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Urea Molasses Block
A Feed Supplement for Mountain Areas

THE BHUTANESE EXPERIENCE AND ITS REPLICATION POSSIBILITIES

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PREFACE

To fulfill its mandate, namely, the promotion of ecologically sound and economically viable development of mountain areas and improvement in the living conditions of mountain people, ICIMOD undertakes several activities in close collaboration with the agencies and experts from countries within the HKH Region.

One of the key activities, in the above context, implemented by the Farming Systems' Programme during 1991-1992, is the identification of successful development experiences relevant to mountain areas and facilitation of their replication in different parts of the HKH Region. This involves identification and assessment of preconditions for the success of a given initiative. Associated activities include documentation and dissemination; location of suitable areas for replication; interaction with agencies which can undertake demonstration and implement the activity; training of the concerned people; and other necessary support facilities.

Mountain Farming Systems commenced work along these lines in the beginning of 1991, and has more than a dozen success stories to its credit. This work is mainly supported by the Asian Development Bank.

The present report documents experiences in the use of Urea Molasses Block as winter feed supplement for ruminants in the mountain areas of Bhutan. The report, after highlighting the major problems of winter feeding in mountain areas, establishes that UMB is an important low-cost, local resource-based option which provides high economic gains through increased animal productivity. This is more so where other options are not available.

In addition to describing the simple technology, the report discusses the preconditions required for the development and wider use of UMB. Empirical evidence from laboratory, government farm, and village experiences are presented to show the value of UMB as a winter feed supplement.

Since the purpose of documentating Bhutan's successful experiences with UMB was to explore the possibility of its replication elsewhere, prospects for its development and use in Nepal were explored, based on the livestock situation, winter feed problems, farmers' conditions, and the status of required raw materials for UMB.

Well before the report was finalised, its results were shared with potential promoters of UMB. An enterprising industrial firm, engaged in the production of animal feed, experimented with UMB and the initial results encouraged them to adopt UMB as one of their products. The necessary groundwork for commercial production of UMB to satisfy the winter feed requirements of ruminants in Nepal has already been completed. Thus, in the present case the follow up action to ICIMOD's initiative has taken place much quicker than expected.

CONTENTS

Introduction

The scarcity of animal feed in winter is a universal concern in livestock development strategies for the hill/mountain areas, especially in tropical and subtropical countries where the vegetation growth is largely determined by a single, short- duration monsoon season. The feed deficit problem is further accelerated by the rapidly deteriorating natural resources caused by intense population pressure, a high degree of deforestation, desertification of pastureland, lack of proper forage, and lack of pasture development strategies suitable for the third world. Generally, the main land resources for animal feed can be categorised into four types: (a) native rangeland, (b) forestland, (c) wasteland, and (d) cropland. The former three land resources are degrading to such an extent that their ability to supply forage for animals decreases annually. On the other hand, the cropland provides enormous amounts of fodder, grasses, and crop residues. The crop residues include straw and stover from crops such as paddy, wheat, oats, millet, maize, and sorghum which are used extensively as animal feed. Apart from this, the cropland provides a wide range of cereal brans and oilseed cakes which form the principal ingredients of compound animal feed.

Ruminants are efficient at drawing nutrients from fibrous feed, and this is a result of the activities of rumen microbes. These animals with their stomachs divided into four compartments, namely, rumen, reticulum, omasum, and abomasum, are regarded as the digesters of the huge quantities of cereal straw, native pasture, and several other industrial by-products and wastes which have otherwise no commercial value. These crop residues are easily digested and are characterised by low levels of nitrogen and other essential nutrients; hence their limited use as a complete diet. However, in the foreseeable future these crop residues will play a much important role in satisfying the demands for animal feed. Therefore, the agricultural planners of developing countries face the challenge of how to make rational use of these feed resources with minimum dependency on foreign inputs in the crop-livestock production system. This type of production system is aimed at creating a sustainable farming system in which the local resources will be efficiently mobilised and, at the same time, maximise the degree of self-reliance within the village economy.

It is well-documented that, when fed on a residual straw diet, a significant increase in ruminant productivity is now possible with proper supplementation practices that create optimum conditions for maximum microbial outputs. The basic strategy for supplementation with the use of cereal straw is to provide the most abundant and inexpensive source of nitrogen and fermentable carbohydrates to the rumen microbes so as to maximise the fibre utilisation efficiency in the rumen. Several attempts have been made to improve the feed value of straw. Pre-treatment of paddy and wheat straw has been carried out in several countries (e.g., India, Bangladesh, and Sri Lanka) using fertilizer grade urea which is a cheap source of nitrogen. Recent developments have made it possible to improve the value of straw as ruminant feed by using cane molasses as a carrier for urea and other food nutrients in the form of urea molasses nutrient blocks.

Semi-liquid molasses, a by-product of sugar factories, is extensively used as animal feed in many parts of the sugarcane growing areas of the world. Mixtures of semi-liquid urea molasses have been successfully distributed among Ethiopian farmers as a survival ration for cattle during droughts (Preston and Lewis 1984). In recent years, FAO has been assisting several countries in Africa to manufacture and distribute urea molasses blocks under village conditions (Sansoucy 1986). In India, the National Diary Development Board (NDDB) has taken the leading role in disseminating nutrient block technology among cooperative farmers. The NDDB (1982/83) has accepted the new approach of feeding nutrient supplementation to ruminants in the form of urea molasses mineral lick, consisting of urea molasses, protein, and minerals. A manufacturing plant has already been installed at the cattle feed factory - Kaira District Dairy Cooperative, Anand, India, for the production of nutrient blocks, popularly known as *"Amul-U-Min"* among cooperative dairy farmers. *"Amul-U-Umin"* is a hard block weighing three kilogrammes. It can be kept in the manger so that animals can lick it whenever they wish. Feeding on this "*Amul-U-Min*" at will has stimulated the intake of straw by 30 per cent reducing the concentrate feed intake by 40 per cent, without losses in milk yield or body weight (Kunju 1985). The introduction of the nutrient lick (with an average intake of 500 g/day/ha) increased milk production from 1.5 to 2.4 with a substantial increase in milk fat (Kunju 1986).

In milk-producing areas, where large amounts of concentrate feed (4-6 kg/d) were fed to dairy buffaloes, the use of the nutrient blocks allowed the farmers to reduce the amount of concentrate feed by two to four kg/d thereby increasing the profitability (NDDB 1982/83). Currently, urea molasses' lick is being used successfully by Gujarat farmers as a multi-nutrient lick for dairy buffaloes and bullocks. In fact, this kind of nutrient block has been commercially produced and distributed among the dairy farmers in India and about a 10 to 25 per cent increase in milk production has been recorded (Kunju 1986). More countries are examining the usefulness of the technology within the existing animal feeding system. However, no literature has described the formulae, cost, and methodology of nutrient block preparation. In Bhutan, efforts have been made recently to prepare an ideal type of nutrient block for ruminants by moulding cane molasses, urea (fertilizer grade), cereal bran, oilseed cake, and minerals into a solid brick size block, known as **Urea Molasses Block (UMB).**

It is intentionally made sufficiently hard in order to regulate a consistent level of intake when animals lick on it. It is palatable to farm animals and provides essential nutrients such as energy, protein, non-protein nitrogen, and minerals to the rumen microbes for better digestion of fibrous materials. The overall result from field demonstrations on UMB supplementation in Bhutan suggested that the technology was a cost-effective approach to maximising the use of locally available feed resources for better animal production.

The primary objective of this paper is, therefore, to explore the relevance of Urea Molasses Block as a feed supplement to ruminants, based on the experiences and the technology developed in Bhutan. It is also intended to deliver the information on the potential use of the technology in achieving sustainable improvement in the nutritional status of livestock in the HKH Region. This paper also deals with the basic preconditions and infrastructure needed to develop a UMB, with special emphasis on the prevailing conditions in Nepal.

Role and Importance of UMB in Livestock Production

All ruminants (e.g., cattle, buffaloes, goats, sheep, and *yak*) have the unique ability to digest fibrous materials by virtue of the microbial action in the rumen. These rumen microbes also convert dietary non-protein nitrogen released from urea into high quality microbial proteins. To do so, the rumen microbes require a certain amount of food nutrients. Under straw-fed conditions, the fibre digestion activities of rumen microbes remain very slow due to inadequate dietary nutrient content in the straw. In the above situation, the fibrous diets are poorly utilised by animals. In other words, a large portion of potentially valuable feed is excreted in the form of faeces, causing a great loss to the farmers. UMB supplies essential nutrients to rumen microbes and helps maximise the microbial activities for better digestion of fibrous feed and for the synthesis of microbial proteins from non-protein nitrogen.

It is a well-known fact that straw and other fibrous plant residues are the main source of feed for ruminants. The nutritional drawback of the feed is the low level of voluntary intake and the negligible amount of protein content. This is further limited by the animals' poor ability to digest straw due to a high degree of lignification. Nevertheless, cereal straws are the only available animal feed that form the principal diet of ruminants in winter. Thus, animals raised on straw alone do not meet the nutritional requirements and are likely to loose their body nutrition throughout the winter months. This kind of under nutrition in farm animals is likely to prevail in many tropical and subtropical regions where cereal straws form the basic diet of ruminants.

