely dependent on rice straw as the sole feed. To sustain the level of milk production, supplementary feeding is essential for dairy cattle. In addition, many of the cattle in Bangladesh calve during the dry season.

Supplementation with UMMB has been proved to be an effective strategy to compensate for the nutrients deficit in the conventional base diet.

A limited area of fallow land, roadsides and other areas has been used as open grazing land (locally called *Bhathan*) in Sirajgonj district in the dry season (November–April). A limited effort has been made to manage this rough pasture land and mixed grasses are grown naturally. Animals are kept temporarily in this area for the dry period (7 months), with a small amount of concentrate (1 or 2 kg/day). Dairy cows are underfed, and poor milk production and body weight loss are common features of this type of cattle rearing. During the rainy season (June–October) these animals are kept in stalls in the farmer's homestead and stall feeding is practised. In this season, land is inundated and no green grass is available in this area for animals. Consequently, rice straw is the only roughage for maintaining body weight and milk production. UMMB supplementation may play an important role in this situation as well. According to farmer's observation and experience, feeding 500 g UMMB/day to a lactating cow can sustain milk production without any concentrate. Many farmers have been making UMMB on their farms and feeding to lactating cows for more milk and to bring their cows into heat early. Some farmers have been using UMMB as a substitute for concentrate. A considerable number of farmers have accepted this technology on their own initiative.

UMMB supplementation in working animals

In Bangladesh, Saadullah (1991) observed that supplementation of UMMB to draught cows fed a basal diet of urea-treated rice straw or untreated rice straw increased feed intake, daily milk yield, lactation period and daily liveweight gain from calving to pregnancy detection. The supplementation also increased the draught output (Table 6.9).

Table 6.9
Performance of draught cows with or without UMMB supplementation on rice-straw-based diets in Bangladesh.

Parameters	Untreated straw		Treated straw	
	-UMMB	+UMMB	-UMMB	+UMMB
Milk yield (g/day)	452	460	515	570
Lactation period (days)	220	235	246	255
Liveweight gain from calving to pregnancy detection (days)	20	40	87	150
First heat after calving (days)	210	210	205	195

Farmers' observations and experiences with UMMB feeding in Bangladesh

- Farmers reported that their animals looked healthier, their skin appeared shiny, and they had good body condition.
- Their animals consumed more feed, especially roughages, with increased straw intake.
- Their animals came into heat earlier after calving.
- Concentrate provision could be reduced by UMMB use to sustain milk production.
- Cows with access to UMMB continued giving milk for a longer period.
- Milk production could be sustained by providing UMMB to low yielding (2–6 kg/day) cows, without feeding any concentrate.

Factors influencing the adoption of UMMB technology in Bangladesh

- The price of ingredients used in UMMB making fluctuate according to the season. For example, the price of molasses in the local market is unstable, reflecting its seasonal availability. Its availability is higher and price lower in the sugar cane crushing season.
- Farmers are interested in getting the blocks in a readymade form in the local market, but there is no large-scale manufacturer in the market.
- Level of education of the farmers is an important factor. The technology was adopted more rapidly in those places having a higher proportion of literate people.
- The economic condition of farmers affects technology adoption. Poor

farmers are unable to purchase UMMBs due to lack of money, as they purchase their food daily and often meet requirements by selling milk on a daily basis.
- Large-scale production of UMMB, which could increase availability, is probably not possible without financial support from the Government, due to lack of capital investment.
- Usually, medium-scale milk producers (5–15 kg milk/day) at village level are more concerned about increasing milk production and are ready to invest in the technology. Farmers having only one or two cows with low production levels are less interested in additional investment.

Factors for successful development and use of UMMB technology in Bangladesh

The use of UMMB has become popular in Bangladesh. Several factors have influenced this development.
- A severe scarcity of feeds and fodder for ruminants, and feeding low quality rice straw results in lower milk yield and poor reproductive performance. Increased milk production and reproductive efficiency can be easily achieved using an N-containing supplement.
- Good demand for milk. This encourages farmers to use a supplement, such as UMMB, that can be produced at home using cheap, locally available, feed resources.

Conclusion

UMMB supplementation is an effective means of correcting nutrient deficits in poor quality roughages. It use as a supplement improved productivity of local and crossbred cows reared on straw-based diets. High-cost concentrates can be replaced by UMMB licks. The studies showed that milk production could be sustained by providing UMMB without any concentrate up to outputs levels of 5 kg of milk per day. UMMB supplementation can be recommended to improve the nutritional status of cattle fed straw-based diets in Bangladesh. There is a need to extend this technology to a greater number of farmers through intensive extension efforts.

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Feed supplementation blocks – experiences in China

Jian-Xin Liu[10], **Ruijun Long**[11] and **Degang Zhang**[12]

Introduction

With the development of animal production and adjustment in the structure of livestock husbandry, the numbers of herbivores in the People's Republic of China increased rapidly in the last decade. This development has been based on both increased utilization of crop residues and increased cultivation of grass and forage. Since 1992, when livestock production based on crop residues was included in the State Agriculture Comprehensive Development Project, significant progress has been made (Guo and Yang, 1997). There has been a large increase in beef and mutton production, with large-scale extension campaigns for utilization of crop residues. However, efficiency of livestock production is not satisfactory because digestibility of straw is low and lacks protein. Many farmers in rural and peri-urban areas usually offer their cattle and sheep only limited concentrate supplementation. The animals suffer from malnutrition due to insufficient supply of minerals, of nitrogen in particular.

As an important and effective supplementary feed, multinutrient blocks were introduced into China in the early 1990s (Guo and Zhang, 1991). Since then, extensive research work has been conducted in China on the preparation and use of multinutrient blocks for ruminant animals, including beef cattle (Lai *et al*., 1997; Liu *et al*., 1995; Ma *et al*., 1995; Zou *et al*., 1998), goat and sheep (Jia *et al*., 1995; Xu, Tian and Wang, 1994; Yang, Jiang and Wen, 1996; Chen *et al*., 2001b; Zhang *et al*, 1998b), buffalo (Guan *et al*., 2001a; Zou *et al*., 1996; Lu *et al*., 1995), dairy cattle (Chen *et al*, 1993a, 1993b; Wang *et al*, 1995; Tang *et al*., 1998), and yaks (Zhang, 1998; Dong *et al*., 2002; Long *et al*., 1998; 2002). Much progress has been made and new techniques have been developed for manufacturing multinutrient blocks in China.

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Formulas and composition of the blocks

Ingredients of the blocks

The multinutrient lick blocks developed in China contain molasses, urea, common salt and minerals, with aim of supplying roughage-based diets with fermentable N, soluble carbohydrates and minerals. In addition to ground maize, rice bran and wheat bran, oilseed meals, grass meal, bone meal and vitamin premix have been included in the blocks (Chen *et al.*, 1993a; Li *et al.* 1995; Zou *et al.*, 1996; Gao and Meng, 2002). Table 7.1 gives some sample formulas of multinutrient lick blocks from China.

Molasses is a source of easily fermentable carbohydrates and is a binder. Blocks are highly palatable when they contain molasses. It has been demonstrated that mixing molasses and urea can greatly slow the release of NH_3-N in the rumen. Mineral premix usually contains calcium, phosphorus and sodium as well as micro-elements such as Fe, Cu, Mn, Zn, I, Se and Co (Liu *et al.*, 1995; Zhang *et al.* 1999). Lime or cement has been used commonly as a solidifer and binder. Ordinary clay or bentonite has also proved efficient for block making (Chen *et al.*, 1993b; Guan *et al.*, 1998). Farmers in some regions used loess as a binder (H.W. Ye, *pers. comm.*).

In a series of demonstration trials in Gansu province, where the basic animal diet comprised wheat straw and other stubble, Chen *et al.* (1993a) chose three formulas to satisfy the needs of cows, heifers and calves (Table 7.1). Many workers have used molasses as one ingredient for blocks (Li *et al.*, 1995; Yang, Jiang and Wen, 1996; Guan *et al.*, 1998), but Liu *et al.* (1995) chose a formula of lick block without molasses, as it is expensive and in short supply in some regions.

Table 7.1
Some formulas of multinutrient lick blocks used in China.

Animal	Urea	Molasses	Salt	Cement	Lime	Clay	Mineral mix	Wheat bran	Maize meal	Oilseed meal	Bone meal	Grass meal	Ref.
Dairy cattle													
Cow	16	8	26	–	10	11.5	23.8	–	5	–	–	–	[1]
Heifer	12	10	26	–	10	15	22	–	5	–	–	–	[1]
Calf	0	15	22.8	–	10	15	22.2	–	10	–	5	–	[1]
Beef cattle	10	38	1	10	–	–	1	40	–	–	–	–	[2]
Sheep	13	26	10	–	–	5	16	30	–	–	–	–	[3]
Sheep	13	26	10	4	–	0	17	30	–	–	–	–	[3]
Sheep	13	26	10	8	–	0	13	30	–	–	–	–	[3]
Sheep	11.8	19.5		13.6	–	–	13.6	20.9	14.6	6	–	–	[4]
Goats	10	35	5	5	10	5	2	25	–	–	–	–	[5]
Goats	10	35	5	–	10	5	2	33	–	–	–	–	[5]
Goats	10	38	5	10	–	5	2	30	–	–	–	–	[5]
Goats	10	35	5	–	–	10	2	36	–	–	–	–	[5]
Yak	10	10	9	–	–	30	–	4	10	20	5	2	[6]
Yak	20	10	10	–	–	30	–	4	3	20	3	–	[7]

SOURCES: [1] Chen *et al.*, 1993a; [2] Liu *et al.*, 1995 [3] Zhang *et al.*, 2000; [4] Zhang *et al.*, 1998b; [5] Guan *et al.*, 1998; [6] Zhang, 1998a; [7] Long *et al.*, 1998.

Nutritional composition of blocks

The nutritional characteristics of multinutrient lick blocks are indicated in Tables 7.2 and 7.3. Most of the multinutrient lick blocks have a high crude protein (CP) value due to the effect of the inclusion of urea. Some workers (Zou *et al.*, 1996; Dong *et al.*, 2002) included oilseed meals in the blocks. Most of the lick blocks contain Ca, P and Mg, and micro-minerals such as Fe, Cu, Mn, Zn, Co, I and Se, but the mineral contents differ greatly between the blocks manufactured by different workers (Table 7.3), depending mainly on the target animals.

Table 7.2
Nutritional characteristics of multinutrient lick blocks.

Animals	DM **(%)**	CP **(%DM)**	Lysine **(%DM)**	Methionine **(%DM)**	ME **(MJ/ kg DM)**	NE **(MJ/ kg DM)**	Reference
Dairy cattle							
Cows	95.8	40.0	–	–	–	3.51	[1]
Heifers	95.1	31.1	–	–	–	–	[1]
Calf	96.1	20.0	–	–	–	–	[1]
Dairy cattle	–	43.0	–	–	–	–	[1]
Beef cattle	–	35.6	–	–	–	2.09	[2]
Yellow cattle	–	40.1	–	–	–	–	[3]
Yellow cattle	–	40.6	–	–	–	–	[3]
Buffalo	87.0	34.2	–	–	–	–	[4]
Buffalo		38.7	0.23	0.15	–	–	[5]
Buffalo	87.0	33.4	–	–	8.2	–	[6]
Sheep	–	29.9	–	–	6.22	–	[7]
Sheep	–	41.54	–	–	1.47	–	[8]
Sheep	93.0	18.75	–	–	–	–	[9]
Goat	87.0	33.4	–	–	–	–	[10]
Yak	–	43.0	–	–	–	–	[11]

NOTES: DM = dry matter; CP = crude protein; ME = metabolizable energy; NE = net energy.
SOURCES: [1] Chen *et al.*, 1993a; [2] Xu, Zhao and Liu, 1993; [3] Zou *et al.*, 1998; [4] Guan *et al.*, 2001a; [5] Zou *et al.*, 1996; [6] Yu *et al.*, 1998; [7] Zhang *et al.*, 1998b; [8] Guan *et al.*, 2001b; [9] Xue *et al.*, 1995; [10] Guan *et al.*, 2001c; [11] Dong *et al.*, 2002.

Table 7.3
Mineral contents of multinutrient lick blocks.

Animal	Ca (%)	P (%)	mg (%)	Fe (mg / kg)	Cu (mg / kg)	Mn (mg / kg)	Zn (mg / kg)	I (mg / kg)	Co (mg / kg)	Se (mg / kg)	Ref.
Dairy cattle											
Cows	2.3	5.0	–	1 193	933	3 140	5 412	113	17	57	[1]
Heifers	1.1	3.3	–	1 198	651	2 825	1 814	–	5	26	[1]
Calf	4.3	0.4	–	1 124	140	804	1 002	–	5	42	[1]
Dairy cattle	5	2	0.2	–	–	–	–	–	–	–	[2]
Beef cattle	4.22	0.54	2	160	110	150	110	60	12	1	[3]
Yellow cattle	–	–	–	5 200	44	235	106	0.8	8.8	0.31	[4]
Yellow cattle	–	–	–	5 200	49.7	218	120	0.5	8.9	0.48	[4]
Cattle and goat	>0.9	>0.5	–	1 300	140	450	520	10	5	3	[5]
Buffalo and goat	9.54	0.17	0.55	5 500	170	450	300	0.22	0.53	0.46	[6]
Goat	6.8	3.0	4.2	2 400	–	1 400	1 500	20	14	6	[7]

SOURCES: [1] Chen *et al.*, 1993a; [2] Chen et al., 2001a; [3] Xu, Zhao and Liu, 1993; [4] Zou *et al.*, 1998; [5] Liu *et al.*, 1995; [6] Guan *et al.*, 2001b; [7] Zhang *et al.*, 1998a.

Manufacture of blocks

Depending on the technical process, preparation of multinutrient blocks developed in China can be classified into two categories: a pressure process, using special equipment (hot process), or a moulding process (cold process), in which the ingredients are automatically bound with each other in mould.

Pressure process

Several specialized equipment sets have been developed to process blocks under pressure (Chang, 1997; Xia *et al*., 1994a, 1994b; Li and Li, 1997; Zhang *et al*., 2000). Xia *et al*. (1994a) designed a novel and simple type of molasses block press system. Zhang *et al*. (2000) developed appropriate equipment for manual processing of lick blocks for cattle and sheep, and observed that there was little influence of pressure intensity (9.7–24.1 kg/cm^2) on density and intake of the blocks by sheep. Liu *et al*. (1995) utilized machinery designed for producing ceramic tiles to manufacture urea-mineral lick blocks with a breaking strength of 40 kg/cm^2. They were easily transported and offered to the animals. Even when they were offered to the animals in situations of high humidity over a long period of time, there were no losses from mould growth or from hydration of the blocks.

Table 7.4 shows the characteristics of two presses used for the formation of blocks, designed by Chen *et al*. (1993a). The blocks were based on a molasses and urea mix. This mixture was heated and the salt added, followed by the addition of the rest of the ingredients, previously mixed together. The complete mixture was then pressed and the resulting blocks were wrapped immediately. Blocks made using both presses had good hardness, the breaking strength being 44 kg/cm^2. The block was oblate (diameter 25.6 cm and thickness 8 cm) and weighed about 7.5 kg.

With these equipment sets, shaped multinutrient lick blocks can be easily produced, while the process does not need much space or labour. The blocks could be rectangular, oblate or cylindroid in shape, and production capacity ranged from 50 to 200 kg/h (Chen *et al*., 1993a; Zhang *et al*., 2000, Xia *et al*., 1994a). The blocks produced were compact, not deliquescent, and hard enough to control their intake. They did not become mouldy nor did they lose shape when exposed to rain or sunshine.

Table 7.4
Characteristics of presses used for making blocks.

Press type	Power source	Dimensions (cm)	Weight (kg)	Working pressure (kg/cm2)	Production capacity (kg/h)
9YK-50 Manual	Hydraulic jack (50 tonne)	60 x 70 x 100	240	52	50
9YK-150 Electrical	Hydraulic pump (0.75Kw)	75 x 40 x 200	640	176	150

SOURCE: Chen *et al*., 1993a.

The moulding process

Many workers have used a simple moulding process to manufacture lick blocks (Ma *et al.*, 1992; Yang, Jiang and Wen, 1996; Chen *et al.*, 2001b). In this process, ingredients are mixed in a manner similar to the hot (pressure) process and then transferred to moulds, using moulds with a wood or metal frame. The blocks produced with this process have advantages compared with hot process blocks, and the cold process is usually fairly simply and requires neither sophisticated equipment nor much energy.

The blocks made by Chen *et al.* (2001b) were rectangular, 15 cm × 5 cm, and weighed about 1 kg each. The blocks produced with a pour process by Ma *et al.* (1992) had the following physical characteristics:

- When water was poured onto the surface of the blocks, blocks would keep their shapes after sun-drying.
- Blocks would hold their shape in water for 1–2 hours, but completely disintegrate after 4–5 hours.
- The shape of the blocks did not change with finger or foot pressure.

The blocks produced by Yang, Jiang and Wen (1996) were square or a compressed cylindroid, with a round hole in the centre (1.5 cm in diameter) to allow the blocks to be hung on a fence. The breaking strength was 56.9 kg/cm^2. The hardness was increased when formaldehyde-treated urea was used in the block instead of urea.

Effects on animal performance

Beef cattle

Some outcomes of multinutrient lick block supplementation on bodyweight change in beef cattle are shown in Table 7.5. Use of the blocks improved the productive performance of beef cattle. Zhang *et al.* (1993) observed that daily weight gain was 15.6 percent higher and consumption of roughage and concentrate per kg of gain were 16.9 and 13.3 percent lower, respectively, when hybrid beef cattle were supplemented with multinutrient lick blocks containing non-protein nitrogenous (NPN) compounds. Supplementation with multinutrient lick blocks, with or without urea and salt, could decrease body weight loss in yellow cattle receiving rice straw ad lib as the sole diet (Yi *et al.*, 2000). In another trial (Ma *et al.*, 1995), beef cattle with access to NPN-containing lick blocks had daily weight gain 0.353 kg higher than those with no blocks (1.478 vs 1.125 kg/day).

In a growth trial with heifers (n = 42), animals having access to lick blocks had a daily gain of 0.835 kg/day, which was 0.112 kg/day ($P < 0.05$) higher than the control group (Chen *et al.*, 1993a). Animals supplemented with lick blocks would reach 380 kg body weight (weight at first service) 65 days earlier, giving an earlier first calving. Other advantages observed during the on-farm animal feeding trials were better skin coat, better body condition and lower mortality. The urea-mineral lick blocks without molasses were also palatable to both cattle and goats (Liu *et al.*, 1995).

Local yellow cattle grazing and with access to the blocks performed better than those on the control diet (370 vs 203 g/day weight gain). The animals offered blocks had better body condition and looked healthier than animals on unsupplemented diets.

Sheep and goats

Xu, Tian and Wang (1994) observed increased feed intake and improved daily gain (23 percent) in sheep having access to lick blocks, compared with controls (Table 7.6). The supplemented sheep produced wool of high quality with higher contents of S, Fe and Zn. Similar results were observed by Jia *et al*. (1995) and Yang, Jiang and Wen (1996). When hybrid goats had access to urea-molasses blocks, average block intake was 80 g/day (Guan *et al*., 2001b). During the last three months of the experiment, daily weight gains were 67 g and 43 g for goats with and without access to the blocks, respectively. Effects of multinutrient lick blocks on performance of growing goats were investigated by Zhang *et al*. (1999), where goats with access to lick blocks had a liveweight gain 38.3 percent higher than those without the blocks.

Table 7.5

Effect of multinutrient block supplementation on performance of beef cattle

	Treatment			
	1	2	3	4
Hybrid yellow cattle (1)				
Intake (kg/day, as fed)				
Concentrate mixture	1.5	1.5		
Brewer's grains	19.7	18.2		
Carrots	1.1	1.1		
Maize silage	3.7	3.6		
Multinutrient block	0	0.19		
Liveweight gain (g/day)	896	1 036		
Huangpo yellow cattle (2)				
Intake (g/day)				
Rice straw	ad lib	ad lib	ad lib	ad lib
Block B	0	120	0	0
Block IB	0	–	46.5	46.5
Urea + salt	0	–	0	suitable
Body weight change (g/day)	-311	-88	-140	-176
Qingchuan bull cattle (3)				
Intake (kg/day, as fed)				
Concentrate mixture (4)	4.5	4.5		
Microbe-treated rice straw	4.0	4.0		
Multinutrient block	0	20		
Liveweight gain (g/day)	930	982		
Angus calves (5)				
Number of calves (head)	10 bulls	10 bulls	10 heifers	10 heifers
Initial weight (average; kg)	111.4	116.1	94.0	105.5
Intake (kg/day, as fed)	2	2	2	2
Liveweight gain (g/day)	542	794	373	591

NOTES: (1) Data from Zhang *et al*., 1993. N = 12 in each group, ca 330 kg body weight. (2) Data from Yi *et al*., 2000. N = 10 in each group, ca 175 kg body weight. Block IB is equivalent to block B but without urea and salt. Animals in treatment group 4 were supplemented with urea and salt to the same level as in group 2. (3) Data from Liu *et al*., 2001. N = 11 in each group, ca 290 kg body weight. (4) Ingredients: maize, 26%; wheat, 30%; millet, 20%; sesame cake, 20%; lime, 2%; and salt, 2%. (5) Data from Zheng *et al*., 2001. All calves suckled for 1 hour in the morning and evening, and each animal was offered 1 kg of hay and 1 kg of concentrate mixture per day.

When the multinutrient lick blocks were provided as a supplement to grazing goats and sheep, the effect on productive performance was significant (Table 7.6), with much higher weight gain in the block-supplemented animals than in the control group without blocks. Liu *et al*. (1995) reported their results with two groups of goats, which grazed together on hill pasture during the day and were offered rice straw ad lib in stalls at night. One group had free access to the urea-mineral lick blocks along with rice straw at night. Goats with access to the blocks performed better than those in the control group. Liveweight gains were significantly higher in animals with blocks compared with those without blocks (95 vs 73 g/day).

Buffaloes

Effects of providing blocks to buffaloes have been observed by some workers (Lu *et al*., 1995; Zou *et al*., 1996, Guan *et al*., 2001a). When buffalo heifers (n = 12) fed on rice straw diets were supplemented with urea-molasses lick blocks, daily weight gain was 650 g, versus 620 g for control animals (Lu *et al*., 1995). Feed cost and concentrate consumption per kg of gain were 9.8 percent and 33.3 percent lower, respectively, for the supplemented buffaloes. Animals were not poisoned, even when block intake exceeded 1 000 g/day, indicating that the blocks were safe for animals. Zou *et al*. (1996) chose a block formula for growing buffaloes with molasses, urea, grain by-products, minerals and vitamin premix. Intake of the blocks increased during the of the experimental period, and was 172.4, 330.2 and 374.1 g/day at 30, 60 and 80 days after start of the experiment, respectively. Compared with control animals with no blocks, the daily weight gain of buffaloes with access to the blocks was 22.6 percent (395.4 vs 484.6 g/day) higher. In animals supplemented with blocks, the feed conversion ratio was 22.5 percent less and concentrate consumption was 22.8 percent less per kg of gain.

Table 7.6
Effect of multinutrient block supplementation on performance of goats and sheep

	Treatment 1	2	3	4
Zaanen castrated goats (1)				
Intake (g/day, as fed)				
Concentrate mixture	200	200		
Fresh grass	3300	3400		
Liveweight gain (g/day)	24	34		
Fine wool sheep (2)				
Intake (g/day)				
Dry matter	1200	1200	1200	
Block I (N:S = 6.1:1)(3)	0	23.8	0	
Block II (N:S = 9.2:1)	0	0	27.8	
Liveweight gain (g/day)	71.7	83.3	80.0	
Wool production (g/day)	4.0	4.3	4.4	
Goats (4)				
Intake (g/day)				
Sugar cane tops/elephant grass	*ad lib*	*ad lib*		
Ground maize	50	50		
Block	0	80		
Liveweight gain (g/day)	43	67		
Sheep (5)				
Intake of supplement (g/day)	300	300		
Liveweight gain (g/day)	116	143		
Castrated goats (6)				
Intake of blocks (g/day)	0	20	40	60
Liveweight gain (g/day)	75	110	179	73
Black goats (7)				
Intake (g/day)				
Blocks	ad lib	ad lib	ad lib	
Ground maize	0	0	100	
Liveweight gain (g/day)	58	73	90	
Black goats (8)				
Liveweight gain (g/day)	60	87	83	
Dressing rate (%)	43.4	47.8	47.9	
Lean meat percentage (%)	64.4	72.6	67.7	
Tibetan sheep (9)				
Intake of block (g/day)	0	152		
Liveweight gain (g/day)	111	192		

(1) Data from Xu, Tian and Wang, 1994. n = 10 in each group, ca 13 kg body weight. Concentrate comprised: maize, 53%; wheat bran, 32%; rapeseed meal, 10%; soybean meal, 4%; common salt, 0.5%; and $CaCO_3$, 0.5%. Group 2 received UMMB supplementation.

(2) Data from Jia *et al*., 1995. n = 5 in each group, ca 31–33 kg body weight. The diet consisted of hay, maize silage, ground maize and groundnut cake.

(3) N:S = Nitrogen to Sulphur ratio.

(4) Data from Guan *et al*., 2001b. n = 15 in each group, ca 15 kg body weight. Animals were fed in-house without supplements.

(5) Data from Xu, Tian and Wang, 1994. n = 20 in each group, ca 20 kg body weight. Animals were grazed without supplements.

(6) Data from Lu and Gao, 2001. ca 24–25 kg body weight. Animals were grazed without supplements. Supplement ingredients were: maize, 60.4%; wheat bran, 25.0%; rapeseed meal, 10%; and soybean meal, 4.6%. UMMB was included in treatment 2.

(7) Data from Chen *et al*., 2001b. n = 9 in each group, ca 16 kg body weight. Animals were grazed with supplements.

(8) Data from Zhang *et al*., 1998a. n = 10 in each group, ca 15 kg body weight. Animals were grazed without supplements. The goats in group 1 formed the control; the animals in groups 2 and 3 were supplemented with multinutrient block with Clenbuterol and Monensin, respectively.

(9) Data from Yu, Chen and Feng, 1998. n = 8 in each group, ca 32 kg body weight. Animals were grazed without supplements.

Dairy cows

Among the limited work on multinutrient lick blocks with dairy cattle, Chen *et al*. (1993a) observed that cows (n = 15) having access to blocks had an average milk yield of 20.7 kg/day, which was 1.3 kg (6.7 percent) higher ($P < 0.01$) than the average of the control group (n = 15). Additional advantages from use of the blocks included an increased conception rate (12.2 percent), decreased morbidity (22.5 percent), improved body condition and increased income (Chen *et al*., 1992). In another trial by Wang *et al*. (1995), dairy cows (n = 10) supplemented with multinutrient blocks produced 1.1–1.5 kg (5.3–5.9 percent) more milk than those without blocks (n = 10), and less metabolic disorders were observed in the supplemented animals. Xu, Zhao and Liu (1993) investigated the performance of Holstein dairy cows (n = 22) in the middle stage of lactation, and found that when urea-containing lick blocks were provided, the cows produced 20.5 kg/day of milk, which was 4.1 kg (25 percent) higher than the average of the control group. It was estimated that cows with access to blocks gave an increased income of RMB¥ 736 per head per year.

Several workers offered their dairy cows lumpish concentrate supplements rather than lick blocks, because the intake of the “block” was high, from 580 g/day (Chen *et al*., 2001a) to 2000 g/day (Zhang, Li and Liu, 1996).

Yaks

Effects of giving UMMBs on productive performance of yak have been observed by Long and colleagues in Gansu Province (Dong *et al*., 2002; Long *et al*., 1998, 2002; Zhang, 1998). Dong *et al*. (2002) studied the effect of the blocks on liveweight change in yak calves, and productive and reproductive performance of yak cows in the feed-deficient cold season on the Qinghai-Tibet Plateau. Each calf in the supplemented group was offered daily 250 g of block and each cow had a 0.5 kg block daily, together with grazing on natural grassland from January to May 1998. Liveweight losses of 1-year calves, 2-year calves and yak cows were reduced by 1.2, 8.3 and 7.9 kg in the experimental period after block supplementation ($P < 0.01$, Table 7.7). One-year-old calves gained liveweight mostly in the first supplementation month, and two-year-old calves and yak cows gained liveweight in the first and last supplementation months. Long *et al*. (2002) reported similar results, and that there were significant effects of UMMB supplement preventing yaks from losing more body weight in inadequate forage seasons (Figures 7.1 and 7.2). In particular, the effect of UMMB on performance in terms of less body weight loss seemed better in April than in February and March, which was clearly reflected in positive monthly liveweight gains for one-year-old calves in April. Again, UMMB contributed much to minimizing cow body weight losses ($P < 0.01$) from both under-feeding and calves suckling during the hard period (Figure 7.2). Daily milk yield of yak cows increased by 0.21 kg/day when the lactating animals were supplemented with block ($P <0.01$, Table 7.8), although there was no significant effect of block supplementation on hair and downy hair production of yak cows ($P>0.01$). Block supplementation also significantly improved yak cowreproductive performance ($P<0.01$, Table 7.8), with increments of 8.8 and 30.9 percent in pregnancy rate and newborn weight, respectively. Economically, the benefits with two-year calves and yak cows were reasonable – the output:input ratio reached 1.8: 1 and 1.4: 1 respectively – but block supplementation for one-year-old calves was far from economic.

Zhang (1998) conducted trials on cold-season supplementary feeding of urea molasses multinutrient blocks in Gansu province: in Tianzhu county with 90 white yak cows and in Luqu county with 60 black cows. The blocks, which contained 10 percent urea and 10 percent molasses, were offered at a daily intake of 500 g per cow for five months, from December to April. The results were 80.3 and 46.8 percent less liveweight in the white and black yaks, respectively. It also lead to 20 and 13.6 percent more milk yield, 17.4 and 20 percent higher pregnancy rate and output:input ratios of 1.35:1 and 2.11:1, respectively in the two yak groups. These authors concluded that supplementary feeding with the blocks was an effective way to mitigate liveweight loss and to improve the productive performance of yaks during the cold season in the pastoral counties.

Table 7.7
Effect of UMMB on liveweight change of yak calves and cows

		Control (no supplement)	Treatment (with supplement)	Standard error of the mean
One-year-old yak calves		n = 10	n = 20	
Initial weight	(kg)	61.4	61.1	0.2
Final weight	(kg)	60.2	61.6	0.4
Gain	(kg)	-1.2 [a]	-0.03 [b]	0.05
Two-year-old yak calves		n = 10	n = 20	
Initial weight	(kg)	95.4	95.9	1.3
Final weight	(kg)	85.7	94.5	2.1
Gain	(kg)	-9.7 [a]	-1.4 [b]	0.61
Yak cows		n = 20	n = 20	
Initial weight	(kg)	162.9	158.9	2.2
Final weight	(kg)	154.7	158.5	1.4
Gain	(kg)	-8.2 [a]	-0.4 [b]	0.081

NOTES: [a,b] Mean values in the same row with different letters are significantly different (P<0.01).

SOURCE: Dong *et al*., 2002

Table 7.8
Effect of supplementary blocks on performance of yak cows

		Control (without supplement)	**Treatment** (with supplement)	**Standard error of the mean**	**Increment** (%)
Milk yield	(kg/day)	1.3 [a]	1.5 [b]	0.04	16.4
Cheese production	(kg/day)	0.03 [a]	0.04 [b]	0.001	18.8
Butter production	(kg/day)	0.05 [a]	0.06 [b]	0.002	15.4
Hair production	(kg)	0.77	0.81	0.09	7.8
Downy hair production	(kg)	0.41	0.46	0.02	12.2
Pregnancy rate	(%)	63.7 [a]	72.5 [b]	0.014	8.8
Caving rate	(%)	86.3	90.2	0.015	3.9
Survival rate of calves	(%)	90.2	96.4	0.023	6.5
Birth weight of newborn	(kg)	13.6 [a]	17.8 [b]	0.011	30.9

NOTES: [a,b] Mean values in the same row with different letters are significantly different (P <0.01).

SOURCE: Dong *et al*., 2002

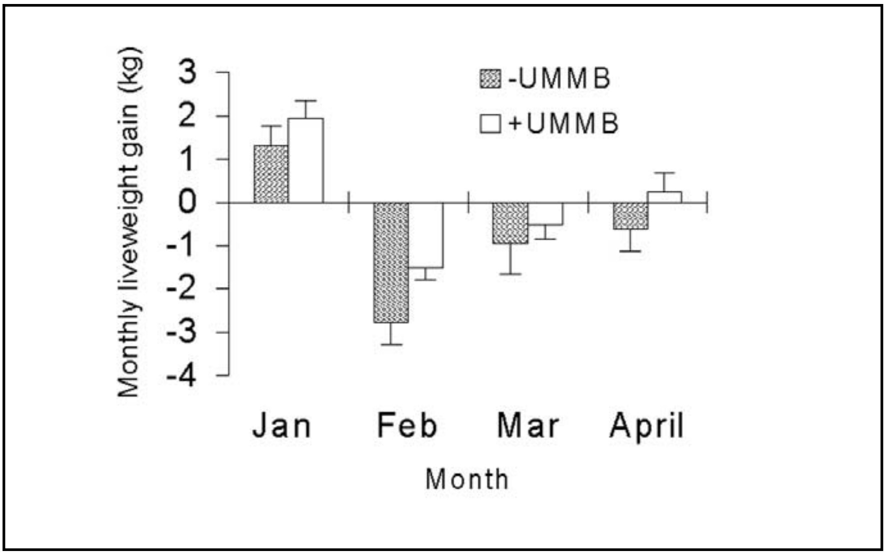

Figure 7.1

Monthly gain in body weight of one-year-old calves with (n = 20) or without (n = 20) UMMB supplementation (from Long, *et al*. 2003)

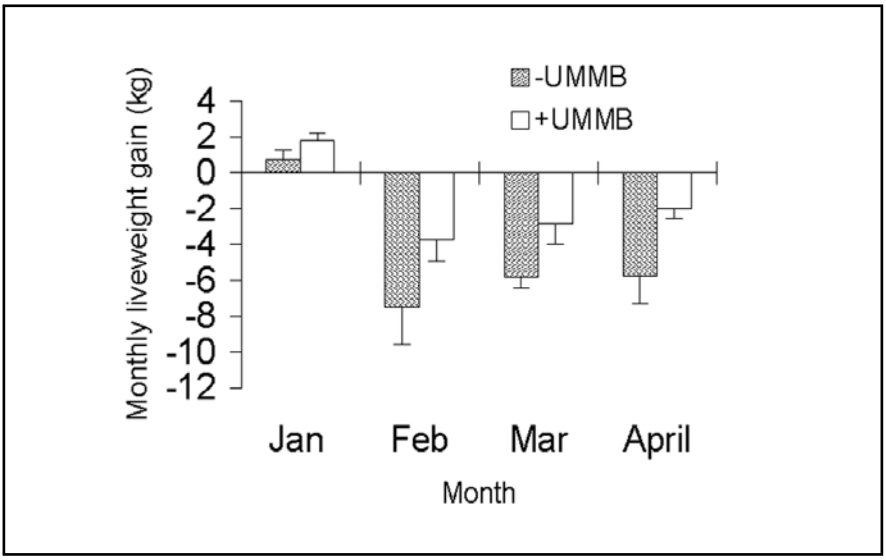

Figure 7.2

Monthly gain in body weight of cows with (n = 20) or without (n = 20) UMMB supplementation (from Long *et al*., 2003.)

Effects on digestion and metabolism

Much of work on blocks in China has been concerned with effects on animal productive performance. In addition, some workers have investigated the effects of block use on rumen fermentation (Zhang *et al*., 1997; Xue *et al*. 1995) and digestion and utilization of nutrients of the diets (Wu and Liu, 1996; Li *et al*., 1999). Blood physiological and biochemical parameters have been compared between animals with and without blocks supplementation (Zhang *et al*., 1998a).

Rumen fermentation

Zhang *et al* (1997) studied the effect of supplementary urea blocks on NH_3-N concentration and pH value in the rumen of wethers. The pH did not alter, while rumen NH_3-N ($P < 0.01$) concentration significantly increased and approached or exceeded 13 mg/100 ml rumen fluid, the optimal level of NH_3-N for rumen microbial activity suggested by Hume, Moir and Somers (1970). Improvement in the rumen ecosystem is beneficial to rumen microbial activity, and hence rumenal digestion. Xue *et al*. (1995) observed that when the animals were supplied with an additional urea block of 50 g per head per day, the microbial protein yield was increased (11.87 vs 10.18 g/day) and synthetic efficiency (26.4 vs 23.0 g/ kg fermentable organic matter) was improved, compared with the control. When rice straw, maize stover and sugar cane bagasse were incubated in the rumen of buffaloes supplemented with urea-molasses block, the 48-hour degradation of feedstuff nutrients was significantly higher than in the rumens of animals without block supplementation (Table 7.9, Guan *et al*., 2001c).

Table 7.9
Degradation (48 hours) of rice straw, maize stover and sugar cane bagasse in the rumen of buffaloes.

	Dry matter		Crude protein		Neutral detergent fibre	
Blocks	without	with	without	with	without	with
Rice straw	68.7 ^{a}	62.3 ^{b}	69.7	67.5	62.7 ^{a}	56.4 ^{b}
Maize stover	85.8 ^{a}	78.6 ^{b}	86.5	85.7	82.1 ^{a}	75.6 ^{b}
Sugar cane bagasse	55.3 ^{a}	50.2 ^{b}	63.8	61.4	47.9 ^{a}	43.6 ^{b}

NOTES: ^{a,b} Figures for same parameter with different superscripts differ ($P < 0.05$).

SOURCE: Guan *et al*., 2001c.

Digestion and utilization of the diets

Many investigators have observed that supplementation with blocks can improve digestion and utilization of nutrients from diets. Wu and Liu (1996) studied the effects of giving a urea mineral lick block on the kinetics of ruminal fibre digestion, nutrient digestibility and nitrogen utilization of rice straw, ammonium bicarbonate (AB)-treated straw and hay prepared from wild forage. The results are summarized in Table 7.10. With block supplementation, the digestibility of dry matter and organic matter of rice straw were increased by 13.1 and 12.7 percent ($P < 0.05$) and approached that of the AB-treated straw, indicating that the effect of the blocks on digestibility of rice straw may be similar to that of AB treatment. The digestibility of the treated straw was improved slightly when animals had access to blocks. Nitrogen retention was highest in lambs on AB-treated straw alone, followed by hay with blocks, and was lowest in animals on rice straw with blocks. However, both the amount of nitrogen retention and proportion relative to intake were increased by block supplementation in lambs fed on hay. The proportion of nitrogen retained to that digested decreased with block supplementation in lambs on both untreated and treated straw. Access to blocks did not significantly influence the rumen degradation of either dry matter or crude protein in any of the three diets. From the results, it is inferred that while the block is effective in increasing nutrient digestibility of low quality roughages through improved ruminal fibre digestion, a simultaneous supply of nitrogen and energy to rumen microbes should be considered to improve the utilization efficiency of nitrogen when the basal diet is ammoniated straw.

In experiments with goats, Li *et al* (1999) observed similar results. The effect of the blocks on digestibility of rice straw was similar to that of treatment with ammonia, and further improvement in digestibility of ammoniated straw was obtained by supplementation with the blocks. Retention and net utilization efficiency of nitrogen were improved more in the animals fed untreated rice straw than in those fed ammoniated straw. It might be due to the oversupply of nitrogen when ammoniated straw diets are supplemented with urea blocks.

Blood parameters

Numbers of red and white blood cells, concentrations of alkaline phosphatase, lactate dehydrogenase and serum levels of total protein, albumin, globulin and haemoglobin were significantly higher in goats supplemented with multinutrient blocks than in goats without blocks (Table 7.11, Zhang *et al.*, 1998b). Compared with the controls, contents of all minerals except copper were higher in serum of goats supplemented with multinutrient blocks.

Table 7.10
Effects of use of a urea-mineral block on the intake and digestibility of diets offered to lambs

	Rice straw				**Hay**		**Significance**		
	Not treated		**AB treated**						
Blocks (without/ with)	**without**	**with**	**without**	**with**	**without**	**with**	**R**	**B**	**R × B**
Intake (g DM/day)	576	534	683	591	735	705	*	NS	NS
Apparent digestibility (%)									
Dry matter	48.9	55.3	54.4	57.1	49.1	55.0	*	**	NS
N × 6.25	39.5	45.7	60.1	61.0	35.2	48.8	**	*	NS
NDF	62.6	66.8	65.6	68.5	66.2	69.4	*	*	NS
Nitrogen intake (g)	8.1	8.1	13.2	12.3	12.5	12.5	**	NS	NS
N in faeces (% of intake)	60.5	54.3	40.9	39.0	64.8	51.2	**	*	NS
N in urine (% of intake)	19.8	27.2	17.4	25.2	9.6	12.8	*	*	NS
N retention (% of intake)	19.7	18.5	41.7	35.8	25.6	36.0	*	*	NS
N retained / N digested	50.0	40.5	70.5	58.7	72.7	73.8	**	*	NS
DM degradability (%)	42.9	44.0	52.0	52.2	43.7	46.3	*	NS	NS
EED (%)	26.6	28.2	33.6	36.1	23.1	28.9	**	*	NS

NOTES: R = roughage effect; B = block effect; R × B = interaction effect between roughage and block; * = significant at P<0.05; ** = significant at P<0.01; NS = not significant; AB = treated with ammonium bicarbonate; EED = effective extent of ruminal fibre digestion.

SOURCE: Wu and Liu, 1996.

Table 7.11
Blood cell counts, enzyme activity, protein and mineral contents in serum of goats with or without multinutrient block supplementation for 30 and 60 days (Zhang *et al*., 1998a)

	30 days			**60 days**		
	Control	Block 1	Block 2	Control	Block 1	Block 2
Red blood cells (×10^4/mm^3)	15.9 ^{b}	18.5 ^{a}	18.3 ^{a}	15.6 ^{b}	18.4 ^{a}	18.2 ^{a}
White blood cells (×10^4/mm^3)	6.9 ^{b}	7.4 ^{a}	7.6 ^{a}	6.9 ^{b}	7.5 ^{a}	7.7 ^{a}
Haemoglobin (g/litre)	72.4 ^{b}	97.3 ^{a}	94.6 ^{a}	72.6 ^{b}	96.8 ^{a}	95.1 ^{a}
Alkaline phosphatase (Units/litre)	16.6	17.1	16.7	16.6 ^{b}	17.8 ^{a}	17.5 ^{ab}
Glutamate dehydrogenase (Units/litre)	15.7	48.2	45.6	48.8	51.4	49.3
Lactate dehydrogenase (Units/litre)	5.1	5.4	5.2	5.2 ^{b}	5.8 ^{a}	5.7 ^{a}
Serum protein level						
Total protein (g/l)	72.0 ^{b}	87.2 ^{a}	85.8 ^{a}	73.6 ^{b}	88.8 ^{a}	85.7 ^{a}
Albumin (g/l)	48.7 ^{b}	57.1 ^{a}	56.8 ^{a}	48.8 ^{b}	59.0 ^{a}	57.1 ^{ab}
Globin (g/l)	23.3 ^{b}	30.1 ^{a}	29.0 ^{a}	24.8 ^{b}	29.8 ^{a}	28.6 ^{a}
Non-protein nitrogen (mg/ml)	0.28 ^{b}	0.41 ^{a}	0.42 ^{a}	0.29 ^{b}	0.37 ^{a}	0.37 ^{a}
Serum mineral content						
Ca (μg/ml)	94.8 ^{b}	113.6 ^{a}	114.5 ^{a}	93.6 ^{b}	114.2 ^{a}	114.7 ^{a}
P (μg/ml)	75.4 ^{b}	91.7 ^{a}	93.6 ^{a}	75.0 ^{b}	93.2 ^{ab}	95.3 ^{a}
Mg (μg/ml)	23.3 ^{b}	34.7 ^{a}	35.5 ^{a}	23.1 ^{b}	34.0 ^{a}	34.3 ^{a}
Na (mg/ml)	2.6 ^{b}	3.0 ^{a}	3.0 ^{a}	2.7 ^{b}	3.0 ^{a}	3.0 ^{a}
Cl (mg/ml)	4.5 ^{b}	5.1 ^{a}	5.1 ^{a}	4.5 ^{b}	5.0 ^{a}	5.0 ^{a}
Fe (μg/l)	28.4 ^{b}	34.9 ^{a}	36.1 ^{a}	29.1 ^{b}	36.1 ^{a}	37.4 ^{a}
Cu (μg/l)	7.0	8.3	8.7	7.2	8.1	8.4
Zn (μg/l)	6.2 ^{b}	8.7 ^{a}	9.2 ^{a}	6.6 ^{b}	9.0 ^{a}	9.7 ^{a}

NOTES: ^{a,b} values within same period with different superscripts differ significantly ($P < 0.05$). The composition of the blocks were the same (see Zhang *et al*., 1988a; Table 7.1) except that the Block 1 formula contained clenbuterol and Block 2 contained monensin.

Conclusion

Since the introduction of multinutrient blocks into China in the early 1990s, much research work has been carried out nationwide. New techniques have been developed to manufacture the multinutrient blocks in China, and the blocks have been demonstrated to be an efficient way to improve performance of beef cattle, goats and sheep, dairy cows and yaks, no matter whether the animals were indoor fed or grazing. The beneficial effects on performance of animals are attributed to improved rumen fermentation, digestion and utilization of diets. However, much effort is still needed to extend the multinutrient block concept and product more widely in China.

Addendum

Note added by one of the Editors (HPSM) after his visit to the sites of IAEA TC Project CPR/5/014 in the People's Republic of China in August 2003. The principal investigator of this project is one of the authors (ZD) of this chapter and the chapter covers in part the activities of this Technical Cooperation Project.

The objective of the project is to enhance livestock production in northwest China, using appropriate feed supplementation strategies, particularly the use of UMMBs. This project became operational in mid-2000 with the setting up of UMMB production facilities at 10 sites in Gansu province. At the time of reporting, approximately 2 000 farmers were feeding the blocks to over 17 000 animals at these sites, and farmers earned an additional income of RMB¥ 3 million in 2002 as a result of this technology, with a rate of return (ROR) of 160 percent on the investment made by IAEA and counterpart institutions (for every dollar invested by IAEA and the national government in extending the technology, the investment generated an additional US$ 1.60 for each US$ 1 invested, after paying the investment). The cost–benefit ratio varied from 1:1.5 to 1:2.9 for beef cattle; 1:5.4 to 1:6.5 for dairy cattle; 1:3.5 for yak cows; 1:4 for sheep for meat; and 1:3 for sheep for wool. Increased income of RMB¥ 1.2 to 3.5 per animal per day for dairy and beef cattle, 44 percent increased reproductive efficiency in yak, and a 40 percentage unit increase in twinning rate (from 20 to 60 percent) in Alpine short-tail sheep have also been recorded. Income of farmers using the blocks has increased by approximately 10 percent. The ROR of 160 percent in the second year of the project clearly shows that the project has had a very good impact. The rate and density of adoption of the technology was higher in those areas where the extension workers could easily contact farmers and where education levels of farmers were higher.

Methodology for preparation of blocks using wheat flour in place of molasses has been standardized. The basic formula (dry ingredients; weight basis) of the wheat-flour-based blocks is: wheat flour, 5%; urea, 10%; sesame cake, 12.5%; rape seed cake, 12.5%; wheat bran, 10%; maize flour, 10%; bone meal, 3%; common salt, 7%; and bentonite, 30%. It is similar to the molasses-based blocks, except that 1 kg of molasses is replaced with 0.5 kg of wheat flour. These blocks are being used by farmers, with considerable beneficial effects. This technology for wheat-flour-based blocks will have spillover effects for other countries short of molasses or where molasses is not produced.

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Feed supplementation of dairy cattle with UMMB in the northeastern region of Thailand

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Introduction

Dairy production in Thailand has developed rapidly in the last decade. The number of dairy farmers has increased from around 6 600 in 1987 to over 24 000 in 2002, and in the same period the number of dairy cattle increased from around 75 000 to about 370 000 and milk production increased from 90 000 to 660 000 tonne/year (Table 8.1).

Table 8.1
Dairy farmers, dairy cattle and milk production, 1987–2002.

Year	Dairy farms **(No.)**	Dairy cattle **(No.)**	Raw milk production **(tonne)**	Milk demand **(tonne)**	Milk imports **(Baht millions)**
1987	6 617	75 791	89 713	126 250	2 812
1990	11 539	116 457	129 248	199 593	4 180
1994	17 190	181 026	205 407	417 986	6 200
1998	24 485	287 732	387 918	796 161	11 604
2002*	24 687	374 648	660 297	1 500 000*	12 872

NOTE: * = estimate.
SOURCE: Office of Agricultural Economics, Department of Livestock Development, 1999.

Progress was mainly due to the concerted efforts of four organizations:
- the Dairy Farming Promotion Organization (DPO) (see Table 8.2);
- the Cooperative Promotion Department;
- the Department of Livestock Development; and
- the Bank of Agriculture and Cooperatives.

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Government policy towards dairy development has also played an important role in this development, as demonstrated through Dairy Extension Projects, the Milk Consumption Campaign, the School Milk Programme and others.

However, despite the sharp increase in milk production during the last decade, the availability of milk been insufficient to meet national demand, and hence Thailand has been importing milk powder and other milk products for a value of about US$ 300 million annually (see Table8.1).

Dairy farming in Thailand is mainly a smallholder activity. An average farm will have 10 cattle, with a range of 5–40. Only around 75 percent of such farmers have a land holding of less than 3 ha.

Table 8.2
Dairy Farming Promotion Organization of Thailand – status as of September 1999.

Site **(date of establishment)**	Plant capacity **(tonne/ day)**	Collection centres **(No.)**	Farmers **(No.)**	Total cows **(No.)**	Cows in milk **(No.)**	Production **(tonne/ day)**
Muaglek (1971)	200	13	2 520	29 321	15 636	110.51
Chieng Mai (1984)	15	5	621	7 661	4 139	28.14
Pranburi (1985)	60	10	1 151	16 864	8 680	74.75
Khon Kaen (1997)	60	6	773	8 128	2 748	25.38
Sukothai (1998)	60	5	319	3 262	1 812	10.13
TOTAL	395	39	5 384	65 236	33 051	248.91

Table 8.3
Availability of feeds and fodder in the northeastern region of Thailand in different seasons of the year.

Feeds and fodder	**Rainy season (May–October)**	**Dry season (November–April)**
Concentrate	Limited availability	Limited availability
Green grass	Plenty	Scarce
Green fodder (Congo grass, para grass, lucerne, guinea grass)	Plenty	Scarce (only some lucerne and Congo grass is available where irrigation is available)
Paddy straw	Not used	Used as main roughage source
Sugar cane top	–	Fed especially during November–February
Cassava hay	Limited availability	Some farmers use it as protein supplement
Cassava chips	Mixed with concentrate (not widely used)	Mixed with concentrate (used widely)
Soybean stems and hull	–	Used only in dry season

The basal diet of dairy cattle in the northeast of Thailand consists of unimproved pasture and crop residues. These forages are generally of low quality because of low digestibility and lack of protein. The quality and quantity of rations fed to dairy cattle vary according to the season: there is an abundance of forage during the rainy season, but there is widespread scarcity during the dry season. Usually concentrates are offered during both rainy and dry seasons, the amounts varying depending on availability and price. Thus, there is a marked fluctuation in nutrient supply to the dairy cattle, and this is a major cause of poor production and reproductive performance, characterized by low milk yields and long calving intervals.

Urea-molasses mineral block (UMMB) licks can improve the utilization of low quality roughages by satisfying the requirement of the rumen microorganisms, creating a better environment for the fermentation of fibrous material and increasing production of microbial protein and volatile fatty acids. Urea, after hydrolyzing into ammonia in the rumen, provides a nitrogen source for the rumen microflora. Molasses is a source of readily fermentable energy. Feeding molasses and urea in the form of a block is convenient and economically feasible for small-scale farmers. To ensure a high rate of milk production, particularly during the dry season, farmers feed large quantities of high-priced concentrates to their cattle, which often constrains profit margins. The promotion of use of UMMB at smallholder level and evaluation of its cost effectiveness as a supplementary source of nutrients have been undertaken since 1995 under an IAEA TC Project, RAS/5/035, *Development of supplementation for milk producing animals in tropical and subtropical environments in the northeast region of Thailand*.

Promotion of UMMB and on-farm experiments.

There were several activities promoting UMMB in 1995–1996 under project RAS/5/035, reported by Pimpaporrn Pholsen and co-workers (1996):

- A training course on UMMB promotion and use was held for extension workers in July 1995, and two production units were established by farmer groups at Koksee village, Muang district and at Khon Kaen Animal Nutrition Research Centre, using a concrete mixer and a 10 kg iron mould. UMMB production at Koksee village was about 8 tonne, and Khon Kaen Animal Nutrition Research Centre produced about 10 tonne. Blocks were prepared using two formulas: high urea content (urea, 10%; molasses, 40%; salt, 2%; triple super phosphate, 2%; sulphur, 1%; cement, 14%; and rice bran, 31%) for the dry season, and low urea content (urea, 5–6%; molasses, 40%; salt, 2%; triple super phosphate, 2%; sulphur, 1%; cement, 11–12%; and rice bran, 37%) for the rainy season. The chemical composition with 10% urea was DM, 87.9%; CP, 34.1%; Ca, 6.5%; P, 0.7%; Mn, 0.4%; K, 1.7%; and Na, 0.8%.
- Fifteen dairy farms were studied for production (milk yield, body weight and condition) and reproduction performance.

Activities in 1997–2000

- Block promotion activities started in 1997 at Srithat Milk Collection Centre (MCC) with the cooperation of the Farmer's Cooperative. Blocks were introduced in 1998 to the farmers' groups from Nasee village at Namphong MCC and from Nong Woa Saw district, and to individual farmers of Kudjub MCC. Blocks were distributed to all six DPO MCCs in the northeast in 1999. The amount of UMMB produced by cooperatives, farmers' groups and MCCs increased from 19.1 tonne in 1997 to 82.2 tonne in 1999 (these figures exclude blocks produced by farmers themselves). Blocks were sold to farmers, establishing a revolving fund system. Blocks were made by farmers at the Farmer's Cooperatives or MCCs using concrete mixers and 10 kg iron moulds, 20–30 kg plastic moulds, and 50 kg rubber moulds made from old car tyres. The percentage composition of blocks was molasses, 40%; urea, 5–10%; rice bran, 36–40%; cement, 10–14%; triple phosphate, 0–1%; sulphur, 0–1%; and mineral mixture, 2%.
- Extension activities involved training programmes for block production and use; setting up of demonstration farms; farm and field visits; and the production of a newsletter, posters and reports on block production and use for publication in the DPO bulletins. A dairy journal was also prepared to encourage the dairy farmers in the area to utilize UMMB as an essential supplement in the daily diet. Four revolving funds (US$ 400–800 each) were established for production units for Nasee group, Kranuan Cooperative, Jareonsin MCC and Srithat MCC. Payments for blocks sold were recovered from milk payments every 15 days.

Effect of UMMB on milk production

Experiment 1

Twenty-three crossbred dairy cows belonging to four farmers of the Sithat MCC were used. The cows selected were already at the declining stage of lactation, around 127 ±10.2 days after calving. They were being given a diet of roughage and concentrate, considered adequate by their respective owners. Daily milk production was recorded for each cow for a period of 15 days. Thereafter the cows were offered a supplement of UMMB. Daily milk production was then recorded for a further 15 days. The average block consumption was 0.68 ±0.07 kg/day.

Table 8.4
UMMB-related activities in 1997–2002.

	1997–1999	2000–2002
Training and demonstration		
Courses for farmers	29 (806 participant days)	19 (680 participant days)
Courses for extension workers	20 (296 participant days)	13 (66 participant days)
Study tours		
For farmers	6 (162 participant days)	6 (130 participant days)
For extension workers	8 (11 participant days)	
Farm demonstrations	9	24
On-farm trials	14	9
Exhibitions	11	5
UMMB posters	1 campaign (1 000 posters)	3 campaigns (1 500 posters)
Revolving funds	4 set up (Baht 125 200)	1 set up (Baht 25 000)
UMMB production (kg.)	144 770	91 900

Experiment 2

Thirty-one dairy cows around 60 days after calving and belonging to ten farmers of Kudjub MCC were used. Five farmers with a total of 16 cows formed the control group with no UMMB supplement, while five farmers with a total of 15 cows received UMMB ad lib. All animals received a basal roughage diet plus concentrate, considered adequate by the respective owners. Daily milk yield per cow was recorded for 30 days. The average block consumption was 0.52 ±0.32 kg/day.

Supplementation with UMMB did not increase milk production significantly, but the persistency of lactation became better and also it reduced to 65 days the mean calving to conception interval.

UMMB altered the rate of decline in milk production observed in late lactation. Before supplementation, daily milk yield declined at -0.0126 kg/day, but supplementation after this changed to +0.0142 kg/day (Experiment 1, Table 8.4 and Figure 8.1). In Experiment 2, however, in both treatments there was a decline, but the UMMB group showed a reduced rate of decline in milk production (Table 8.4) compared with the unsupplemented control.

Table 8.4
The effect of UMMB supplementation on milk production – Experiment 1.

	Experiment 1		Experiment 2	
	without UMMB	with UMMB	without UMMB	with UMMB
Duration of experiment (days)	15	15	30	30
Number of farmers	4	4	5	5
Number of cows	23	23	15	16
Average milk production* (kg per cow per day)				
At the beginning of experimental period	9.9	9.7	10.6	10.6
At the end of experimental period	9.7	9.9	10.4	10.6
Mean rate of change (slope) in milk production (kg/day)	-0.0126	+0.0142	- 0.0077	- 0.0011

Note: * Estimated by regression analysis

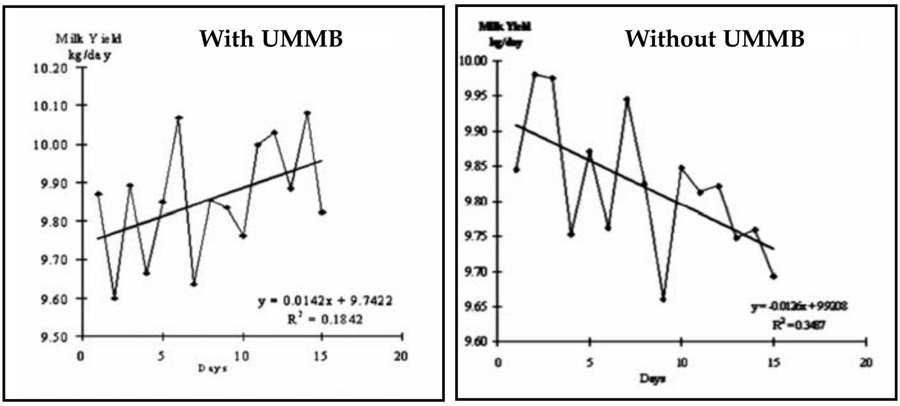
UMMB promotion activities in 2001–2002

In 2001–2002, a revolving fund system was established at Kudjub MCC and five molasses storage tanks (8–12 tonne capacity) were provided to farmers groups, MCCs and cooperatives. Three UMMB production units (Srithat MCC; Namphong MCC; and Tung fon MCC) stopped producing UMMBs, but they continued to supply molasses for farmers to produce their own blocks on-farm.

Twenty-four pilot farms were established. Coral tree (*Erythrina subumbrans*) and leucaena (*Leucaena leucocephala*) were introduced as tree fodder and to provided shade. UMMBs have a wide dissemination as proven technology, and have been demonstrated on the pilot farms. The extension activities conducted involved training programmes for block utilization, visits to pilot farms and the production of a newsletter and posters.

In 2002, UMMBs were promoted to Sukhothai Project, with the cooperation of Narasuan University and the North DPO Division. Farmers have been trained and some have started to produce UMMBs. The Sawankhaloke Cooperative also produces and sells blocks to farmers. A production unit plans to establish a revolving fund to promote UMMB use in Sukhlothai Project, north Thailand.

Experiment 1



Experiment 2

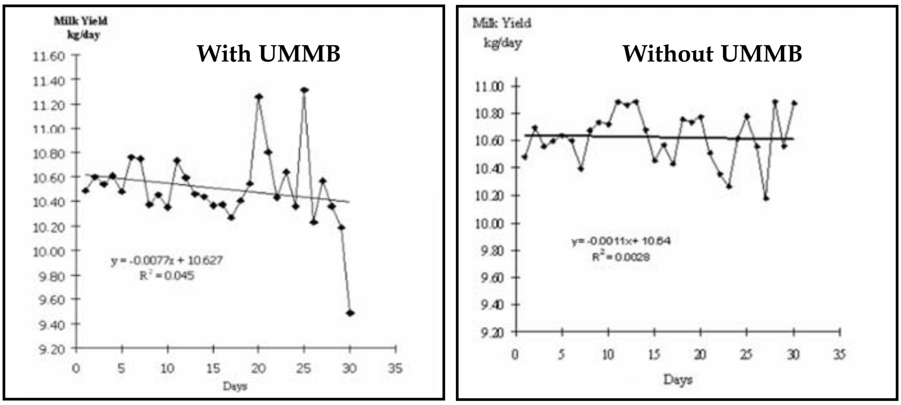


Figure 8.1

Regression lines of milk yield before and after UMMB supplementation

Medicated block on-farm trial

A study was carried out in Kranuan during the dry season, from December 2001 to April 2002, for 120 days. Forty-six dairy-cross heifers, aged between 6 and 18 months, from nine farms were divided into three treatment groups: T1, T2 and T3. Medicated urea molasses block (MUMMB) containing fenbendazole @ 0.5 gram/kg were given to 14 heifers (9 had zero egg counts) in T1; normal UMMBs were given to 17 heifers (11 of which were egg free) in T2; and 15 heifers (11 with zero egg counts) received no supplement (T3). In T1, MUMMB were given for 15 days, followed by UMMB for 45 days, and the cycle was then repeated. In T2, UMMBs were continuously offered during the 120 days. The UMMBs had molasses, 40%;

rice bran, 40%; urea, 5%; cement, 12%; and mineral mixture, 3%. Faecal egg count per gram, packed cell volume and body condition score were determined before the trial and then every 30 days. The average daily gain was also estimated 60 days before and after supplementation. MUMMB and UMMB were given ad lib, and daily consumptions were 1.11 ±0.15 kg and 1.18 ±0.27 kg, respectively.

Reproductive performance of cows supplemented with UMMB

Seventy cows from nine demonstration farms in the Nasee Village of Namphong MCC were used to monitor reproductive performance from September 1995 to September 1997 (without supplementation). From October 1997 to September 1999 these cows received UMMB as a supplement to their regular diet. Records were kept of all reproductive parameters, such as first oestrus after calving, calving to first service, calving to conception, number of artificial insemination services until confirmation of pregnancy by rectal palpation, and calving interval. The results are summarized in Tables 8.6 and 8.7.

The first-service conception rate was low (41.4 percent) and services per conception were high (2.54) on cows without UMMB. Following UMMB supplementation, the first service conception rate improved by 15.3 percentage units (to 56.7 percent). Interestingly, there was a significant decline ($P < 0.01$) in services per conception (1.88). UMMB supplementation also reduced the culling rate due to infertility (8.6 vs 3.2 percent). The significant decline in services per conception reduced ($P < 0.01$) the mean calving to conception interval (days open) from 127.2 to 92.4 days (Table 8.7). Use of UMMB also reduced the calving to first service interval and the calving interval from 77.5 and 405.4 days to 65.9 and 365.1 days, respectively (Table 8.7).

The distribution of calving to conception interval illustrated in Table 8.8 further reveals the beneficial effect of UMMB supplementation. Before UMMB use, among the cows that conceived, 62.6 percent became pregnant by 120 days post partum compared with 76.7 percent with UMMB use.

An improvement in the reproductive efficiency of cows following UMMB supplementation is further evident on perusal of mean values for calving interval, which also was reduced significantly ($P < 0.01$, Table 8.7). This is further illustrated in Table 8.8, which shows that before UMMB, out of 64 calving intervals, 42.2 percent were below 360 days, compared with 50.0 percent after UMMB use.

Table 8.6
Effect of UMMB on reproductive performance of crossbred dairy cattle in northeastern Thailand (DPO Programme).

Parameter	Without UMMB	With UMMB
Number of animals in trial	70	62
Number in oestrus (%)	70 (100.0)	60 (96.8)
Number inseminated	70	60
Number conceived to 1st AI (%)	29 (41.4)	34 (56.7)
Overall pregnancy (%)	68 (97.0)	60 (100.0)
Total number of inseminations	173	117
Services per conception	$2.54^a \pm 0.25$	$1.88^b \pm 0.19$
Number of animals culled or aborted (%)	6 (8.6)	2 (3.2)

NOTES: AI = artificial insemination. ^{a,b} indicate significant differences (P < 0.01) (one sample t-test)

Table 8.7
Effect of UMMB on fertility of crossbred dairy cattle in northeastern Thailand (DPO Programme).

Fertility measurements	Before UMMB		After UMMB	
	n	Mean ± SEM.	n	Mean ± SEM.
Calving to first service interval (days)	64	$77.54^a \pm 5.20$	60	$65.91^b \pm 3.53$
Calving to conception interval (days open)	64	$127.21^c \pm 11.30$	60	$92.35^d \pm 6.65$
Calving interval (days)	64	$405.40^e \pm 11.34$	60	$365.06^f \pm 5.33$

NOTE: SEM = Standard Error of the Mean. Means with different letters within a row differ significantly (P<0.01) (one sample t-test).

Table 8.8
The effect of UMMB supplementation on calving to first artificial insemination (AI) service, calving to conception (open days) and calving interval of cross-bred dairy cows.

	Cows without UMMB (n = 64)		Cows with UMMB (n = 60)	
	Number of cows	percentage	Number of cows	percentage
Calving to first AI service (days)				
<60	27	42.2	33	55.0
60–90	23	35.9	18	30.0
>90	14	21.9	9	15
Calving to conception (days)				
<60	12	18.8	21	35.0
60–120	28	43.8	25	41.7
>120	24	37.4	14	23.3
Calving interval (days)				
<360	27	42.2	30	50.0
360–480	26	40.6	29	48.3
>480	11	17.2	1	1.7

On-farm evaluation of UMMB

Faecal egg counts and packed cell volume.

There was no re-infection by nematodes in the MUMMB supplementation group, with faecal egg counts at zero at all counts (30, 60, 90 and 120 days). Heifers in the UMMB group showed lower egg counts than control heifers. Packed cell volume (PCV) in the MUMMB group increased from 27.4 ±5.4 to 31.5 ±2.9 at 60 days, and it was higher than in the UMMB and control groups ($P < 0.05$), which were similar ($P > 0.05$). PCV was not significantly different at 30, 90 and 120 days ($P > 0.05$).

Daily weight gain and body condition score

The differences in liveweight gain and body condition score (BCS) between the treatment groups T1, T2 and T3 was attributed to the imbalance of eggs per gram (EPG) and PCV between groups. The measurement of daily weight gain for some heifers was made 60 days after supplementation and body score was also determined every 30 days. The daily weight gain of animals in MUMMB groups (0.73 ±0.17 kg/day) was higher than UMMB heifers and heifers without block ($P < 0.05$), with no difference between the last two groups ($P > 0.05$). The body score improved in every group.

Cost effectiveness of UMMB supplementation

Regrettably, data on actual intake of roughage, concentrate and UMMB by cows and the extent to which concentrates have been replaced by UMMB are not available in all cases, and therefore it was not possible to perform an exact cost–benefit analysis for UMMB supplementation. However, there is no doubt that UMMB supplementation reduced the rate of decline in milk production, which could be inferred as an increase in milk production during the declining phase of lactation. This sustaining or extension of the lactation period undoubtedly would have increased the total lactation yield.

Assuming that UMMB could replace about 25 percent of the concentrate supplement, the economic benefit of supplementation with UMMB was calculated to be in the region of Baht 4.5/cow/day. Studies conducted in Sri Lanka have demonstrated that UMMB could replace 40–60 percent of concentrate supplement without affecting milk production, suggesting that the economic benefits could be even higher.

Table 8.9
EPG values in the groups free of nematodes.

Groups	n	Time of evaluation (days)				
		0	30	60	90	120
MUMMB	9	0	0	0	0	0
UMMB	11	0	9.1 ±30.2	22.7 ±75.4	0	0
Control	11	0	68.2 ±129.0	81.8 ±255.2	0	63.6 ±167.5

Table 8.10
EPG values for dairy heifers during a 120-day period.

Groups	n	Time of evaluation (days)				
		0	30	60	90	120
MUMMB	14	32.1 ±49.0	0^{a}	0	0	0
UMMB	17	52.9 ±92.2	5.9^{ab} ±24.3	20.6 ±63.9	11.8 ±48.5	0
Control	15	30.0 ±65.9	50.0^{b} ±113.4	60.0 ±218.9	0	46.7 ±144.5

Table 8.11
Packed cell volume (PCV), weight gain and body condition score (BCS) of dairy heifers over 120 days.

	Group	n	Time of evaluation (days)				
			0	30	60	90	120
PCV	MUMMB	14	27.4 ±5.	29.6±3.91	31.5^{a} ±2.9	28.4±2.8	29.6 ±3.4
	UMMB	17	27.0 ±3.0	28.5±3.4	26.5^{b} ±7.5	26.2±4.2	27.4 ±3.0
	Control	15	28.7 ±3.7	29.3±3.5	27.1^{b} ±2.9	28.2±2.8	28.4 ±2.5
Weight gain (kg)	MUMMB	13			0.7^{a} ± 0.2		
	UMMB	12			0.5^{b} ± 0.2		
	Control	10			0.2^{b} ±0.2		
BSC	MUMMB	14	2.6^{a} ±0.6	2.9^{a} ±0.5	3.0^{a} ±0.5	3.2^{a} ±0.6	3.2^{a} ±0.6
	UMMB	17	2.3^{b} ±0.5	2.5^{b} ±0.4	2.7^{b} ±0.3	2.8^{b} ±0.2	2.8^{b} ±0.2
	Control	15	3.0^{c} ±0.4	3.1^{c} ±0.5	3.2^{c} ±0.5	3.3^{a} ±0.5	3.4^{c} ±0.6

Note: ^{a,b,c} Values bearing different superscripts within the same column differ significantly at P<0.05.