Significant developments could take place for the nutrition of ruminants, if marginal improvements could be achieved in raising the feed value of cereal straw. Several methods for pre-treatment of straw have been advocated in recent years. Chopping straw and soaking it into water before feeding is a laborious practice. Treatment with sodium hydroxide or ammonia gas is routinely carried out only on large commercial farms in many developed countries. Ensilation of paddy/wheat straw with urea solution under anaerobic conditions has become a popular farm practice in many developing countries. In recent years, the Department of Livestock Services, HMG Nepal, has introduced this method of straw treatment on government farms and at field level. The ensilation of straw with urea solution, or the spraying of urea solution on straw before feeding, appears to be simple and, often, has been often reported to result in an increase in animal productivity. But, despite this, it has not been used as an ideal approach under field conditions. Many of the farmers who dug silage pits, in order to treat straw with urea, abandoned them after heating a few batches of straw. Some of the reasons for this are enumerated below.

Effort Needed

Preparation of urea solutions, spraying it on to straw, and ensilation under anaerobic conditions are some of the effort and skill-demanding processes needed and are often laborious tasks for small-scale farmers. They also demand additional effort that interferes with normal farm activities.

Element of Risk

When employing this method there is a high risk of urea toxicity in animals, arising from an uneven distribution of urea. Another problem is the risk of straw spoilage which often occurs when unchopped straws are ensiled without the right anaerobic conditions.

In this context, the urea molasses' blocks have been more widely accepted, partly because the technology is easier to apply. The blocks can be made available to animals all times of the day and night and can be given in troughs or hung within the reach of animals kept in the stall. When the pasture is dry and low in nitrogen content, these blocks can also be taken to the fields so that they are available at all times. The technology is almost free of the problems associated with urea toxicity and is easier to handle as per the prevailing conditions for small-scale farmers. It has also been claimed that a significantly higher digestibility of straw can be achieved by supplementing UMB (15% urea), rather than treating the straw with urea alone (Sudana and Leng 1986). This can be attributed to the fermentable carbohydrate and mineral content in the UMBs.

It has long been realised that the responses to supplementation of urea alone (nitrogen), in terms of the productivity of ruminants fed on straw-based diets, are often limited by other nutrients that are lacking in straw. The digestion of fibre in rumen depends on microbial activities that are directly proportional to the population of these microbes in the rumen. The synthesis of rumen microbes not only requires nitrogen but also energy and minerals, because the microbial bodies are made up of organic compounds. This kind of nutritional deficiency in the rumen of ruminants fed on straw diets can largely be corrected by supplementation of multi-nutrient blocks.

The concept of giving UMB supplementation to ruminants is not only to supply nitrogen but also to provide a wide range of nutrients to make up for the nutritional deficiency in rumen. Application of UMB technology has demonstrated a remarkable impact on ruminant production, particularly in India (Leng 1984b), and its use is now being extended to many countries in Africa.

The potentials of multi-nutrient UMB for upgrading the nutritional status of ruminant livestock raised under poor quality roughage include those listed below.

The administration of:

- essential nutrients such as fermentable carbohydrate and nitrogen,
- macro and trace minerals,
- Vitamins (A, D, B), and
- By-pass carbohydrate, protein, and fats.

In future the prospects of UMB supplementation for livestock production are as given below.

The administration of:

- chemicals to manipulate rumen fermentation; anti-protozoal agents,
- methane inhibitors in the rumen; Rumensine,
- Drugs against flukes, ticks, and the endo parasites, and
- hormones to manipulate growth, lactation, and reproduction.

Thus, the multi-nutrient UMB can be used extensively to solve the diversified problems of livestock production.

Feeding Ruminants in Bhutan

Bhutan is a landlocked, mountainous country with an area of about 46,000 sq. km., situated in the eastern part of the HKH Region. It is basically an agricultural country where more than 95 per cent of the national labour force derive their livelihood from agriculture. Livestock are a major component of agriculture in Bhutan and consist of about 3,50,000 cattle, 26,000 *yak*, 40,000 sheep, and 42,000 goats. (AHD, RGOB, 1981-1987). The country is sparsely populated with an estimated figure of about 1.4 million and has good forest coverage. *Yak, mithun* (indigenous cattle), and sheep are the common domesticated animals found in the high altitude areas of Northern Bhutan whereas local *Siri* cows, sheep, and goats are popular farm animals in Southern Bhutan where buffaloes are rarely kept as farm animals.

Livestock raising in Bhutan provides many essential items, such as meat, milk, cheese, and wool, which generate cash income to purchase other household commodities, *Yak* and *Mithun* are used extensively for the transportation of goods across the steep mountains. Apart from this, livestock are the only source for replenishing soil fertility through the application of manure and for draft power for crop cultivation. Many of the nomadic farmers living in the high mountains (above 3,000masl) have no suitable land for crop cultivation. Most of them earn their living from livestock farming. These farmers keep on moving with their flocks throughout the year in search of animal feed and markets in which to sell animal products. During summer they take their herds as high as 5,000m and, in winter, they drive their flocks lower down to around 2,000m. Most of the *yak* herds do not come down to the lower mountains even in winter because of many environmental and topographical reasons. The farmers know the exact limits beyond which they can never take their herds. They rely on their homeland pastures only for about three months, over the period from July to October, during which enough forage is available to feed the livestock population. As soon as the summer pasture dries up, the body conditions and the productivity of the animals begin to deteriorate because of the highly fibrous and poor quality of pastures which are inadequate to meet the normal voluntary intakes of animals. In winter, these animals depend on dry and matured native grass, bamboo shoots, tree bark, residues of millet, and oats. It has been repeatedly claimed that due to lack of animal feed thousands of *yak* die in the high mountain areas, where almost all the land is covered with snow for three to four months during the year.

Lack of animal feed during the winter months is an acute problem for almost all Bhutanese farmers, and this is because of open and uncontrolled animal grazing on pasture rangeland and traditional animal feeding practices. On the southern hills where maize, rice, and wheat are grown on terrace lands and along rivers banks, crop residues make up the bulk of the feed given to ruminants; fodder leaves, sun-dried hay, and silage are rare commodities for small farmers in the rural areas. The productivity of communal pastures decreases every year despite the implementation of various fodder and pasture development projects. This has made crop residues, which are locally available, reliable animal feed during the periods of feed scarcity. Feeding on surplus amounts of cereal grain by-products and oilseed cakes with salt is a good practice commonly used to supplement feed. But this kind of practice is generally adopted in the case of animals having higher production levels. Feeding cattle on commercial concentrates is still a milestone practice at the village level.

During 1987/88 a 'Feed Mixing Plant' of about 10 MT capacity was installed under the FAO/UNDP/BHU/84/020 Project located in the southern border area of Bhutan. The production of cattle concentrates represents only about 15 to 20 per cent of the total production. Almost all of these cattle concentrates were consumed at government farms. Farmers having genetically improved cattle producing more than three litres of milk daily are likely to use cattle concentrates provided they have access to roads. These farmers are residing largely in southern Bhutan, at altitudes of 500 to 1,500m. The recently established Milk Processing Plant in the border town collects milk from farmers and provides various livestock services, including field level training on the feeding and management of farm animals. This has encouraged local farmers to feed compounded feed to their farm animals. However, it is unlikely that the compounded feed can form the bulk of the daily ration under field conditions, even during periods of feed scarcity in winter, because most of the livestock are local species with low production potentials but multipurpose functions.

It should also be considered that the country has a poor source of feed ingredients and almost totally depends on neighbouring countries for the raw materials required in manufacturing animal feed. Only about 10 per cent of the total maize and mustard oilseed cakes is available in the local market. The country suffers a great drain on foreign currency for importation of animal feed ingredients.

In this context, an efficient use of locally available feed resources would be an appropriate approach to meet the feed deficit problem during winter. Several forage conservation and resource utilisation techniques have been developed and experimentally tried on farm animals. Some of the resource improvement techniques developed in Bhutan are listed below.

- Treatment of straw with urea.
- Incorporation of farm wastes into grass silage.
- Inclusion of sun-dried poultry litter into cattle concentrates.
- Development of UMB

The treatment of straw with urea has become a regular farm practice on all government farms but has not been adopted by many farmers at the village level. In fact, many of them are being discouraged due to the complications that arise during the preparation of urea-treated straw. The normal practice is to ensile the straw that is treated with four per cent urea solution, with straw and water in a ratio of 1:1 (Premasiri 1985).

The maize (forage) silage mixed with poultry litter was successfully prepared and fed experimentally to eight lactating cattle for two months. This type of poultry waste mixed with maize silage was found to be equally palatable to dairy cows as silage prepared with maize forage alone. All cows consumed more than 15 kg of poultry litter-mixed silage daily without any deleterious effects on animal health (Bajracharya 1988).

The inclusion of 30 per cent of poultry litter (on DM basis) with maize forage, at the time of ensiling, improved the nutritional value of the final product in terms of crude protein and mineral content. It was also observed that a kilogramme of concentrate was saved daily when cows received supplements of the farm waste-mixed silage and they still maintained the same level of milk production. The experimental results suggested that the poultry waste-mixed silage was much more cost effective than that prepared from maize forage alone. It is now possible to prepare silage out of poultry wastes even under field conditions when poultry litter is easily available and farmers are familiar with silage preparation.