Table 8.12
Quantities of UMMB and total milk produced in the six MCCs in 1997–2002, and farmer income.

	Milk Collection Centre						Total
	Namphong	Kranaun	Srithat	Kudjub	Jareonsin	Tungfon	
1997							
UMMB production (kg)	–	–	19 110	–	–	–	19 110
No. of cows	551	291	850	271	572	–	2 535
Total milk yield (tonne/year)	1 858	1 375	3 069	946	1 144	–	8 374
Income from milk (Baht)	17 153 022	12 436 648	28 183 707	8 786 829	10 539 681	–	77 099 887
1998							
UMMB production (kg)	13 460	–	18 000	12 000	–	–	43 460
No. of cows	739	311	658	410	323	265	2 706
Total milk yield (tonne/year)	2 135	1 356	2 702	1 160	1 252	712	9 317
Income from milk (Baht)	21 498 261	13 616 890	26 751 295	11 678 808	12 459 463	7 432 944	93 437 661
1999							
UMMB production (kg)	35 000	7 900	20 500	10 840	7 360	600	82 200
No. of cows	777	414	702	453	341	249	2 936
Total milk yield (tonne/year)	2 371	1 657	2 444	1 228	968	997	9 665
Income from milk (Baht)	25 261 164	17 609 567	26 141 845	13 142 398	10 333 992	10 646 635	103 135 601

NOTE: UMMB production is the total from all sources: MCCs, farmer groups and cooperatives.

In six DPO MCCs between 1997 and 1999 (Table 8.12), UMMB production increased from 19 tonne to 82 tonne, and total milk production increased from 8.37 million to 9.66 million litres, an increase of 1.29 million litres. While some of this increase could be attributed to the increased number of cows (up from 2 535 to 2 936), there is no doubt that a substantial part of the increase was due to improved feeding due to UMMB supplementation and the consequent improvement in reproductive performance. Considering the information given in Table 8.13 and assuming that the cost of production of 1 kg of UMMB is Baht 4, the total cost incurred in the production of UMMB during 1999 was Baht 328 000. The value of increased milk production at Baht 12/kg of milk would be Baht 4 172 000. Even if one assumes that only 10 percent of the increase in milk production was due to UMMB supplementation, it appears that UMMB feeding is cost effective (an income of Baht 417 000 as against a cost of Baht 328 000) and beneficial to the dairy industry. Increases in milk production due to UMMB supplementation have brought additional income while improving reproductive performance, leading to more calves. This has undoubtedly improved the social status of the farmers.

Acknowledgements

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Development, use and impact of feed supplementation blocks: experiences in Sri Lanka

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Introduction

The dairy industry in Sri Lanka has declined rapidly during the past two decades due to various causes. One of the major factors in this decline has been nutrition. Traditionally, dairy farmers are smallholders, comprising about 95 percent of the dairy farms in the country. Under smallholder conditions, feeding has become an important and critical factor with tremendous effect on productivity. The feed and feeding practices in Sri Lanka differ significantly from many other tropical developing countries. The dairy animals in Sri Lanka are malnourished, not because of unavailability of feed resources, but due to underutilization.

About 98 percent of the smallholder dairy farmers neither cultivate nor conserve forage, but instead depend entirely on naturally available forage. Natural forage is abundant during the wet season, but the quantity and quality of green biomass declines as the dry season progresses. Under such circumstances, there is no choice other than to utilize agricultural crop residues to keep the animals alive.

Farming systems in Sri Lanka

Since 95 percent of the dairy farmers are smallholders, there is little organized dairy farming in Sri Lanka, although there are some recognizable categories (see Table 9.1).

The type of dairy farming system depends on land availability, allocation to other agricultural crops, environment, and animal productivity.

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Table 9.1
Dairy farming systems in Sri Lanka.

System	Agro-ecological zone	Type of management
Plantation crops		
Coconut	Wet to intermediate	Semi-intensive
Tea	Wet hill country	Intensive
Rubber	Low country wet to intermediate	Semi-intensive
Rice based	Wet	Semi-intensive
Rice based	Dry	Extensive
Home garden	Wet	Intensive and semi-intensive
Urban and peri-urban	Wet	Intensive

Ruminant feeding systems

Feed for dairy animals is totally from natural forage, and rainfall determines the quantity and quality of such forage. Quality and quantity are therefore highly seasonal. During the dry season, when good quality forage becomes scarce, farmers have to use alternative feeds, such as agricultural crop residues. In this respect, rice straw plays a vital role. The availability of rice straw is also seasonal, since rice is cultivated only during the two monsoon periods, and the straw becomes available during the harvesting period, which falls in the dry season. This is the season during which animals require a supplementary feed source.

Compared with other straws, rice straw is low in nutritional quality, palatability and digestibility, so upgrading of straw prior to feeding becomes necessary. To achieve this, urea-ammonia treatment was introduced to the country under a straw utilization project funded by the Government of the Netherlands in the early 1980s. After many on-station and on-farm studies, 4 percent urea treatment and storing for 7 days was recommended. However, this technique did not become popular among the farmers, for various reasons. Eventually this practice almost disappeared from Sri Lanka. Later, under the same project, use of urea-molasses mineral block (UMMB) was tested under on-farm conditions in the mid-1980s. The readymade blocks ("Mol-u-min") were imported from India. The results of these experiments were not satisfactory. The effect of UMMB supplementation on dry matter digestibility (DMD) and dry matter intake (DMI) was not significant (Schiere *et al.,* 1987). These trials were done primarily for performance testing under controlled on-farm conditions, and were not extended to the field, probably due to unsatisfactory results. Later, in the mid-1990s, with the assistance of the International Atomic Energy Agency (IAEA) and the Swedish Agency for Research and Economic Cooperation (SAREC), the UMMB technology was modified and widespread use in the field was promoted. Today, this technology is accepted and used at all levels by the dairy farming sector.

Due to extensive cultivation, diminishing land availability, seasonality and uncertainty in income from crop cultivation, an intensive buffalo management system called Smallholder Intensively Managed Buffalo Units (SIMBU) was developed in the dry zone of Sri Lanka. The objective of this model unit was to manage dairy animals under stall-fed conditions, based predominantly on rice straw feed and UMMB (Abeygunawardane *et al.*, 1995).

HISTORY OF UMMB PRODUCTION IN SRI LANKA

In the mid-1980s, state farms in Sri Lanka started to feed molasses to dairy cattle as a source of energy and to improve the intake of low quality forages. No urea was used and liquid molasses was sprinkled over the forage before feeding. This led to uncontrolled intake of molasses by the animals and waste of molasses due to spillage.

The Mahaweli Livestock Development Division (MLDD) manufactured an initial stock of UMMB at Girandurukotte farm. A foreign expert arbitrarily recommended a formula, with no consideration of the available feeds and production potentials of the animals. Following project inception, a number of investigations were conducted on-station and on-farm, and four formulas were developed that reflected the locally available feed types, quality and milk production potentials of the animals. UMMBs with these final formulas were initially manufactured at the same location, in parallel with those already being manufactured. Field testing of these blocks was carried out by distributing them to farmers free of charge. After field testing the blocks and training livestock officers and farmers in the different agro-ecological zones, the current formulas (see Table 9.2) were recommended and released to the farmers. At present, this technology has received wide acceptance and is in use on both state farms and smallholdings.

Table 9.2
UMMB formulas recommended for use in the various agro-ecological regions.

Ingredient	**Agro-ecological Zone**			
(g/kg block)	Wet Zone	Intermediate Zone	Hill Country	Dry Zone
Molasses	400	400	400	400
Urea	100	100	100	120
Rice polish	340	320	300	330
Fish meal	10	30	50	–
Common salt	30	30	30	30
Mineral mixture	20	20	30	20
Cement	100	100	100	100
Total	1 000	1 000	1 000	1 000

SOURCE: Perera, 2002.

During the development of blocks for field application, many on-station and on-farm trials were conducted. The results of these extensive studies showed that 100 g of urea per kilogram of block is sufficient to maintain an optimum rumen ammonia levels for efficient microbial activity. The level of external urea input depends on the nitrogen content of the diet. For those animals fed on medium quality forages (CP 10–12 percent), the 10% w/w level was found to be satisfactory. However, in the dry zone, where the feed quality was low (CP 8–10 percent), and highly variable (mainly mature grasses and straws), the level of urea in the block had to be slightly higher (120 g/kg) (Perera and Perera, 1996). For moderate (10–12 litre/day) to high (>13 litre/day) milk yield, there is a requirement for some "bypass" protein since the cow's protein requirements cannot be met by rumen microbial protein production alone. The studies conducted using high milk production cows showed improved response to UMMB when bypass protein was included. Therefore, the formulas developed and recommended for the wet, intermediate and hill country zones also included 10, 30 and 50 g/kg of fish meal, respectively. Although addition of flavomycin has elsewhere improved milk yield in dairy cattle, in these trials there was no significant improvement – it merely increased the feed cost (Perera and Perera, 1996). In developing formulas for the blocks, due consideration was given to selecting suitable local ingredients. Even though coconut oil meal was the most common, freely available and widely used crude protein source in ruminant feeds, it was purposely eliminated from all the formulas, because it tends to become rancid rapidly due to its high oil content (8–12 percent), and its extensive use in other commercial feeds, where demand fluctuations lead to significant price fluctuations during the course of the year. With such price fluctuations, if coconut oil meal is used in the block, the price of the block will fluctuate, discouraging farmers from using the block.

Availability of molasses

Molasses is one of the key ingredients in UMMBs. This is a major source of readily fermentable energy and a good carrier for urea. In addition, molasses supplies micro-minerals, thus eliminating the need to add micro-mineral salts. Molasses is produced in three sugar processing plants in the country and is available for use as animal feed. Average annual molasses production in Sri Lanka is about 35 500 tonne, of which a small quantity is used by the distillery industry for alcohol production. The balance is available for animal feed. This quantity is quite sufficient to satisfy the local demand for animal feed. Molasses is also used in the concentrate feed industry for other livestock, but it is not expected that molasses supply could be a limiting factor in the near future when promoting UMMB technology.

Effect of UMMB on animal performance

Animal performance improved tremendously after the introduction of UMMB under field conditions. This improvement was attributed to "supplementary" and "catalytic" effects of UMMB, as UMMB promotes an optimal ammonia level for efficient microbial activity in the rumen, and the inclusion of fish meal helps to satisfy the total protein requirement of high producing animals (Kunju, 1986).

Effect on intake

According to Schiere *et al.* (1989), the effect of UMMB on DMI was not significant. However, when compared with untreated straw, 4 percent urea-treated straw (5.5 vs 3.3 g/kg$W^{0.75}$) increased DMI fourfold. According to Soetanto, Budi and Sulstri (1987), intake and beneficial effects of UMMB depended on the type and the quality of the basal feed and other supplements fed. Kunju (1986), who reported greater intake by cows fed rice straw supplemented with UMMB compared with cows fed rice straw with 1 kg of concentrates, confirmed this. In his experiment, the straw DMI increased by 29.5 percent when concentrate was replaced by 500 g of UMMB. In Sri Lanka, Badurdeen, Ibrahim and Ranawana (1994) reported daily intake of 226 g of UMMB per 100 kg body weight when untreated rice straw was fed to cattle. However, when untreated rice straw was replaced with 4 percent urea-treated rice straw, the daily UMMB intake dropped to 155 g per 100 kg body weight. This is a 31 percent reduction in intake of UMMB, which clearly demonstrates the self-regulation effect of UMMB use, determined by the dietary nitrogen level. In the dry zone, when rice straw was fed as the sole roughage diet for buffaloes, supplementation with UMMB increased the daily rice straw intake from 1.3 ±0.2 to 2.9 ±0.2 as a percentage of body weight. This was a 110 percent increase in total roughage DMI, and was achieved after 11 weeks of supplementation (Abeygunawardane *et al.*, 1996). Considering the nature of the basal diet, this increase was attributed to a catalytic rather than a supplementary effect. According to Preston and Leng (1987), this catalytic effect phenomenon is the result of optimization of rumen ammonia concentration in the rumen by the supplemental nitrogen, resulting in more effective microbial activity.

Another field study revealed that the intake of UMMB by both adults and calves of cattle and buffalo gradually increased with time. Within one month, the intake of UMMB by Nilli-Ravi buffalo cows increased from 0.17 ±0.02 to 0.43 ±0.04 and in Sahiwal cows from 0.22 ±0.02 to 0.50±0.03 kg per head per day. The overall intake of UMMB in Nilli-Ravi buffalo cows was lower than in Sahiwal cows when fed on the same basal diet (medium quality *Panicum maximum,* 12 percent CP). This may be attributed to the ability of buffaloes to utilize urea nitrogen more efficiently than cattle. In the same study, a similar intake response was observed with Nilli-Ravi and Sahiwal calves. Overall, intake of UMMB by buffalo calves (0.096 ±0.01 kg/head/day) was lower than that of Sahiwal calves (0.165 ±0.02 kg/head/

day) (Perera and Perera, 2000). Sivayoganathan *et al.* (2001) reported that, from field data collected from mid-country smallholder dairies, intake of UMMB was higher under extensive systems of management (600–1 000 g/head/day) than under stall-fed conditions (450–800 g/head/day). Roughage DMI increased by 20–30 percent and the animals readily accepted highly fibrous roughage when UMMB was provided, compared with no supplementation. Fishmeal showed beneficial effects only with high yielding (>10 litre/day) dairy cattle. Addition of 30 g/kg of fishmeal to blocks significantly increased DMI and OMI, and gave a high nitrogen balance (Uthayathas, Perera and Perera, 1999). Under the SIMBU system in the dry zone, when cross-bred buffaloes were raised under stall-fed conditions using rice straw as the sole roughage, supplementation with UMMB increased the daily intake of rice straw from 4 to 7 kg/head/day (75 percent increase) within 60 days (Abeygunawardena *et al.*, 1996).

Effect on reproduction

At initialization of the SIMBU model in the field in the dry zone, cross-bred buffalo cows feeding on medium quality grass and 5 kg/day of traditional concentrates were brought from a state farm. During the field observation period the diet was gradually changed to straw and UMMB. When the animals had completely changed diet, the anticipated results were achieved. The reproductive performance was similar to that under their original farm conditions. The annual calving rate was 62 percent and the calving interval was 584 ±80 days. This long calving interval was not related to nutrition but to inefficient detection of oestrus (Abeygunawardane *et al.,* 1996). Sivayoganathan *et al.* (2001) reported that cross-bred cows with exotic blood in the mid-country region of Sri Lanka responded significantly in reproductive performance to feeding of medium quality fresh grass and 500 g/day of UMMB with 3 percent fish meal compared with traditional concentrates (coconut oil meal + rice bran). When supplemented with UMMB, the period from parturition to first oestrus was reduced from 120 ±60 to 90 ±30 days, with a reduced number of inseminations per conception and an improved rate of conception.

The birth weight of buffalo calves born to cows supplemented with UMMB was 27.1 ±4.0 kg, which was 8.4 percent higher than that of calves born to cows on traditional feed plus concentrates. The calves born to UMMB-supplemented cows had a pre-pubertal daily gain of 250 ±30 g/day, similar to gains by calves on state farms under best feeding and management conditions (Abeygunawardane *et al.,* 1996).

Effect on growth and other parameters

Supplementation with UMMB has proven to exert beneficial effects, such as increased DMI, digestibility and optimum rumen environment, all of which contribute to improved body weight gain by the animal. Buffalo cows supplemented with UMMB exhibited a superior daily body weight gain of 380.9 ±25 g) compared with the control group (238 ±21 g).

In the same study, Sahiwal cows showed even better daily body weight gain response: 261 ±2 g with UMMB supplementation compared with 95.2 ±9 g in the control group. This experiment concluded that UMMB supplementation gave greater response in Sahiwal cows than in buffalo cows. A similar trend was observed in buffalo and Sahiwal calves. One contributory factor for this may be the ability of buffaloes to recycle urea into the rumen more effectively than pure cattle (Perera and Perera, 2000). Abeygunawardane, Abeywansa and Perera (1995) reported a daily body weight gain of 256 ±73 g in buffaloes fed untreated rice straw supplemented with 600–800 g/day of UMMB under the SIMBU model system in the dry zone of Sri Lanka. Dairy farmers in many agricultural zones reported satisfactory growth rates for calves and body weight maintenance of cows – both cattle and buffaloes – irrespective of the type of basal feed, when the bulk requirement was satisfactorily met and supplemented with UMMB. BCS is an important criterion in evaluating the nutritional status of cows. According to Perera *et al.* (1997), cross-bred dairy cattle feeding on medium quality natural forage supplemented with 500 g/day UMMB had a higher BCS (2.75) than cows supplemented with 2 kg of commercial concentrate mixture. Similar observations were made by Sivayoganathan *et al.* (2001) from a two-year field observation in the same region. The BCS improvement in response to UMMB was more prominent in buffaloes than cattle, because most of the buffaloes in Sri Lanka are usually fed on poor quality roughages (including crop residues) that are naturally low in nitrogen (Perera and Perera, 2000).

Supplementation with UMMB facilitates maintenance of optimum rumen ammonia levels, especially when feed quality is low. Badurdeen, Ibrahim and Ranawana (1994) reported both a rumen ammonia level of 10.30 ±0.30 mg/100 ml and a higher rumen mineral content with UMMB supplementation.

Effect on lactation

As a result of the effect of facilitated feed nutrient utilization with supplementation with UMMB, lactation length, yield and quality of milk also improved. In the dry zone of Sri Lanka under the SIMBU model, buffalo cows maintained on a straw-based diet supplemented with UMMB gave a similar milk yield with 800 g intake of block to that from 5 kg of traditional concentrate intake. However, the persistency of lactation was greater with UMMB than with concentrate (Abeygunawardane *et al.*, 1996). Perera and Perera (2000) reported that Nilli-Ravi buffaloes under field conditions gave 11 percent more milk daily when supplemented with UMMB compared with commercial concentrates. In addition, this lactation yield was maintained over a longer period compared with cows on traditional concentrates, resulting in an 18 percent improvement in total milk yield. In the same experiment, the response by the Sahiwal cows was not as satisfactory as that of buffaloes. This low response in Sahiwal cows could be due to comparatively lower nutrient demand due to smaller body size and lower milk yield, which may have been satisfied by the basal diet.

Uthayathas, Perera and Perera (1998) reported that Sahiwal cows given UMMB in the intermediate zone, with or without 3 percent fishmeal, produced 475 kg of milk more than cows fed traditional concentrates. In addition, milk quality also improved due to higher butterfat content (4.59 percent). This study also indicated that the addition of fishmeal to UMMBs had no effect when the daily milk yield was less than 8 litre. Similar improvements in butterfat content were observed by Sivayoganathan *et al.*, (2001) in the intermediate zone with cross-bred cattle. The butterfat content of milk from these cows increased by 0.8 ±0.1 percent. This might be attributable to higher celluloytic fibre utilization by the microbes in the presence of the optimum urea ammonia provided by UMMB. Perera *et al.* (1997) reported 12 percent increase in daily milk yield of Sahiwal cross-bred cows with no change in butterfat when UMMB was supplemented as a substitute for traditional concentrates. In addition, Salgado, Perera and Perera (1996) reported an 18 percent improvement in total milk yield in Australian Milking Zebu cows, not from daily milk yield but from improved lactation persistency with UMMB supplementation. In this study, the increase in daily milk yield (1.5 ±0.5 litre) became significant and prominent during the latter part of the lactation. All these findings suggest that the lactation curve was more prolonged with UMMB supplementation compared with traditional concentrates.

Cost–benefit ratio

Many studies have indicated economic gains as a result of supplementation with UMMB, deriving from factors such as reduced cost of supplementary feeding, increased milk yield, prolonged lactation, better milk quality, reduced calving interval, improved conception rate and younger age at puberty. A field study conducted by Uthayathas, Perera and Perera (1998) in Sri Lanka using Sahiwal cows under a free-grazing management system showed that 1 kg of traditional concentrate produced 1.88 kg milk while UMMB gave 3.69 kg of milk, and that the cost of supplementary feeding to produce 1 kg of milk was SL Rs 2.93 with traditional concentrates and SL Rs 1.38 with UMMB. This was a 112 percent reduction in supplementation cost. Overall, the total daily costs of feeding traditional concentrates vs UMMB per cow were SL Rs 14.40 vs SL Rs 8.70, respectively. Under the SIMBU model in the dry zone state farm, daily supplementary feed cost was reduced by 77 percent in buffalo cows following a change of feed from commercial concentrates to UMMB, with no change in milk production or reproduction parameters. In the same study, periodic monitoring of plasma micro-minerals revealed that when UMMB is supplemented, addition of micro-minerals is not necessary. The total micro-mineral requirement was satisfied by the ingredients used, particularly the molasses (Abeygunawardena *et al.*, 1996). As a result, only dicalcium phosphate and common salt were included in the block. Sivayoganathan *et al.* (2001) monitored nearly 250 small-scale dairy farmers in the intermediate zone of Sri Lanka and showed that, due to improved butterfat content in milk, an additional SL Rs 2.00 ±0.75/litre of milk was received. This was in addition to the reduction in supplementary feed cost due to use of UMMB to replace part of the usual concentrates. After UMMB supplementation, the cost of concentrate feed for cows producing up to 5 litre of milk per day was reduced by 100 percent, whereas for cows producing 5–10 litre/day it was reduced by 45–60 percent. The reduced concentrate feed cost, coupled with the improved butterfat content, gave the farmer a net overall daily economic gain of SL Rs 28.50 per cow. This amount, when expressed in terms of milk yield, is equivalent to an additional 2.85 litre per day per cow. Perera *et al*. (1997) reported a net daily economic gain of SL Rs 8.00/cow due to 12 percent increased milk yield in Sahiwal cows. Compared with the average daily milk yield per cow, this can be considered a substantial return under the present management system. In another extensive field survey conducted to compare the economics of UMMB feeding for cows managed under intensive systems with cows on high-concentrate diets (peri-urban conditions) and semi-intensive management conditions, it was concluded that the profit per cow per day under intensive low-roughage condition was SL Rs 13.00, whereas under semi-intensive and high-roughage condition it was SL Rs 39.00, or three times as much (Perera, 2002). These findings indicate financial benefits from UMMB supplementation in extensive systems where the diet is high in poor quality roughage. Therefore, under Sri Lankan conditions, UMMB supplementation has more of a catalytic than a supplementary effect. Generally, under Sri Lankan conditions, the reported cost–benefit ratio of UMMB supplementation ranged between 1 and 3.5.

Limitations

After a decade of effort in promoting UMMB technology in Sri Lanka, it has become a success story, and one of the national feeding strategies to improve the productivity of dairy animals. However, the process of promotion has not been smooth sailing. There are still certain limitations with UMMB supplementation observed in the field and reported by farmers, namely:

- High cost of molasses.
- Irregular and unreliable availability of manufactured blocks.
- Limited availability of manufacturing units.
- Difficulty in obtaining molasses by private farmers.
- Low quality of ingredients used (e.g. rice polish).
- Lack of infrastructure for distribution.
- Lack of preference by some animals.
- Insufficient farmer knowledge of UMMB use due to poor extension and training.
- Insufficient promotion by the state sector.

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Use of urea molasses multinutrient blocks for improving cattle productivity in Viet Nam

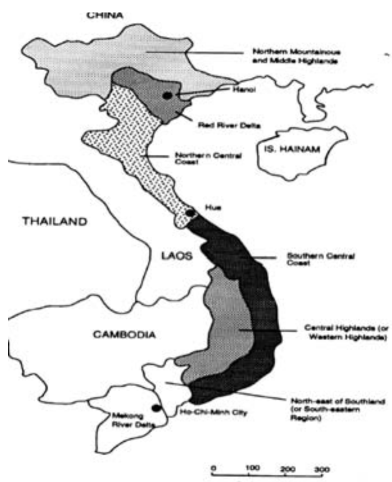
Doan Duc Vu[16]

Introduction

Viet Nam is tropical country with a hot and humid climate. The total land area is 332 000 km^2 and it is densely populated, with about 76 million inhabitants. The rural community accounts for around 80 percent of the population, and some 70 percent of the rural population relies almost exclusively on agriculture for their livelihood. Agriculture is based mainly on rice production, supported by other crops such as maize, potato, sweet potato, cassava, groundnut, sugar cane and perennial commercial trees such as coffee, rubber, tea and coconut. Vietnamese agriculture has been classed in seven zones according to ecological and economic conditions.

The zones are:

- Northern Mountainous and Middle Highlands.
- Red River Delta.
- North Central Coast.
- South Central Coast.
- Central Highland.
- North East of Southland.
- Mekong River Delta.



In Viet Nam, dairy production started in the 1970s and developed slowly. In 1980, national milk consumption was barely 0.3 kg per capita. It was still only 0.5 kg by 1990, but it rose to 6 kg per capita in 2000. At present, the fresh milk supply meets only 10 percent of demand (Anon., 2002), and developing domestic milk production is a priority strategy of the National Food Programme in

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Viet Nam. Decision No. 167, signed on 26 October 2001 by the Prime Minister, spelled out some specific goals: increasing the dairy population from 35 000 head (in 2000) to 200 000 head by 2010; and increasing milk production from 54 000 tonne (in 2000) to 350 000 tonne by 2010 in order to meet 40 percent of local demand.

Dairy and beef cattle production is almost entirely in the hands of smallholders. Although it is reported that there are 1 million hectares of so-called natural pasture, in fact Viet Nam has very few areas of natural pasture. With the increasing human population and the establishment of new economic zones, natural pasture has been reduced to small areas mixed among crop and built-up areas.

Because of the shortage of grass, farmers use many agro-industrial by-products as feed for cattle, such as rice straw, sugar cane tops and cassava root waste. Nutritionally, these feedstuffs are unbalanced, especially in terms of their mineral and protein contents. Their use results in poor body condition, short lactation periods, low reproductive performances, early culling and ultimately poor economic efficiency.

However, these feedstuffs can be better used if the rumen environment is improved through supplementation with limiting nutrients, such as nitrogen, carbohydrate, minerals and vitamins. One of the most suitable methods under tropical smallholder conditions of supplying the nutrients that are lacking is to give the animals urea and molasses in the form of urea-molasses mineral blocks (UMMBs).

Since 1996, within the framework of IAEA TC Projects RAS/5/030 and RAS/5/035, studies have been carried out to assess the effects of UMMB supplementation on productivity, reproductive performance and economic efficiency of dairy cattle fed rice-straw-based diets. Based on the results of these studies, pilot farms have been established in order to disseminate this technology to more farmers.

Formulation and chemical composition of UMMB

Based on locally available ingredients, two formulas for UMMBs have been developed and introduced to sugar factories and smallholder farms (Table 10.1).

Table 10.1
Ingredients of UMMBs (percentage) used in Viet Nam

Ingredients	Formula 1 (For sugar factories)	Formula 2 (For smallholder farms)
Molasses	40	37
Urea	5	5
Rice bran	25	43
Bagasse	15	–
Lime	7	7
Cement	6	6
Salt	1	1
Pre-mix	1	1

NOTE: The chemical composition of UMMBs was dry matter (DM) = 89.3 percent; crude protein (CP) = 16 percent of DM; and metabolizable energy (ME) = 2 350 Kcal/kg.

Effects of UMMB on milk production and reproductive performance in dairy cows fed diets based on rice straw

Experimental design

A trial was carried out on 11 smallholder farms around Ho Chi Minh City (Southern Viet Nam), where there are two seasons: a rainy season (from June to November) and a dry season (from December to May). Sixty cross-bred Holstein Friesian cows with accurate records from the survey phase were divided randomly into one control group of 20 cows and two trial groups of 20 cows each. Each group included lactating and non-lactating cows. The control group was traditionally fed (without any intervention), and lactating cows were fed 25.2 kg of grass, 4.3 kg of rice straw, 11.6 kg of brewers grains, 2.1 kg of soybean residue and 4.2 kg of concentrate, while non-lactating cows were fed 17.5 kg of grass, 5.6 kg of rice straw, 4.5 kg of brewers grains, 1.2 kg of soybean residue and 1.2 kg of concentrate.

Cows in trial group 1 received a diet based on untreated rice straw plus supplementation with UMMB, and cows in group 2 were on a diet of treated rice straw and were not supplemented with UMMB. The average quantity of UMMB fed was 1.5 kg/cow/day during lactation and 1.0 kg/cow/day during the dry period. Urea-treated rice straw (UTRS) was produced by adding 4 percent urea, and given to the cows *ad lib*. The crude analysis of UTRS was 49.1 percent DM, 8.6 percent CP in DM, and 24.5 percent of CF in DM.

The trial experimental rations were balanced to meet nutrient requirements calculated for F_1 (half Holstein Friesian + half Red Sindhi) and F_2 (three-quarters Holstein Friesian + quarter Red Sindhi) cows (Nguyen Van Thuong, 1992) with a milk production of 12.6 litre/cow/day in the control group, 14.1 litre/cow/day in trial group 1 and 13.9 litre/cow/day in trial group 2. In order to balance the trial rations, the quantity of brewers grains was deceased to 4.3 kg and 3.3 kg in lactating cows in group 1 and 2, respectively, and to 1.9 kg and 1.8 kg in non-lactating cows, respectively. The quantity of concentrate fed to non-lactating cows was decreased from 1.2 kg for the control group to 0.5 kg for group 1 (Table 10.2).

Milk yield was recorded daily and the milk fat content for each cow was determined by the Gerber method at two-week intervals. The profit per cow per day for the whole lactation was calculated by deducting the cost of feeds from income generated from milk sales (exchange rate: US$ 1 = VND 11 000). Every two weeks, the body weight of each cow was estimated with a weight tape and body condition score (BCS) determined by the 5-point system. Milk samples for progesterone analysis were collected once a week from month 1 after parturition and stored at -20°C until analysed (Plaizier, 1993). Data were recorded for date of onset of ovarian activity, oestrus, date of insemination and conception rate, and analysed statistically by T-test and χ^2.

Results of the study

Effects of UMMB on productivity of dairy cows and profit of farmers

Data in Table 10.3 show that the milk yield of cows fed rations containing UMMB or UTRS increased significantly by 1.5 kg (11.9 percent) and 1.3 kg (10.3 percent), respectively, compared with the control group. The milk fat content increased significantly, from 3.21 percent in the control group to 3.32 percent and 3.36 percent in groups 1 and 2, respectively. However, feeding either UMMB or UTRS did not significantly increase body weight or BCS. As a result of the improvement in milk yield and reduction in ration cost, profit increased from VND 20 290/cow/day in the control group to VND 28 700 in trial group 1 and VND 25 850 in trial group 2.

Table 10.2
Details of diets fed to dairy cows

Parameter	(unit)	Control L	Control NL	Trial group 1 L	Trial group 1 NL	Trial group 2 L	Trial group 2 NL
Daily ration							
Grass	(kg)	25.2	17.5	23.5	16.0	26.3	19.4
Rice straw	(kg)	4.3	5.6	5.9	3.6	-	-
UTRS	(kg)	-	-	-	-	8.8	5.2
Brewers grains	(kg)	11.6	4.5	4.3	1.9	3.3	1.8
Soybean residue	(kg)	2.1	1.2	2.2	1.2	2.1	0.8
UMMB	(kg)	-	-	1.5	1.0	-	-
Concentrate	(kg)	4.2	1.2	2.5	0.5	3.9	1.2
Cost of ration	(VND '000s)	20.03	9.13	16.42	7.39	18.63	8.46
Nutrients supplied							
ME	(Mcal)	32.1	19.5	28.8	15.2	28.7	15.2
CP	(g)	2 125	1 066	1 645	854	1 772	950
Nutrients required							
ME	(Mcal)	27.0	15.2	28.9	15.2	28.7	15.2
CP	(g)	1 496	802	1623	802	1606	802

KEY: L = lactating cows; NL = non-lactating cows; UTRS = urea-treated rice straw; ME = metabolizable energy; CP = crude protein.
NOTE: Exchange rate at the time of reporting was US$ 1 = VND 11 000.

Effects of UMMB on reproductive performances of dairy cows

The effects of UMMB on some reproductive parameters of dairy cows are shown in Table 10.4. The data show that the intervals from calving to onset of ovarian activity, to first oestrus and to conception, and the calving interval, in the trial groups were significantly shorter than in the control group. Conception rate at first artificial insemination was not significantly affected by the different feeding regimes.

The important finding from this study was that supplementation of the diet of dairy cows in Viet Nam with either UMMB or UTRS significantly improved productivity. This improvement was seen not only in comparison with the control group but also with the data obtained from the survey phase of the field studies when UMMBs were introduced.

The improvement in milk yield and milk fat content when the ration was supplemented with UMMB or UTRS may be explained by the fact that the ME/CP ratio was balanced in the rations and the subsequent maintenance of NH_3 content in the rumen led to an improved ruminant environment for micro-organisms, with consequent increased digestibility and dry matter intake of rice straw and other feedstuffs (Wanapat, 1985; Preston and Leng, 1987).

Perdok *et al.*, (1982) carried out experiments on Surti buffaloes and demonstrated an increase in milk yield and milk fat content when the ration was supplied with UTRS. Results from Thu, Dong and Preston (1996) showed that the milk production of the swamp buffalo in the Mekong Delta of Viet Nam increased by 14.1 percent when the ration was supplemented with UMMB and UTRS. Total volatile fatty acid (VFA) content is an important factor for milk quality, and in particular for milk fat content. Chanthai, Wanapat and Wachirapakom (1986) noted that the total VFA with the UTRS ration was higher than that with untreated rice straw rations (87.86 vs 68.86 mol/litre). At the same time, addition of UMMB to a rice straw ration increased straw digestibility, feed intake, total nutrient absorption and protein:energy ratio in the nutrients absorbed (Leng, 1991). This also led to improvement in reproductive performance. Energy from the diet an important factor for dairy cows both before and after calving. The importance of energy after parturition is well known, as well as during the first two to three weeks of lactation. Energy from any source is important for onset of ovarian activity and coming into oestrus (Lotthammer, 1991; Leng, 1991) and, related to this, for uterine involution. Energy deficiency has been reported to lead to acyclicity, silent and delayed ovulation, and follicular cysts (Lotthammer, 1991).

Table 10.3

Effects of UMMB on milk production and body weight of lactating cows (Mean ±Standard Deviation).

Parameter (unit)	**Control**	**Trial group 1**	**Trial group 2**
Number of cows	20	20	20
Milk yield (kg/cow/day)	12.6 ±2.2 [a]	14.1 ±2.5 [b]	13.9 ±2.0 [b]
Milk fat content (%)	3.21 ±0.12 [a]	3.32 ±0.22 [b]	3.36 ±0.25 [b]
Profit (VND '000s)	20.3	28.7	25.9
Body weight (kg)	434 ±76 [a]	462 ±85 [a]	451 ±93 [a]
Body condition score (1–5)	3.3 ±0.70 [a]	3.3 ±0.60 [a]	3.5 ±0.75 [a]

Note: Within rows, values with different superscripts are significantly different ($P < 0.05$).

Table 10.4
Effects of UMMB on some reproductive parameters in dairy cows.