In another experiment, all four experimental sheep consumed two kilogrammes of each type of cattle concentrate prepared with and without sun-dried broiler litter (Bajracharya 1990). The inclusion of 30 per cent of sun-dried litter (on DM basis) helped to replace about 72 per cent of the oilseed cake ingredients in the concentrate without changing the nutritive value of the final mixture. The farm waste-mixed cattle concentrate, thus prepared was about 80 per cent cheaper than the commercial cattle concentrate, and it was also found to be cheaper than paddy straw in terms of digestible nutrient content. Nevertheless, further research on the use of local resources for preparing animal feed is required.

None of the above-mentioned methodologies, for the conservation and utilisation of local resources in preparing animal feed, was found appropriate to the existing conditions at high altitude where cropland does not contribute a considerable amount of feed for livestock. Silage-making has rarely been adopted to prepare winter feed in appreciable quantities. Only a limited quantity of plant residues from oats and millet are available during winter. Thus, the major source of animal feed at high altitude is the communal native pastures which are highly fibrous and contain negligible amounts of nutrients when mature. Even this low quality feed is not adequate to satisfy the maintenance requirements of animals. This type of feed deficit forces animals to lose their body weight and production for a considerable period of the year. Further limitations are caused by the frequent movement of herds from one place to another. Under such practical field conditions, many of the proven resource utilisation technologies contribute little to solving the problems of farmers, especially *yak* farmers.

It has been a great challenge for the Department of Animal Husbandry to overcome the severe feed deficit problem during winter in the high alpine areas of Bhutan. Livestock workers and advisors should also look for a suitable technology for the conservation and utilisation of local resources in preparing animal feed. Several formal as well as informal meetings were called by the head of the Department of Animal Husbandry to solicit alternative means of feeding in the *yak*-raising areas of the country. The development of UMB received highest priority among the technologies developed so far in Bhutan for the preparation of animal feed using local resources.

Development of UMB in Bhutan

For the first time in Bhutan, Mittel et al. (1985) prepared about 11 types of sun-dried urea molasses' blocks incorporating various levels of calcium hydroxide as a binding agent. Growing steers and lactating cattle, fed on straw-based diets, found this palatable. In the same year, a feeding trial was conducted on growing Jersey cross-bred calves, fed on paddy straw, to investigate the effect of UMB supplements on live weight gain. A positive weight gain was reported (not quantitatively indicative) among growing calves with a daily intake of about 239 grammes of UMB, and no deleterious effects from urea toxicity were reported throughout the UMB supplementation period (Premasiri 1985).

From these findings it was claimed that UMB supplements improve the overall performance of growing cattle on straw diets. However, there was a major drawback in the unit cost of the UMB (10% urea) which was prepared with eight per cent calcium hydroxide as a hardening agent. The above mentioned batch of workers used the same type of UMB formula, and this resulted in a cost of about 40 *Ngultrum** per kilogramme of UMB in which more than 80 per cent of the ingredient's total cost was attributed to the binding agent alone. The excessively high cost of the UMB was the major failure in implementing the UMB technology in field conditions. Initially, the UMBs were prepared with 10 per cent calcium hydroxide, making the block hard, but it turned out to be very expensive. Later on, they prepared several batches of UMB with different proportions of calcium hydroxide. It was noticed that the incorporation of the hardening chemical at a rate of less than eight per cent of the total die did not give rise to a sufficiently hard UMB. Both batches of workers prepared the UMB at the farm itself and dried them in the sun, requiring more than ten days. In the later preparation of UMB, different levels of bentonite, calcium hydroxide, and cement were used as an alternative inexpensive binding agent but none of them reduced the cost of UMB to an appreciable extent. Hence to find an alternative inexpensive means for preparing hard UMB was of great concern. The determining factor for the practical use of UMB lies in its hardness which controls over-consumption of the block while animals lick it. The UMB contains fertilizer grade urea as a source of non-protein nitrogen and, when animals lick it, the urea breaks down into ammonia in the rumen. The ammonia is rapidly taken up by the rumen microbes for multiplication of the microbial population. However, an excess consumption of urea as a result of a soft and loose type of UMB could lead to urea toxicity in ruminants. Therefore, an ideal UMB should be hard enough regulate the level of intake by animals.

Preliminary Work on the Preparation of UMB

In early 1988, the Department of Animal Husbandry showed a keen interest in the utilisation of local resources to prepare animal feed, with a special emphasis on solving the feed scarcity problem in the high altitude areas of the country. In the same year, several visits were made to the Feed Mixing Plant where a number of urea molasses' mixtures were prepared and tested for their firmness without the use of chemical binding agents.

A paddy blade mixture was used in the ingredients in order to obtain a homogeneous urea molasses' mixture. To start with, several batches of 50 kg urea molasses' mixture were prepared using different qualities of feed ingredient; the main three types of UMB are shown in Table 1.

Characteristics of each ingredient were carefully studied for their roles in contributing to the hardness of the final mixtures. It was observed that the inclusion of molasses having 24 per cent moisture content gave better firmness to the mixture than molasses having 44 per cent moisture. It has been noted that the inclusion of course types of wheat bran gave more hardness to the mixture than the inclusion of fine types of wheat bran. These characteristics of cane molasses and wheat bran, which represent about 62 per cent of the total UMB mixture, were largely neglected during previous studies.

Ground and cooked oilseed cakes were introduced into the urea molasses' mixture in order to provide some rumen by-pass proteins to improve the levels of animal production. Normally, about 50 per cent of the total protein content in *Til* cake is by-pass protein. This proportion of by-pass protein can be raised to as high as 60 per cent in heat-treated *Til* cakes. This is the reason why the *Til* cake was cooked up to 60° C before mixing it with the rest of the UMB mixture. The inclusion of up to 12 per cent of oilseed cakes gave an exceptionally hard and firm consistency to the final UM mixture which could not be achieved in the previous mixture prepared without mixing the chemical binding agent. Another noticeable change in the viscous nature of the UM mixture was that the block could be lifted up and transported to another section immediately after moulding. In this way the same moulding block could be brought into use to prepare other batches of UMB. These characteristics were essential in order to make this a commercially viable technology for the production of UMB.

* *Nu:* Bhutanese Currency equivalent to the Indian *Rupee*

Table 1: UMB with Different Ingredient Mixes

Ingredients/types	1	2	3
* Cane molasses	45	45	40
** Wheat bran	28	28	22
*** *Til* cakes (Sesame oil cake)	-	-	12
Urea	10	10	9
Cement	12	12	12
Cost in *Nu*/Kg	2.40	2.40	2.48
Water	+	+	+

* Molasses of 44 per cent moisture in Type No. 1 and 24 per cent in Types No. 2 and 3.
** Fine wheat bran in Type No. 1 and coarse wheat bran in Types No. 2 and 3.
*** *Til* cake ground and cooked up to 60º C.
+ More than three litres of water for 12 kg of cement.

Cost of ingredients in *Nu*/kg at the time of preparation (1989)

(1) Cane molasses = 2.5,
(2) Wheat bran = 2.7
(3) Urea = 2.25
(4) *Til* cake = 3.25
(5) Cement = 2.0 and
(6) Salt = 1.0
(1 *Nu* = 1 Indian *Rupee*)

In addition several other changes were made in the internal characteristics of the individual ingredients and in the processing techniques to achieve a low cost and a sufficiently hard UMB without the use of chemical agents. The role of the cement was to provide a consistent hardness to UMB. It was initially used to replace the expensive binding agent. The inclusion of cement in the UMB has virtually no significant nutritional value to ruminants. At the same time, it has no ill effect on animals as long as it represents less than five per cent of the total dry matter intake. The other ingredients, such as fertilizer grade urea and common salt, were included as an inexpensive source of non-protein nitrogen and minerals for the UMB mixture.

There was no significant difference in the total cost of ingredients among the three types of UMB mixtures. The mixture with *Til* cake was found to be the best among the three mixtures in terms of firmness at the time of moulding. A few of these moulded blocks were taken to the Feed Analytical Laboratory for chemical analysis. Some of the blocks were dried in the sun, and this also made them sufficiently hard, but this drying process took a long time and was a laborious task that depended upon the weather. Some of the moulded blocks were partly dried in the oven at low temperature (60º to 65ºC) for 18 hours. This reduced the moisture content of UMB from 25 per cent to about 13 per cent, and interestingly, the partly-dried UMB turned out to be exceptionally hard and was comparable to that prepared by using eight per cent of calcium hydroxide.

It was necessary to monitor the cost involved in the oven treatment of UMB in order to compare it with the cost of the binding agent. It was calculated that the cost of drying a kg of UMB in a dry-air oven at 60° C for 18 hours was found to be about *Nu* 0.25 which was only about 10 per cent of the total cost of the UMB. But the cost of calcium hydroxide, at eight per cent inclusion, was about 32 *Nu*/kg; an exceptionally high cost. In this way a low cost and sufficiently hard UMB was prepared at the cost of *Nu* 2.48/ kg for the ingredients alone, and the selling price of 1 kg of UMB was estimated at *Nu* 4.64, after adding the production cost and profit margin. However, the final price was set at *Nu* 5/kg by the Department of Animal Husbandry.

These initial findings and observations helped to further develop the urea molasses' mixture into a multi-nutrient feed supplement for all kinds of grazing animals. This feed supplement package was found to be extremely useful not only in the southern hills but also in the high mountain areas of the country. However, the transportation of urea molasses' blocks from the production unit to the target areas can be a major constraint to the overall impact of this technology on a particular village community. Another foreseeable disadvantage of UMB supplements in this context of Bhutan is the importation from neighbouring countries of almost all raw materials required to prepare UMB. No doubt, this has left a big question mark on the applicability of UMB supplementation technology in Bhutan. Nevertheless, the prospects of UMB technology are positive as long as the technology is cost effective and helps to improve the net income of small farmers without disturbing the social, political, and traditional heritage of the country. The primary target of UMB technology in Bhutan is the manufacture of low cost and sufficiently hard UMB, so that each farmer living at high altitudes, as well as in the hills, can afford to buy the blocks and supply essential nutrients to their farm animals. One big advantage of the UMB supplement technology is that it provides an integrated approach to optimising the use of available resources within the existing animal production strategy, based on indigenous livestock and small holders.

Chemical Analysis of UMB

Chemical analysis for two types of UMB (with and without inclusion of *Til* cake) were carried out at the Feed Analytical Laboratory, Animal Husbandry Complex, Serbithang, following the traditional procedure of proximate analysis of feed. The results are given in Table 2.

Table 2: Chemical Analysis of UMB

Types of UMB	DM %	On DM basis			* TDN %
		CP %	Ash %	Ca %	
1) With *Til* cake	88	34	21.8	5.5	53
2) Without *Til* cake	87	31	21.5	5.4	49

* Calculated value

Palatability Test on Animals

Having been successful in preparing a hard and reasonably low cost UMB at the Feed Mixing Plant, it became necessary to find out its acceptability to farm animals. It was also essential to determine the level of UMB intake by the animals. In principle, the daily intake of UMB should support and maximise the activities of rumen microbes for efficient digestion of fibrous diets. In other words, the level of UMB intake should be such that the requirement of rumen microbes for essential nutrients is met at all times. It is also equally important that the level of UMB intake should not exceed a certain limit which leads to urea/ammonia toxicity in animals. Therefore palatability tests were conducted on farm animals to determine the level of intake and also to note any adverse effects. For this purpose about 50 oven-dried UMBs, each weighing about 2.7 to 3 kg, were prepared.

Laboratory Animals

Four laboratory rams and two bulls fed on fibrous diets were individually given UMBs to lick at will for eight days. The weight of each block was recorded every morning. Rumen fluids were drawn from each of the two fistulated rams and bulls before and after supplementation of UMB to determine the ammonia concentration in the rumen of each animal. (The level of ammonia in the rumen indicates whether the animal in question requires an extra amount of dietary nitrogen or not). It is generally regarded that when the ruminal ammonia falls below 100 mg/litre of rumen liquid, it indicates that the animal requires additional dietary nitrogen for the normal functioning of rumen microbes (Preston and Leng 1987). However, the optimum level of rumen ammonia for maximum microbial fermentation was reported to be above 200mg/litre of rumen fluid (Mehrez et al. 1977). The recorded results of the daily intake of UMB and ruminal ammonia concentration are given in Table 3.

Table 3: UMB Intake and Ammonia Concentration in the Rumen of Laboratory Animals

	Sheep	Bulls
1. UMB intake, l/h/d	147.5	1120
2. Ruminal ammonia concentration (mg/litre of rumen fluid)		
(a) Before supplementation	129.5	121
(b) After supplementation	195.0	210

Note: The animals were fed daily on shunted orchard grass supplemented with cattle concentrate @ 0.5 kg for sheep and 1.0 kg for bulls.

Farm Animals

In another observation, it took about four days for 14 adult sheep housed in a group to finish a 6.1 kg block. All the sheep showed great interest the UMB and most of them licked it immediately. The UMBs were also individually given to four Jersey cross-bred dairy cows at Wangchutaba Dairy Farm for five days. All cows were fed on paddy straw with some concentrate supplements and produced about two to three litres of milk daily. The sheep and dairy cows took a consistent daily intake of 109 and 925 grammes per head and no deleterious effects of urea toxicity were noticed in the animals.

The daily consumption of urea during the short-term UMB palatabilility test was recorded at 13.3, 84, and 101 grammes for sheep, cows, and bulls respectively. For large ruminants the urea intake can be as high as 300 grammes/day (Preston and Leng 1987). It has also been claimed that there is little risk of urea toxicity when urea is given with readily fermentable energy in the form of a molasses' block.

The energy and protein supplied by the above levels of UMB intake by farm animals are shown in Table 4, where it can be noted that a large part of the crude protein (CP) required for body maintenance is met through the use of UMB supplement. It can also be noted that the energy supplied by the UMB was small in comparison to the total energy required for body maintenance. However, this small amount of energy plays a crucial role in stimulating the rumen microbes for better digestion of fibrous material.

Feeding Experiments on Dairy Cattle

Feeding UMB supplements to farm animals should also be regarded as an additional farm input which demands an optimum return to satisfy the overall economic needs of farmers. Hence, a better production performance is obviously expected from animals receiving UMB, in terms of milk yield, liveweight gain, better reproductive performance, and in overall productivity. Among them the most common and relevant measure of production is the daily milk yield of cows. It was, therefore, proposed to conduct feeding trials on dairy cows, given paddy straw as a base diet, at government farms as well as in field conditions, to study the effect of UMB supplements on milk yield so that an input output assessment could be made.

On receiving approval for the study from the Animal Husbandry Department, more than 300 kg of UMB (with *Til* cake and oven dried) were moulded at the 'Feed Mixing Plant' and brought to the Feed Analytical Laboratory where all the blocks were dried at controlled temperatures. These blocks were used for feeding experiments on dairy cattle at government farms and in field conditions.

Table 4: A Comparison between Nutrient Supplied by Supplementation of UMB and that Required by Farm Animals

		Sheep	Cow	Bull
1	Average liveweight (kg)	40	350	400
2	Daily UMB intake (grammes)	147.5	925	1120
3	Crude Protein (CP) supplied by UMB (g/d)	50.1	315	381
4	CP required for body maintenance (g/d)	75.0	432	478
5	TDN supplied by UMB (g/d)	78	490	595
6	TDN required for body maintenance (g/d)	410	2600	2900

Government Farms

The first feeding trial was conducted on Jersey cross-bred dairy cattle, fed on paddy straw and offered UMBs at will, from December 1990 to February 1991, at Wangchutaba Dairy Farm, situated at about 9,000 ft. A total of six cows were divided into two equal groups making sure that the total amount of milk in each group was the same. Then, they were randomly given UMB at will or UMB was with-held. Concentrate feeds were supplied to all cows according to the existing feeding schedule of the farm.

The average amount of UMB licked daily, at will, by the three experimental cows for 32 days was 0.787 kg/day/head. The control group of cows received an additional amount of 0.5 kg cattle concentrate/head/day as a replacement for UMB. The intake of UMB alone supplied about 267 grammes of crude protein which was sufficient to meet 95 per cent of the amount required for the maintenance of cows. This level of UMB consumption also supplied daily about 71 grammes of urea, which was a safe level. No harmful effects of UMB on animals were noticed throughout the experiment.

The average amount of milk yield observed for six weeks, in cows given UMB at will, was recorded at 2.04 litres per day per head which was about 0.5 litres higher than recorded for cows not receiving UMBs (Table 5).

Table 5: Average Performances of Cows Given UMB Supplement and Control Groups

Observations	Experimental Group	Control Group
1. Straw intake, kg/d/h.	4.19	4.2
2. Cattle concentrate, kg/d/h.	2.0	2.5
3. UMB intake, g/d/h.	787.	---
4. Milk yield, 1/d/h.	2.04	1.54
5. Cash from milk, *Nu*./d/h.	14.28	10.78
6. Cost of feed, *Nu*./d/h.	13.74	11.58
7. Profit and loss, *Nu*./d/h.	+ 0.54	- 0.80

Note: Cost of straw = 1 *Nu*/kg
Cost of Cattle concentrate = 2.95 *Nu*/kg.
Selling price of milk = 7 *Nu*/1.

There was substantial improvement (24.5%) in the milk yield of cows receiving UMB throughout the experiment. But a noticeable fall in milk yield was observed in cows not given UMB and under a control diet (Figure 1). However, these results might have been affected by factors other than the supplementation of UMB such as limited numbers of experimental animals, difference in lactation stage, and difference in calving dates.

The UMB supplements did not cause a significant improvement in the intake level of paddy straw by the experimental cows (Table 6). The lack of effect of UMB on straw intake can be explained by the fact that the nitrogen requirement for maximum microbial activity in the rumen was satisfied by the provision of cattle concentrate, which was given to all cows. The normal concentrate supplementation practice on the farm was two kg/head/daily, providing about 390 g of crude protein. The crude protein requirement of rumen microbes for maximum microbial activity would be about 285 g for an adult cow with a 300 kg body weight (the average live weight of the cows under study).

The cost analyses of feed input and milk output showed a net profit of about 0.5 *Nu* from the sale of milk produced by each cow given UMB compared to a daily net loss of 0.80 *Nu* per cow in the control group (Table 5). The overall observation of the feeding trial indicated that the daily UMB supplements to cows not only increased the milk yield but also improved the economic status of the dairy enterprise.