Parameter (unit)	**Control**	**Trial group 1**	**Trial group 2**
Number of cows	20	20	20
Calving to onset of ovarian activity (days)	112 ±25 [a]	94 ±19 [b]	91 ±36 [b]
Calving to 1st oestrus (days)	135 ±39 [a]	110 ±26 [b]	114 ±28 [b]
Calving to conception (days)	152 ±51 [a]	121 ±49 [b]	122 ±42 [b]
Calving interval (months)	14.4 ±1.7 [a]	13.4 ±1.5 [b]	13.4 ±1.4 [b]
Conception rate at 1st service (%)	60 [a]	70 [a]	65 [a]

NOTE: Within rows, values with different superscripts are significantly different ($P < 0.05$).

Medicated blocks

Gastro-intestinal nematode parasitism of ruminant livestock causes significant losses in production in Viet Nam through mortality and reduced production of meat, milk and work potential. Some researches have been carried out to develop means of controlling nematode parasites through use of UMMB containing anthelmintic in production systems where the regular use of UMMB supplements has proven to be beneficial. Before disseminating this technology to farmers, two experiments were carried out in order to determine the effects of medicated blocks on controlling parasites in cattle.

Experiment 1

Experimental design

Twenty-four dairy heifers on a farm in Long Thanh district, Dong Nai Province, were divided into 3 groups with 8 animals per group. The animals in group 1 were supplied with UMMB containing fenbendazole (FBZ), at a dose of 0.5 g FBZ/kg (FBZ-UMMB); animals in group 2 were fed UMMB without anthelmintic; and animals in group 3 formed a control group (Table 10.5).

The experiment last three months. The animals were kept all day in a cattle shed and each animal received a daily ration of 30 kg of natural grass and 1 kg of concentrate. FBZ-UMMB was provided every tenth day. The daily intake of both UMMB and FBZ-UMMB was 950 ±154 g/head. Faecal samples were collected after 10 days, 1 month and 3 months for analysing gastro-intestinal nematodes, and the body weight of the animals was determined every 15 days by weight tape.

Results

Table 10.6 shows that FBZ-UMMB supplementation progressively decreased parasite infection to 75 percent, 82.8 percent and 87.9 percent of the initial level after 10, 30 and 90 days, respectively. In addition, use of UMMB alone also helped ruminant parasite control, as the egg per gram (EPG) count decreased 37.5 percent, 45.4 percent and 51.7 percent after 10, 30 and 90 days, respectively.

Table 10.7 shows that as a result of the decreasing level of parasite infection, animal weigh gain improved, as, compared with the control group, animals increased about 7 kg/head/month in group 3 (with FBZ-UMMB) and 3 kg/head/month in group 2 (with UMMB alone).

Table 10.5
Experimental design for the trial with FBZ-UMMB.

Treatment Group	Treatment	Number of animals	Body weight (kg/head)
Group 1	FBZ-UMMB	8	178.9 ±4.8
Group 2	UMMB	8	177.7 ±5.2
Group 3	Control	8	176.9 ±3.7
Total & Average		24	177.8 ±4.4

Table 10.6
Effect of FBZ-UMMB on infection of parasites in dairy heifers

Group	% of animals infected by parasites			
	Before trial	**After 10 days**	**After 1 month**	**After 3 months**
Group 1 – Control	100.0	100.0	91.5	100.0
Group 2 – with UMMB, without anthelmintics	100.0	62.5	54.6	48.3
Group 3 – with FBZ-UMMB	100.0	25.0	17.2	12.1

Table 10.7
Effect of FBZ-UMMB on average weight gain in dairy heifers after 3 months of treatment.

Group	**Weight gain**	
	kg/month	kg/day
Control group	8.5 ±3.08 [a]	0.28 ±0.10 [a]
UMMB group	11.21 ±3.14 [b]	0.37 ±0.10 [b]
FBZ-UMMB group	15.38 ±3.39 [c]	0.51 ±0.11 [c]

NOTE: [a,b] Means with different superscripts within column are significantly different ($P < 0.01$)

Experiment 2

Experimental design

From a population of 220 cattle at the Ruminant Research and Training Centre of the Institute of Agricultural Science, 45 animals were selected that had worm EPG counts of around 380 each. They were divided into three groups of 3×5 animals – i.e. three replicates of five animals each in each of two treatments and a control. Animals in group 1 formed the control set, while group 2 was supplied with 1 kg/head/day of UMMB containing 150 g dried ground pineapple leaves (PL-UMMB)/kg (a single dose, at the beginning of the experiment). Animals in group 3 were given Levamisole at a dose of 1 ml/10 kg body weight. The experimental plan is summarized in Table 10.8.

The faecal samples of the animals were collected on the day before treatment and 3 and 10 days after treatment, and worm EPG counts were assessed.

Results

Table 10.7 indicates that use of dried ground pineapple leaves as a herbal medicine incorporated in UMMB can control nematodes in cattle, as the faecal worm EPG count fell from 379 to 53 after 3 days and to 71 after 10 days. Data of the table also showed that two methods of Levamisole injection and PL-UMMB had the same results in controlling parasites.

Establishment of pilot farms for disseminating UMMB technology

Farm selection

Farm selection is an important step when establishing pilot farms in order to ensure that the farms are an effective tool for technology transfer. The criteria include:

- Farm size (number of animals) must be representative of most of the farms in the area.
- The farmers must be willing to participate and have the financial capacity to apply new techniques and invest in them.
- The farmers must have knowledge and skill in livestock production so that they can understand the technology, can implement it themselves; and can demonstrate it to other farmers.
- There is easy access to the farm and good communication infrastructure so that it is easy for extension workers to organize training courses and visits.

Table 10.8
Experimental design for PL-UMMB.

Group	De-wormer	Number of animals			Body weight (kg/ head)
		First replicate	Second replicate	Third replicate	
1	Control	5	5	5	214.9 ±8.6
2	PL-UMMB	5	5	5	222.7 ±7.2
3	Levamisole	5	5	5	215.7 ±8.2

Table 10.9
Effects of herbal UMMB on worm egg counts

Group	Worm faecal EPG counts (mean ±Standard Deviation)		
	Before	**After 3 days**	**After 10 days**
Control	371.00 ±40.99 [a]	378.00 ±42.00 [a]	377.93 ±34.55 [a]
Levamisole (injected at 7.5 mg/10 kg body weight)	385.00 ±46.05 [a]	26.60 ±47.93 [b]	22.40 ±44.52 [b]
Herbal UMMB	379.73 ±51.73 [a]	53.2 ±22.26 [b]	71.40 ±27.26 [c]

NOTE: [a,b,c] Means with different superscripts within column are significantly different ($P<0.05$)

Implementation steps

- Conduct a survey in the region to identify potential farmers on the basis of the above-listed criteria.
- Organize a meeting with farmers in order to introduce them to UMMB technology.
- Register the farmers willing to participate in the programme.
- Implement technology transfer, through on-farm demonstrations; assistance in maintaining records; monitoring and evaluation of the response to the intervention; organization of training workshops; bringing other farmers to the pilot farms; and promoting farmer to farmer horizontal learning.

Results from the establishment of pilot farms

Southern Viet Nam

Dairy cattle. Six farms, two in Binh Duong Province producing UMMB for themselves and four in Ho Chi Minh City using blocks from the Dairy Research and Training Centre (DTC). Farms averaged 5 dairy cows and the roughage was mainly natural grass and rice straw.

Beef cattle. Ten farms in Binh Duong and Dong Nai Provinces in two groups making blocks themselves, and two farms in An Giang Province using blocks from the DTC. The average was 3–4 local beef cattle per farm. The feeding system was mainly based on grazing poor natural pasture, with rice straw in the cattle shed in the evening.

Meat goats. Two farms in Ninh Thuan Province, with 80 animals in total. They produced their own blocks but sometimes purchased from the DTC if molasses was not available. Animals grazed all day on very poor natural pasture with no supplementation.

Cooperatives. One dairy cooperative at Lai Thieu, Binh Duong Province producing blocks for 30 members (about 100 milking cows) of the cooperative.

Sugar factories. One sugar factory, at Hiep Hoa, Long An Province, made an industrial line for UMMB production. At the time of writing, the factory was producing 1–2 tonne/day of UMMB, depending on the market, being sold to dairy farmers in Long An Province and in Ho Chi Minh City.

Northern Viet Nam

Dairy cattle. Ten farms with 42 animals in total.

Beef cattle. Eight farms with 52 animals in total.

Dairy goat. Five farms with 96 animals in total.

Analysis of economic efficiency

It is clear from Table 10.10 that the use of UMMB as a supplement for both dairy and beef cattle is beneficial to farmers.

Table 10.10
Economics of block use with an average intake of 1 kg/head/day.

	Blocks produced by farmers	Blocks purchased from DTC
Dairy Cattle		
Production cost (VND/kg)	1 200	1 600
Average milk increase(kg/cow/day)	0.6	0.6
Average income increase[1] (VND/animal/day)	2 100	2 100
Cost–profit ratio	1:1.75	1:1.31
Beef cattle		
Production cost (VND/kg)	1 200	1 600
Average daily gain (kg/day)	0.15	0.15
Average income increase(VND/ animal/day)	1 950	1 950
Cost–profit ratio	1:1.63	1:1.22

NOTE: (1) 1 kg of milk was worth VND 3 500 (US$ 1 = VND 15 000 at the time of reporting).

Activities and mechanisms for establishing a stable technology

- Transferral of technology through a revolving fund for cooperatives. In this approach, an initial amount is provided to a cooperative to start UMMB production. The UMMBs are then sold to farmers at a small margin over costs, and that "profit" is used for maintenance and replacement of equipment.
- Transferral of technology to sugar factories with plenty of molasses. This enables use of molasses at source and decreases transport costs. It also provides the factory with a value-added product from a process by-product.

Conclusions

The use of UMMB has increased productivity, improved animal reproductive performances and helped farm economic efficiency. For effective and stable cattle industry development, it is necessary to disseminate this technology widely through appropriate extension. The use of revolving fund approaches and transferring production to sugar factories could help make the technique sustainable.

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Experiences with multinutrient blocks in the Venezuelan tropics

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Introduction

The extensive grasslands in the Venezuelan tropics constitute a most valuable feed resource for development of ruminant production systems. However, their use and outputs are constrained by quality, availability and management.

Strategic supplementation considers the limitations of feeding ruminants and develops strategies and resources that contribute to improve the efficiency of use of the abundant low quality fibrous resources, addressing the various animal groups and the local conditions and resources available.

Supplementation with multinutrient blocks (MBs) has had a great impact on Venezuelan livestock husbandry, with beneficial effects on both the biological response of the supplemented animals, and in economic terms. The use of blocks enables the use of non-traditional feed resources, both by-products and residues produced on-farm and others found within local production systems. They can be integrated into and provide a broader basis for agronomy and animal husbandry in the same environment.

With an integrated systems focus and using participatory research approaches, the dual producer-researcher teamwork can extend achievements, yielding innovations that go beyond the traditional use of agro-industrial resources. As well as the traditional whole cotton seed and rice polishings, the resources of the savannah itself, such as *cañafistola*

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(*Cassia moschata*), and traditional local minor and subsistence crops, such as the yard-long bean (*Vigna unguiculata*) and cassava (*Manihot esculenta*) can be integrated to expand potential strategic supplementation. Using MBs based on local resources has a significant socio-economic impact for communities, when using otherwise waste materials for an activity that supports two of the most important elements of the plains: man and beast.

Principles of multinutrient blocks in the venezuelan tropics

The most outstanding characteristic of the Venezuelan Central Plains is the dominance of low-quality fibrous resources, which constitute the basal diet of a significant part of the national bovine herd. The vegetation is subject to the vagaries of recurrent rainy and dry periods that, due to their intensity, degrade resource quality and quantity.

The stimulus for strategic supplementation with MBs was precisely the availability of abundant fibrous resources in Venezuelan savannah, but resources that required, initially, a source of fermentable nitrogen (N) capable of promoting better fibre utilization (Combellas, 1994) and increasing degradability by regulating rumen-N levels.

Some fundamental parameters determine the use of MBs under local conditions. Firstly, the availability and quality of forage at the time of supplementation. In relation to the availability of basal diet, even though no specific work seems to have been done on this, it has been observed that limited basal diet availability has limited response to MB supplementation. Regarding quality of basal diet, Mata and Combellas (1992) have indicated that the utilization of medium to high quality grass does not improve with soluble-N supplementation. At the same time, Domínguez (1994), working with on-farm basal diets of different types, with weekly measurements of forage protein content and DM intakes, found a high significant negative correlation ($r = -0.92$) between forage protein content and DM intake, with a high determination coefficient ($Y = 0.36 - 0.023X$; $R^2 = 0.85$).

Another important aspect of MB as a supplementation strategy is the fermentation pattern. Urea ferments rapidly in the rumen. With grazing animals in extensive areas, it has been observed that the frequency of MB intake is only once or twice daily, due to availability and distribution of the MB in the pasture (Birbe *et al.*, 1998c). This prevents rumen ammonia levels from becoming high enough to obtain satisfactory response.

As pointed out by Domínguez *et al.* (1998), a possible means to correct NH_3-N deficiencies in the rumen is either to ensure consumption of the supplement several times a day, or to use protein sources, such as whole cotton seed, with low degradation rates that prolong higher N levels. Other protein sources have been tested with grazing cattle, including *Gliricidia* *sepium* leaves, yard-long bean, cassava and the fruits of native legumes such as *cañafistola* and *saman* (*Albizia saman*). The responses indicated a slower degradation rate, with the consequent positive effects mentioned above.

Evaluation of the physical characteristics, acceptability and intake of multinutrient blocks

An important feature, not well documented in the literature, is namely the physical characteristics of the MB. This is an important aspect to be considered during manufacture, particularly under artisanal conditions. It must be emphasized that the ingredients used in the MB and their proportions determine the physico-chemical characteristics, and hence affect acceptability and intake by ruminants.

An MB is an aggregate of components that each has individual physical characteristics, *inter alia* particle size and shape, density, and moisture content. The manner in which ingredients arrange themselves in the mixture determines its physical characteristics, affecting MB hardness and intake.

Birbe *et al.* (1994) reported that numerous factors affect MB utilization, including environmental, biological, chemical, technical and physical, but highlighted the technical factors. The more important variables have been evaluated and some of their effects are summarized in Table 11.1.

MB moisture content plays a fundamental role in relation to blending, setting and mixture manipulation. As indicated in Table 11.1, variations in the water content modify compaction and hardness. The water is a critical agent in achieving a good mixture between the agglutinant and the fibre, obtaining the chemical reactions needed for block hardening.

Table 11.1
Technical factors in production that affect MB hardness.

Variable		Level	Effect in MB	
			Penetrometer resistance (kg/cm^2)	**Press resistance** (kg/cm^2)
Mb moisture content	(%)	10	3.7	6.86
		15	2.8	4.1
		20	2.1	3.2
Lime content	(%)	5	2.2	4.4
		10	4.1	8.1

Table 11.2
Subjective evaluation of ease of blending, compaction and manipulation for MBs with two ingredients and three moisture levels.

Main ingredients and proportion in the MB	Moisture content (%)	Score (Scale of 1 to 5)			
		Blending	Compaction	Handling	Total
MB with 27 percent whole cotton seed	10	3	5	3	11
	15	4	3	2	9
	20	4	2	1	7
MB with 27 percent bean leaves	10	1	5	4	10
	15	2	5	5	12
	20	3	3	3	9

In the search for the appropriate moisture content for producing MBs, a simple methodology is often used (Guzmán *et al.*, 2000; Birbe *et al.*, 2000) whereby blending, compaction and handling are evaluated under different moisture percentage regimes, using a subjective scale from one to five, where 1 = very difficult, 2 = difficult, 3 = intermediate, 4 = easy and 5 = very easy. An example of this methodology is shown in Table 11.2.

It should be noted that for the determination of the moisture level for MB production, component particle size plays an important role. As can be seen from Table 11.2, in two MB formulas, as the main ingredient changes, there are related changes as particle size influences the water necessary for production. Whole cotton seed with 98.3 percent of its particles with diameter greater than 4.7 mm required less water than bean leaves with 95.7 percent of the particles less than 4.7 mm in size.

The hardness (penetration resistance) (measured in kg/cm^2) is a factor that markedly defines animal intake (Mwendia and Khasataili, 1990; Hadjipanayiotou *et al.*, 1991; Birbe *et al.*, 1994), and acquires greater importance when MBs are used for drug and minerals delivery, since dosages are based on MB intake. As block hardness increases, animal intake diminishes (Figure 11.1).

Productive and reproductive responses in grazing ruminants with blocks

The poor quality and low feed intake of the forages available, as well as management factors, lead to suboptimal nutritional status in grazing animals, and this directly affects both production and reproduction. With poor forages, there is a limiting effect on consumption, directly affecting herd productive and reproductive performance (Adesipe and Oyedipe, 1985; González *et al.*, 1988; Meirelles, Abdalla and Vitti, 1991; De Moraes *et al.*, 1992; Wetteman, 1993; Vale *et al.*, 1993; Mathis *et al.*, 2000).

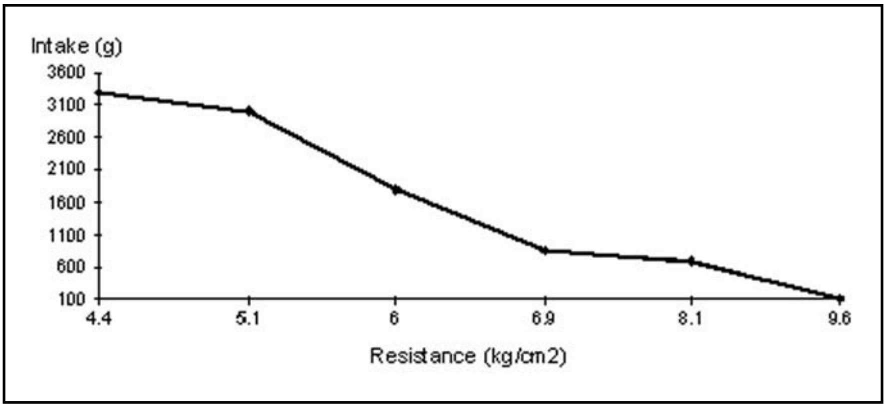

Figure 11.1

Relationship between intake (g) and block hardness (resistance; kg/cm^2) (Birbe *et al.*, 1988b).

In FAO/IAEA trials, MB supplementation has shown variably favourable responses in terms of reproductive performance of cows in the Venezuelan central plains, but MB supplementation produces its best results in reproduction, with positive responses in all the grazing females, both heifers and cows.

Experiences with growing heifers

Grazing heifers deserve special attention, because this group has both reproductive needs and growth requirements. These factors have to be considered when designing strategic supplementation.

Table 11.3 gives some examples of blocks prepared with different local raw materials, reflecting location-specific conditions. In the case of well drained savannahs, where, besides protein, phosphorus is the most limiting element, additional phosphorus was added in addition to the commercial minerals used in the block at a 15 percent level. This ensured adequate phosphorus supply to meet animal requirements. Phosphorus contents in the blocks used in well drained savannahs were 2.51 percent on average, with 37 percent crude protein. Heifer weight gain varied from 121 to 568 g/day with MB intakes of around 300 g/day/animal. These responses imply not only an improvement in weight but also an earlier first mating and first calving 300 days before the unsupplemented group.

In the various studies reported in Table 11.3, it is evident that ovarian activity rises from 17 to 45 percent with the use of MB. A reproductive response of 17 percent in 2-year-old heifers, in the dry season, represents a positive impact for cattle in well drained savannahs, considering that the normal initiation of ovarian activity is more usually at four years of age. These effects could be improved on, when base diet availability is guaranteed and using good quality MB.

In the work by Santaella (2001) reported in Table 11.3, productive and reproductive traits among heifers groups supplemented with minerals and MB did not differ. The block effect was minimized by factors such as good supply (5 571.7 kg/DM/ha) and reasonably good quality of basal fibrous feed resource (sorghum with 5.35 percent crude protein), a compensatory effect of mineral salts (animals that had never previously been fed minerals), a low stocking rate and an off-season rain during the dry season.

Table 11.3
Productive and reproductive responses of heifers with MB supplementation during the dry season in the Venezuelan central plains.

Ecosystem (base diet)	MB Raw material	MB Intake (g/day)	Variable	Response With mineral	Response With MB	Ref.
Well drained savannah (*Trachypogon*)	Gliricidia (*Gliricidia sepium*) (leaves)	305	No. of heifers(1)	16	16	[1]
			DWG (g)	-182	302	
			% OA	31	76	
			% pregnancy	26	70	
Well drained savannah (*Trachypogon*)	Whole cotton seed	357.5	No. of heifers(1)	27	27	[2]
			DWG (g)	189	324	
			% OA	45.6	66	
			% pregnancy	39.2	61.8	
Well drained savannah (*Trachypogon*)	Cañafístola (*Cassia moschata*; fruit)	328	No. of heifers(4)	21	21	[3]
			DWG (g)	121	191	
			% OA	66.7	90.5	
Well drained savannah (*Trachypogon*)	Cañafístola (*Cassia moschata*; fruit)	328	No. of heifers(5)	23	23	[4]
			DWG (g)	120	202	
			% OA	0	17	
Hills zone (*Hyparrhenia rufa* and rice hay)	Cassava (leaves and root)	291	No. of heifers(1)	25	49	[5]
			DWG (g)	-353	568	
			% OA	31	54	
Hills zone (sorghum stubble)	Yard-long bean (whole plant)	318.3	No. of heifers(1)	24	24	[6]
			DWG (g)	555	542	
			% OA	91	83.3	
			% Pregnancy	79.1	79.1	

NOTES: (1) No age given. (2) DWG = daily weight gain. (3) OA = ovarian activity. (4) 3-year-old heifers. (5) 2-year-old heifers.

SOURCES: [1] Birbe *et al.*, 1998c. [2] Domínguez *et al.*, 1998. [3] Herrera *et al.*, 2001. [4] Jaimes *et al.*, 2000.
[5] Martínez *et al.*, 2000. [6] Santaella, 2001.

Experiences with dual purpose cows

In dual-purpose cows, similarly to heifers, the responses have been mainly on reproductive efficiency. There have been improvements in postpartum body condition (Martínez *et al.*, 1998), but there are few experiences reported of supplementation pre-calving. In relation to milk production, no positive responses have been observed, although significant responses have been reported in weight gain in calves from MB-supplemented mothers (Herrera, Birbe and Martinez, 1995).

As reported in Table 11.4, differences observed in ovarian activity and pregnancy percentages with grazing cows ranged from 18 to 52 percent among those consuming minerals and MB.

In the study reported in Table 11.4, from Domínguez *et al.* (1998), MB supplementation was provided in the morning at milking time and in the evenings at suckling time, for an hour each time. Intakes reached 774 g/animal/day, which resulted in the observed responses, being superior in the supplemented group by 52.9 and 64.7 percent in ovarian activity and pregnancy, respectively, compared with the control group.

Table 11.4
Reproductive response in dual-purpose cows consuming MB in the dry season in the central plains of Venezuela.

Ecosystem (base diet)	MB		Variable	Response		Ref.
	Raw materials	Intake (g/day)		With mineral	With MB	
Well drained savannah (*Trachypogon*)	Whole cotton seed	355	No. of cows	21	21	[1]
			BCS	1.54	1.77	
			% OA	22.2	54.5	
			% Pregnancy	18.3	48.2	
Well drained savannah (*Trachypogon*)	Whole cotton seed	774	No. of cows	15	14	[2]
			BCS	1.48	1.79	
			% OA	40	92.9	
			% Pregnancy	6.7	71.4	
Hills zone (*Hyparrhenia rufa* and maize stubble)	Gliricidia (leaves)	270	No. of cows	80	80	[3]
			BCS	1.55	1.74	
			% OA	32	50	
			% Pregnancy	27.6	47.1	
Hills zone (sorghum stubble and paddocks of *Echinocloa polystachya*)	Whole cotton seed and sorghum grain	256	No. of cows	20	21	[4]
			BCS	1.6	1.9	
			% OA	47	74	
			% Pregnancy	43.2	70.1	

NOTES: BCS = Body Condition Score. OA = ovarian activity.
SOURCES: [1] Herrera, Birbe and Martinez, 1997. [2] Domínguez *et al.*, 1998. [3] Domínguez *et al.*, 1998.
[4] Taylhardat *et al.*, 1998.

Conclusions

In the conditions in the Venezuelan tropics, strategic supplementation with MB, manufactured from local raw materials and with a formulation taking into account local ecosystem deficiencies and animal physiological requirements, resulted in better reproductive performance in cows grazing poor quality fibrous resources.

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Experience with development and feeding of multinutrient feed supplementation blocks in Pakistan

G. Habib[20]

Feed Resources and Requirements

Livestock in Pakistan are predominantly reared in mixed crop-livestock farming systems. Major feed resources are supplied by the agriculture sector in the form of crop residues (44 percent), fodder crops (15 percent) and by-products as concentrate (3 percent). Grazing serves as the second major feed source and contributes the balance of total feed supply. Local feed supply is not adequate to support the requirements of the large livestock population, comprising 20.4 million cattle, 20.3 million buffaloes, 23.5 million sheep and 41.2 million goats. The major reason is that crop residues and grazing, classified as of poor quality, form the bulk (82 percent) of the feed supply, but these feeds are low in fermentable nitrogen, less digestible, low in minerals and are poorly consumed by animals. In the conventional feeding systems, severe feed shortages occur for 2–3 months in summer and 4–6 months during winter. Crop residues serve as the main feed during these periods. In the mountainous region, due to climatic constraints, grazing during winter is almost entirely substituted by stall feeding with crop residues and mature-grass hay. Most of the farmers are subsistence and cannot afford to feed expensive concentrates. Due to high pressure on cultivable land due to the increasing human population (0.13 ha/person), only 2.9 percent of land in arid and 17.5 percent in irrigated areas can be spared for fodder cultivation. Comparing feed supply and livestock requirements indicates deficiencies of 42, 53 and 41 percent in dry matter, crude protein and total digestible nutrients, respectively (Table 12.1).

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Assuming that livestock numbers continue to increase by 2.5 percent per annum, and with a 3 percent annual increase in crop production, the feed gap would by 2010 further widen to 61 percent, 69 percent and 60 percent in dry matter, crude protein and total digestible nitrogen, respectively. The feed deficit would be aggravated if drought conditions continue. The recent drought decreased enormously the carrying capacity of grazing lands, especially in the arid zone. For three locations in Balochistan province, the average dry matter yield per hectare decreased from 352 kg before the drought in 1996–97 to 69 kg after the drought in 2000. Such feed shortages for grazing animals has seriously threatened their survival.

Table 12.1
Livestock feed shortfalls in Pakistan ('000 tonne)

	Biomass (DM)	Crude protein	Total digestible nitrogen
Available	87 642	5 736	42 928
Demand	152 373	12 161	72 292
Deficiency	42%	53%	41%

Feed shortage is a major constraint in sustainable livestock production in Pakistan, and dairy animals clearly suffer more seriously from feed inadequacy, as they share more than 63 percent of the overall feed requirement. The current annual milk yield of 23 million tonne is far below the estimated genetic potential of 44 million tonne in the country, with the gap of 21 million tonne/year attributable to suboptimal feeding of dairy animals (Iqbal and Ahmad, 1999).

Conventional feed supplementation practices

Supplementation of poor quality diets with home-made concentrate mixtures is general practice among urban and peri-urban dairy farmers, where input costs are high due to market-oriented farming. However, concentrates are not always fed to animals in the subsistence smallholder system that constitutes 72 percent of the livestock farms in the country, and animals for most of the time subsist on cereal straw, stovers and other dry roughages. In the northern mountainous areas of Pakistan, farmers grow some lucerne and conserve it as hay for supplementary feeding together with crop residues during winter. However, the quantity is insufficient for the long, dry, 6-month winter period.

Previous efforts to promote urea treatment of straw in arid and semi-arid areas of Pakistan did not attract farmers. The labour and input demands associated with the technology probably constrained its on-farm adoptability under local conditions. Instead, the use of multinutrient feed block as a supplementation strategy has become increasing popular in the rural livestock farming community during the last few years. The experience and progress made in implementation of feed block supplement technology in the country is reported below.

Urea-Molasses Block as a supplementation strategy – Research and Development

Formulation of urea-molasses mineral blocks

Work first started on preparation of urea-molasses mineral blocks (UMMB) in March 1983, under UNDP/FAO Project PAK/80/019. Initially, efforts focused on finding a suitable hardening agent. Various chemicals, including MgO, bentonite, NaH_2PO_4, CaO, $Ca(OH)_2$ and cement, were tested in different combinations in laboratory-scale experiments. The first recipe that produced hard blocks contained molasses, 49 percent; urea, 10 percent; magnesium oxide, 1 percent; bentonite, 5 percent; common salt, 5 percent; minerals, 5 percent; and wheat bran, 25 percent, and was adopted. However, the cost of the block was high, mainly due to expensive chemicals like MgO and bentonite, and work on block formulation continued with a view to make a cheaper product. These cheaper formulations are shown in Table 12.2.

There were practical problems with the initial formulations, as some of the ingredients, such as monosodium phosphate, were not available in rural areas, and calcium oxide was difficult to grind. The formulation was therefore further refined in the 1990s to use ingredients that were easily available in rural areas and were less expensive, such as calcium hydroxide, cement and clay. The final recipe selected for farmer demonstration in villages consisted of molasses, 47 percent; urea, 7 percent; calcium hydroxide, 8 percent; clay, 5 percent; common salt, 3 percent; dicalcium phosphate, 7 percent; and wheat bran, 23 percent. This produced hard blocks and the cost was 40 percent less than the previous formulas. The block composition is kept flexible, and alternative ingredients, such as oil-cakes or meals, are being used in various commercially manufactured UMMBs. For example, one manufacturer uses cottonseed meal, 8 percent, and gypsum, 2 percent, with no clay in UMMBs.

Table 12.2
Percentage composition of trial urea-molasses mineral blocks (initial investigation).

Ingredient	Formula						
	1	2	3	4	5	6	7
Molasses	45	45	45	45	45	45	45
Urea	10	10	10	10	10	10	10
CaO	10	8	8	10	6	12	8
NaH_2PO_4	5	5	5	2	3	1	5
Cement	–	2	2	–	2	2	1
NaCl	–	–	–	3	2	2	1
Minerals	5	5	5	5	5	5	5
Rice polishings	–	–	–	–	10	5	25
Maize gluten	–	–	25	–	–	18	–
Wheat bran	25	25	–	25	17	–	–

Methods of UMMB Preparation

Hand mixing

In the beginning, a hot process was used that involved heating molasses for about 30–40 minutes in a container. After cooling the molasses to 60°C, urea and then the other ingredients were added in the order shown in Table 12.2, and mixed manually using a steel scoop or piece of wood. The mixture was then transferred to a rectangular mould or any suitable container. After pressing into the mould, the block was removed and allowed to harden over 48 hours. After that the blocks were hard enough to be offered to animals. A longer hardening period was allowed if the blocks were still soft.

The hot process was replaced by a cold process to reduce the energy cost and reduce labour in order to make the process more convenient for farmers. In the cold method, all the ingredients were mixed with cold molasses without adding any water. The mix was then pressed into home-made mould of timber or metal sheet, using a pressing implement or by simply standing on it. The blocks were then removed from the moulds and allowed to harden off in a shady place for 48–72 hours.

Mechanical mixing

On a commercial scale, ingredients are mixed with molasses in a paddle mixer for about 20 minutes, transferred to moulds and pressed with a power-driven hydraulic press. Since blocks are hygroscopic, they are packed in polythene bags and sealed.

Feeding Trials with UMMB

Studies both on-station and under private farm conditions were conducted by different institutions in the country to investigate intake and the productive and reproductive responses in animals to UMMB supplementation. The main findings are summarized below.

Adaptation pattern and UMMB consumption levels in farm animals

Animal adaptability to block licks varied enormously among different animal species and among individual within the same species. Generally, block intake gradually increased over two weeks, with large diurnal variations, and thereafter intake became more or less constant (Figure 12.1). Some animals did not consume blocks for the first 10 days, and then slowly started licking. Farmers reported that buffaloes adapted to UMMB use less easily than milch cattle, but there was great variability.

Block hardness also affected intake by animals. Very hard blocks did not attract licking, while soft blocks were chewed rather than licked. Blocks that on pressing showed no finger impression were considered to be the desirable texture. Block urea content also affected block consumption, as shown in Table 12.4. The quality of the basal diet was another factor affecting block consumption. Animals receiving dry roughages (cereal straw and stover) consumed more block than those given green fodder.

Some farmers (about 25 percent) induced block licking by spreading small quantity of salt or wheat flour on top of block for the first few days. In cases where animals refused to consume blocks on their own, farmers cut the block into small pieces and fed one piece daily mixed in concentrate or forced into the animal's mouth. Variation in block consumption by different species of farm animals is summarized in Table 12.3.

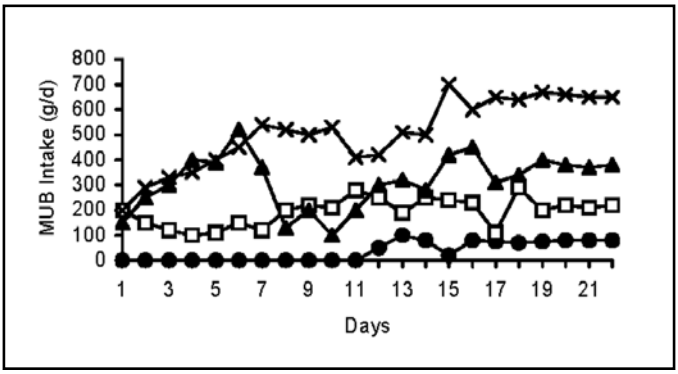

Figure 12.1

Diurnal variation in UMMB consumption by farm animals

Key: –×– Buffaloes; –▲– Cows; –❑– Bull calves; –●– Cow calves.

Table 12.3
Average daily intake of UMMB in different farm animals.

Animal Specie	Daily block consumption (g/day)	
	Average	**Range**
Adult cows	350	100 – 450
Adult buffaloes	500	150 – 714
Cow calves	196	50 – 300
Buffalo calves	292	80 – 496
Sheep	80	30 – 200
Goats	100	63 – 214

SOURCE: Habib *et al.*, 1991; Habib, unpublished.

The large difference in block intake (g/day) between cattle and buffaloes is explained by different body weights, but the calculated block intake per unit of body weight were similar (117 g vs 100 g/100 kg body weight in cows and buffaloes, respectively). Block consumption on a body-weight basis was found to be higher in sheep and goats (276 g/100 kg body weight) than in large ruminants.

Optimum UMMB urea levels

The urea level in feed blocks is important as it influences the rumen ammonia level, affecting fibre digestion. A study evaluated different levels of urea in blocks. UMMB with 2, 10, 15 and 20 percent urea were prepared and fed to rumen-cannulated sheep in a 4×4 Latin square design. The animals were given a basal diet of wheat straw ad lib. As shown in Table 12.4, UMMB consumption decreased linearly with increasing levels of urea. Daily intake of oat chaff showed a curvilinear response to urea levels, and was at a maximum when the UMMB contained 10 percent urea. *In sacco* DM digestibility of wheat straw increased from 31.3 percent with 2 percent urea, to 35.9 percent with 10 percent urea in the blocks. Further increases in urea level in UMMBs did not change the digestibility. However, ammonia concentrations in the rumen progressively increased with increasing levels of urea. The findings suggested that 10 percent urea was an optimum level in the feed blocks. The negative effect of high urea levels on block intake may be related to low palatability or excessive ammonia concentrations in the rumen.