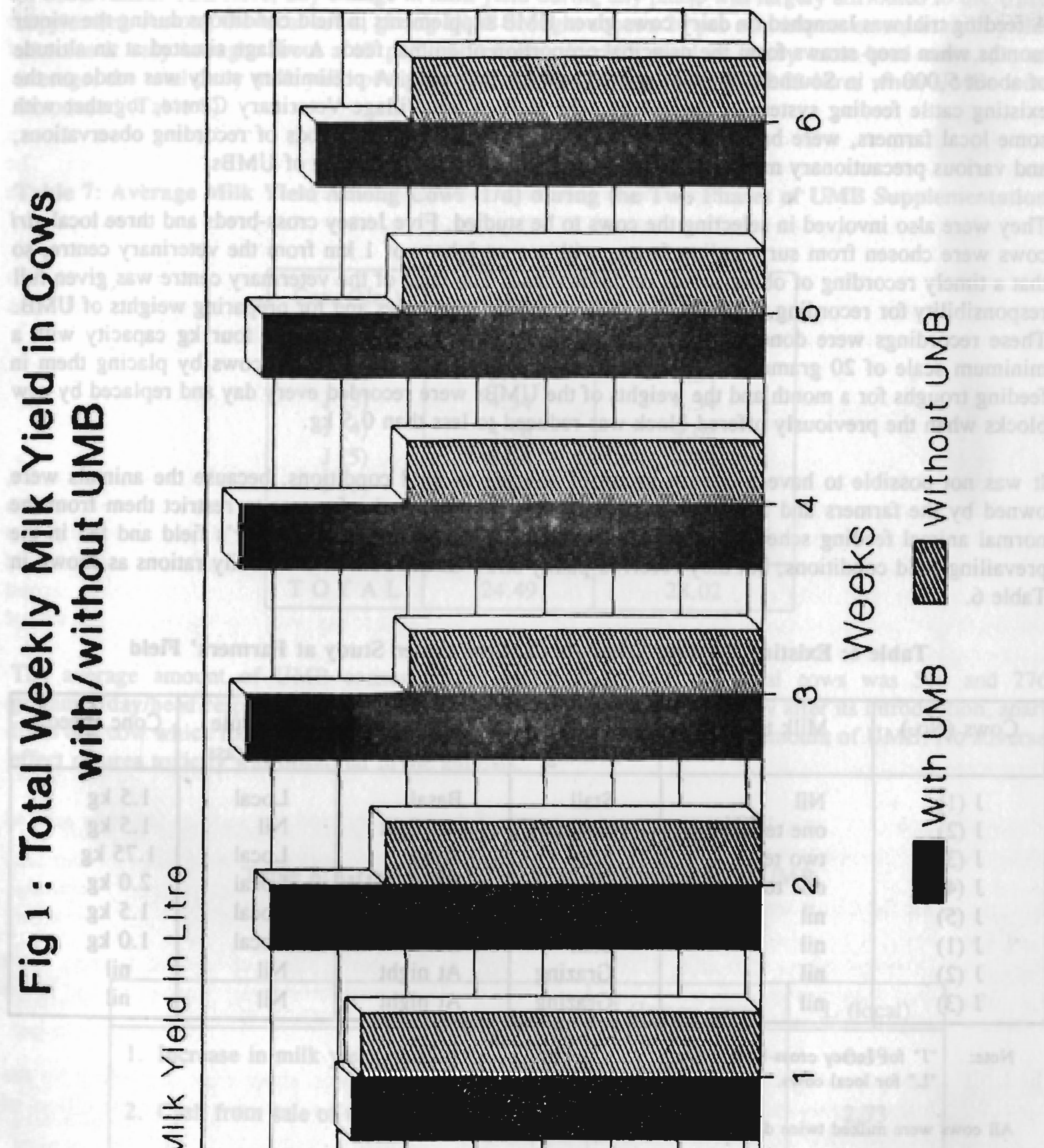
Fig 1 : Total Weekly Milk Yield in Cows with/without UMB
Milk Yield in Litre
16
14
12
10
8
6
4
2
0
1
2
3
4
5
6
Weeks
With UMB
Without UMB

Village Level

A feeding trial was launched on dairy cows given UMB supplements in field conditions during the winter months when crop straws form the principal proportion of animal feed. A village situated at an altitude of about 5,000 ft, in Southern Bhutan, was chosen for the study. A preliminary study was made on the existing cattle feeding system in the village. The staff of the Village Veterinary Centre, together with some local farmers, were briefed on the nature of the experiment, methods of recording observations, and various precautionary measures to be undertaken for proper handling of UMBs.

They were also involved in selecting the cows to be studied. Five Jersey cross-breds and three local *siri* cows were chosen from surrounding farms, within a periphery of 1 km from the veterinary centre, so that a timely recording of observations could be made. The head of the veterinary centre was given full responsibility for recording the daily milk yields of individual cows and for preparing weights of UMB. These recordings were done with the help of pocket size spring balance for four kg capacity with a minimum scale of 20 grammes. The UMB was made available *ad lib* to all cows by placing them in feeding troughs for a month and the weights of the UMBs were recorded every day and replaced by new blocks when the previously offered block was reduced to less than 0.5 kg.

It was not possible to have a control group of animals in field conditions, because the animals were owned by the farmers and it would not have been acceptable to the farmers to restrict them from the normal animal feeding schedule. All cows were herded in the respective farmer's field and fed in the prevailing field conditions, but they received paddy straw as the bulk of their daily rations as shown in Table 6.

Table 6: Existing Feeding Schedule of Cows under Study at Farmers' Field

Cows (No.)	Milk to Calf	Daily Grazing	Feeding Straw	Schedule Cut Grass	Conc. Feed
J (1)	Nil	Stall	Basal	Local	1.5 kg
J (2)	one teat	Grazing	At night	Nil	1.5 kg
J (3)	two teats	Stall	Basal	Local	1.75 kg
J (4)	one teat	Stall	Basal	Local	2.0 kg
J (5)	nil	Stall	Basal	Local	1.5 kg
J (1)	nil	Stall	Basal	Local	1.0 kg
J (2)	nil	Grazing	At night	Nil	nil
J (3)	nil	Grazing	At night	Nil	nil

Note: "J" for Jersey cross-bred cows,
"L" for local cows.

All cows were milked twice daily

The owners of the cows were asked to feed their cows according to their usual feeding practices, without any ad hoc change in daily rations, throughout the observation period of two months, from February to March 1991.

The observations regarding milk yield were made in cases where UMB supplements were given and in control conditions. The milk yield of individual cows, prior to giving the UMB supplements, was recorded for 15 days and was regarded as the first phase. This was followed by a month-long recording of milk yield in cows given UMB supplements.

The composition of the daily ration was relatively similar among all cows throughout the three phases of observation. Therefore, any change in milk yield during any phase was largely attributed to the UMB supplement. Among the local cows, giving UMB brought about a 26 per cent improvement in milk yield, whereas it only brought about a 12 per cent increase in milk yield in Jersey cross-bred cows. On an average, the total daily milk yield of eight cows increased from 24.49 to 28.03 litres when UMBs were introduced (Table 7).

Table 7: Average Milk Yield Among Cows (l/d) during the Two Phases of UMB Supplementation

Cow (No.)	Before	During
J (1)	3.87	5.06
J (2)	3.17	3.51
J (3)	4.34	4.34
J (4)	4.98	4.68
J (5)	3.69	4.83
J (1)	1.77	1.73
J (2)	1.70	2.28
J (3)	0.97	1.59
T O T A L	24.49	28.02

The average amount of UMB consumed by Jersey cross-bred and local cows was 510 and 276 grammes/day/head respectively (Table 8). All cows licked UMB immediately after its introduction, apart from one cow which took about five days before consuming an appreciable amount of UMB. No adverse effect of urea toxicity was observed in the animals.

Table 8: Gross Return from the Introduction of UMB

	J (Jersey cross)	L (local)
1. Increase in milk yield, l/d/h.	0.474	0.39
2. Cash from sale of milk *Nu*/d/h.	3.32	2.73
3. Amount of UMB intake, g/d/h.	510	276
4. Cost of UMB input, *Nu*/d/h.	2.3	1.28
5. Profit in *Nu*/d/h.	0.96	1.45

Note: Cost of Milk = 7 *Nu*/l
Cost of UMB = 4.64 *Nu*/kg

The economic aspect of UMB technology was also studied during the village level trial at Tala. The improvement in the milk yield can be considered to be directly related to the intake level of UMB, since the UMB supplement was the only major change in the feed input given to each cow within the two phases of milk production. The overall results showed that an additional amount of 0.441 litres of milk/cow/day was produced when the cows were given UMB (with 0.42 kg UMB intake/cow) Table 9). This increase in milk yield was equivalent to 3.09 *Nu*/day/cow and gave a net profit of 1.15 *Nu*/day/cow, a higher figure than the 0.54 *Nu*/day recorded at the Wangchutabe Dairy Farm (Table 6). The net return was higher than from local cows (*Nu*/d/cow) compared to Jersey cross-bred cows (*Nu* 0.96/d/cows). The general impression regarding the application of UMB technology in village conditions suggested that the technology could be a cost-effective approach to improving the economic status of dairy farmers.

The veterinary centre at Tala provides artificial insemination (A.I.) services to animals and maintains progeny records. It was observed that five out of eight cows came into heat when the UMB was introduced. General improvements in the body condition of the animals were also reported.

UMB Feeding Demonstration on Farmers' Fields

A field-level feeding demonstration was approved by the Department of Animal Husbandry, Thimphu, to study the acceptability of UMB technology for ruminants such as cattle, sheep, and *yak* at high altitudes where a large number of animals die because of inadequate nutrition. Five northern districts (*Dzongkhags*) of the country namely, Haa, Thimphu, Wangdi, Bumthang, and Tashigang were selected to carry out the proposed field demonstration. The preliminary identification of target farmers was carried out by the Training, Research, and Extension Division of the Department with the help of district animal husbandry officers (DAHO).