Urea levels in UMMB for dairy buffaloes

Nitrogen dynamics in the rumen of buffaloes and cows differ. Buffaloes have more efficient urea recycling in the rumen and that may affect dietary urea requirements. UMMB containing 5, 10 and 15 percent urea were offered to rumen-cannulated buffalo steers fed wheat straw ad lib. Results in Table 12.5 show that intake and *in vivo* and *in sacco* digestibilities of wheat straw increased with UMMB supplementation, but did not show response to varying levels of urea in the blocks. Rumen NH_3-N concentrations improved from a suboptimum level of 21.11 mg/litre in controls to optimum levels varying from 59.19 to 96.11 mg/litre in UMMB-fed steers.

The results shown in Table 12.5 indicate that the urea level in feed blocks should not exceed 5 percent for efficient utilization by dairy buffaloes.

Table 12.4
Changes in feed intake and rumen parameters in sheep fed UMMB with different urea concentrations.

Parameter	Level of urea in UMMB			
	2%	10%	15%	20%
Block intake (g/day)	131	123	224	82
Oat chaff intake(g DM/day)	649	777	725	681
Rumen ammonia concentration (mg N/litre)	53.5	162.5	206.3	226.4
In sacco DM digestibility of wheat straw (% at 24 hours)	31.3	35.9	36.1	34.8

SOURCE: Habib *et al.,* 1991.

Table 12.5
Urea levels in feed blocks for buffaloes.

Observations	Control	Urea level in feed blocks		
		5%	10%	15%
Wheat straw intake (kg DM/day)	6.30^{b}	7.04^{a}	7.20^{a}	7.40^{a}
Block intake (g/day)	–	606^{a}	714^{a}	606^{a}
In vivo organic matter digestibility (%)	46.89^{b}	55.56^{a}	52.31^{a}	53.72^{a}
In sacco DM digestibility of wheat straw (% per hour)	1.30$^{a b}$	3.80^{a}	4.00^{a}	3.40^{a}
Rumen NH_3-N concentration (mg/litre)	21.11^{d}	59.19^{c}	96.11^{a}	79.38^{b}

NOTE: Means with different superscripts in the same row differ significantly ($P < 0.05$).

Comparison of feeding UMMB vs urea supplement

Positive changes in rumen fermentation with UMMB feeding are related to the sustained supply of urea supporting optimum ammonia concentrations for rumen microbes. The same could be achieved through spraying urea solution onto straw before feeding. The two strategies of urea supplementation were compared. Three groups of rumen-cannulated buffalo steers (3 animals per group) were fed a basal diet of wheat straw. One group had free access to UMMB containing 10 percent urea, and the second group was given wheat straw sprayed before feeding with an aqueous solution of 50 g urea in 2 litre. The third group served as control. All animals received 70 g/head/day of mineral mixture. The daily consumption of UMMB averaged 546 g. Daily wheat straw intake per animal increased from 5.33 kg in the control group to 6.93 kg and 7.27 kg in the UMMB- and urea-fed steers, respectively. *In vivo* digestibility of

DM, organic matter and crude fibre did not vary among the three diets, presumably due to high rumen passage rate in animals fed UMMB or urea, as indicated by higher feed consumption. However, in line with increase in rumen ammonia concentrations, *in sacco* DM digestibility at 24 hours increased to the same extent with UMMB and urea feeding compared with the control animals. The results indicated that both methods of urea feeding were equally effective in stimulating straw intake and ruminal digestibility. However, daily spraying of urea solution onto straw was highly labour intensive and would not be practical on a routine basis for farmers. In contrast, UMMB use required no extra management and was highly compatible with existing feeding practices in smallholder systems.

As illustrated in Figure 12.2, maintenance of high ammonia concentrations in the rumen throughout a 24-hour feeding cycle is important in optimizing rumen fermentation. This is obtained by continuous intake of urea from UMMB licks. In contrast, if urea is fed only once a day, rumen ammonia concentration peaks during the first hour and then gradually declines to a pre-feeding level. Thus ammonia concentrations would remain suboptimal for most of the time, limiting microbial activity in the rumen.

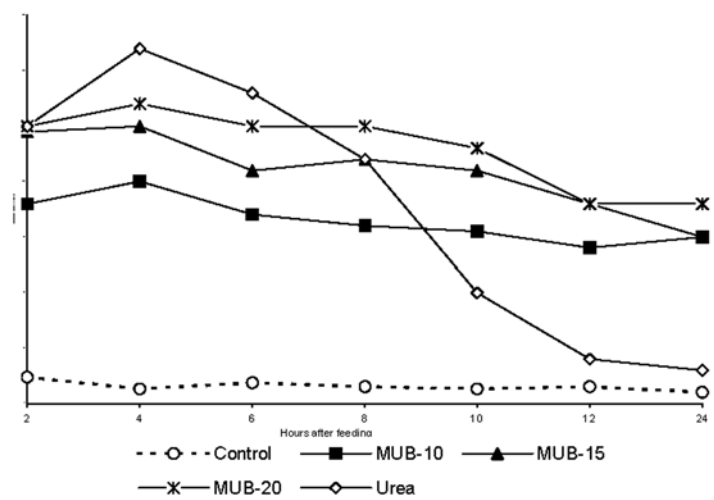

Figure 12.2

Rumen ammonia concentrations in sheep supplemented with UMMB or with urea 14 g once daily on a basal diet of oat chaff.

Associative effect of UMMB and forage quality

Generally, UMMB is considered an appropriate supplement with poor quality roughages that are deficient in nitrogen and with poor digestibility, but it may also be useful when animals are given good quality forage. Two experiments were conducted to determine the associative effect of UMMB feeding and quality of the basal diet in sheep and growing calves.

A nitrogen balance trial in a 4×4 Latin square design with four wethers was reported by Saeed, Siddiqui and Habib (2002). The four diets were maize stover with and without UMMB, and lucerne hay with and without UMMB. Intake of basal diet and *in vivo* DM and organic matter digestibility were not affected by UMMB with both maize stover and lucerne diets. However, UMMB feeding significantly increased nitrogen retention by a factor of 2.5 in wethers given maize stover, but had no effect in wethers fed lucerne hay. Nitrogen retention as a percentage of total N intake was 26.7, 29.4, 38.0 and 39.6 percent on maize stover; maize stover + UMMB; lucerne; and lucerne + UMMB diets, respectively. These findings suggested a positive effect of UMMB on N status in sheep on solely a poor quality diet.

Similarly, when Faizi (2000) fed untreated and urea-treated maize stover to Holstein Friesian calves with or without UMMB, daily consumption of stovers and *in vivo* digestibility of DM and organic matter significantly increased with UMMB on untreated stover, but had little affect with urea-treated stovers (Table 12.6).

Table 12.6
Response in feed intake and nutrient digestibility to urea-molasses block feeding with untreated and urea-treated maize stover

Parameter	Untreated maize stover		Urea-treated maize stover	
	- UMMB	+ UMMB	- UMMB	+ UMMB
Maize stover intake(kg DM/day)	1.72^{c}	2.35^{b}	2.78^{a}	2.85^{a}
Block intake (g/day)	-	496^{a}	-	180^{b}
Water intake (litre/day)	14^{b}	16^{a}	15^{ab}	16^{a}
In vivo DM digestibility (%)	43.7^{b}	55.8^{a}	58.0^{a}	58.1^{a}
In vivo OM digestibility (%)	55.1^{c}	62.6^{a}	65.7^{a}	65.7^{a}

NOTES: OM = organic matter. DM = dry matter. ^{a,b,c} Means with different superscripts in the same row differ significantly ($P < 0.05$).

SOURCE: Faizi, 2000.

These results suggested that UMMB significantly increased feed intake and digestibility when the basal diet was of poor quality, but had no positive effect with a high quality diet. Secondly, UMMB feeding was as equally effective as urea treatment of straw in improving utilization of poor quality roughages. However, the comparison set out in Table 12.7 logically justifies the use of UMMB as a more appropriate strategy for local smallholder farming.

Productive responses to UMMB

Milk production

Both on-station and on-farm studies demonstrated that daily milk yield consistently increased with UMMB supplementation in all species of lactating farm animals. The response was more pronounced in rural animals receiving no or little concentrate allowance. In urban and peri-urban dairy farms with improved feeding of animals, milk response to UMMB supplementation was relatively low.

Feeding of UMMB to lactating buffaloes and cows on 16 farms in an arid region of NWFP demonstrated a persistent increase in daily milk yield over 90 days in both cows and buffaloes (Figure 12.3). The response was 42 percent greater in cows than in buffaloes (22 percent increase over controls). Average daily milk yield over 90 days in control cows was 3.8 litre, which increased to 5.4 litre with UMMB feeding, and averaged 3.7 and 4.5 litre in control and UMMB buffaloes, respectively. Daily block intake was 320 g per cow and averaged 450 g per buffalo.

An extensive study was recently conducted by Khanum and co-workers (personal communication) in an irrigated area of Punjab Province. It included 350 milking buffaloes from 75 peri-urban and rural smallholder dairy farms. The animals on each farm were divided into control and UMMB groups, and all of them received 3 to 4 kg home-made concentrate mixture, mainly comprising cottonseed cake and wheat bran (Table 12.8). Milk yield response was classified in lactation stages: early (1–60 days), mid (61–120 days) and late (>120 days).

More importantly, the lactation curve remained persistently higher in UMMB-fed buffaloes in all the three groups. Daily milk production increased in 78 percent, did not change in 15 percent and fell slightly in 7 percent of buffaloes in response to UMMB supplementation. Daily UMMB consumption was variable, and averaged 500 g/day/animal.

In another trial with milking buffaloes in 18 peri-urban farms, daily milk yield was higher during most of the lactation period in response to UMMB feeding, despite all the animals receiving 3–4 kg of concentrate mixture (Figure 12.4). The difference in milk yield between the two groups was pronounced after 13 weeks of lactation. Farmers reported that the effect of UMMB on milk yield started showing 3–5 days after the start of UMMB supplementation. Milk production over a 38-week period averaged 8.86 and 10.30 litre/day in control and UMMB buffaloes, respectively.

Table 12.7
Comparison of UMMB and urea-treatment of straw technologies for improving livestock nutrition in smallholder farming systems.

Parameter	UMMB	Urea treatment
Feeding management	Easy.	Labour intensive
Storage	Easy	Difficult
Shelf life	Long	Limited
Transportation	Easy	Difficult (bulky)
Relative cost	Low	High (twice UMMB)
Nutrient supply	Diverse (multinutrient)	Energy and N only
Risk of urea poisoning	Low	High
Scope for income generation activity (mini-enterprise)	High	Nil
Environment pollution	Nil	Yes
On-farm adaptability	High	Low

Reproductive efficiency

A study with 100 lactating buffaloes at three different research institutes in Punjab showed that buffaloes consuming 200 to 600 g of UMMB per day not only had higher milk yield than a control group but their reproductive efficiency was also improved (Hussain *et al.*, 2002). Buffaloes fed UMMB resumed postpartum ovarian cyclicity earlier than the un-supplemented group. Milk progesterone assay in 16 buffaloes revealed that UMMB buffaloes resumed ovarian activity 88–102 days after parturition, indicated by higher milk progesterone levels of 3 to 5 ng/ml, while the control group resumed ovarian cyclicity later (138–172 days) with little fluctuation in milk progesterone levels.

Khanum and co-workers (personnel communication) further confirmed a positive effect of UMMB feeding on reproduction in 85 milking buffaloes from 18 peri-urban dairy farms, using a milk progesterone assay. UMMB-supplemented buffaloes resumed postpartum ovarian activity earlier than the control group. Difference in the distribution of cycling buffaloes in control and UMMB groups over the experimental period of 51 days (Table 12.9) is of great economic importance. The practical implication of these findings is that UMMB-supplemented buffaloes would increase farm income through higher milk yield and a shorter calving interval resulting from early resumption of postpartum oestrus.

Table 12.8
Daily milk yield (litre) in peri-urban and rural dairy buffaloes with or without UMMBs.

Lactation stage	Control buffaloes	UMMB buffaloes
Early lactation (1–60 days)	9.6 –13.4	13.2 – 15.5
Mid-lactation(61–120 days)	7.0 – 10.2	11.0 –12.8
Late lactation (>120 days)	4.5 – 8.5	6.8 – 9.5

SOURCE: Anonymous, 1999.

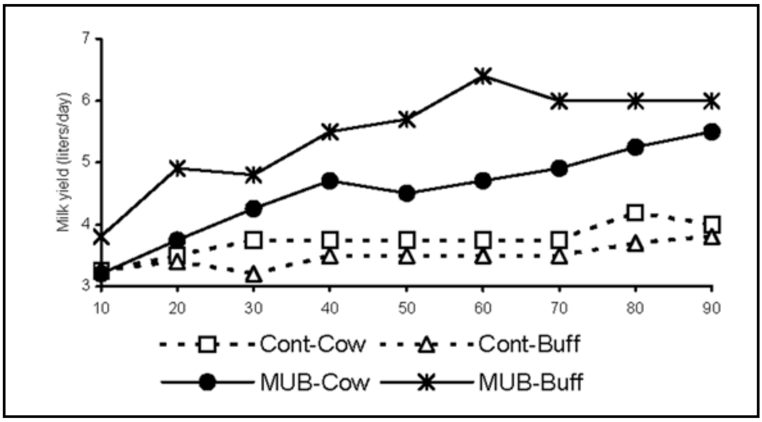

Figure 12.3
Effect of urea-molasses block on milk yield in rural cows and buffaloes
KEY: Cont. = control. Buff. = buffalo. MUB = UMMB supplemented

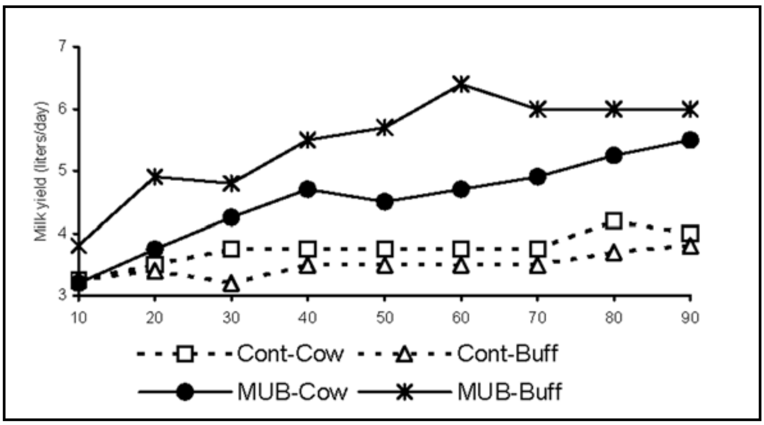

Figure 12.4
Milk yield response to UMMB feeding in dairy buffaloes.
KEY: MUB = UMMB supplemented.

Table 12.9
Reproduction response to UMMB feeding in peri-urban buffaloes.

Postpartum interval	Control		UMMB	
	Oestrus (%)	Conception[(1)] (%)	Oestrus (%)	Conception[(1)] (%)
12 to 18 weeks	4.6	0	12	12
21 to 36 weeks	64	71	72	71
39 to 51 weeks	30	92	16	90

NOTE: (1) Conception expressed as a percentage of those that showed oestrus.

Table 12.10
Effect of UMMB lick on growth performance in different species of animals.

Animal	Basal diet	Block intake (g/day)	Body weight change (g/day)	
			- UMMB	+ UMMB
Buffalo calves	Wheat straw + wheat bran (300 g/day)	292	+ 32	+ 187
Cattle cow calves	Wheat straw + wheat bran (300 g/day)	196	+ 137	+ 307
Lambs	Grazing	38	- 29	+ 133
Lambs	Grazing	200	- 11	+ 38
Lambs	Grazing + concentrate	75	+ 66	+ 90
Goats	Grazing	138	+ 21.3	+ 32.4

Growth performance

Supplementary feeding of UMMB was found equally effective in stimulating growth rates in all species of ruminant farm animals studied (Habib *et al.*, 1991). Response to UMMB was related to quality of the basal diet and grazing conditions. Findings from various studies conducted by our group under local conventional farming systems are summarized in Table 12.10.

In general, the quality of communal rangelands used for grazing of animals in Pakistan, except possibly the high altitude alpine pastures, is very poor and is constantly declining. Range vegetation is predominantly unpalatable and consists of drought resistant species that have poor feeding value, with low crude protein contents of 3 to 8 percent and *in vitro* DM digestibility varying from 35 to 45 percent (Habib and Bashir, 1982–83). Block supplementation under such conditions was found highly useful. It was not possible to provide block licks on common-property rangelands during free grazing. Blocks are offered to the animals in the evening on their return from grazing. As goats are more selective in grazing and browsing behaviour and select higher protein herbage (fodder trees and shrubs), growth response to block supplementation was not marked and weight gain increased only slightly, from 21.3/day in the controls to 32.6/ day in UMMB-supplemented goats. This is similar to our findings reported above that UMMB feeding did not significantly improve digestibility and nitrogen retention in sheep and calves on good quality forages.

Field experience

UMMBs were distributed among farmers of various community organizations in arid and semi-arid regions of NWFP through various non-governmental organizations (NGOs). Farmers' observations were recorded using a structured questionnaire during weekly visits by extension workers. These are summarized below and classified on the basis of comments received from respondents.

UMMB consumption

- Average daily intake of block Cow, 300 g; buffalo, 500 g.
- Licking 65 percent.
- Biting 35 percent.
- Fed in pieces 17 percent.
- Started licking on day 1 60 percent.
- Stated licking after day 7 30 percent.
- Never licked 10 percent.
- Self licking 58 percent.
- Induced licking 25 percent.

Feed consumption

- More feed consumed 100 percent.
- Less selective when fed stover 100 percent.
- Active grazing 100 percent.
- Consumed more water 100 percent.

Milk production

- Daily milk increased 94 percent.
  Milk increased 0.5 litre/day 43 percent.
  Milk increased 0.750 litre/day 31 percent.
  Milk increased 1.0 litre/day 26 percent.
- Daily milk did not change 6 percent.

Depraved appetite

- Stopped eating abnormal things 82 percent.
- Reduced eating abnormal things 12 percent.
- Continued eating abnormal things 6 percent.

Changes in health/body condition

- Improved 100 percent.

Oestrus resumption

- Started showing heat signs 30 percent.
- Did not notice 70 percent.

The above observations by farmers showed that UMMB was successful in increasing milk production and had many positive effects. Variation in milk yield was apparently related to the quantity of block consumed and quality of the basal diet the animals received. Most of the animals had no problem in adapting to the blocks as a new feed supplement. Changes in milk yield were visible on the third day after starting feeding UMMB. Pica is a common problem in almost all the animals of arid regions due to mineral deficiencies, but it was effectively reduced by UMMB supplementation. In some cases, animals suffering from haemoglobinurea due to phosphorus deficiency recovered when UMMB was supplemented. Interestingly, all farmers invariably reported higher feed intake with UMMB supplementation. The majority of animals received wheat straw, sorghum stover or maize stover with little or no green fodder and concentrate. In such situations, UMMB stimulated feed consumption and the animals were less selective in consuming stovers, thus minimizing wastage. Similarly, grazing animals were more active in searching for feed on ranges with sparse vegetation. However, their requirement for drinking water was increased, probably due to high feed consumption and urea intake from the blocks.

The farmers reported better general body condition of the animals, with glossy coats and healthier appearance. Due to prolonged mineral deficiency in the animals, milking and pregnant buffaloes and cows especially suffered from bone disorders, manifested by stiff joints, ataxia and characteristic posture with bulging scapula and stiff neck. Interestingly, when the animals were offered UMMB that contained 5 percent dicalcium phosphate and 5 percent other minerals, the symptoms subsided with a week's intake of the blocks. Cows that had not shown oestrus signs for a long time due to inadequate nutrition were reported to be resuming their oestrus cycle when given mineral-rich blocks.

Farmers in the arid and semi-arid regions very much appreciated the management aspect of UMMB use, because block feeding did not demand extra arrangements. In some cases where animals chewed the blocks, these were then offered in a close fitting wooden box. No case of urea poisoning was reported, except in one instance when a farmer cut the block into small pieces and fed it all at one time to a cow to boost milk production.

During a field investigation in Punjab province, Khanum and co-workers (personal communication) found that UMMB feeding increased feed intake and prolonged the lactation period in dairy buffaloes. The response in daily milk production among 350 buffaloes was that 70 buffaloes (20 percent) increased by 10 percent; 140 (40 percent) increased by 11 to 20 percent; 60 (17 percent) increased by 21 to 30 percent; 17 (5 percent) increased by >30 percent; 49 (14 percent) showed no change; and 14 (4 percent) showed a decrease.

In comparison with the observations from arid and semi arid areas of Pakistan reported earlier, the lower response in milk yield to UMMB in the irrigated area in Punjab Province was attributed to the fact that the feeding regime included green fodder and a concentrate allowance for milking buffaloes. This may also explain the absence of response in 14 percent of the buffaloes. Decreased milk yield in 4 percent of buffaloes with UMMB feeding was associated with the pregnancy status of the animals.

Considerable fieldwork on preparation and feeding of UMMB was been carried out in Balochistan, another drought-prone province of Pakistan, by a UNDP/FAO project during 1995–96 (Soomro *et al.*, 1996). Large-scale production of UMMB was accompanied by feeding to sheep and goats as the major livestock species in five pilot areas, and in some places also to cattle. In all cases, farmer interest in the technology was very high. Farmers generally allowed a limited access period to the blocks, but invariably reported that animals consumed them and their health condition improved. The work showed that UMMB strategy was highly relevant to drought-affected areas and proved to be one system for maintaining live weight in small ruminants when fed cereal straw, with little alternative for cheaper supplements.

Training Of Farmers And Extension Workers

Extension workers of the Livestock Departments in all the four Provinces of Pakistan received training in UMMB technology, including awareness creation and preparation of UMMB by hand. Special matrix lessons were developed on UMMB technology for teaching to livestock extension workers and trainees in various in-service training institutes. Female extension workers of the Livestock Departments and NGOs were also given such training (Figure 12.5) .

Figure 12.5 Small scale preparation of feed block is a relevant activity for women: extension workers are trained on the block technology .

The extension workers first prepared blocks (Figure 12.6) and then distributed these among farmers, and regularly monitored animal performance and farmer response using a structured questionnaire developed in local languages.

Figure 12.6 Extension workers preparing blocks

Under an IAEA project (Feed supplementation and reproductive management of cattle, IAEA/RCA 05/035) at the Nuclear Institute for Agriculture and Biology (NIAB), Faisalabad, more than 21 000 blocks were distributed among rural farmers to familiarize the technology in the field. Similarly, in Balochistan Province, farmers were helped in making UMMBs (Figure 12.7) and provided with an extension brochure on block technology under a UNDP/FAO project (Livestock Development in Balochistan, PAK/88/050). In NWFP, Livestock Production Officers and extension workers were helped in making blocks. Different village organizations received demonstrations of the on-farm method for making UMMBs. Information leaflets in local languages on preparing and feeding blocks were being produced at the time of writing. In all cases, farmers have shown keen interest in and want to adopt this new technology. However, molasses is not available to a common farmer and, being liquid, it is difficult to transport over long distances. Therefore, due to high demand for UMMB in the field, five commercial UMMB manufacturing plants in the country have become operational during the last five years, with a leading role being taken by the Feed Technology Unit of the National Agricultural Research Centre, Islamabad. These plants have variable production capacity and prepare blocks on demand. At present they have also been meeting the increasing demand for UMMBs from neighbouring Afghanistan.

Figure 12.7 Young farmers preparing on-farm molasses-urea blocks.

New Experience In Making Mulberry Fruit Multinutrient Blocks

The Hindu Kush northern mountainous belt of Pakistan is a semi-arid region where livestock is a major source of livelihood. Due to extremely limited cultivable land and climatic constraints, livestock subsist on grazing and crop residues. During the long 6-month winter dry period, livestock are kept indoors and stall fed with crop residues and forage hay. UMMB feeding is therefore highly relevant to the feed situation in the region. However, molasses is not available locally and transporting molasses or UMMB to such remote areas over poor roads is expensive.

The area is rich in fruit trees, including mulberry, a popular native tree. Drying mulberry fruit for human consumption is a centuries-old practice throughout the region. The harvesting season of mulberry fruit is short and limited to about the two summer months of July and August. During this period, it is not possible to harvest all the mulberry fruit, and more than one-third of the fresh fruit and a similar proportion of the sun drying fruit is wasted. To prevent such wastage, feed blocks were prepared, substituting molasses with mulberry fruit. Small laboratory-scale studies (Habib and Ishrat, 2000) were followed by on-farm preparation of mulberry feed blocks. Block recipes using fresh mulberry fruit with different ingredients are given in Table 12.11.

Table 12.11
Composition (percentage) of trial mulberry-based urea-multinutrient blocks.

Ingredient	Block formula					
	1	2	3	4	5	6
Mulberry fruit (fresh)	48	45	45	45	45	45
Urea	7	7	7	7	7	7
Lime powder	10	10	5	5	5	5
Cement	0	5	5	5	5	0
Clay	0	0	0	0	0	5
Mineral mixture	10	10	10	10	10	10
Common salt	3	3	5	5	5	5
Wheat bran	22	20	23	0	13	23
Lucerne leaves (dried)	0	0	0	23	10	0
Hardness after 24 hours	Soft	++	+	Nil	+	+
Hardness after 48 hours	Soft	+++	+++	Nil	++	+++

Formula 6 was finally selected for on-farm implementation. More than thirty farmers, including females, in two village organizations in Chitral were given training in making the mulberry feed blocks on their farms. Farmers having waste dried mulberry fruits were given a demonstration of making blocks based on the formula given in Table 12.12.

The farmers readily accepted the innovation, and when the blocks were fed to animals they produced highly encouraging results in terms of increased milk production, and improved health and fertility. The animals readily adapted to the block licks and on average consumed 300 g/cow/day or 70 g/goat/day. Increased milk yield was notable after 3 days of feeding the blocks. Local cows in the area are of small frame size (150–200 kg body weight) and maximum milk production varies from 1 to 2 litre/day, primarily due to poor genetic make up and undernutrition. Feeding of mulberry feed block increased milk by 33 to 43 percent (Figure 12.8).

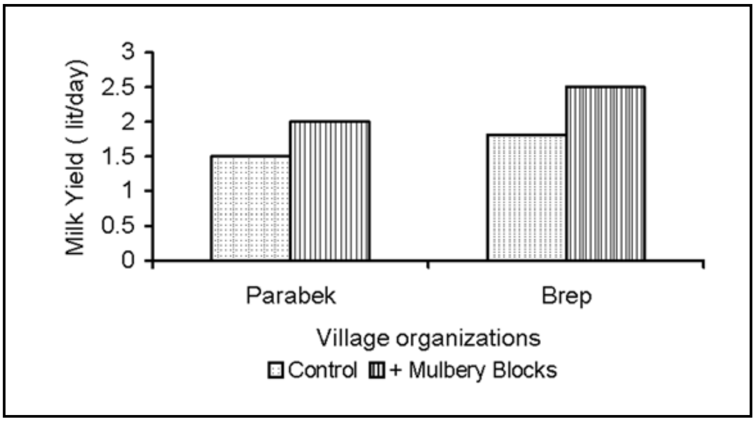

Figure 12.8

Milk yield response to mulberry-based urea-multinutrient block supplement in cows.

Recently, Roomi (2002) investigated the effect of mulberry fruit-based blocks on digestibility parameters in two local cattle breeds. Mulberry feed block licks significantly increased the digestibility of dry matter, organic matter and acid detergent fibre (Table 12.13). The calves on average consumed 416 g/day, or 8.25 g/kg body weight, and readily adapted to the lick, with no lag period.

Table 12.12
Composition of multinutrient block (3 kg weight) produced using dried mulberry fruit.

Ingredient	By percentage	By weight (g)
Dried mulberry fruit	23	690
Water	22	660
Urea	7	210
Lime	5	150
Clay	5	150
Minerals	10	300
Common salt	5	150
Wheat bran	23	690
Total	100	3 000 (3 kg)

Table 12.13
Effect of mulberry-based urea-multinutrient feed block on *in vivo* digestibility in two breeds of calves given a basal diet of maize stover.

Observations	Control diet			+ Mulberry block licks			Significance		
	Sahiwal	Achai	Mean	Sahiwal	Achai	Mean	Diet (D)	Breed (B)	D × B
DM digestibility (%)	47.01	45.69	46.35	55.56	58.42	56.99	P <0.001	NS	NS
OM digestibility (%)	50.74	49.49	50.11	59.16	60.42	59.79	P <0.001	NS	NS
ADF digestibility (%)	42.63	41.36	42.00	48.91	46.64	47.78	P <0.01	NS	NS

NOTES: DM = dry matter. OM = organic matter. ADF = acid detergent fibre. NS = not significant.

Convinced by the positive responses in animal performance, farmers after training have started preparing blocks on their own (Figure 12.9 and 12.10). Almost every farmer in the Northern Areas of Pakistan has a few mulberry trees. An average size tree would produce more than 50 kg of mulberry fruit in a season. Thus every farmer can easily make mulberry feed blocks for winter feeding of their animals. Some farmers have already started preparing blocks as an income generation activity, selling to other farmers. The Agha Khan Rural Support Programme (AKRSP) in Chitral has recently commenced an impact study on supplying mulberry feed blocks to milking cows, and have plans for introducing the innovation as a mini-enterprise for income generation in the project area.

Figure 12.9 Fresh mulberry fruit is crushed into a paste and mixed with urea and other ingredients to make mulberry feed blocks.

Figure 12.10 On-farm training of household members to make mulberry feed blocks for winter feeding of their animals.

Future Use Of Feed Blocks

Solidified feed blocks (both UMMB and the mulberry variety) can be used as a carrier for delivering anthelmintics, rumen modifier and specific minerals. Gastro-intestinal parasites are a common problem in almost all farm animals in Pakistan, and their incidence peaks during the humid months of July to September. Repeated oral dosing of animals with anthelmintics is difficult and farmers cannot do it on regular basis. Work on incorporating anthelmintics in blocks and their strategic use for controlling worms in animals is planned for the near future. Locally available herbal anthelmintics that are cheaper than imported drugs will be investigated. In the northern areas of Pakistan, farmers have identified some plants as anthelmintic, and these could potentially be incorporated in mulberry-based blocks for animals.

Feeding feed blocks fortified with minerals can effectively control location-specific mineral deficiencies, such as haemoglobinurea and osteodystrophic disorders associated with phosphorus deficiency. Work on this aspect through farmer field school campaigns should be initiated soon with the help of a community-based rural development organization in NWFP.

Rumen modifiers of herbal origin, such as tree leaves, can be included in blocks as antiprotozoal agents and rumen fermentation enhancers. Similarly, drugs for controlling bloat, a frequent problem with legume feeding, can be controlled through medicated blocks.

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Feed supplementation blocks for increased utilization of tanniniferous foliages by ruminants

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Abstract

Ruminant animals raised in arid, semi-arid and mountainous regions in various parts of the world rely heavily on shrub and tree species as the main diet component. The presence of secondary compounds – mainly tannins – in a wide range of these plant species constrains their fodder potential. Tannins may cause toxicity when present in the hydrolysable (HT) form, and may reduce considerably the nutritive value of browse and tree foliage when they are present in the condensed (CT) form. Tannins form complexes primarily with proteins, but also with carbohydrates, amino acids and several minerals, thereby reducing intake, digestion and animal growth. A number of methods have been tested to de-activate tannins in, or to remove them from, woody species. Amongst these, the use of polyethylene glycol (PEG; MW 4 000 or 6 000), which inactivates tannins by forming complexes with them, was shown to be a promising way to increase the nutritive value of tanniniferous browse and tree foliage. PEG was supplied to animals on tannin-rich diets in different ways (in concentrate or feed blocks, dissolved in water, or sprayed on feed). Feed block, a solidified blend of agro-industrial by-products, was found to be an efficient supplement for increasing intake, rumen fermentation, digestibility and daily weight gain in sheep or goats fed on shrub foliage high in tannins. These positive effects were further strengthened when PEG was incorporated into these blocks. The advantage of these supplements lies in the synchronized, fractionated and balanced supply

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of main nutrients to rumen microflora and the host animal on tannin-rich diets, results attributable to the slow release of PEG on licking of the block by the animal. This slow-release characteristic provides an economic use of this relatively costly tannin-inactivating compound, and maximizes its positive effect on the fodder potential of tanniniferous browse or tree species. Information on the use of feed blocks as supplements for ruminant animals on tannin-rich shrub and tree foliage diets is scanty. The importance of these alternative supplements to livestock raised under agro-pastoral systems and the need to pay more attention to this promising technology are highlighted in this paper. An auxiliary role of feed blocks is their possible use as a carrier for additives: several specific minerals for increasing reproductive performance; anthelmintic medicines to control gastro-intestinal parasites in browsing animals; and rumen modifiers such as saponins to decrease protozoa in the rumen, leading to more efficient microbial protein production. Therefore research and development programmes must be undertaken, aimed at field evaluation, economic analysis, dissemination to a large number of farmers, and better integration of the block technology in feeding systems.

Introduction

Increasing population, economic growth and urbanization are increasing demands for livestock products, which in turn is driving demand for increased feed, and generating additional pressure on natural grazing resources. In addition, lack of regulatory mechanisms to control grazing combined with the expansion of cultivation into previously uncultivated areas is aggravating degradation of rangelands worldwide. It has been proposed that fodder shrubs and trees can be integrated into production systems to provide additional feed resources for use in mixed diets for livestock, to provide a source of fuel, to reduce wind erosion when planted as wind breaks and to stabilize or rehabilitate degraded areas. A major part of diets for ruminants in arid, semi-arid and mountainous areas is derived from shrubby vegetation. Recent research into the constituents of many of these woody plants has shown these plants to contain appreciable quantities of secondary compounds. Among the most investigated of these compounds are tannins. Numerous reviews (Kumar and Vaithiyanathan, 1990; Reed, 1995; Waghorn, Red and Ndlovu, 1999; McSweeney *et al.*, 2001) deal with the structure and biological role of tannins in livestock feeding. These aspects are therefore only briefly mentioned here. This article reviews various methods to de-activate tannins, and discusses the potential use of feed blocks with and without polyethylene glycol (PEG), a tannin-inactivating agent, to promote effective utilization of tanniniferous shrub and tree foliage.

Potential use of tanniniferous feedstuffs

Numerous multipurpose browse trees and shrubs have been identified as having significant potential in agroforestory systems in tropical and Mediterranean-type regions (FAO, 1992; Topps, 1992). In many parts of the world, a wide range of shrub species contribute extensively to livestock feed, mainly for sheep and goats, and contain in most cases a high level of proteins. Admittedly, protein is the most limiting nutrient in the diet of livestock, and which, because of its limited supply, should be used more efficiently to promote fermentation of roughage in the rumen to improve animal performance. Tannins are the most widely occurring anti-nutritional factors found in plants. These compounds are present in numerous tree and shrub foliages, seeds and agro-industrial by-products (Aregheore, Makkar and Becker, 1998; Makkar and Becker, 1998, 1999). The availability and usage of various unconventional feed resources, including new and lesser known ones, the presence in them of deleterious factors, and approaches to remove or inactivate these factors have been dealt with in several reviews (Kumar and Vaithiyanathan, 1990; Makkar and Becker, 1999; Makkar, 2002). Phenolic compounds – particularly tannins and lignin – were shown to reduce the nutritive value of feedstuffs and thereby to limit livestock production and reproductive performance (Waghorn, Red and Ndlovu, 1999). Tannins are classified into two groups: hydrolysable tannins (HTs) and condensed tannins (CTs). Both types are hydrosoluble polymers that form soluble and insoluble complexes, mainly with proteins. They also have some affinity towards carbohydrates, amino acids and minerals. HTs, in contrast to CTs, are partly degraded in the gastro-intestinal tract and several precursors may derive from their glucose and phenolic constituents. Untransformed HTs and their phenolic degradation products may be absorbed from the gastro-intestinal tract, resulting in animal intoxication (Waghorn, Red and Ndlovu, 1999; Makkar, 2002). However, most researchers agree that CTs are not degraded in the animal gut and therefore are not toxic (Makkar, Blümmel and Becker, 1995; Makkar, 2000) under normal feeding situations when browse and tree foliage is used as a supplement. At very high level of browse and tree foliage intake, the intestinal wall may become damaged, leading to absorption of CTs and causing toxicity. However, CTs directly affect the nutritive value of feedstuffs. Until a few years ago, CTs were regarded as useless compounds with only negative effects on intake, digestion, production and reproduction in animals. Recent studies have confirmed that CTs may also have positive effects in ruminants (Barry, and McNabb, 1999; Barry, McNeill and McNabb, 2001). Low CT levels in several plant species, e.g. *Acacia albida* pods (Nsahlai, Umunna and Osuji, 1999), *Lotus pedunculatus* (Barry, Manley and Duncan, 1986) and *Acacia cyanophylla* Lindl. (syn. *Acacia saligna*) foliage (H. Ben Salem, unpublished data) increased daily gain in sheep given protein-rich diets. This effect was ascribed to increased levels of post-ruminally available proteins.

Techniques to de-activate tannins

Various methods have been attempted to de-activate tannins in a wide range of browse species, grain seeds and agro-industrial by-products (Makkar, 2000). These methods have included mechanical or physical techniques (e.g. wilting, processing, ensiling, etc.), inoculation with tannin-resistant bacteria (Miller, Brooker and Blackall, 1995; Molina, Pell and Hogue, 1999) and chemical techniques (treatment with alkalis, organic solvents, precipitants, etc.). The use of polyethylene glycol (PEG; MW 4 000 or 6 000), for which tannins have higher affinity than for proteins, is by far the most used reagent to neutralize these secondary compounds (Makkar, Blümmel and Becker, 1995; Silanikove, Perevolotsky and Provenza, 2001). Consequently, it would be possible to increase the nutritive value of tannin-rich browse by adding compounds such as PEG, which preferentially binds the tannins, making plant proteins more available for digestion. This strategy is very useful in situations where foodstuffs contain high concentrations of tannins. Different means of administering PEG have been used in the literature to assess the fodder potential of tanniniferous plant species. PEG was included either in concentrate supplement (Ben Salem *et al.*, 1999a; Decandia *et al.*, 2000), dissolved in drinking water (Ben Salem *et al.*, 1999a), infused orally (Wang *et al.*, 1996; Gilboa *et al.*, 2000) or sprayed in solution on browse foliage (Ben Salem *et al.*, 1999b) given to ruminant animals. The response to PEG supply in terms of intake, digestion and production varied with the mode of PG application. To our knowledge, Ben Salem *et al.* (1999a) were the only authors who have reported a comparison of the three methods of PEG provision for sheep on *Acacia cyanophylla* Lindl. foliage. On the basis of improvement in rates of acacia intake, apparent diet digestibility, rumen fermentation and microbial synthesis, PEG in concentrate ranked first, followed by PEG in drinking water and then PEG sprayed on foliage. However, the relatively high cost of this tannin-inactivating agent for smallholder farmers encouraged a search by others for alternative, more cost effective means of administering PEG, thereby economizing in the use of this tannin-neutralizing agent. Feed blocks seem to satisfy the objective.

Feed block technology to valorize tannin-rich diets

What are feed blocks and why to use them?

Feed blocks are a solidified blend of ingredients based on use of a high level of agro-industrial by-products. The formula of this non-conventional supplement includes one or more binders (quicklime, cement, bentonite, etc.), common salt as a preservative, urea as a non-protein nitrogen source, and other ingredients as carrier of nutrients, mainly energy, nitrogen and minerals. They are intended to supplement ruminants on poor quality diets (cereal straw, stubble, native pastures, etc.). The use of feed blocks in livestock feeding seems to be older than indicated in the literature, where most papers have been published in the last two decades (Sansoucy, 1986, 1995). It appears from Cordier's (1947) review that these alternative supplements were used in Tunisia in the 1930s, but were overlooked thereafter, until the 1990s, when research and development efforts gathered momentum, aiming at wide dissemination and adoption of this technology, mainly for smallholder farmers. At least 60 countries are now using this technology as a strategic supplement for ruminants, mainly cows, sheep and goats raised under harsh conditions. Mini-blocks free of urea have also been developed for rabbits (Sansoucy, 1995; Ramchurn and Ragoo, 2000).

A series of feed block formulas have been developed, evaluated 'on-station' and 'on-farm', and many of them have been adopted by farmers. Ben Salem and Nefzaoui (2003) have recently reviewed about 25 formulas for both molasses-free and molasses-containing blocks. Although several authors considered molasses to be an essential ingredient for feed block manufacture and acceptance by livestock, the lack of this agro-industrial by-product in many countries has encouraged researchers to develop formulas without molasses. Different types of molasses-free blocks have been shown to be efficient in terms of degree of acceptance by ruminant animals and positive effects on the nutritive value of low quality roughages given to penned or grazing animals, with consequent better livestock growth.

The wide use of feed blocks throughout the world indicates their importance in the development of the livestock sector and improvement in farmer revenues. Their use allows a continuous and balanced supply of nutrients (energy, nitrogen, minerals and vitamins) to the animal. Moreover, their greatest value lies in their role as a cost-effective supplement and as a means for utilizing several high-moisture-content agro-industrial by-products (e.g. olive cake, tomato pulp, citrus pulp), and thereby extending their usefulness. Also, material unfit for human consumption can be converted into high quality animal protein. Such technology is technically simple and does not require high investment, so it is easily adoptable by small-scale farmers. This technology offers a mean of making use of agro-industrial by-products and waste so far not fully utilized by domestic livestock. Additionally, it may play an important role in protecting the environment from pollution associated with disposal of some agro-industrial by-products. Finally, current research studies showed that feed blocks are an efficient carrier for tannin-neutralizing reagents, particularly PEG for ruminants on tanniniferous plant species, and also as a carrier for medication, such as anthelmintic medicines to control gastro-intestinal parasites. Table 13.1 reports formulas for blocks used as supplements for tannin-rich diets. These blocks were both with or without molasses and with or without PEG.

Feed blocks as catalytic supplements for animals on tannin-rich diets

Woody vegetation is often the main diet of ruminant animals raised in arid, semi-arid and mountainous zones. The low nutritive value of these diets – due to low levels of energy and nitrogen or the presence of tannins – results in reduced animal performance. In many situations, farmers use considerable quantities of concentrate feeds as supplements for their animals. The replacement of these expensive supplements with alternative feed sources would decrease the cost of feed. Feed blocks seem to be an interesting alternative.

Table 13.1
Formulas and chemical composition of feed blocks given to sheep or goats fed tanniniferous shrubs and trees.

Item	Formula								
	1	2	3	4	5	6	7	8	9
Ingredients (as percentage of DM)									
Olive cake	38.0	31.2	40.1	38.0	35.6	36.7	33.1	13.8	10.2
Wheat bran	28.0	23.0	25.1	23.7	22.2	24.3	21.8	36.5	30.3
Wheat feeds	11.0	9.0	12.3	11.6	10.9	–	–	–	–
Molasses	–	–	–	–	–	–	–	9.5	9.3
Opuntia fruit	–	–	–	–	–	9.0	8.0	–	–
Urea	5	4.1	7.3	–	6.4	7.3	6.6	11.4	11.2
Cement	–	–	–	–	–	–	–	11.6	11.2
Quick lime	12.0	9.9	9.2	8.7	8.1	15.4	13.9	–	–
Salt	5.0	4.1	7.3	–	6.4	7.3	6.6	5.8	5.6
Di-calcium phosphate	–	–	–	–	–	–	–	5.7	5.5
Mineral-vitamin supplement	1.0	0.8	1.3	1.0	1.0	–	–	5.7	5.5
PEG 4000	–	18.0	–	12.5	11.7	–	10.0	–	11.2
Chemical composition (g/kg DM)									
Dry matter (g/kg)	691	705	866	857	863	860	830	–	–
Ash	249	245	309	291	284	357	421	295	280
Crude protein	214	210	235	101	235	225	193	381	369
NDF	206	209	219	212	218	323	199	261	210
ADF	133	121	187	184	182	225	187	117	87

KEY: NDF = neutral digestible fibre. ADF = acid digestible fibre.

SOURCES for formulas: 1 and 2 – Ben Salem *et al*., 2000b. 3, 4 and 5 – Ben Salem *et al*., 2002; 6 and 7 – Ben Salem *et al*., 2003; 8 and 9 – Moujahed *et al*., 2000.

However, very little is known about the effect of feed blocks on the nutritive value of tannin-rich diets and consequent livestock production. Ben Salem, Nefzaoui and Ben Salem (2000) concluded that supplementing with olive-cake-based blocks for goats grazing shrubland dominated by tannin-rich shrub species (*Olea europea, Pistacia lentiscus*, etc.) did not affect their feeding behaviour, but increased their daily gain by 60 percent compared with those not receiving supplements (Table 13.2). The growth rate was further increased when a mixture of small amounts of spineless cactus pads (100 g dry matter) and fresh foliage of *Atriplex nummularia* (100 g dry matter) was offered to goats. The authors are not aware of any other study dealing with the effect of feed blocks on the nutritive value of tree and shrub foliage high in tannins. However, McMeniman (1976) and Gartner and Niven (1978) showed beneficial effects with several minerals (phosphorus, sulphur, etc.) given to sheep on *Acacia aneura*, a tannin-rich shrub species. Increased intake, digestion, daily gain and wool growth suggest that blocks may be used successfully as a carrier for these minerals. The enormous advantage in this case is the possibility of providing a supplement to animals on tanniniferous shrub species whilst they are still in the rangeland.

Feed blocks as a cost-effective carrier of PEG to de-activate browse tannins

Does the synchronization of tannin consumption and PEG supply optimize the beneficial effect of PEG on the nutritive value of tanniniferous browse species? This hypothesis has been investigated and results seem to favour the use of PEG as a tannin inactivating agent in feed blocks. Synchronization with a fractionated and balanced supply of nutrients are the main advantages of feed block use from the nutritional point of view. Therefore, hardness and compactness are crucial criteria that should be borne in mind when defining a formula and making blocks. The choice of appropriate binder and its proportion in the ingredient mixture is important. The assessment of feed block hardness and density, as well as the manufacturing techniques for these non-conventional supplements, have been reviewed by Ben Salem and Nefzaoui (2002). PEG should be dissolved in water, and then the urea and salt added. The final solution is sprinkled gradually on the other solid ingredients. The most-used binders have been cement and lime, in proportions between 10 and 15 percent. A harder block makes the animal lick the feed block continuously. This releases small amounts of the main nutrients relatively continuously into the rumen, in short bursts depending on the licking frequency, which would be catalytic for microbial activity and stimulate digestion of poor quality feedstuffs. Moreover, this also avoids urea intoxication.

Using hard feed blocks could be a way to ensure continuous and slow release of PEG to the animal. Ben Salem *et al*. (2000) confirmed the enormous advantage of PEG-containing feed blocks for sheep on a tannin-rich browse foliage, namely fresh leaves of *Acacia cyanophylla*. These authors included graded levels of PEG 4000 (0, 6, 12, 18 and 24 percent) in olive-cake-based feed blocks (see Formulas 1 and 2 in Table 13.1). Linear increases were recorded in acacia intake, and in organic matter, crude protein and fibre *in vivo* digestibilities of the diet. An improvement was evident in the nitrogen value of the diet, as reflected by an improved nitrogen balance and increased microbial nitrogen supply.

Table 13.2
Effect of feed block supply on behavioural activities and growth of goats on shrublands.

Parameter	Treatment			Standard Error (Significance)
	No supplement	Feed blocks(1)	Cactus + atriplex	
Browsing time(2)	41.9	38.0	43.7	2.76 (NS)
Grazing time(2)	45.7	48.7	44.5	2.72 (NS)
Walking time(2)	6.7	7.3	6.3	0.68 (NS)
Resting time(2)	5.8	5.9	5.4	0.78 (NS)
Daily gain (g)	25	41	60	5.02 (*)

NOTES: (1) Using formula 1 in Table 13.1. (2) Expressed as the percentage of total time spent by goats in the rangeland. NS = non-significant effect ($P > 0.05$). * = $P < 0.05$.

SOURCE: Ben Salem, Nefzaoui and Ben Salem, 2000.

The improvement of the nutritive value of diets resulted in increased growth rates in sheep. Since responses obtained with 18 and 24 percent PEG in feed blocks were similar, the authors recommended limiting the level of PEG to 18 percent to obtain an optimal positive effect from feed block use. Sheep given feed blocks containing 18 percent PEG consumed approximately 23 g PEG/day. The slow release of PEG, and therefore the synchronized consumption of tannins and PEG, is probably the main explanation of the beneficial effect of PEG-containing feed blocks. This hypothesis was corroborated *in vitro* by Getachew, Makkar and Becker (2001), who found that PEG introduced into the *in vitro* rumen fermentation system as split rather than single doses gave the highest microbial nitrogen synthesis from some tannin-rich fodder shrubs.

The contention of one of the authors (H.P.S. Makkar) that inclusion of high levels of urea in PEG-containing blocks may not be necessary since PEG is expected to dissociate tannin-protein complexes, and thus increase the level of available nitrogen was confirmed by Ben Salem *et al.* (2002), who showed that lambs on acacia foliage supplemented with blocks containing PEG and urea had increased dry matter intake of supplemented acacia foliage, microbial nitrogen supply and growth rate (Table 13.4), similar to those with blocks containing PEG without urea (see formulas 3, 4 and 5 in Table 13.1).

Table 13.3
Intake, *in vivo* digestibility, nitrogen balance, microbial synthesis and daily gain in sheep fed on fresh foliage of *Acacia cyanophylla* and supplemented with molasses-free feed block with or without PEG.

Parameter	Acacia + PEG-free block(1)	Acacia + PEG-containing block(2)
Dry matter intake (g/kg $W^{0.75}$)		
Acacia	37.7	58.8
Feed block	13.7	14.0
Total	51.4	72.8
Diet digestibility (%)		
Organic matter	33.3	43.2
Crude protein	43.5	55.1
Nitrogen retained (g/day)	- 1.5	2.5
Microbial nitrogen(g/kg DOMI)(3)	4.9	11.5
Daily gain (g/day)	14	61

Notes: Except for intake, the difference between the two diets was significant ($P < 0.05$) for each parameter. (1) Formula 1 in Table 13.1. (2) Formula 2 in Table 13.1. (3) DOMI = digestible organic matter intake.

Source: Ben Salem *et al.*, 2000b.

Table 13.4
Effect of administering PEG in concentrate or feed blocks on dry matter intake (DMI; g/day), microbial nitrogen supply (g/kg digestible organic matter intake), daily weight gain and meat quality of Barbarine lambs fed *Acacia cyanophylla* Lindl.

	C	CPEG	BU	BUPEG	BPEG	S.E.
Intake factors [1]						
Acacia DMI	599^{a}	656^{a}	457^{b}	688^{a}	704^{a}	18.1
Microbial N supply	9.9^{b}	24.1^{a}	1.3^{c}	10.0^{b}	14.9^{b}	1.08
Daily gain	78^{b}	116^{a}	2^{c}	59^{b}	62^{b}	5.2
Meat factors [2]						
Lightness (L*)	45.21^{ab}	42.60^{c}	45.89^{a}	43.57^{bc}	42.21^{c}	0.643
Shear force (kgF)	2.51^{b}	2.73^{ab}	3.42^{a}	3.26^{a}	3.27^{a}	0.211
Tenderness	7.65^{a}	7.80^{a}	6.97^{b}	7.32^{ab}	7.27^{ab}	0.180

Key: C = acacia ad lib + 300 g concentrate daily. C_{PEG} = C + 20 g PEG daily. BU = acacia ad lib + urea-containing block (Formula 3 in Table 13.1). BU_{PEG} = acacia ad lib + block containing urea and PEG (Formula 5 in Table 13.1). B_{PEG} = acacia ad lib + urea-free block containing PEG (Formula 4 in Table 1). S.E. = standard error.

Notes: Tenderness: Five panellists were asked to score the meat samples, using a nine-point intensity scale for tenderness at first bite (extremely tough to extremely tender) (for further details, see Priolo *et al.,* 2002).
a,b,c = Means in the same line with different superscripts are significantly different ($P < 0.05$).

Sources: [1] Ben Salem *et al.*, 2002. [2] Priolo *et al.*, 2002.

Excessive nitrogen supply, mainly in soluble form, results in a release of ammonia that often exceeds its rate of incorporation into microbial protein, resulting in loss of a great part of this nitrogen as ammonia absorbed from the rumen. The situation is aggravated in the rumen in the absence of adequate levels of energy source. In addition, excretion of ammonia from the body in the form of urea in the urine is an energy-expensive process. Therefore, the nitrogen profile and energy content of block ingredients and the basal diet should be considered when fixing the urea level in the block.

In another experiment, amounts close to the optimum level of PEG included in feed blocks (i.e. corresponding to a daily intake of 23 g) observed by Ben Salem *et al*. (2000) eliciting the highest improvement in the daily weight gains of lambs on acacia-based diets were incorporated in concentrate, drinking water or sprinkled as solution on acacia foliage (Ben Salem *et al*., 1999a). Table 13.5 compares the four modes of administering PEG in terms of the response in feed intake, apparent digestibility, nitrogen balance, microbial protein synthesis, rumen fermentation parameters and growth rates. The responses were expressed as percentage change compared with the corresponding PEG-free diet (control diet). Inclusion of PEG in feed blocks was generally associated with the highest increase in dry matter intake. However, the response for crude protein digestibility was lowest when administered in feed blocks. PEG-free feed blocks are often high in crude protein (200 to 350 g/kg DM) compared with concentrate. Therefore, the level of CP in the diet may be sufficient for rumen microflora and probably for the host animal, and therefore the inclusion of PEG in feed blocks did not lead to a significant increase in the CP digestibility of the diet. Whatever the administering mean, PEG had no effect on pH and molar proportion of short chain fatty acids in the rumen fluid. However, similar to findings from *in vitro* investigations (Getachew, Makkar and Becker, 2001), the levels of NH_3-N and the concentration of volatile fatty acids were significantly increased with PEG supply. The extent of this increase was highest with PEG-containing concentrate, while PEG in drinking water or in feed blocks resulted in similar increases in NH_3-N in the rumen fluid of sheep on acacia foliage (+34 and +31 percent, respectively).

Table 13.5
Effects of PEG on intake, digestibility and fermentation parameters in sheep and goats given tannin-rich diets (responses expressed as percentage change compared with corresponding PEG-free diets).

	PEG administration mode[4]			
	Concentrate	Drinking water	Sprinkled on foliage	Feed block
Acacia DM intake				
	+35	+23	NS[1]	+73
	–	–	–	NS[c]
	+9	–	–	+54
Apparent digestibility				
Dry matter	NS[a]	NS[1]	NS[1]	+47[2]
Crude protein	+105[1]	+90[1]	+72[1]	+27[2]
Crude protein	–	–	–	+25[3]
Crude protein	+38[4]	–	–	+45[4]
In sacco degradation of acacia				
DM	+75[1]	+84[1]	+84[1]	NS[3]
Nitrogen	–	–	–	+28[3]
Fermentation parameters				
pH	NS[1]	NS[1]	NS[1]	NS[c]
NH_3-N	+202[1]	+34[1]	+95[1]	+31[3]
Total VFA	+34[1]	+22[1]	+33[1]	+10[3]
Acetic acid	NS[1]	NS[1]	NS[1]	NS[3]
Propionic acid	NS[1]	NS[1]	NS[1]	NS[v]
Butyric acid	NS[1]	NS[1]	NS[1]	NS[3]
Protozoa	–	–	–	+13[3]

KEY: NS = Effect not significant. VFA = volatile fatty acids. DM = dry matter. NOTES: (1) Data from Ben Salem *et al*. (1999a). Control diet: fresh foliage of acacia ad lib + 300 g concentrate daily. (2) data from Ben Salem *et al*. (2000b). Control diet: fresh foliage of acacia ad lib + feed block (see Formula 1 in Table 13.1; Formula 2 corresponds to PEG-containing block). (3) Data from Moujahed *et al*. (2000). Control diet: air-dried foliage of acacia ad lib + 400 g oat-vetch hay + feed blocks (see Formula 8 in Table 13.1; Formula 9 corresponds to PEG-containing block). (4) *Amounts of PEG administered in concentrate, water, feed blocks or sprayed on acacia foliage were quite similar (20–23 g/day).

This trend seems to be related to the time needed for consumption of the entire amount of PEG. Indeed, PEG-containing concentrate is consumed rapidly by sheep in a few minutes, and therefore a peak of NH_3-N in the rumen fluid is observed during the first few hours post-feeding, which rapidly decreases thereafter. In contrast, consumption of PEG-containing drinking water and feed blocks was fractionated over the day. Consequently, the increase in ammonia concentration generated by PEG-containing blocks would be less pronounced than that from PEG in concentrate.

The effect of PEG supply on the turnover rate of particles in the rumen of sheep fed acacia foliage and 400 g oat-vetch hay was investigated by Moujahed *et al*. (2000). Feed block supply (Formula 8 in Table 13.1) increased the particle outflow rate (from 3.27 to 4.04 percent per hour). The enrichment of these feed blocks with PEG (Formula 9 in Table 13.1) further increased this parameter (to 4.67 percent per hour). Energy, nitrogen and minerals simultaneously provided to sheep through feed blocks may have stimulated microbial activity and thereby increased the rate of fibre degradation in the rumen. Moreover, these authors suggested a possible physical effect of blocks resulting from increase in the proportion of dense particles near the reticulo-omasal orifice, leading to an increased amount of dry matter evacuated. The PEG in feed blocks was released slowly. This may have further increased the level of available proteins from the diet through dissociation of acacia tannin-protein complexes and therefore further stimulated fibre degradation in the rumen. Additionally, the increase in water consumption by sheep given feed blocks with or without PEG may have accelerated the rate of digesta outflow. It is evident that increased water consumption with feed block supply was due to the presence of salt. In addition, salt restricts free intake of the block and obliges the animal to consume small amounts continually over the day. This results in slow release of nutrients and of PEG. However, the increased water consumption by sheep receiving PEG-containing blocks is surprising in the absence of any variation in block and total diet intakes between groups with PEG-containing or PEG-free blocks. Moujahed and co-workers (2000) ascribed this to possible increase in the rate of fermentation in the rumen because water intake seems to be the mechanism by which ruminants adjust the osmotic pressure in the rumen. In the absence of other studies confirming these findings, the effect of PEG supply on water intake by ruminants on tannin-rich diets warrants further investigations.

Irrespective of administration mode, PEG supply increased urinary excretion of allantoin and consequently microbial nitrogen supply. The response was more pronounced when PEG was included in concentrate or feed blocks than when in drinking water or sprayed as solution on browse foliage (Table 13.6). Worth noting is that the highest nitrogen retention was seen when PEG was included in blocks. The improved intake of the tannin-rich shrub (acacia foliage), higher organic matter, fibre and protein digestibility of the diet, better rumen fermentation, increased microbial nitrogen supply and better nitrogen balance due to PEG supply explain the increased daily gain of sheep on acacia-based diets. Interestingly, the highest response for growth rate was with PEG-containing blocks.

Table 13.6
The effects of PEG on particle transit, allatoin excretion (as an index of microbial systhesis), microbial synthesis, N balance and daily weight gain in sheep given *Acacia cyanophylla*-based diets (responses are expressed as percentage change from corresponding PEG-free diets).

	PEG administration mode[5]			
	Concentrate	**Water**	**Treatment**	**Feed blocks**
Ruminal mean retention time	–	–	–	-14[3]
Microbial synthesis				
Allantoin in urine	+85[1]	+49[1]	+24[1]	+65[2]
Allantoin in urine	NS[d]	–	–	+1046[d]
Nitrogen retention	+218[1]	+218[1]	+82[1]	+270[2]
Nitrogen retention	–	–	–	+88[3]
Nitrogen retention	+67[4]	–	–	+93[4]
Daily gain	–	–	–	+336[2]
Daily gain	+49[4]	–	–	+3000[4]

Key: NS = Effect not significant.

Notes: (1) Data from Ben Salem *et al*. (1999a). Control diet: fresh foliage of acacia ad lib + 300 g concentrate daily. (2) data from Ben Salem *et al*. (2000b). Control diet: fresh foliage of acacia ad lib + feed block (see Formula 1 in Table 13.1; Formula 2 corresponds to PEG-containing block). (3) Data from Moujahed *et al*. (2000). Control diet: air-dried foliage of acacia ad lib + 400 g oat-vetch hay + feed blocks (Formula 8 in Table 13.1; Formula 9 corresponds to PEG-containing block). (5) Amounts of PEG administered in concentrate, water, feed blocks or sprayed on acacia foliage were quite similar (20–23 g/day).

The effect of PEG-free or PEG-containing block supplementation on meat and milk quality of ruminants fed on tannin-rich diets has not been fully investigated. To the present authors' knowledge, the only work addressing this was recently published by Priolo *et al*. (2002). It was evident from this work that meat from Barbarine lambs on air-dried foliage of *Acacia cyanophylla* (CT = 60.0 g equivalent leucocyanidin/kg DM) and supplemented with concentrate or olive-cake-based blocks had the same chemical composition (moisture, ash, protein and fat). Using PEG as the tannin-neutralizing agent, these authors concluded that CT in acacia affected lean colour and lightness. The lightness was higher in those lambs that did not receive PEG, indicating that CT can make meat lighter in colour. Meat from sheep that received supplementation of concentrate had lower values for Warner-Bratzler shear device resistance compared with those that received blocks. The panel test confirmed this result: meat from concentrate-receiving lambs was more tender than that obtained from block-receiving lambs. PEG introduced in either concentrate or blocks increased intensity of flavour, but had no effect on overall acceptability (Table 13.4). According to Priolo *et al*. (2002) and Priolo and Ben Salem (2003), blood haemoglobin level – which was lowered by CT – is correlated with muscle lightness. Increased meat lightness is probably a consequence of reduced muscle iron content in animals fed CT-rich diets. Ben Salem *et al*. (2002) and Priolo *et al*. (2002) concluded that increasing the energy level of feed blocks by including an energy-rich ingredient such as prickly pear fruit (*Opuntia* spp.) or molasses might result in a significant positive improvement in the nutritive value, growth and meat quality of lambs fed on acacia-based diets. This recommendation was considered by Ben Salem *et al.* (2003) in a recent study in which the effects of PEG-containing, PEG-free blocks and PEG given separately in a small amount of barley with a PEG-free block were investigated, assessing intake, digestion, clinical and biochemical parameters in goats given kermes oak (*Quercus coccifera* L.) foliage (Table 13.7).

Kermes oak (*Quercus coccifera* L.) is a shrub species widespread in Mediterranean garigue ecosystems. Its nutritive value is low due to a low level of crude protein and relative high proportion of tannins. Foliage of kermes oak (CT = 71.0 g equivalent leucocyanidin/kg DM) was given as sole diet to goats or supplemented with blocks incorporating olive cake and prickly pear fruit. Prickly pear is the fruit of a cactus, *Opuntia* spp., and is high in soluble carbohydrates, and thus used as an energy source in the block formula. PEG was included in these blocks or supplied separately, i.e. mixed with 5 g of processed barley grains, and offered to the animal at the same time as the blocks (using Formulas 6 and 7 in Table 13.1).

Table 13.7

Effect of PEG-containing feed block (B_{PEG}), PEG-free feed block alone (B) and PEG supply with PEG-free feed block (B + PEG) on intake, digestion and nitrogen balance in goats given kermes oak (*Quercus coccifera* L.) foliage.

Basal diet	**Supplement(1) with kermes oak foliage ad lib**				**SEM**	**C1**	**C2**
	Control	B	B + PEG	B_{PEG}			
DM intake (g/day)							
Kermes oak	331^{b}	627^{a}	604^{a}	747^{a}	34	**	*
Feed block	-	113	141	149	–	–	–
Diet digestibility (%)							
Organic matter	55.2^{b}	65.5^{a}	63.1^{a}	64.9^{a}	1.2	**	NS
Crude protein	33.2^{b}	47.1^{ab}	57.8^{a}	59.6^{a}	2.4	**	**
NDF	42.9^{b}	56.6^{a}	56.7^{a}	55.5^{a}	1.8	**	NS
N intake (g/day)	3.9^{b}	13.6^{a}	12.5^{a}	14.9^{a}	0.8	***	*
Faecal N (g/day)	2.4^{b}	7.2^{a}	5.5^{a}	5.9^{a}	0.4	**	NS
Urinary N (g/day)	0.1	0.1	0.2	0.1	0.03	NS	NS
N retained (g/day)	1.3^{b}	6.3^{a}	6.7^{a}	8.8^{a}	0.5	***	**

KEY: SEM = standard error of the mean. C1 = contrast 1: mean effect of feed block (control vs (B + (B+PEG) + B_{PEG})). C2 = contrast 2: mean effect of PEG supply (control + B) vs (B_{PEG} + (B+PEG)). NS = not significant. ^{a,b} Means in the same line with different superscripts are significantly different ($P < 0.05$).

NOTES: (1) Supplementation: Control = no supplement; B = feed block without PEG; B+PEG = PEG-free feed block, with PEG supplied once daily separately in a small amount of processed barley; B_{PEG} = PEG-containing feed block. The amount of PEG distributed to goats in group B+PEG corresponded to the amount of PEG consumed by goats given PEG-containing blocks (B_{PEG}). On average, goats on B+PEG and B_{PEG} diets consumed 15 g PEG/day.

SOURCE: Ben Salem *et al.*,2003.

Although DM intake of feed blocks was low (113 g/day), supplementation with PEG-free blocks almost doubled consumption of kermes oak foliage (61.2 vs 34.8 g DM/kg $W^{0.75}$) and DOMI and CP intake increased from 17.4 and 1.0 g/kg$W^{0.75}$ to 46.6 and 33.0 g/kg$W^{0.75}$, respectively. There was no obvious improvement in these parameters from incorporation of PEG in the block or by supplying PEG alongside the block (B_{PEG} and B+PEG versus B). Irrespective of dietary treatments, blood constituents, such as glucose, urea, total proteins, albumin, creatinine, calcium, phosphorus and magnesium, and the enzyme gamma-glutamyltranspeptidase were within the normal range for local goats. Feed blocks increased serum urea significantly, probably as consequence of improved nitrogen availability from the diet. Supplementation with feed blocks with or without PEG improved cardiac, respiratory and rumen contraction frequencies, and raised body temperature to the normal value (37°C). Olive-cake-based feed block enriched with squeezed cactus fruits was found to be a cost-effective supplement to substantially improve the nutritive value of kermes oak-based diet and to maintain goat health. This study indicated that the optimal increase in the nutritive value of kermes oak-based diets was obtained with PEG-free blocks. This seems to suggest that appropriate supplementation with major nutrients may be sufficient to improve digestion of browse species high in tannins. The further increase expected from PEG supply is most likely to be plant species specific, based on the level and structure of tannins. Increased intake of PEG with increased tannin content has been demonstrated (Provenza *et al.*, 2000). The level of PEG in the block would depend on the level and activity of the tannins present in the browse fed to the livestock. Protein and PEG both bind tannins and inactive them. The degree of effectiveness of PEG incorporation, therefore, also depends on the level of protein present in the browse (Makkar, Blümmel and Becker, 1995).

Other possible uses of feed blocks

In addition to nutrient supply and slow release of PEG, feed blocks have been used successfully as carriers of anthelmintic medicines to control gastro-intestinal parasites in grazing sheep (Anindo *et al.*, 1998). This is an additional advantage, which facilitates management of grazing livestock and reiterates the importance of this technology in enhancing animal production and promoting sanitary conditions. Improved reproduction performance in ewes and rams supplemented with feed blocks containing

Cu and Zn (Al-Haboby *et al*., 1999) would suggest that these blocks may be enriched with some specific minerals to stimulate digestion of tannin-rich shrub species. Although not yet investigated, it would be interesting to include some specific amino acids and peptide-containing agro-wastes in feed blocks for ruminants on poor quality diets. Finally, some tannin-rich agro-industrial by-products might be introduced into feed blocks (grape marc, etc.) to increase their nutritive value and to increase the level of by-pass proteins in the diet.

Conclusion and research needs

In mountainous, arid, semi-arid and humid zones, shrub and tree foliage is the only feed for ruminants most of the year, so the exploitation of their full nutritional potential is vital for achieving enhanced animal productivity. A wide range of these plant species are good sources of proteins, some others are high in energy or minerals. However, the presence of several secondary compounds, considered to be plant defence mechanisms developed against herbivores, negatively affect the nutritive value of browse species. The feeding of such shrub and tree foliage reduces animal productivity and in some cases causes intoxication. Tannins have been shown to be constraining elements in intake and digestion of numerous temperate and tropical shrub and tree foliage feeds. The effect of tannins can be mitigated by use of tannin counteractants, such as PEG. Amongst various ways of PEG incorporation in the diet, the use of feed blocks containing PEG has several advantages over other methods. The use of these blocks allows slow release of PEG, which enhances its overall effectiveness, leading to higher microbial protein synthesis in the rumen and improved animal responses. In addition, this gives an opportunity to reduce overall cost, as less PEG is needed when incorporated in the feed block, and it enables animals to control their intake of PEG according to the level and activity of tannins in the browse. Block technology offers advantages in terms of easy preparation, storage, transport and use by the farmers. In addition to utilization of agro-wastes, and in particularly those having a short shelf life, block technology provides opportunities for farmers to manage supplementary feeds throughout the year based on the availability of feed resources. The most important advantage of these blocks lies in the possible reduction in concentrate use, thereby reducing feeding costs. The feed blocks could also be used as a carrier for various medicines, natural plant products, minerals, etc. Although the potential of blocks is gradually being recognized, there is need for more research on appropriate formulations and use of these alternative supplements. More effort needs to be directed to ensuring wider adoption of this technology by farmers.

There are some research and development topics related to the use of block technology for enhancing utilization of shrub and tree foliage, including:

- characterizing the nutritional parameters of fodder shrubs and trees, mainly for the presence of secondary compounds and their effect on the nutritive value of shrubby vegetation;
- developing block formulas that use locally available and inexpensive ingredients and reflect the nutrient and anti-nutrient contents of local shrub and tree foliage;
- investigating whether the introduction of PEG in feed blocks is necessary, and, if in the affirmative, identifying national optimal levels based on protein content and tannin content and activity;
- convincing farmers of the effect of secondary compounds on animal production and hence the beneficial effect of blocks, without or with PEG, for increasing utilization of tanniniferous plants;
- conducting economic analyses (cost–benefit ratio) of incorporating PEG in feed block;
- integrating fodder shrubs and trees into existing range-livestock and crop-livestock production systems, in a way that is economically and socially acceptable to farmers and herders;
- developing strategies for facilitating technology transfer and adoption by farmers; and
- assessing the effect of feed blocks containing PEG on product quality – milk and meat in particular – considering consumer preferences for these products.