About 900 kg of UMB (300 in number) were prepared according to the improved methodology. All UMB mixtures were molded at the Feed Mixing Plant and brought to the Feed Analytical Laboratory where they were partly over-dried.

Feedback forms were prepared for the three-week long field demonstration. As soon as the team arrived at the district headquarters, the following work was undertaken.

1. All field staff were briefed on the role of UMB in the presence of the DAHO.

2. Demonstrations of feeding UMB to ruminants in the nearby sheds of selected farmers were conducted in the presence of field staff from the Department of Animal Husbandry and in the presence of the local farmers.

3. Subsequent follow-up field visits to farmers' houses and animal sheds were carried out for the following two days. The feedback reports were received at the department from the offices of all five DAHOs.

About 182 blocks were used for the field demonstration which covered 91 farmers from 20 villages in the five districts and more than a thousand animals, including cattle, *yak*, and sheep. The field technicians fed UMB to local animals kept in sheds as well as in pastures. Based on the feedback received from the farmers, it was indicated that feeding UMBs to grazing animals was safe and no deleterious effects of urea toxicity were noted in the cattle, sheep, or *yak*. The duration required to finish a UMB varied from a few days among cattle and sheep to a few weeks among *yak*. Some *yak* showed reluctance to lick the block in the beginning but many of them consumed appreciable amounts of UMB when the blocks were sprayed with salt or grain flour. Some farmers observed an increase in milk yield among cows given

UMB for two weeks. A high demand for UMB by farmers was also reported by almost all field staff in their feedback reports. However, rural farmers reported that the cost of the UMB (5 *Nu*/kg) was high. It was suggested by farmers and village leaders that the UMB should be made available to farmers at government-subsidised rates.

After completion of the detailed study on the use of UMB as a feed supplement to ruminants, a consolidated report was presented to the Department of Animal Husbandry, Thimphu, with conclusions listed below.

1. UMN mixture containing 12 per cent of *Til* cakes (sesame oilseed cakes) was estimated to be the most suitable among all other mixtures in terms of nutritive value.

2. The control drying system for hardening UMB was cheaper and commercially more viable than the use of chemicals.

3. UMB supplements markedly improved the milk yield in dairy cows fed on straw-based diets.

4. Use of UMB as a nutrient supplement to dairy cows was a cost-effective input, even in field conditions.

5. The UMB supplement technology for ruminants on low-quality, high-fibre diets, was widely accepted by livestock owners even in high altitude areas.

6. The UMB technology was safe, simple to handle, and met the essential nutrient requirements for ruminants, so as to achieve efficient utilisation of local resources as animal feed in times of feed scarcity, especially during winter.

Institutional Background for the Development of UMB in Bhutan

The study on urea molasses' blocks was carried out as a part of his duties under the job description of the author, while he was working for the Department of Animal Husbandry, Thimphu, as a UN Volunteer (Animal Nutrition specialist and Feed Analyst) for four years from 1987 to 1991. All the activities involved in developing the present form of UMB (9% urea, 12% *Til* cake, and oven dried) were carried out under the existing institutional infrastructure of the Department of Animal Husbandry. The Feed Analysis Laboratory, Serbithang, has the normal facilities to carry out proximate analysis of feeding material. The laboratory is also equipped with fistulated lambs and bulls which are useful for experimental work.

The newly-established Feed Mixing Plant at Phuntsholing (the border town) was a focal point for preparing several batches of UMB with different proportions of ingredients. The plant has been handed over to a private party under an agreement that compound animal feed shall be produced according to the technical guidelines of the Department of Animal Husbandry. The department will also be able to carry out necessary nutritional test studies for quality control of animal feed. The plant has the capacity to produce 10 to 15 MT of feed per day and is equipped with almost all modern feed-mixing equipment such as grinding and mixing mills, molasses mixer, mineral + vitamin mixer, an automatic weighing machine, and bag-sealing equipment. The paddle blade mixer made by Morrison in the USA was used to mix the UMB ingredients. Wooden frames for moulding blocks of 10 x 5 x 3 cubic inches were prepared locally.

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The Department of Animal Husbandry launched a day-long seminar on the use of UMB in animal production and strongly recommended the dissemination of the technology at field level. The department has already allocated a budget to meet the UMB distribution target at the district level as well as for production farms.

The Feed Analysis Laboratory was used for drying the moulded blocks. So far, about 1,300 kg of oven-dried UMBs have been prepared for animal feeding trials and field demonstrations. As a result of the field demonstration, a remarkable demand for UMB from the Feed Analysis Laboratory was created among farmers and livestock farms. These demands were forwarded to the Feed Mixing Plant where the block is to be prepared commercially. The proprietor at the plant has expressed a deep interest in manufacturing UMB on a commercial scale. For this purpose, a hot chamber has to be installed in the plant to dry the moulded UMB. Two molasses tanks, each of about 10 MT capacity, have been constructed to store the molasses. The preliminary study for installing a hot chamber in the plant has been completed. According to the proprietor, almost all the formalities have been completed, including the allocation of a budget for the hot chamber. The estimated capacity of the hot chamber will be about 50 cubic feet and it will dry about 300 blocks a day. However, the installation of the hot chamber had not been completed when the author's assignment in Bhutan ended (June 1991).

Preconditions for the Development and Use of UMB

The principal concept of UMB supplementation to ruminants is to maximise the rumen function for efficient utilisation of cereal crop residues resulting in better milk and meat production. Basically, the UMB itself is made up of local resources such as molasses, cereal brans, and oilseed cakes. These are being produced on a large scale and are locally available as by-products and wastes from agro-based industries in the HKH Region. An ideal UMB is constituted of more than 75 per cent of these materials. The other constituents of UMB are urea, cement, and salt which constitute about 25 per cent of the total. Although fertilizer grade urea and common salt are foreign imports, nevertheless they are also available in the village without much difficulty. Cement is an expensive item and, in future, it is expected that the inclusion of cement can be reduced substantially or totally eliminated from the UMB mixture in the case of mud-based nutrient blocks. The overall view on the make-up of urea molasses' blocks indicates that almost all of the ingredients are available locally in the South Asian Region where cane molasses, cereal brans, and oilseed cakes are produced. Furthermore, cereal straw and sugar cane (source of cane molasses) represent the bulk of the ruminants' diet for most part of the year in the HKH Region.

Where cereal straws, poor pasture, and matured cut grasses are the main feed resources available, the productivity of ruminants can be markedly stimulated by adapting an appropriate feeding practice that ensures an efficient functioning of the rumen. This can be achieved through the use of urea molasses' multi-nutrient blocks, in which the essentially residual energy and protein, and a range of micro-nutrients, can be included to meet the marginal production function of animals, even under straw-fed conditions.

The role of UMB supplements is to improve the use of fibrous and low nitrogen diets in principal ruminants by correcting the nutritional deficiencies and imbalances. Based on this principal guideline, the development of UMB supplementation technology should meet the following pre-conditions to make a successful impact on the use of locally available feed resources.

(a) UMB technology is best applicable in those regions or countries where the majority of the ruminant population are raised on cereal crop residues and high fibre, low nitrogen feed for several months a year.

(b) UMB supplementation influences the production performance in animals raised in marginal feeding conditions more than those raised in high level production conditions; emphasising that the technology would be more appropriate for multipurpose farmers in the HKH Region.

(c) Based on the principal functions and basic constituents of UMB, the technology of block supplementation would be best fitted to the crop-livestock integrated farming system where the livestock production is dominated by multipurpose animals.

(d) The requirements for cane molasses as a carrier for urea and other nutrients reflect that suitable areas for the commercial preparation of UMBs would be at and around sugarcane growing areas with firmly established sugar mills. However, it is indicative that a similar type of nutrient blocks (mud based-blocks) can also be prepared from various materials without necessarily incorporating molasses.

(e) Although the UMB feeding practice has been demonstrated to be a cost-effective input, the success of UMB supplementation depends on the full cooperation and participation of farmers. This necessitates a well-coordinated field extension infrastructure, which more often then not is not effective in many developing countries because of socioeconomic conditions. The role of government agencies, such as the Department of Livestock and Agriculture, will have to be well-coordinated to promote such extension activities in field conditions. In recent years, several organisations and institutions, having well-planned and targeted field extension programmes, have developed within the government as well as non-government sectors of this region.

(f) The amount of feed resources for ruminants from forestlands and native pastures is deteriorating year after year, due to the overgrazing of pastureland in almost all parts of the HKH Region. Wherever this agro-ecological deterioration prevails, the use of UMB greatly helps to preserve the entire ecosystem through efficient use of crop and plant residues.

(g) Grazing animals are kept in sub-maintenance or semi-starved conditions from October to May each year in this region. In the dry season, there is an acute shortage of animal feed and its nutrient content is so poor that it can hardly provide the nutritional requirements of farm animals. This sort of feed deficit during winter causes much more distress in the high alpine areas of the HKH Region. Small supplements of UMB could serve as a survival dose for ruminants in times of feed scarcity and play a significant role in solving the nutritional problems of grazing animals.

Replication Possibilities in Nepal

Nepal is considered to be a country with a high density of livestock population per unit of land area. The majority of the population (more than 90%) earn their living from agriculture and are distributed in the mountains, the hills, and the *terai*, with an estimated distributional figure of 8.6 per cent, 47.7 per cent, and 43.7 per cent respectively. Only 17 per cent of the total land is brought under cultivation of which about 39 per cent and 56.5 per cent of the cultivated land lie in the hills and the *terai* respectively. It has been reported that there are about 5.4 million livestock units in the country, of which about 11.1 per cent, 51.9 per cent, and 37 per cent are in the mountains, the hills, and the *terai* respectively (Shrestha and Sherchand 1988).

Feed for Livestock

The total livestock population requires about 8643.4 thousand metric tonnes (MT) of the total digestible nutrient (TDN) for a minimal level of nutrition. This would pose a demand of about 1,071, 4,316, and

2,354 thousand MT of TDN by ruminants in the mountains, the hills, and the *terai* respectively. The total availability of livestock feed in the country is estimated to be about 5589.6 thousand MT of TDN, of which about 37 per cent of the total is derived from cereal crop residues and by-products alone. It is also indicative that cropland contributes 24 per cent and 37 per cent of the total requirements and availability of livestock feed in the country respectively (Table 9).

Table 9: Contribution of Cropland to Ruminant Feed

TOTAL	Mountains	Hills	*Terai*
1. Cultivated land, 2.3 million hectares	(4.1) (0.1)	(39.1) 0.9	(56.5) 1.3
2. Livestock units, 5.4 millions	(11.1) (0.6)	(59.9) 2.8	(37) 2.0
3. Total feed requirements, 8643.4 x 1000 MT of TDN	(12.4) 1071.9	(49.9) 4316.7	(37.7) 2354.8
4. Availability of feed, 5589.6 x 1000 MT of TDN	1240.7	2029.5	2319.5
5. Feed balance, 3053 TDN x 100 MT	+ 168.8	- 2287.3	- 935.4
6. Contribution of cropland to the total requirement of feed, 2085 x 1000 MT of TDN	(6.5) 70.9	(14) 602.3	(60) 1411.8

The total production of paddy, wheat, millet, and barley was estimated at 4,323 x 1000 MT in 1988/89 (Central Bureau of Statistics, Nepal, [CBSN] 1990), which gave about 4,323 x 1000 MT of crop residues, assuming the minimum proportion of grain to straw to be 1:1. If the utilisation of cereal straws for animal feeding is estimated to be 70 per cent of the total, it will provide about 1000 x 1,000 MT of TDN which will be enough to maintain two million LUs for seven months.

Sugarcane tops and maize stover are also considered important feed for ruminants in many parts of the country. Sugarcane as a cash crop is well-known and produces the highest amount of biomass among all cultivated crops. The total sugarcane production during 1988/89 was estimated at 900 x 1,000 MT (CBSN 1990) and a large portion of this was used by sugar factories. A significant amount of sugarcane tops are used for animal feeding, although these are highly fibrous and contain a negligible amount of nitrogen. Many working animals are fed on cane tops for several months a year in the plains. The work performance of these animals can also be improved by nutrient block supplements.

It is claimed that about three per cent cane molasses can be obtained from processed sugarcane stalks. This gives a figure of about 27 x 1,000 MT of molasses 900 x 1,000 MT of sugarcane which is equivalent to 20 x 1,000 MT of maize and almost equal to the total quantity of wheat bran produced in the country. The other feed ingredients, such as cereal brans and oilseed cakes, are locally available and fairly distributed throughout the hill and the *terai* regions. Traditionally, the cereal grains and oilseed cakes were used as concentrate supplemental feeds for estimated production of oilseeds in 1988/89 was about 99 x 1,000 MT. From this figure it can be calculated that more than 50 x 1,000 MT of oilseed cakes are available in the country. However, the extent to which these agro-industrial by-products are used in animal feeding has not been studied in detail.

Molasses in Livestock Feeding

Molasses are the by-product of sugar factories and are the only available source of readily fermentable carbohydrates that are widely available in the tropics. Historically, they are not a part of the human diet and are largely used in distilling alcohol (rum). The lack of technical knowhow regarding the efficiency of molasses in animal feeding has resulted in waste which are often discarded in rivers. However, the recent developments concerning the potential of molasses have indicated that the use of molasses in animal feed could be profitable and economically superior to its use as a raw material in alcohol production.

Molasses are widely used in feed compounds in the developed countries to improve the palatability and binding nature of pelleted feed. It is also used in reducing the dustiness of commercial animal feed. The inclusion rates of molasses in concentrated feed are at low levels (5% to 10%) because they increase the moisture content in the final product. Nevertheless, molasses are widely available in the country compared to other feed ingredients. The importance of molasses in terms of the their use are enumerated below.

a) As a major source of fermentable carbohydrate in ruminants' diets.

b) As a palatable carrier for urea and minerals to improve the use of fibrous and low nitrogen diets.

c) As a survival feed for ruminants during periods of feed scarcity, especially in winter.

d) As a binding agent to improve the dusty nature of compounded livestock feed.

Currently, molasses are used only in commercial feed mills in the country to improve the palatability and dusty nature of commercial livestock feed. The other ways and means of efficient use of molasses for production purposes have not been tried yet to any appreciable extent. The reason behind this limited use of molasses in animal feed can be attributed largely to the lack of technical knowhow in field conditions, rather than the complications and limitations arising from the indigenous farming system of the country. The traditional as well as the currently ongoing farming systems in Nepal are highly integrated with crop, livestock, and forestry systems, with an ultimate goal to optimise the overall agricultural and livestock productivity from the available resources by growing multipurpose crops, rearing multipurpose livestock, and recycling residues and by-products as nutrients for farm animals as well as for plants. Therefore, there is an unlimited prospect for the development of UMB in Nepal where many of the prerequisite conditions for successful application of the UMB technology are present as can be seen by the existing feed resources, types of farm animal, level of farmers' skills, climate, and the ecological conditions of the country.

Socioeconomic Conditions of Farmers

Most ruminants are owned by small farmers having less than 0.5 hectares of land. The size of landholdings in the hills is smaller than in the *terai*. The average family size of an average Nepalese farmer in the hills of Nepal is six persons with a livestock holding size of 2.4 cattle, 1.2 buffaloes, and 2.2 goats/sheep. This indicates that he must first earn enough food for his six family members then only he can think of improving the conditions of the livestock he owns. It was also reported that an average household produces a little more than 800 kg of cereals from about 0.49 ha of land (Shrestha and Sherchand 1988). This amount of cereal production also gives about 500 kg of cereal bran and about 1,500 kg of crop residue. The overall picture reflects that a normal household would be able to produce food to meet family needs for about five to six months in a year and for the rest of the time it would have to rely on external sources. Part of his daily household cash requirements can be met by selling one to two litres of milk from livestock raised on available pasture and on crop residues. The crop residues received from half a hectare of land would hardly be enough to meet the voluntary intake of his household livestock even for two to three months. For the rest of the winter farmers have to depend on community grazing land, forest, fodder trees, and cut grasses which, in most circumstances, are rare commodities for a small farmer.

A large part of the winter feed is provided by cereal straws and mill by-products in the *terai* where the average landholding size is about 1.7 hectares (about 70% larger than in the hills). In the above context, the conditions in high altitude areas is poor mostly because of the rugged and steep topography. Many data on the village economy and farming constraints are unknown. However, it has been reported that there is heavy livestock pressure in the high mountains with an estimated stocking rate of 0.48 LU/hectare of land and a large livestock holding of about 8 *yak*, 5.1 cattle, and 6.7 goats/sheep/ per household. Most of 'these livestock are migratory flocks which are grazed on alpine meadows and on rangelands. In recent decades, the productivity of these feed resources has declined continuously as a result of heavy soil erosion and deteriorating ecological trends. Nevertheless, during the dry season all of these feed resources, whether they are from native rangelands or are cut grasses or crop residues, are made up of highly fibrous contents with insufficient nitrogen to provide the ammonia needed by the rumen microbes for efficient fermentation. In the above situation, supplementing ruminant animals with urea in the form of UMB can bring about marked improvements in production as well as increased survival rates during winter scarcities.

Prospects of UMB Adoption among Nepalese Farmers

Almost all farmers do have a limited cash income and a large part of it is usually invested in household commodities. The foremost preference of a farmer is to ensure a food supply for his family. Afterwards he will mobilise his finances to purchase farm inputs such as fertilizers, insecticides, improved seeds, medicines for animals and plants, farm tools, and animal feed. Supply of these inputs is subject to socioeconomic constraints or lack of constraints. Hence the prerequisite for technical innovation, if it is to be successful, is that financial returns must ensue from capital investment within a short period of time.

In this context, several village level studies have shown that the provision of UMB supplements is a cost-effective input in dairy husbandry. Feeding UMB (10% urea) to cows in the village of Khaira District, India, resulted in a net saving of about Rs 250 (Indian Currency) per day (Kunju 1985). In a village in Bhutan, UMB gave a net return of about *Nu* 1.45/day through a 26 per cent increase in milk production from cows fed on a straw diet. The cost of UMB was 4.64 *Nu*/kg and that of the milk was 7 *Nu*/kg at the time of the study (1990). The study was conducted in the southern hills of Bhutan (Tala village) at an altitude of about 5,000 ft and accessible by gravel road. The climatic and topographical conditions of Tala village are similar to those prevailing in the mid-hills of Nepal.