Whatever strategy is to be followed for promoting feed block integration in feeding regimes based on tanniniferous plant species, the farmer-participation approach should be an integral element. Research on feed block formulation and use must not only address farmers' problems, but also seek their participation and involvement in the adaptive research. The objective is to ensure that technology is developed to meet specific needs, and that it applies to the target environment. This type of research provides researchers with feedback from farmers and end users, enabling the researchers to modify their technology to better respond to end-user circumstances. On-farm trials are a substantial step beyond on-station research, allowing more realistic testing of new technologies while stimulating new research. A participatory approach is a recognized alternative for generating, adapting and transferring new technologies. It is therefore important that scientists develop a working relationship with farmers at all stages of the livestock research process, from the laboratory to on-farm trials to general adoption.

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Experiences with urea-molasses blocks manufacture and use in the Sudan

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Introduction

From the mid-1970s and into the 1980s, the Sudan witnessed successive incidents of drought, coupled with land misuse (e.g. overgrazing, range fires, encroachment, and mechanical plantation of cash crops into rangelands). These led to desertification and deterioration of the natural pasture, which provides about 80 percent of the feed required by the huge national herd, estimated at 102 million head. This difficult situation triggered thoughts of utilizing agro-industrial by-products as animal feeds. The idea was further strengthened by the wide drought that hit the country in 1984, leading to great losses of livestock and a subsequent request from the Government of the Sudan to FAO for assistance in manufacturing and distribution of urea-enriched molasses blocks (UMBs) to save livestock from starvation.

Molasses is a major by-product of the sugar industry and is considered a good source of energy for feeding ruminants as it contains high levels of sugars (48–56 percent). Molasses is deficient in protein (<3.5 percent), but it contains water soluble vitamin B, together with iodine, sulphur, cobalt, lead, zinc and manganese. Its proximate analysis indicates 26.5 percent moisture, 3.5 percent crude protein, 0.15 percent ether extract, 57.65 percent N-free extract and 12.2 percent ash.

The sugar industry in the Sudan started initially in 1963, and currently there are five sugar factories, at Kenana, Assalya, Sinnar, Geneid and New Halfa. These factories produce about 250 000 tonne of molasses annually. Although molasses is a good source of energy, its physical form – a sticky liquid – limits its wide use in animal feeds in the Sudan, where storage facilities, transport tankers and pumps that can handle molasses are not easily found in the traditional livestock sector. There was also a great need for efficient extension services among livestock owners who, when

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the project started, lacked understanding of the benefits they could gain by using molasses as a feed substitute. The use of UMBs could have an enormous impact in the Sudan, due to:

- The huge size of animal herd.
- The presence of a flourishing sugar industry in the country.
- An estimated seven-million-tonne animal feed deficit.

The UMB Project

The UMB project was established in 1986 with financial support through FAO, with an annual production capacity of 600 tonne, that could be increased to 2 500 tonne/year. The set up of the project was simple so that the idea could be transferred to other localities. It constituted:

- a 12 × 12 m shed;
- a 12-tonne-capacity tank for molasses storage;
- a 5-tonne-capacity holding tank with tower;
- a mono-pump with three-inch steel pipes, a filter and valves;
- a cement mixer;
- a skip bucket and pulley system; and
- weld-free moulds

UMB production

Initial output was small in volume due to the difficulty of marketing the blocks, as the animal producers were not familiar with them and their use. However, as a result of widespread extension efforts, distribution of the molasses feed supplementation blocks increased from 20.4 tonne in 1986 to over 2 000 tonne in 2000. It is noteworthy that the project contributed to alleviating the effect of shortage of animal feed during the drought of 1990 in the Red Sea area.

Composition and feed ingredients

The project was started in 1986, and production was based on a formula of 50 percent molasses, 25 percent wheat bran, 10 percent cement, 10 percent urea and 5 percent salt. However, it was later observed later that the livestock producers did not follow instructions when offering the blocks to the animals. Some herders used to dissolve the cubes in water, and others broke them into small pieces. It was then felt necessary to reduce the percentage of urea to only 6 percent and cement to 7.5 percent.

Other ingredients that can be used in UMMBs are groundnut hulls and bagasse as structural materials. However, they are not as desirable as wheat bran, which has a high nutritive value and gives a smooth, coherent and compact block. When wheat bran is used, a 25×25×16 cm block weighs about 12 kg. With bagasse or groundnut hulls instead of wheat bran, the same sized blocks are lighter, at about 8 kg. However, it is advisable to use the bagasse and hulls in areas where they are found in abundance. Quicklime (CaO), ash and clay could also substitute for cement as a binding material. Quicklime is a good source of calcium, but its use is constrained by two factors:

- it needs grinding before use, and the dust generated during the milling process is injurious to the workers; and
- its efficiency as a binding material declines quickly upon exposure to air as it absorbs environmental moisture and changes into Ca (OH) in about 3–4 days of open storage.

The use of UMB for maintenance and production

A series of experiments were conducted at the Animal Production Research Centre, Kuku, in 1989 to investigate the use of UMMB for feeding sheep. Table 14.1 shows the results when UMMB licks were offered to sheep with a basal diet of sorghum straw, compared with a conventional concentrate supplement comprising 40 percent cottonseed cake, 16.7 percent wheat bran, 41.7 percent sorghum grain and 1.6 percent salt.

It is noteworthy that all sheep slaughtered at the end of the experiment had no abnormalities in their internal organs. In another experiment (Table 14.2), it was found that addition of groundnut cake at a rate of 5.5 percent in the blocks increased feed intake and daily gain in sheep.

Table 14.3 shows the results of feeding UMB to three groups of dairy cows. Supplementation with UMB substantially increased daily milk production of the three groups of cows.

It is evident from the above that the use of UMB could have a very high impact on increasing livestock productivity in the Sudan. There is need to extend the technology to many more farmers.

Table 14.1
Daily weight gain and nutrient intake with UMB supplementation compared with feeding concentrates, for sheep on a sorghum-straw diet.

Parameter	UMB	Concentrate	Significance
Number of animals	8	8	-
Experimental period (days)	73.5	73.5	-
Initial live weight (kg)	50.9	49.5	NS
Final live weight (kg)	51.8	59.7	**
Daily gain (g/day)	13	140	***
CP intake (g/day)	251	248	NS
ME intake (MJ day)	10.8	14.5	***
Water intake (litre/day)	5.3	3.76	***

NOTES: CP = crude protein. ME = metabolizable energy. NS = not significant.
SOURCE: El Khidir *et al.*, 1989a, b.

Table 14.2
Results of adding groundnut cake to the UMBs

	UMB	UMB + cake	Concentration
Number of sheep	10	10	10
Period (days)	84	84	84
Initial live weight (kg)	20.2	20.4	20.1
Final live weight (kg)	25.3	30.6	29.9
Daily gain (g/day)	61	121	117
Concentrates intake (g/day)	189	370	362
Roughage intake (MJ day)	678	617	451
Total daily intake (g)	867	987	813
DCP intake (g/day)	47	76	72
ME intake (MJ/day)	7.4	8.5	7.8
kg DMI per kg gain	14.1	8.2	6.9

NOTES: DCP = digestible crude protein. ME = metabolizable energy. DMI = dry matter intake.
SOURCE:: El Khidir *et al.*, 1989a, b.

Table 14.3
Daily milk production (litres) of cows fed on diets with or without UMB.

Group of cows	Without UMB	With UMB	Percentage increase
High producers	10.25	12.28	19.8
Medium producers	5.79	7.13	23.1
Low producers	4.13	5.45	32.0

SOURCE: Ahmed and Mohamed, 1992.

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Editors' note

Readers wishing to know more about the work in the Sudan are directed to the references listed.

Production and evaluation of medicated urea-molasses mineral blocks for ruminants in Malaysia

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Introduction

Nutrient deficiencies and imbalances are among the principal constraints that severely inhibit the improvement of ruminant productivity in Malaysia (Wan Zahari and Devendra, 1985). Much of the pasture herbage available throughout the country does not completely satisfy all of the nutrient requirements of grazing animals. Under extensive management systems, grazing ruminants normally have access to native grass and crop residues, which have low crude protein (CP) content (<6 percent), high fibre content (>25 percent), low in digestibility (<45 percent) and are deficient in many minerals and vitamins. Poor body conformation, low growth rates and low fertility are some of the clinical symptoms associated with undernutrition. Production losses are aggravated when undernutrition is associated with gastro-intestinal nematodes.

Strategic supplementation with energy, protein and minerals offers an important approach to ensure animal performance is not reduced, especially during critical periods of feed shortage. The supplements can provide ruminal microbes with the nutrients that may be deficient in basal diets, thus stimulating animal digestion and intake. Improvements in feed intake, body weight gain and reproductive efficiency of ruminants associated with feeding urea-molasses mineral blocks (UMMBs) have been

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reported by many researchers (e.g. Leng *et al.*, 1991; Kunju, 1986; Sansoucy, 1995; Knox and Steel, 1996; Knox and Wan Zahari, 1997).

Gastro-intestinal Nematodes and Helminthiasis

In Malaysia, helminthiasis is a common problem in grazing animals, particularly in sheep and goats. *Haemoncus contortus* is the main parasite, mainly causing anaemia and hypoproteinaemia (Sani and Rajamanickam, 1990). Other common nematodes include *Trichostrongylus* and *Oesophagostomum* species, both damaging the intestinal epithelium and causing leakage into the gastrointestinal tract of ruminants. These parasites cause heavy mortality and production losses, which has led to heavy anthelmintic use. In 1990, the estimated cost for controlling local ruminant diseases was $M 100 million. Chemicals widely used for parasite control in Malaysia include benzimidazoles, levamisole, closantel and ivermectin. The last two drugs have been used intensively by smallholders and the efficacy in sheep has been 100 percent (Chandrawathani and Waller, 1997) with 6–12 treatments annually (Chandrawathani *et al.,* 1994). However, where anthelmintics have been used frequently, anthelmintic resistance is emerging as a major problem. Based on local surveys, about 34 percent of local goat farms showed resistance in *H. contortus,* while 25 percent showed levamisole resistance (Dorny *et al.,* 1994). Closantel resistance in *H. contortus* was also reported (Sivaraj *et al.,* 1994).

Apart from intensive use of drugs, the threat of anthelmintic resistances has necessitated a search for alternative method of helminth control in local flocks of small ruminants (Sani and Chandrawathani, 1996). To date, strategies such as pasture management and breeding worm-resistant animals have been adopted, with partial success, but the use of drugs is still on the increase. This has lead to increasing concern about chemical residues in livestock products and the environment. Although rotational grazing is effective under plantation systems, it is not suitable for smallholder farmers due to the high cost of fencing and limited land availability.

Another approach is to introduce medication through nutrient supplementation using medicated urea-molasses mineral blocks (MUMMBs). This method saves labour, as drenching is not required, the animals are not stressed, and it mitigates the problem of drug resistance.

MUMMB Production

Work on non-medicated UMMBs was initiated in Malaysia in the late 1980s, using a cold production process. ACIAR Project 9132 introduced the use of MUMMBs from early 1993. One of the objectives of this project was to determine a suitable MUMMB formulation for use as nutritional supplement for grazing small ruminants whilst providing a steady dose of medication. The main aim was to develop suitable parasite control strategies by using medicated-nutritional blocks as a supplement in sheep production, particularly for immature and peri-parturient females. This is in line with the national interest in sheep rearing under major plantation crops, including oil-palm.

Similar methodologies were applied in the production of both MUMMBs and UMMBs. Several local feed resources were utilized as components, mainly as fillers. These included agricultural by-products like palm kernel cake (PKC), palm oil mill effluent (POME), rice bran, cassava starch, tapioca waste, brewer's waste and others. In certain formulations, meals from high-protein legumes and weeds were used as nitrogen (N) sources. These included *Leucaena leucocephala, Asystasia intrusa* and kenaf (*Hibiscus cannabinus*). Table 15.1 shows the nutritive values of selected legumes and agricultural by-products suitable for use in MUMMB production.

All of the raw ingredients were accurately weighed and the sequence of mixing is as shown (Figure 15.1). The mixing time for each ingredient was 3 minutes. Depending on the formulation and the ingredients used, sun drying took between 2 and 6 hours.

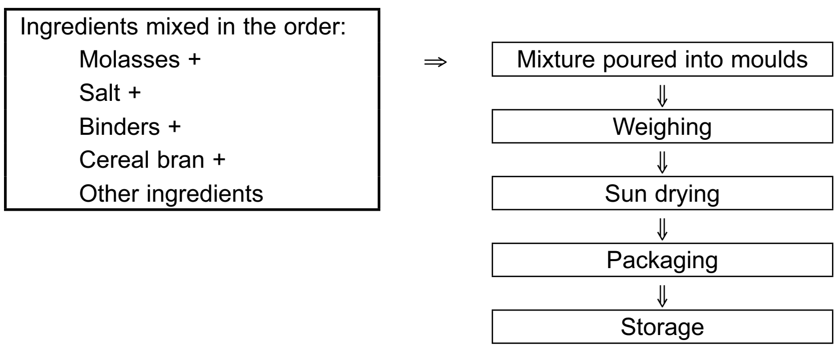

Figure 15.1

Flow chart of MUMMB and UMMB processing

Table 15.1
Nutritive values of selected legumes, agricultural by-products and other feed sources for MUMMB.

	CP(1)	Ca	P	Mg	K	Na	Mn	S	Cu	Zn	Co	B	Fe
	%	%	%	%	%	%	ppm	%	ppm	ppm	ppm	ppm	ppm
	expressed on a dry matter (DM) basis												
Legumes													
Asystasia intrusa	13.8	0.50	0.31	0.50	4.70	0.06	203	–	11.0	69	–	–	–
Centrosema pubescens	23.9	0.55	0.33	0.23	1.92	–	77	–	15.2	47	–	–	–
Leucaena leucocephala	27.1	0.47	0.16	0.16	1.27	0.01	38	0.23	15.0	25	–	17	147
Stylosanthes sp.	20.4	1.47	0.31	0.38	1.71	–	178	–	15.5	55	–	–	–
Agricultural by-products and other sources													
Banana, whole, rejected(2)	–	0.40	0.68	0.73	1.54	0.28	11	0.06	2.8	18	–	–	35
Fish meal	55.0	4.33	1.92	0.31	0.82	1.00	37	–	4.4	54	–	–	1 671
Cocoa bean shell	20.0	0.42	0.76	0.68	2.65	0.18	145	0.29	45	118	–	–	1 792
Cocoa pod husk	10.8	0.34	0.11	0.41	5.00	0.01	287	0.21	12.3	61	–	23.6	92
Copra cake(3)	20.5	0.09	0.52	0.31	2.28	0.11	87	0.29	34.8	53	–	8.6	398
Copra cake(4)	–	0.07	0.35	0.25	1.63	0.11	69	–	20	42	–	–	1 202
Corn	–	0.28	0.06	0.06	0.52	0.05	61	0.08	–	22	–	–	44
Distillery waste	–	0.25	0.61	0.16	1.51	0.06	16	–	3.7	70	–	–	224
Oil-palm fronds	6.8	0.36	0.07	0.10	0.67	0.03	44	0.10	2.1	10	–	–	104
Oil-palm trunk	2.3	0.18	0.06	0.04	1.13	0.02	12	0.10	0.6	43	–	4.9	281
Palm kernel cake (SE) (5)	16.3	0.20	0.57	0.30	0.80	0.01	126	0.22	21.4	50	–	6.0	636
Palm kernel cake (EP) (6)	15.9	0.17	0.61	0.20	0.61	0.11	218	0.16	19.2	42	–	8.5	987
Palm oil mill effluent(3)	–	0.46	0.72	0.32	6.50	0.05	180	–	8.5	120	–	–	6 100
Palm oil mill effluent(4)	–	1.18	0.24	0.38	1.29	0.07	47	–	46	54	–	–	91
Palm press fibre	5.4	0.27	0.08	0.14	0.44	0.01	25	0.07	10.1	37	–	6.1	879
Poultry litter@(7)	–	5.65	2.42	1.35	3.48	0.45	498	–	62	568	–	0.4	2 529
Rice bran	9.5	0.15	0.60	0.29	0.59	0.08	47	0.10	–	47	–	–	88
Rice husk	–	0.07	0.08	0.42	1.69	0.03	1	–	0.1	0.2	2.3	–	–
Rice straw	7.4	0.32	0.11	0.10	2.00	0.02	300	0.17	2.4	60	–	–	470
Sago meal(8)	–	0.10	0.89	0.35	1.02	0.02	119	0.18	5.1	64	–	–	171
Sago waste(8)	0.6	0.23	0.11	0.19	0.16	0.74	80	–	5.5	19	–	–	720
Soya bean meal	–	0.25	0.66	0.25	2.02	0.02	38	0.33	7.9	43	–	–	232

Alternative processing method

Collaborative work between the Japan International Research Centre for Agricultural Science (JIRCAS) and the Malaysian Agricultural Research and Development Institute (MARDI) has developed an alternative processing method for block processing, intended for pilot-scale production (Oshibe and Wan Zahari, 1998). The technique consists of grinding and homogenizing the solid components, mixing the solid components with molasses, and then moulding (Figure 15.2). Table 15.2 outlines the general composition of the MUMMB or UMMB suitable for the process. The uniformity of the blocks produced by the current method is encouraging, both in terms of physical characteristics and nutritive values. The labour requirement for this method is minimal.

Table 15.2
The general composition of MUMMBs and UMMBs suitable for the alternative method.

Ingredient	Proportion
Molasses	More than 50 percent
Filler	Less than 25 percent
Binder	Less than 10 percent
Salt	More than 10 percent

MUMMB formulation and nutritive value

The generalized formulation for preparing MUMMB licks for use in Malaysia is shown in Table 15.3. Fenbendazole (FBZ, containing 40 percent active ingredient) was added at a rate of 0.5 g/kg block. The hardness (penetration resistance) of the blocks is between 5 and 8 cm/kg^2. This is suitable to allow reasonable intakes of blocks of 100–120 g/day for small ruminants and 600–800 g/day for large ruminants. The typical nutritive value of MUMMB is shown in Table 15.4. Several MUMMB formulations for sheep and goats suitable for different feeding systems have been developed by MARDI and the Department of Veterinary Services.

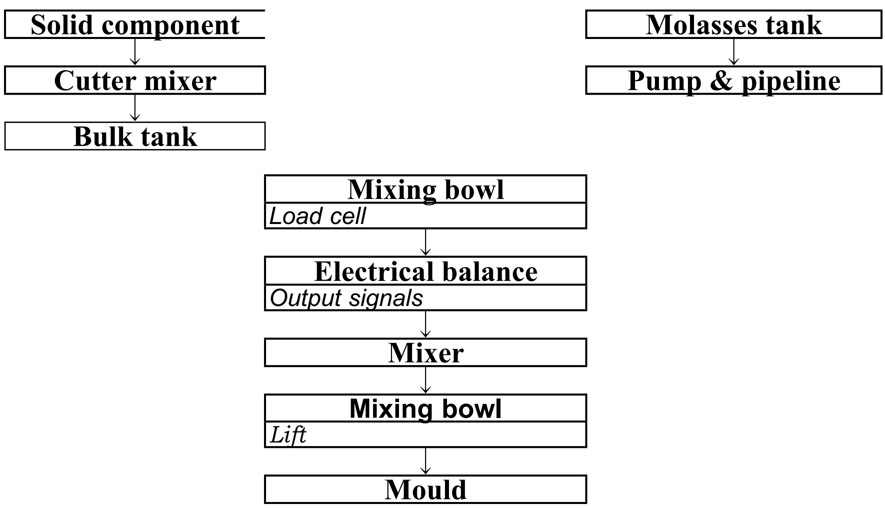

Figure 15.2
The process flow for MUMMB or UMMB using the alternative method

Table 15.3
Generalized formulation for the preparation of MUMMBs for Malaysian conditions

Component	Component ingredients	Quantity (%)	Example (%)
NPN[(1)]	Urea, poultry manure	5 – 10	10
Molasses	Sucrose, minerals	20 – 40	10
Salt	Common salt	1 – 10	10
Binder[(2)]	CaO, $Ca(OH)_2$, MgO, cement, Na-bentonite	5 – 15	10
Water		0 – 30	15
Mineral mix	Commercial products or tailor-made to meet local requirements	1 – 2	1
Protein meal	Fishmeal, coconut meal, leucaena leaf meal, kenaf leaf meal, *Asystasia* leaf meal	5 – 25	10
Filler	Wheat bran, rice bran, rice husks, ground oil-palm fronds	5–25	19

NOTES: (1) = non-protein nitrogen source. (2) Local cost and availability will determine the most appropriate binder or combination of binders. (3) Locally available agricultural by-products (preferably those high in P).

SOURCE: Knox and Wan Zahari, 1997.

UMMB and MUMMB performance evaluation

It is interesting to highlight some Malaysian experiences with regard to the use and benefit of MUMMB and UMMB with pen-fed and grazing small ruminants. The main aim of supplementing with these blocks is to provide additional nutrients to the animals. The effect of anthelmintic agent supplied through MUMMB will appear most clearly when requirements for major nutrients (especially energy and protein) are met.

Table 15.4
Nutritive value of MUMMB (Block DM in range 92.4–94.2 percent).

Component	Range
Percentage in DM	
Crude protein	14.7 – 30.1
Crude fibre	4.21 – 8.80
Ether extract	0.90 – 1.62
Ash	24.2 – 40.8
Energy (cal/g)	1 755 – 2 751
Calcium	0.15 – 5.1
Phosphorus	0.20 – 0.35
Magnesium	0.16–0.83
Potassium	0.60–6.19
Sodium	0.29 – 4.22
Sulphur	0.22 –0.30
ppm in DM	
Iron	5.9 – 424
Copper	4.7 – 31
Zinc	29 – 60
Manganese	20.9 – 69

Several UMMB and MUMMB formulations have been tested on sheep raised under plantation conditions, with varying results (Table 15.5). Trials undertaken on oil-palm, rubber and coconut small-holdings in Peninsular Malaysia revealed that responses under extensive grazing conditions have been variable, and a major problem was intermittent or limited intake. Block consumption was much less than the targeted intake of about 100 g/ head/day. Intake was observed to depend largely on the type and nutrient status of feed available, and animal-related factors such as exposure time, previous experience and behaviour (Bowman and Sowell, 1997). Factors implicated in poor MUMMB consumption included higher salt content in the blocks, water shortage in sheds or grazing areas, and, in certain cases, the extension of grazing periods. Sheep grazing pasture of high nutritive value seemed to consume less block if dry matter intake is not limiting. In the majority of the trials, responses in term of liveweight gain (LWG) were not conclusive, despite improved parasite control through MUMMB use.

Field evaluations on pen-fed sheep revealed that low protein + low salt block was consumed well by the animals when compared with other formulations, with no significant differences in LWG. Intake was comparatively higher than similar studies conducted elsewhere (see, for example, Knox, Berger and Anderson, 1990). The formulation was also successful in reducing parasitic infection in sheep, based on later studies undertaken at institutional and smallholder farms (Table 15.6). The improved nutritional level achieved through MUMMB was generally sufficient to eliminate infective larvae ingested from pasture, as has been reported (Chandrawathani *et al.,* 1996).

Infected ewes receiving about 60 g MUMMB/head/day increased their lambing percentage to a level exceeding those without supplementation (Table 15.7). The supplementation markedly improved the survival rate 9of newborn lambs from ewes with poor nutrition. There was no significant improvement in terms of birth weight and litter size between treatments. In a separate trial, growing performances of Siamese Long Tail (SLT) ram lambs supplemented with MUMMB were comparable to those receiving commercial salt lick (Table 15.8). The use of low protein + low salt MUMMB (containing 16.6 percent CP and 1.83 percent Na) was found to reduce the incidence of "fallen-fleece" in growing lambs raised on *Leucaena leucocephala* wafer (containing high mimosine content), while maintaining intake and live weight. Improved lambing performances were also observed in grazing SLT and Malin (Malaysian indigenous) lambs, but, surprisingly, not in Dorset-Horn lambs (Abdullah *et al.,* 1995).

Further development of MUMMB formulation is being carried out, and the use of local copra meal as a non-degradable bypass protein source in block making seemed to be beneficial.

Table 15.5
UMMB and MUMMB formulations tested at selected locations in Peninsular Malaysia

Location	Type of plantation	Sheep breed	Management system	Major feed resources	Block formula	Block intake (g/head/day)	Mean live-weight gain (g/d)
Changkat Cermin Estate Perak	Oil palm	Polled Dorset x SLT	Rotational grazing	*Asystasia*(1) *intrusa*, Native grasses	WZ 38(3)	UMMB 15 - 17.4 MUMMB 5.7–18.0	48.2(8)
	–	Polled Dorset x SLT	Rotational grazing		WZ 37A(4)	MUMMB 19.1–37.7	ND
Sungai Siput Research Station, DVS Perak	–		Rotational grazing	Improved pasture *Guinea grass* + *Setaria* sp.	WZ 38	MUMMB 5	16
	–	SLT + CMBL crosses	Set-stock		WZ 38	MUMMB 4.5–7.2	46.8
Veterinary Research Institute, Perak	–	NC	Pen-fed	Grass pellet(2)	WZ 38	MUMMB 12.9–54.3	ND
UPM, Serdang Selangor	–	NC	Free grazing	-	WZ 37A	UMMB 17 MUMMB 22	38.6 40.6
MARDI, Serdang Selangor	–	Dorset Horn	Pen-fed	Chopped rice straw + 20% concentrate. Straw intake increased	WZ 30(5) WZ 20(6) WZ 28(7)	UMMB 29.3 UMMB 38.7 UMMB 31.7	10.9 15.4 7.9

NOTES: (1) Containing 21 percent CP, 37.3 percent CF; (2) Containing 12.1 percent CP, 15.8 percent CF; (3) Containing 20.5 percent CP; (4) Containing 25.6 percent CP; (5) Containing 35.4 percent CP; (6) Containing 34.8 percent CP; (7) Containing 35.6 percent CP; (8) Liveweight gain obtained comparable to PKC supplemented group receiving 50–60 g/d.

KEY: UPM = Universiti Putra Malaysia; SLT = Siamese Long Tail; UMMB = urea-molasses mineral blocks (non-medicated); MUMMB = medicated urea-molasses blocks; DVS = Department of Veterinary Services; ND = not determined; NC = not indicated; SLT = Siamese long-tailed.

Table 15.6
Evaluation of low protein+low salt blocks for grazing sheep

Location	Plantation type	Sheep breed	Management system	Major feed resources	Block intake (g/head/day)	Mean live-weight gain (g/day)	Note
Rubber Research Institute (RRI) Sg. Buluh, Selangor	Rubber	NC	Free grazing	Native pasture	UMMB 100–150 MUMMB 100–200	14.6 17.1	(1)
Felda Laka Selatan Jitra, Kedah	Rubber	NC	Free grazing	Native pasture	UMMB 79–209 MUMMB 62–184	ND	–
Gopeng[(2)], Perak	Oil palm	Mixed	Free grazing	Native pasture	MUMMB 60	ND	Limited supply of MUMMB
Veterinary Research Institute (VRI) Ipoh, Perak	–	NC	Pen fed	Free grazing	MUMMB 31-225	ND	–

KEY: NC = Not reported; ND = Not determined; UMMB = Urea-molasses mineral blocks; MUMMB = Medicated urea-molasses mineral blocks; * = Nutritive value (CP, 16.6%; Na, 1.83%; Ca 4.9%; P, 0.34%).

NOTES: (1) Liveweight gain obtained was less than PKC supplemented group (22.4 g/day).
(2) Smallholder farm.

Table15.7
Lambing and mortality of newborn lambs from ewes raised by a smallholder farmer.

Treatment	Lambs born	Mortality
UMB	8 (2 twin)	0
UMMB	8 (2 twin)	0
Control (No supplement)	4 (1 twin)	1
Supplementation via liquid feeder	6 (1 twin)	1 (due to dystokia)
Total	26	2

NOTES: Location: Bachok District, Kelantan, Malaysia. Feeding system: free grazing under coconut plantation. Lamb mortality was about 85 percent throughout the 3 years of rearing; Farmer's income through the sale of lamb increased 70 percent after supplementation. Body condition of ewes improved markedly with supplementation.

SOURCE: Wan Zahari *et al.*, 1996a,b.

Table 15.8
Growth performances of Siamese Long Tail ram lambs supplemented with UMMB and salt lick.

Treatments	Initial live weight (kg)	Live weight changes (kg) (1)	Liveweight gain (g/day)
UMMB	12.4	+19.1	78.7
Salt lick (2)	13.1	+17.8	74.1
Control (3)	12.9	+13.0	53.5

NOTES: (1) Determined after 242 days of the trial. (2) Phosphorus-rich blocks with a basal diet of oil-palm frond silage (OPF)-based rations. (3) Grazing native pasture with salt lick. n = 30.

SOURCE: Hassan *et al.* (1994)

Efficacy and Effectiveness of MUMMB For Parasite Control

Several efficacy studies were carried out on the use of MUMMB for parasite control in small ruminants in Malaysia. Based on the concentration of FBZ and oxfendazole (OFZ), MUMMB was observed to maintain safe therapeutic levels throughout the 18-day trial period. In contrast, the FBZ and OFZ concentrations of drenched animals dropped after 48 hours, leaving them again making them susceptible to infective larvae (Chandrawathani *et. al.* 1996).

Two trials were conducted at the Veterinary Research Institute, Malaysia, on 10-month-old pen-fed sheep, where two groups of five animals were given either MUMMB or UMMB. In the first trial, the MUMMB contained 0.25 g/kg FBZ and animals were challenged with a single dose of infective *Haemonchus* larvae. In the second trial, MUMMB contained 0.5g/kg FBZ and animals were challenged with 500 infective larvae per day for 6 days. A faecal egg count (FEC) was performed twice, once before and then four weeks post-challenge. In the pen-fed sheep, FECs fell by 84 percent in Trial 1 and 90 percent in Trial 2 (Table 15.9).

In a field trial, 42 five-month-old lambs grazing under rubber trees were divided into three groups of 15 animals each. All animals were grazed together from 08.00 to 12.00, and were exposed to natural infection. Each group were separately penned after grazing. One group had access to MUMMB containing 0.5 g/kg FBZ while another group had access to simple UMMB. The third group had no blocks, but was given PKC supplementation. FECs were done before and fortnightly after exposure to natural infections for a period of 100 days. FECs were lowest in the group given PKC supplementation throughout the 100-day study period. There did not appear to be a difference between the FECs of the UMMB and MUMMB groups. The mean block intake per animal and the average daily gain values are as shown in Table 15.10. An analysis of variance showed that differences in the average daily gain values between the groups were not significant. The reduction in FEC (at the sixth week post-challenge) was only 42 percent. This reduced efficiency under field conditions may be attributed to the greater infection challenge provided by increased numbers of infective larvae in the herbage contaminated by the control animals, since all animals were grazed together. Another reason was that the grazing animals consumed much less of the blocks compared with penned animals (Sani *et al.*, 1995).

In a separate study, 45 2.5-month-old lambs (half Santa Ines × quarter Dorset × quarter Malin crosses) were used for the MUMMB evaluation. The lambs were grazed extensively together from 08.00–12.00 under mature rubber trees. They were divided into three groups and were housed separately in pens. The first group was given concentrate (100 g/day) based on PKC, while the other two groups were given MUMMB and UMMB blocks, respectively. All lambs were given a single injection of ivermectin to remove existing worm burdens at the start of the trial. The mean FEC in the MUMMB group was consistently lowest among the three groups, while FECs for the UMMB and PKC groups did not differ.

Table 15.9
Block consumption, faecal egg count (FEC) and efficacy of medicated block in pen-fed sheep.

Trial	**FBZ (g/kg)**	**Treat-ment**	**Ave-rage intake** (g/day)	**Chal-lenge**	**Mean FEC** Pre-challenge	Post-challenge	**Efficacy** (%)
1	0.25	Medicated (MUMMB)	40	200 L3	10	100	84
		Unmedicated (UMMB)	23		30	640	
2	0.50	Medicated (MUMMB)	63	6 × 500 L3	0	175	90
		Unmedicated (UMMB)	37		0	1 840	

NOTE: FBZ = Fendbendazole. Dose is g a.i. per /kg block.

SOURCE: Sani *et al.*, 1995.

Table 15.10
Mean block intake and average daily gain of sheep

Treatment	**n**	**Mean birth weight**	**Block intake (g/day)**	**ADG + SE (g/day)**
MUMMB	14	3.0	22	40.6 + 5.0
UMMB	14	2.7	17	38.6 + 5.1
No block	13	2.8	–	46.5 + 3.7

Table 15.11
Block intake and average daily gain values in three groups of sheep (148-day period).

Treatment	n	Mean birth weight (kg)	Block intake (g/day)	ADG (g/ day)	CV	ADG (+ PKC)	CV
PKC	15	3.2	-	22.24	57.07	95.3	27.02
UMMB	15	3.2	100 – 150	14.61	64.25	92.6	24.51
MUMMB	15	3.2	100 – 200	17.06	60.12	109.7	23.34

NOTES: CV = coefficient of variation. ADG = average daily gain
SOURCE: Sani *et al.*, 1995.

Table 15.11 shows the mean block intake and the average daily gain values for the respective groups. The mean average daily gain in the group given PKC was highest, but the differences between treatments were not significant. After the study ended and the blocks were withdrawn, all animals were given PKC at the rate of 150 g/head/day and joined the main herd during grazing. The average daily gain values at two months post-treatment with PKC were 95.3, 92.6 and 109.7 g/day respectively.

MUMMB was shown to reduce markedly the FEC. However, the nutritional benefits of UMMB and MUMMB were not manifested in improved LWG. The improved nutritional status with PKC supplementation was found to be more important than parasite burden in affecting LWG. It should be noted that the parasite burden in these animals was relatively low (<2 000 epg) in comparison with other farms in Malaysia.

In a separate study, four farms were selected, each with an average population of 80–100 head of sheep. Ten sheep, 3–4 months old, weighing 10–15 kg, were identified from each farm. Sheep on Farm 1 were supplemented with MUMMB, while sheep on Farm 2 also received UMMB. The initial anthelmintic treatment given was an oral drenching of moxidectin 1 g/litre (Cydectin R) at 0.2 mg moxidectin per kilogram live weight. Farm 3 sheep were only given an initial treatment of anthelmintic, while sheep on Farm 4 were given MUMMB with no initial anthelmintic treatment. All sheep on the four farms were grazed under rubber trees and had similar management. No concentrate supplement was given. The mean pre-treatment FEC of sheep in the four farms ranged from 1 480 to 4 188 epg (Table 15.12), indicating the high incidence of helminthiasis, a common phenomenon on smallholder sheep farms. The post-treatment FEC after 1 month dropped drastically, to 0–30 epg for farms 1, 2 and 3. However, high FECs were recorded from farm 4, despite adequate MUMMB intake. The mean FEC (2 months post-treatment) of farms 1 and 2 were lower (less than 500 epg) compared with farms 3 and 4 (more than 1 500 epg). Intake of MUMMB ranged between 62 and 184 g/day/animal, and it is evident here that the amount of FBZ consumed was 2–6 times higher than the recommended amount of 15 mg FBZ/day for sheep (Knox, Barger and Anderson, 1990). Higher intake of MUMMB can be expected to increase the FBZ metabolite levels in the blood and this can give full protection against larvae ingested from pasture.