It is envisaged that the cost of UMB production is much cheaper in Nepal than in Bhutan, since all the ingredients needed to manufacture UMB are available in Nepal, whereas in Bhutan almost all of the raw materials have to be imported from India and Nepal. Based on the above facts, a remarkable improvement in the net saving could be achieved through adopting the UMB feeding practice for dairy cattle. In the case of farm animals, other than lactating or draft animals, the immediate impact of UMB feeding may not be always detectable because the response to UMB supplements in terms of growth rate and draft power is difficult to measure quantitatively in field conditions.

Another characteristic of the UMB feed is that it is simple to handle and does not demand extra time from farmers and neither does it interfere with normal farm activities. All that is required is to leave the UMB in the feeding trough or to hang it within the reach of animals at all times. The application of UMB is not hazardous and almost free from risk, e.g., from urea toxicity. When the animals lick it, a continuous supply of fermentable carbohydrate (through molasses) helps the effecient use of ammonia (relecesed from urea) by microbes in the rumen without the absorption of free ammonia molecules into the brain of the animal. Furthermore, the feeding of UMB to ruminants does not conflict with any religious and cultural taboos.

Past experiences suggest that it is not easy to implement scientific innovations in livestock production at the village level, because it is quite a difficult task to convince small farmers to accept innovations, particularly when the farmers have to buy the farm input themselves. However, as long as the innovation has the ability to generate a marginal return from its application, farmers do adopt them; they are practical enough to carry out their own financial analyses before accepting any new technology.

Another critical problem is the difficulty in disseminating information on the new technology among large numbers of targetted farmers. The reason behind this are many and varied. The communication barriers among small farmers are further aggravated by the poorly developed transport and institutional infrastructures in many developing countries, and Nepal is no exception. In recent years, noticeable developments have been taking place in the field of transport and communications. For example, the total length of roads increased remarkably from 624 km in 1956 to 7,007 km in 1989, but only about 28 per cent of the roads are connected to districts and villages, of which more than 89 per cent are not suitable for trucks during all seasons. In high altitude areas, the means of transportation are limited to human porters and pack animals. Household commodities, such as food crops and salt, receive first priority for transportation and it is unlikely that remote area farmers will agree to transport secondary commodities such as insecticides, propagated seedings, or medicines for animals. The same applies to UMBs, unless handsome incentives are provided by some government or external institution. Therefore, it is too early to expect a high level of diffusion of UMB technology in the high mountain areas, not only because of poor transportation linkage but also because many livestock production functions as well as the local constraints are not adequately understood. In the rest of the country, there seems to be a great potential for UMB technology, especially in the milk-producing pocket areas of the hills and the *terai*.

It has been proved that the longer-term consequences of the transfer of technology from developed to developing countries has led to ultimate dependency on foreign inputs of superior animals and farm inputs to attain sound benefits from the transferred technology. Although the concept of nutrient blocks originated from the developed countries, its basic field technology field has been developed mostly in countries of Africa and Asia having similar socio-ecological conditions and livestock production constraints. The most important features of UMB technology for Nepal in terms of self-reliance are listed below.

(1) Adequate availability of raw materials for the preparation of UMB within the country.

(2) The UMB itself is made up of urea and agro-industrial by-products which are required for efficient utilisation of crop residues and low quality roughage; the only winter feed resources available for ruminants not only in the *terai* but also in the hills and the mountains.

(3) Feeding UMB to ruminants will help create a better environment and bring about a sound improvement in indigenous breeds, village farming systems, and available feed resources which have been seriously neglected so far.

Conclusions

The general objective for manufacturing UMB in Bhutan was to present a scientific approach for better livestock production within the framework of the utilisation of local feed resources. The detailed laboratory tests and field demonstration on the application of UMB illustrated the following points.

1. Oven-dried UMB, based on *Til* cake, was the most suitable for nutrient supplementation in terms of its hardness and nutritive value.

2. The temperature-controlled drying system for hardening UMBs was cheaper and more commercially viable than the use of chemical agents.

3. Use of oven-dried UMBs was a safe and practical approach for correcting nutritional deficiency in farm animals.

4. UMBs were palatable to all ruminants, *yak* took a longer time to finish a block than cattle and sheep.

5. The field demonstrations of UMB technology in high altitude areas indicated a high degree of acceptability on the part of livestock owners.

6. UMB supplements markedly improved milk production in dairy cows given fibrous diets.

7. The application of UMB technology in village conditions remarkably increased the net return from dairy enterprises.

The preliminary work for commercial production of UMBs in Bhutan was successfully completed. The outcome of the experiences on UMB technology and its broad application in ruminant production in Bhutan revealed the following.

1. The application of UMB technology is highly appropriate in those countries or regions where the agricultural production system is based on the integration of crop and livestock farming.

2. The technology can also be advocated to supplement feed in those areas where severe feed deficit problems are experienced each year.

3. The supplemental nutrient package, in the form of UMB, is widely accepted as the most appropriate technology providing essential nutrients to ensure that ruminal microbes digest local feed resources efficiently.

4. The prerequisites needed to develop UMBs are adequately available in Nepal and other HKH countries.

5. In order to improve the nutritional status of livestock in Nepal, UMB technology is feasible and promising.

6. A detailed study on the possibility of manufacturing nutrient blocks in Nepal is recommended.

POST SCRIPT

The Undertaking of UMB Production in Kathmandu Valley: Preliminary Observation

Information on the prevailing situation of livestock keeping in Nepal primarily indicates that the production performance of farm animals can be greatly improved by adopting a simple feed utilisation technology: urea molasses' block supplementation. It has been proved that feeding UMB to livestock plays a significant role in the use efficiency of straw for better animal production in the tropical and subtropical areas of Nepal, where the available feed for ruminants is limited to cereal straws.

Keeping in mind the background, a preliminary survey was made regarding whether entrepreneurs would be interested in launching UMB production. In this context, Ratna Feed Industry (RFI), located at Balaju in Kathmandu, was contacted. Their response to having a pilot-scale project on the preparation of UMB was instantaneous and enthusiastic.

In fact, RFI was also considered to be the most appropriate industry to introduce UMB production on a pilot scale. It is equipped with all the prerequisites and necessary infrastructure needed; e.g., mechanical mixers, drying oven, suitable space, and the basic ingredients needed for UMB production. It was also agreed that the required materials and facilities would be provided by the industry and that the product would be part of their product line.

The procedure recommended above for the preparation of UMB was principally followed with minor changes in some ingredients; wheat bran was totally replaced by boiled rice bran since the former is much more expensive than the latter and is not easily available in Kathmandu.

Wooden frames for moulding UM mixtures into brick size blocks were constructed locally. The preliminary preparation of UMB was commenced in February 1992 at Thecho, Lalitpur, where all the required facilities were made available. Altogether, about 250 UMB weighing 2.5 kg each were prepared by using a small electric drier, which could accommodate eight blocks at a time. This meant that only eight blocks could be produced per day. Therefore, it was decided to dismantled and reconstruct an old incubator to produce a drying oven that could accommodate more than 100 blocks at a time. The large size drying oven is now ready for use.

Feeding Demonstration

UMB, thus prepared, were fed to cows, buffaloes, and goats in the pastures and on a Balaju farm owned by the RFI proprietor who had some Jersey and Holstein-Freisian cows. More than 16 local farmers were involved in the short duration feeding demonstration at and around Thecho village. In all cases the UMBs were hung with a rope within the reach of farm animals at all times. Each farmer received one to four UMB for the test.

It was repeatedly reported that the daily straw intake of cows and buffaloes substantially increased, i.e., from five kg (without UMB) to eight kg (with the provision of UMB). On an average, the cows and buffaloes took a daily intake of 400 grammes and 600 grammes respectively. One farmer (Mr. Gopal Shrestha) observed an increase in the milk yield of a Jersey cow when she was continuously given UMB for 16 days. Other farmers who offered UMB for less than a week did not notice any change in milk production But in all cases it was claimed that there was an immediate positive response to straw consumption in cows.

At the Balaju farm, UMB were given to one Jersey and three Holstein Freisian cows for almost a month. All of them were basically fed on straw and concentrate-based diets. It was observed that among the four cows, the daily straw consumption increased from two *bhari* (15 kg = one *bhari)* to three *bhari* and the milk yield increased from 34 to 40 litres per day. These cows were given a new block every four to six days. The daily amount of concentrate feed for each cow was kept constant throughout the observation period.

Currently, there are about 100 blocks in stock. Further production of these blocks has been delayed for some time due to some formalities to be fulfilled before marketing this product. Advertisements directed at wholesale dealers have already been published in "*Krishi* Dairy" and other additional appropriate avenues of publicity will be made as soon as details regarding proper packaging of blocks are complete. It has been decided to cover the final block with printed wax paper to make it air tight. Necessary proof-reading sample and advanced payments have already been made for processing the wax paper with the label describing the type of product and its use. The final product should be launched within a month.

Expected Cost of UMB

As per the basic formula of UMB mixture, the tentative cost of raw ingredients alone may cost about five to six Rs/kg. However, is expected that the initial overhead cost will be much higher than estimated. Much of the overhead cost depends on advertisement and publicity. However, preliminary indications show that the final selling price could be between Rs 9 and Rs 10/kg. This cost can vary based on the demands for UMB in the market. Farmers' demands for UMB will depend on the degree of response of animals in terms of animal production. Its quick and positive effect on high fibre diets (such as paddy straws) could encourage farmers to accept the new product. Needless to say, the role of an appropriate marketing strategy for introducing and promoting any new product is crucial.

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