Both MUMMB and UMMB given with an initial anthelmintic treatment to clear out existing adult worms were found effective in controlling helminthiasis, as shown by the results from Farms 1 and 2. With the use of MUMMB, there was a continuous supply of anthelmintics at a low dose. Therefore, it is advantageous to give MUMMB with the initial treatment as the medication in MUMMB would be able to kill incoming larvae, as shown on Farm 1, with the lowest FEC after 2 months. This will prevent the serious consequences of helminthiasis, thus improving the productivity of sheep. MUMMB or UMMB alone or treatment alone were ineffective in controlling helminthiasis, as shown on Farms 3 and 4.

Table 15.12
Average daily intake of blocks and pre and post mean faecal egg counts of sheep

Farm	Treatment	Block intake (g/day/animal)	Faecal egg count (epg)		
			Pre-treatment	1 month post-treatment	2 months post-treatment
1	MUMMB + Tx	62 – 184	1 480	0	390
2	UMMB + Tx	79 – 209	1 600	30	510
3	Tx only	–	3 980	10	1 856
4	MUMMB only	101–111	4 188	5 038	2 275

NOTES: Location: smallholder farms in FELDA, Laka Selatan, Jitra, Kedah, Malaysia. Tx = treatment with Cydectin^{R}. epg = egg per gram.

SOURCE: Maria *et al.*, 1996.

Blocks as a carrier for biological parasite control

There are many biological methods known to be effective for parasite control. Methods of current interest include the incorporation of fungal spores through the blocks. Studies in Denmark (Gronvold *et al.*, 1993), Australia (Waller and Faedo, 1993) and Malaysia (Chandrawathani *et al.*, 2001; Chandrawathani *et al.*, 2002) have shown the positive implications of using nematophagous fungi as a biological agent for ruminant helminthiasis. *Duddingtonia flagrans* and *Arthrobotrys oligospora* have been reported to be the most suitable fungi apart from their ability to survive gut passage and delivery as a feed additive to ruminants (Chandrawathani *et al.*, 2001). About 2 000 spores of *Arthrobotrys oligospora* were needed to reduce the *Strongyloides* larvae from calf faeces by 90 percent (Chandrawathani, Omar and Waller, 1997).

Incorporation of pasture plants in blocks for parasite control

Several legumes and plant extracts are known to have anthelmintic properties. Forages containing condensed tannins have been reported as providing some resistance to parasite infection in sheep. This might be attributable to direct anthelmintic properties of tannins, or to better supply of protein to the intestine due to the role of tannins in protecting dietary protein from ruminal degradation. Work is in progress in Malaysia to incorporate plants containing tannins as components in UMMB. Raw materials include leucaena, OPF and kenaf. A MLPR leucaena line established in Malaysia contained higher tannin content (31.6–55.6 mg/g compared with ML1 (containing 12.9–23.2 mg/g). Condensed tannin levels in OPF were found to vary between 15.21 and 34.80 mg/g. Supplementation of pelleted kenaf-based diets (at 45 percent inclusion level) was found to decrease FEC by 69 percent compared with the control group (Figure 15.3). The diets for all groups were isonitrogenous and isocaloric, with CP and energy content of 14.1 percent and 9.60 MJ/ kg, respectively.

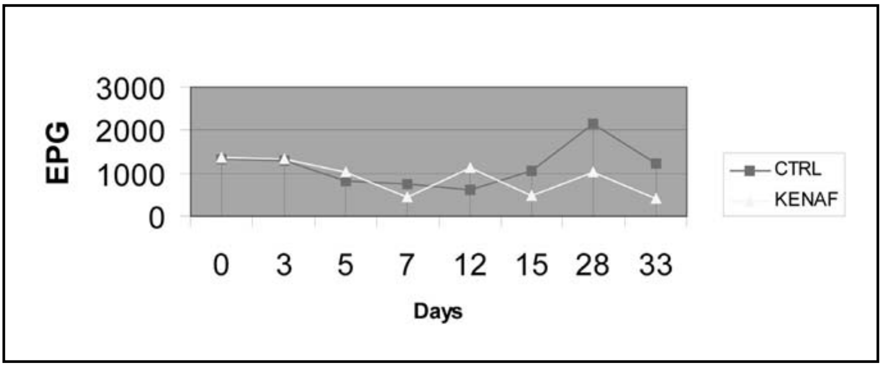

Figure 15.3

Effect of kenaf (at 45 percent feeding level) on mean faecal egg count (FEC) (eggs per gram (EPG)) of infected sheep (n = 5; 33-day experimental period).

Other anti-nutritional factors of interest in overcoming parasites are saponins. Local plant species that are rich in saponins are *Albizia stipulata, Medicago sativa* and *Sesbania sesban*. Leaves from Neem (*Azadirachta indica*) were found effective in overcoming parasites in goats. Other plants of potential use are sentang (*Azadirachta excelsa*), jackfruit (*Artocarpus heterophyllus*), angsana (*Pterocarpus indicus*), hibiscus (*Hibiscus* spp.), and forest species such as ludai (*S. baccatum*), memaya (*Sapium discolor*), kesinai (*Streplus asper*) and ficus (*Ficus* spp.), which are thought to have anthelmintic properties as well as being good protein sources (Chin, Wong and Halim, 1998). Jackfruit leaves are extensively used for feeding sheep and goats in villages. Further studies are needed to identify other locally available feed resources with high tannin and saponin levels, mainly as feed additives to increase the supply of microbial protein post-ruminally, and that are at the same time effective for parasite control in small ruminants.

Transfer of the Technology and The Benefits of MUMMB to Smallholders

Extension workers, technicians and several groups of small-scale farmers from selected districts in Malaysia were trained in MUMMB production through demonstrations at experimental sites or at MARDI and the Department of Veterinary Services. *In situ* trials were carried out in selected villages as models for small-scale farmer associations. Crop residues and agricultural by-products available in those areas were utilized as ingredients in MUMMB making. Discussions and visits were undertaken separately to meet specific needs of interested groups. With further promotion efforts, MUMMB production technology and knowledge concerning the benefits of supplementation could be further disseminated to users, thus supporting socio-economic development.

The benefits to the farmers are related to better animal appetite, higher rate of growth, improved body condition and reduction in animal mortality, resulting in higher sales and higher income. The improvement in livestock productivity, coupled with more efficient utilization of locally available feed resources (especially fibrous feed), will lead to economic and social benefits for the local population.

MUMMB Commercialization Potential

MUMMB technology has the potential to be commercialized for supplementing ruminants in Malaysia. The production cost is low compared with the cost of producing salt blocks or importing MUMMBs. The use of MUMMB should be better suited to local environments as formulation can be adjusted according to breed requirements, the local environment and local resource availability. MUMMBs need to be used strategically when the parasite challenge is high or expected to increase.

Conclusion

Adequate intake is imperative in utilizing MUMMB as a nutritional supplement and chemotherapeutical delivery agent for the control of helminth parasites in grazing small ruminants. MUMMB containing 0.05 percent fenbendazole given at a rate of about 60 g/head/day has been found to be effective in controlling helminths in sheep. In situations where pasture management (rotational grazing) is not possible, the introduction of MUMMBs is advocated as an alternative to frequent drug use for the control of helminthiasis in sheep. The integration of sheep under major plantation crops also justifies the use of MUMMB as a replacement for commercial mineral blocks, which at present are being imported. Having extra nutrients like protein and energy sources, MUMMBs provides greater benefit to ruminants. Its use is cost–effective compared with routine de-worming programmes. This method of worm control is suitable for smallholders, whereby an initial treatment with anthelmintic followed by an improved nutritional regime with MUMMB or UMMB licks can keep sheep from developing severe helminthiasis.

The processing technology and formulations can be improved or simplified to suit the needs and requirements of the users. The main objective is to produce a cost-effective feed supplement that can be adapted and adopted by local farmers by utilizing cheap, available resources. MUMMBs can be made with a variety of feed resources, depending on their availability, nutritive value, cost and the facilities available. The proper strategy in any livestock venture is to produce and utilize this feed supplement to achieve a maximum benefit to cost ratio.

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Nematode parasitism of cattle and buffalo: prospects for control using medicated urea-molasses blocks

Malcolm Knox[28]

Introduction

Attempts to increase the productivity of ruminants in developing nations generally encounter two principal constraints: nutrition and health. Depending on the particular environment and production system, undernutrition interacts with infectious or parasitic disease, or frequently both, to limit animal performance. Nutrition of ruminant animals in these areas is constrained by the available forage, which is usually of medium to low quality and made available by grazing or cut-and-carry methods. At certain times of the year, the quality of this resource deteriorates due to seasonal influences, and productivity consequently declines unless supplements are offered. As demonstrated elsewhere in this book, urea-molasses blocks can provide a low-cost means of providing deficient nutrients and optimizing production from the available feed resource. Of the health constraints, bacterial and viral diseases can be successfully controlled in most livestock production systems through conventional vaccination and quarantine procedures. However, for parasitic disease, these approaches are either not yet possible or impractical, and chemotherapy, coupled with grazing management, is the only control method currently available. In developing nations, the losses induced by clinical and subclinical parasite infections have been estimated to equal the value of the present output of ruminant industries, and improved control has the potential to yield considerable productivity benefits.

The primary focus of the present chapter is to describe the potential for using urea-molasses blocks (UMBs) for the delivery of anthelmintic medication to control gastrointestinal nematode parasitism. However, before describing the formulation and application of medicated blocks, it

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is essential that a basic understanding of the epidemiology of infection be gained through studies of the livestock system of interest. This includes an assessment of the factors affecting parasite abundance and survival, and the impact of parasitic infection on production. These parameters are briefly described below so the reader can gauge the scope of the problems likely to be encountered in their local environment. Only after this assessment is complete, and any missing information identified and gathered, can an informed decision be made as to whether or not to treat with anthelmintic, and strategies formulated to control nematode parasites.

Gastrointestinal nematode parasitism of cattle and buffalo.

The incidence and severity of nematode parasite infection is dependent on several interacting factors, determined by the species of parasites present, the environmental conditions, and the host and its physiological state. The following section describes the important factors influencing infection with nematode parasites.

Table 16.1
Gastro-intestinal nematode parasites infecting cattle and buffalo.

Species of major economic importance	Species of minor economic importance
Haemonchus placei, H. contortus	*Bunostomum phlebotomum*
Trichostrongylus axei	*Dictyocaulus viviparous*
Cooperia pectinata, C. punctata, C. oncophora	*Strongyloides papillosus* (calves)
Ostertagia ostertagi	
Oesophagostomum radiatum	
Mecistocirrus digitatus	
Toxocara vitulorum (calves)	

The parasites

In general, for most developing countries, little information exists about the incidence and severity of nematode parasite infection of large ruminants beyond the identification of species present in animals at post-mortem after untimely death or from slaughter observations. One or more of the major pathogenic species are usually present, but species of minor importance are also routinely encountered (Table 16.1).

Most of these nematodes have a direct life cycle with a pre-parasitic stage on pasture and the parasitic stage in the host animal. Eggs passed in the faeces hatch to produce the larvae (L_1), which feed on bacteria, grow and then moult to progressively become L_2 and L_3, when the sheath is retained for protection against desiccation. The L_3 are the infective stage and do not feed but migrate from the faeces onto nearby herbage to await ingestion by a suitable host. Once inside the host, the protective sheath is cast off and the larvae are transported with the digesta to the predilection site, where they remain to grow and become adult. Eggs produced by adult worms are voided into the digesta and are eventually passed in the faeces. For *Bunostomum phlebotomum* and *Strongyloides papillosus,* infection occurs by larval penetration of the skin and migration to the predilection site via the bloodstream and lungs. *Toxocara vitulorum* eggs are consumed by animals with pasture and the larvae hatch and penetrate muscle tissue, where they can remain dormant for many years. Near parturition, the larvae migrate to the mammary glands and are passed to the calf in the colostrum in the first few days after birth (Roberts, Fernando and Sivanathan, 1990). The larvae then develop into adults that commence passing eggs at around 27–42 days and may cause clinical disease in the calf. Treatment of calves at 10–16 days of age with effective anthelmintic has been shown to be a simple and effective means of controlling this problem and reducing calf mortality (Roberts, 1990).

Factors affecting parasites abundance and survival

Environment

Climatic conditions have a major impact on the development, migration and survival of free-living stages of nematode parasites and, depending on the climatic region, different nematode species predominate. In tropical and subtropical areas, *Haemonchus* spp., *Cooperia. punctata, C. pectinata, Oesophagostomum radiatum* and *Mecistocirrus digitatus* are the main species, along with *T. vitulorum* in calves. In temperate areas *Ostertagia ostertagi, Trichostrongylus axei* and *C. oncophora* predominate. Seasonal weather patterns within climatic zones determine the abundance of infective larvae surviving on pasture at different times of year, and hence rates of infection of animals. Seasonal factors also determine the abundance and growth of feed resources, which influence the nutritional status of the host animal and its ability to resist infection. Surveys to establish the seasonal incidence of infection and the abundance of larvae on forage are therefore essential elements for consideration before trying to determine the most appropriates methods for controlling nematode parasite infections. Other factors that require consideration are: what happens to the dung after being deposited by the animal (dried and burnt; composted and used for fertilizer; spread on pasture area) and whether other animals enter areas where the target group graze or their forage is collected (nomadic herdsmen on communal lands; free ranging goats).

Host factors

Disease caused by gastrointestinal nematodes in cattle and buffalo is primarily a problem of young animals. From the time of first exposure to infective larvae, calves will harbour nematode infections until they reach mature body weight, when they normally attain a level of acquired immunity and resist further infection. In temperate areas, this usually occurs between 1 and 2 years of age in well-grown animals but in tropical areas, resistance to infection may be delayed due to inadequate nutrition and slow growth rates of young animals. Immunity to helminth parasites may render the animal totally refractory to infection but immunity is often exhibited through reduced size and fecundity of adult worms, increased numbers of inhibited larvae and/or delayed maturation of developing worms (Gasbarre, Leighton and Sonstegard, 2001). All of these factors result in reduced transmission of the parasite within the cattle or buffalo herd and its environment. Mature animals may therefore exhibit low levels of infection with standard diagnostic procedures, such as faecal egg counts (FECs), but still harbour a number of parasites. The metabolic cost of maintaining the immune response during continued infection is difficult to estimate and, depending on the severity of infection or larval challenge, or both, may reduce weight gain or milk production in situations where nutrients are limiting, as is the situation in many developing country livestock production systems.

Considerable variation exists between and within breeds of cattle in their ability to resist infection with parasitic nematodes (Barger, Brenner and Waller, 1983; Gasbarre, Leighton and Sonstegard, 2001). In general, locally adapted breeds appear more resistant to infection than imported breeds particularly those that have been bred for high productivity. In many tropical environments, imported breeds suffer heat stress, are more susceptible to endemic diseases and parasites and require high nutritional inputs to maintain production. Ideally, breeding programmes in these areas should attempt to retain the resistance status of locally adapted breeds while integrating the higher production characteristics of imported animals through appropriate cross-breeding strategies.

Impact of gastrointestinal parasites on production in ruminants

In general the efficiency of any ruminant production system is determined by the extent to which gastrointestinal parasitism affects mortality; growth rate or product yield; reproductive performance; and utilization of available feed resources. Each of these factors is considered in more detail below.

Mortality

The most severe form of production loss due to gastrointestinal parasitism is death since there is a cost in terms of the replacement value of the animal and often the year's production by that animal is also lost. Post-natal infection with *T. vitulorum* has been shown to result in up to 30 percent mortality of buffalo calves in some areas of South-East Asia (Fabiyi, 1986) and helminth parasitism is considered to be a major factor in mortality rates of up to 40 percent in calves in tropical areas during their first year of life (Hörchner, 1990). The stress of weaning combined with immature immunological status renders the young animal more susceptible to severe levels of infection and in temperate areas mortality rates in young cattle may be as high as 33 percent (summarized in Barger, 1982). Although adult animals are normally less susceptible to high levels of parasite infection, mortality of adults does occur, particularly during or after periods of stress. Stresses such as presence of other diseases, parturition and lactation, drought or other periods of nutritional insufficiency and certain husbandry practices render adult animals more susceptible to infection and increased mortality may occur. Periparturient infection of females can affect the post-natal survival of offspring through reduced birth weight and reduced availability of milk for their growth and development. Maternal behaviour can also be altered in infected animals, with increases in mismothering and desertion the likely result.

Reduced growth rates and product yield

Production losses due to helminths at subclinical levels of infection can appear as lower carcass growth rates and lower yields of milk. In field experiments in temperate areas with grazing cattle, 24 to 40 percent reductions in weight gains have been observed (summarized in Barger, 1982). Studies in infected cattle in southeast Asia have shown similar reductions in weight gain (Supan, 1986; de Rond *et al.*, 1990). For some time, the effect of nematode parasites on milk production of dairy cattle has been a contentious subject, but a recent review of 87 studies in 382 dairy herds in temperate areas demonstrated an average 3 percent increase in milk production attributable to nematode control (Gross, Ryan and Ploeger, 1999). In developing nations, treatment with nematocides increased milk production by 12 percent in Sri Lanka (de Rond *et al.*, 1990), by 11 percent in cattle in India (Sanyal, Sigh and Knox, 1992) and by 13 percent in buffalo (Sanyal *et al.*, 1993). Use of albendazole, which has nematocidal and some flukicidal activity, yielded increased milk of 0.5 litre/day in cattle in Indonesia (Supan, 1988) and 0.8 litre/day in buffaloes in India (Kumar and Pachauri, 1989). Milk quality was also affected by helminth infection, with higher levels of total fat, total solids and protein content being recorded in treated animals (Kumar and Pachauri, 1989).

Reduced reproductive potential

Infestation with helminth parasites can affect the reproductive performance of a herd or flock. In efficient dairying enterprises, farmers try to minimize the time taken for replacement heifers to reach sexual maturity thereby reducing the unproductive portion of the animal's lifetime. By reducing bodyweight gains, parasitism can significantly delay the onset of puberty and increase the age at first service in young cattle (O'Kelly, Post and Bryan, 1988; de Rond *et al.*, 1990). Liveweight depression post parturition can affect the time to first oestrus, and healthy animals are more likely to have minimal time intervals between births of offspring than those suffering from infection with helminth parasites. This is of particular importance to dairy enterprises, where dried-off cows waiting to calve are unproductive but still need to be fed and maintained. In developing nations, one of the biggest herd management problems is the number of anoestrus animals, and improved control of helminth parasites may help to reduce the occurrence of this problem. Infection by helminth parasites can affect reproductive potential through decreasing the conception rate in the herd, as shown in studies in the USA, where treatment with anthelmintic increased pregnancy rates in maiden heifer cattle by 44 percent (Loyacano *et al*., 2002) and by 22 percent in lactating cows (Stuedemann *et al*., 1989).

Reduced efficiency of feed utilization

Livestock must make optimal use of available feed resources to achieve maximum production potential. Gastrointestinal helminth parasites can affect the utilization of feed through depression of both intake and conversion efficiency of feed and by causing behavioural changes in the host, rendering it a less efficient gatherer of forage. Parasites can also cause losses of nutrients through their feeding habits or by damaging host tissues during migratory phases. The interactions of parasites and nutrition are quite complex and are reviewed in more detail elsewhere (McKellar, 1993; Coop and Kyriazakis, 1999) but consideration of the situation in developing nations where helminth parasites are usually present generally leads to the conclusion they will probably exacerbate problems caused by suboptimal nutrition.

Anthelmintic delivery through feed supplement blocks

During the past 30 years, attempts at delivery of anthelmintic medication through feed supplement blocks have met with varying levels of success. Blocks containing phenothiazine at sufficient concentration to inhibit the development of parasite eggs to larvae proved successful in reducing nematode parasite levels in intensive livestock rearing systems (Martin, 1986; Beriajaya *et al.*, 1988) but in extensive grazing systems effective control was not demonstrated (Elliott, 1970; Cummins, Callinan and Atkinson, 1978). The inclusion of the benzimidazole anthelmintic fenbendazole (FBZ) into feed blocks in sufficient concentration to give an effective dose from expected normal daily consumption of block successfully controlled nematode parasites of sheep (McBeath, Preston and Thompson, 1979; Bogan and Marriner, 1983) and cattle (Blagburn *et al*., 1987; Bransby, Snyder and Webster, 1992; Miller *et al*., 1992), but adoption of this means of control has been poor due to low requirement for supplementary feeds in the livestock rearing systems where these blocks were promoted (United Kingdom; USA) and the low cost of alternative treatments. Variability observed between individuals in intake of the blocks (Cummins, Callinan and Atkinson, 1978) may have also contributed to the limited adoption of this technology in extensive grazing systems.

With the emergence of strains of parasitic helminths resistant to anthelmintics, coupled with the high cost of developing new compounds for commercial application, considerable research effort has been devoted to seeking methods of increasing the efficacy of available compounds in order to extend their useful commercial life. The observation that prolonged application of low levels of some benzimidazole anthelmintics enhanced their efficacy (Prichard, Hennessy and Steel, 1978; Boisvenue, Colestock and Hendrix, 1988) led to the development of continuous release devices (CRD) for the intraruminal administration of anthelmintics (Anderson *et al.*, 1980). The increase in efficacy is thought to be due to the continued presence of the anthelmintic preventing establishment of incoming larvae, decreasing viability and fecundity of mature worms in the host and having an ovicidal effect on any worm eggs that are produced. Studies of CRDs containing albendazole by Barton, Rodden and Steel (1990) and Barger, Bremner and Waller (1993) in sheep have demonstrated the effectiveness of this technology in areas where parasite strains are known to be partially resistant to benzimidazole anthelmintics, with no exacerbation of the resistance problem after treatment. Similarly, a CRD containing fenbendazole (FBZ) was shown to be effective in controlling major nematode parasites of calves during their first grazing season (Le Stang and Hubert, 1995).

Research by the author's institute has followed similar pharmacokinetic principles to those applied in CRD applications to develop a UMB containing FBZ for use in livestock production systems where regular consumption of the block occurs. Control of parasites can be achieved through the animals consuming a daily low-level dose of FBZ via the feed block. Early studies determined that the bioavailability of FBZ was not affected by incorporation into the block formulation, but that dose rates differed between target host species (Knox *et al.*, 1994, 1995). Field testing of the efficacy of the block formulations has been carried out in cattle and buffalo and the results of these tests are presented below.

medicated block Studies with Indian dairy buffalo and cattle

Efficacy studies

Sanyal and Singh (1993) carried out two experiments to determine the therapeutic and prophylactic efficacy of medicated urea-molasses blocks (MUMB). First, ten 20–24-week-old, worm-free calves were divided into 2 groups of 5 animals each and maintained in tick-free pens and fed on chaffed *Sorghum* spp. hay, UMB and water ad lib. Fifteen days after acclimatization to the specified diet, both groups were experimentally infected with 10 000 infective *Haemonchus* spp. larvae. After patency of infection, one group was given access to MUMB containing 0.5g FBZ/ kg for 15 days while the other had continued access to drug-free UMB. Faecal egg counts (FECs) indicated that within 4 days of being offered MUMB, FECs declined to zero, while the counts in the untreated group remained above 400 epg (Figure 16.1). At slaughter, 45 days after infection, no adult worms or larvae could be detected in the abomasum of animals receiving MUMB, while animals in the untreated group had 378 ±72 (mean ±SD) worms.

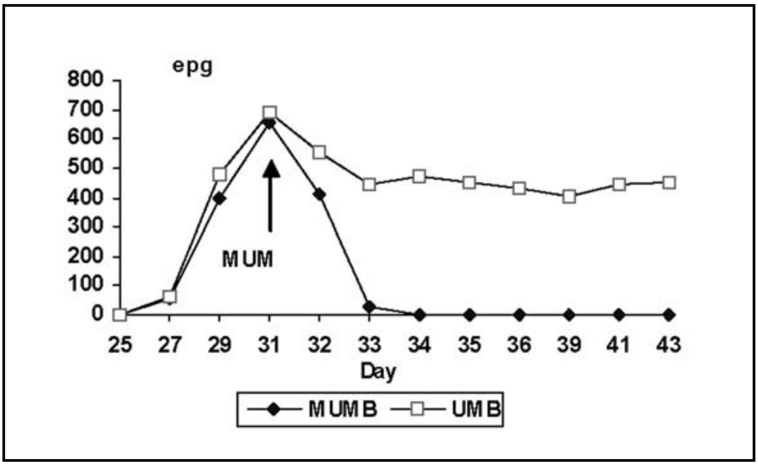

Figure 16.1

Therapeutic efficacy of medicated (MUMB) vs unmedicated (UMB) supplementary feed blocks.

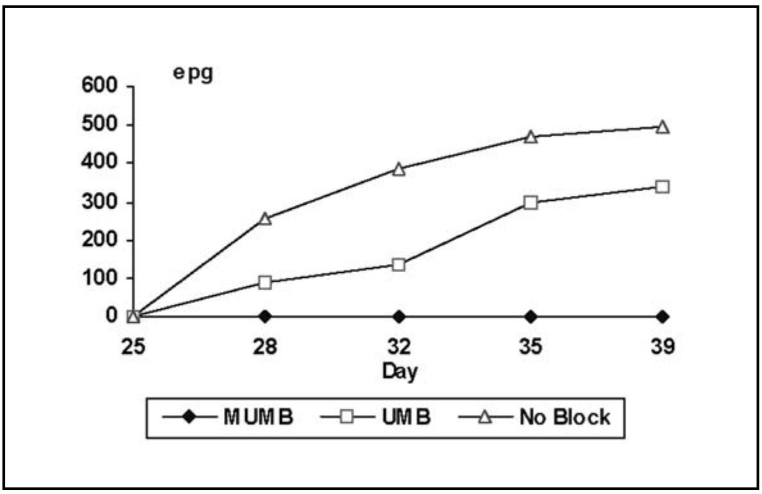

Figure 16.2

Prophylactic efficacy of medicated (MUMB) and unmedicated (UMB) supplementary feed blocks compared with no blocks.

In the second experiment, fifteen 20–24-week-old worm-free calves were divided into 3 equal groups and maintained in controlled conditions and fed on chaffed *Sorghum* spp. hay, UMB and water *ad lib*. After fifteen days acclimatization to the diet, one group was given access to MUMB and 4 days later was experimentally infected with 1 000 infective larvae of *Haemonchus* spp. per day for the next 10 days. MUMB access was continued up to the last day of experimental infection. The same parasite infection schedule was followed for the other groups, which were offered UMB or received no blocks. Zero FECs (Figure 16.2) and worm counts demonstrated that MUMB was able to prevent infection in calves undergoing daily parasite challenge. It was also interesting to note that animals receiving UMB showed lower egg counts and worm counts than those animals without access to blocks, which suggests that the nutritional benefits of the supplement assisted the host to inhibit establishment of infection.

Replacement heifers

Sanyal and Singh (1995a) evaluated the benefits of MUMB on a commercial dairy farm in India where cattle were maintained in open barns and fed on green fodder, protein concentrate pellets and UMB. Forty 20–33-month-old heifers weighing 165–240 kg were divided into two equal groups and maintained in two different barns. Over a period of 5 months, one group had unlimited access to MUMB (containing 0.5g FBZ/kg) at two sites in the barn, and the second group had similar access to UMB. FECs indicated moderate levels of infection in the untreated animals, while MUMB animals were zero on all occasions after MUMB introduction. MUMB animals gained 18 percent more weight during the experiment compared with untreated animals (Table 16.2). Such an increase in growth rate would enable the MUMB heifers to reach the target weight for first service some 6 to 7 weeks earlier than those that remained untreated.

Lactating cows

An experiment to test the efficacy of MUMB in adult lactating buffalo was conducted on an organized farm where the animals were tethered in barns and fed on dry and green fodder and UMB (Sanyal and Singh, 1995b). Twenty-five buffaloes showing low grade subclinical nematodosis were divided into two groups of 13 and 12 animals, and maintained in separate rows of the animal shed. One group was offered MUMB (0.5g FBZ/kg) individually in dispensers kept in front of each animal, and the other group was offered drug-free UMB. FECs of MUMB buffaloes declined to zero after MUMB introduction, and remained zero throughout the experiment, while egg counts of UMB animals remained at low levels (<30 epg). Comparison of daily lactation records indicated milk yield in MUMB buffaloes was 1.2 litre/day higher compared with those buffaloes offered UMB without medication. A similar study in cross-bred cattle showed a 0.6 litre/day advantage in cows treated with MUMB (Sanyal *et al*., 1995) (Table 16.2).

Table16.2
The effects of MUMB on weight gain of replacement heifers.

Group	Gain/month (kg)[1]	Gain/day (kg)[1]	Net milk yield gain/day (kg)[2]
MUMB	12.02	0.40	0.06
UMB	10.14	0.34	–

SOURCES: [1] Sanyal and Singh. 1995a. [2] Sanyal *et al.*, 1995.

Further evaluation of MUMB was undertaken by the same authors in the mid-1990s through large-scale field trials in Gujarat State, India (P.K. Sanyal, personal communication). FECs were reduced with MUMB use and farmers indicated that the general health of MUMB-treated animals had improved and estimated that a >5 percent improvement in milk production had occurred. Detailed lactation records were, however, not kept due to the inherent difficulties involved in such recording at the village level.

Alternative anthelmintics for use in medicated blocks

Apart from fenbendazole, albendazole has been used to prepare anthelmintic blocks for nematode parasite control in sheep (Tan *et al.*, 1996) and triclabendazole included in blocks for *Fasciola* spp. control in cattle and buffalo (Sanyal and Gupta, 1998). Febantel, a probenzimidazole anthelmintic, has been successfully used in in-feed formulations for nematode control (Stiefelhagen and Uhlemann, 1978; Kutzer, 1981) but initial trials of inclusion of this compound in UMB were unsuccessful since bioavailability was reduced to zero even at three times anticipated dose rates (M.R. Knox, unpublished). Other modern anthelmintics do not have the safety index or stability of the benzimidazoles and their use in blocks is not recommended without detailed studies of toxicity and bioavailability.

In developing nations where commercial anthelmintic preparations are expensive or difficult to obtain, farmers sometimes rely on traditional herbal remedies for nematode parasite control. Although anthelmintic activity has been attributed to numerous plant species in most localities (FAO/APHCA 1991a,b,c, 1992), quantitative data on efficacy is rarely available and detailed studies are required to determine the efficacy of herbal remedies before more wide-ranging recommendations for their use can be made. These studies should include botanical description, records of stage of growth and plant component used (leaf, stem, flower, seed, root), mode of preparation, dose rate and frequency and details of response to treatment. Once effective remedies are identified and their preparation standardized, they may then provide a simple, low-cost means of controlling helminth parasitism. The inclusion of some of these compounds in UMB formulations may be particularly beneficial if ease of delivery is improved.

Discussion

Gastrointestinal nematode parasites continue to be a major constraint on efficient production of milk and meat in cattle and buffalo throughout the world. This problem is exacerbated in production systems in developing countries where nutritional inputs are sub-optimal and anthelmintic compounds are costly and often difficult to obtain. Coupled with this, the lack of knowledge of nematode parasite epidemiology in these systems leads to treatments only being given when acute disease is evident, or provided sporadically when budgetary allocations are provided through government veterinary services. This means that production losses due to subclinical levels of infection will continue unless greater recognition of this problem occurs and alternative approaches are adopted. To maximize the production potential in these areas, there is an urgent need to gather essential epidemiological information on helminth parasites so that locations where losses are occurring are identified and a more integrated approach to control can be taken. Identification of the parasite species present, their seasonal abundance and impact on production will determine whether changes to grazing management (or fodder gathering) practices can reduce helminth infection, or whether anthelmintic intervention is necessary to derive economic benefits for the livestock producer. Once this is established, the timing and means of anthelmintic therapy can be decided from the locally available options, with cost and efficacy being important drivers of the decision-making process.

Medicated UMB may provide one option for anthelmintic intervention in production systems where this form of nutritional supplement is part of routine husbandry practice. It has been clearly shown that MUMB containing FBZ at 0.5 g/kg can satisfactorily clear established infections of *Haemonchus* spp. in calves and that infection can be prevented by offering MUMB to calves during parasite challenge (Sanyal and Singh, 1993). Efficacy of MUMB treatment has also been established in field trials, with increased growth rates in young cattle, which substantially reduces the time to first service. Similar results after treatment for nematode parasites have been observed in young cattle by de Rond *et al*. (1990) in Sri Lanka, with considerable savings in husbandry costs involved with keeping the non-lactating portion of the herd. Milk production increases after MUMB treatment of lactating adult buffaloes and cattle recorded above were of similar magnitude to those achieved by suppressive anthelmintic treatment of buffalo (Sanyal, Singh and Knox, 1993) and cattle (de Rond *et al*., 1990; Sanyal, Singh and Knox, 1992). In subtropical areas where *Haemonchus* is the predominant parasite species it appears that MUMB may be an appropriate treatment, particularly at times when parasite larvae are seasonally abundant.

From the studies of Sanyal and Singh (1993), it is also noteworthy that, in young calves in India, UMB supplementation resulted in lower FECs and reduced worm burdens compared with unsupplemented animals. These findings demonstrate the practical nutritional benefits of UMB supplements and further support the proposal that such supplements can influence the animal's ability to resist infection, as shown in pen studies with young sheep (Knox and Steel, 1999) and field studies with sheep in Fiji (Manueli, Knox and Mohammed, 1995). In situations where nutritional deficiencies are likely to exacerbate the detrimental effects of parasitic infection, the use of such supplements should therefore be considered an integral part of husbandry practice in order to reduce the debilitating effects of parasitism and minimize the requirement for anthelmintic chemotherapy, as suggested by Knox and Steel (1996). Substitution of MUMB for UMB can then occur for short periods during times when parasite challenge is high or during periods of lowered host immunity caused by immaturity or physiological stresses such as reproduction and lactation. For these reasons, it is likely that MUMB will form an integral part of strategic parasite control programmes in developing nations where UMB have been shown to offer substantial nutritional benefits.

Summary

Gastrointestinal nematode parasites continue to be a major constraint to efficient production of milk and meat in cattle and buffalo throughout the world. This problem is exacerbated in production systems in developing countries, where nutritional inputs are sub-optimal and nematode parasitism is not adequately controlled. To maximize the production potential in these areas, there is an urgent need to gather epidemiological information on nematode parasitism so that appropriate control measures can be implemented. In situations where urea-molasses blocks are considered beneficial, introduction of blocks containing anthelmintic medication can then occur for short periods during times when parasite challenge is high or during periods of lowered host immunity caused by immaturity or physiological stresses such as reproduction and lactation. For these reasons, it is likely that medicated blocks will form an integral part of strategic parasite control programmes in developing nations where urea-molasses blocks have been shown to offer substantial nutritional benefits.

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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. This publication provides a comprehensive overview of development and use of the block technology in countries around the world and it might be of great practical value to extension workers, students, researchers and those thinking of using such feed supplementation technology or of starting commercial production.

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