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Improving Animal Productivity by Supplementary Feeding of Multinutrient Blocks, Controlling Internal Parasites and Enhancing Utilization of Alternate Feed Resources

A publication prepared under the framework of an RCA project with technical support of the Joint FAO/IAEA Programme of Nuclear Techniques in Food and Agriculture

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FOREWORD

A major constraint to livestock production in developing countries is the scarcity and fluctuating quantity and quality of the year-round feed supply. Providing adequate good quality feed to livestock to raise and maintain their productivity is, and will continue to be, a major challenge to agricultural scientists and policy makers all over the world. The increase in population and rapid growth in world economies will lead to an enormous increase in demand for animal products, a large part of which will be from developing countries. Future hopes of feeding the millions and safeguarding their food security will depend on the enhanced and efficient utilization of alternative feed resources that cannot be used as food for humans. In addition, a large area of land in the world is degraded, barren or marginal and the amount is increasing every year. This also calls for identification and introduction of new and lesser-known plants capable of growing in poor soils, which can play a vital role in the control of soil erosion in addition to providing food and feed.

In developing countries, livestock are fed mainly on low quality roughages, including natural grazing and agro-industrial by-products, such as cereal straws/stovers, sugarcane by-products and other similar feeds, all of which contain large quantities of ligno-cellulosic material. These feeds are deficient in protein, energy, minerals and vitamins. In addition, at certain times of the year, the quality of grazing and browse deteriorates substantially due to seasonal influences, and livestock, productivity consequently declines, and in the case of lactation ceases, unless supplements are offered. Addition of foliage from tree leaves or supplementation with seed meals, or for ruminants' urea in the form of urea-molasses multi-nutrient blocks, can improve the utilization of low quality roughages mainly through the supply of nitrogen to the rumen microbes.

Attempts to increase the productivity of ruminants in developing countries generally encounter another principal constraint: health. Of the health constraints, bacterial and viral diseases can be successfully controlled 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, are the only methods of control method currently available. In developing countries, the losses induced by clinical and subclinical parasite infections have been estimated to equal the value of the present output of ruminant industries, therefore improved control has the potential to yield considerable productivity benefits.

The RCA (Regional Cooperation Agreement for the Asia and Pacific Region) project, RAS/5/035 entitled Improving Animal Productivity and Reproductive Efficiency was initiated in 1999 to assist RCA Member States to improve animal productivity and reproductive efficiency. This project had two components: animal nutrition, and animal reproduction. The animal nutrition component focused on: (i) developing and feeding of urea-molasses multi-nutrient blocks to supply nutrients deficient in crop residues and forages; (ii) using the urea-molasses multinitrient blocks for the delivery of anthelmintic medication to control gastrointestinal nematode parasitism; and (iii) enhancing efficiency of utilization of feed resources which are locally available and for which humans are not competing with livestock for food. The present publication presents results on these three aspects obtained by the participating groups from the RCA Member States and presented at the Final Review Meeting of the project held in October 2004 in Bangkok, Thailand.

This publication is a good source of reference for research workers, students and extension workers alike. It will help promote efficient utilization of feed resources and enhance animal productivity to meet the challenges imposed by the '*Livestock Revolution*' taking place in developing countries.

The IAEA officer responsible of this publication was H.P.S. Makkar of the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture, assisted in its compilation by a consultant, T. Smith from the University of Reading, United Kingdom.

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IMPROVING ANIMAL PRODUCTIVITY THROUGH MEETING NUTRIENT DEFICIENCIES WITH MULTI-NUTRIENT BLOCKS, ENHANCING UTILIZATION EFFICIENCY OF ALTERNATE FEED RESOURCES, AND CONTROLLING INTERNAL PARASITES: A SUMMARY

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1. INTRODUCTION

Livestock farming is crucially important for provision of animal-based food products for the population, and as a source of income for many resource-poor farmers in developing countries. With the increase in human population and economic growth of many Asian countries, the demand for livestock products is likely to double in the coming 20 years. However, the main constraint to livestock development in these countries is the scarcity and fluctuation in the quality and quantity of the year-around animal feed supply. Increased populations and industrialization are making arable land scarce and in addition a large area of the available arable land is being degraded due to human activities. For sustainable development of the livestock sector it is essential for RCA (Regional Cooperative Agreement for Asia and the Pacific) member countries to secure sufficient supplies of balanced feeds from resources which do not compete with human food. The conventional feeds such as soya bean, groundnut, rapeseed meals etc. are either not available or are available at very high cost. Most of the RCA member states have recognized the need to efficiently utilize locally available feed resources such as tree and shrub leaves, agro-industrial by-products and other lesser-known and new plants adapted to the harsh conditions and capable of growing in poor, marginal and degraded soils. A severe setback impacted to the livestock industry during the nineties by the financial crisis in Indonesia, Thailand, South Korea and Malaysia has played an important role in highlighting the importance of research and development in this area.

Another important limiting factor for enhancing animal productivity in tropical countries is the heavy internal parasitic load in livestock. The development of economically viable and environmentally friendly strategies and their strategic use for controlling internal parasites were also identified by the participating countries as one of the priority areas to be addressed in the project.

2. BACKGROUND AND OBJECTIVES

The regional Technical Co-operation (TC) project RAS/5/035 was initiated during the 1999–2000 biennium with the dual objectives of: (a) strengthening and extending the field applications of feed supplementation strategies (mainly Urea Multi-nutrient Blocks–UMB) for ruminant livestock; and (b) applying progesterone radioimmunoassay (RIA) in milk for monitoring and improving the reproductive management and fertility of smallholder dairy cattle subjected to artificial insemination (AI). This was subsequently extended for the 2001–2002 biennium with the new and expanded objectives of: (a) promoting the use of integrated management practices based on technologies developed under previous projects, through the establishment of pilot farms; (b) evaluating the suitability of lesser-known seed bearing or fodder producing plants as a source of low-cost animal feed; (c) establishing a regional capability for production and distribution of essential reagents for RIA; and (d) developing a database system for use by livestock service providers to assist farmers.

Each participating Member State (MS) nominated two Project Co-ordinators (PCs), one for the Animal Nutrition component and the other for the Animal Reproduction/AI component.

The first meeting to plan project activities was held in January 1999 in Yangon, Myanmar, and included training on use of the computer database, AIDA (Artificial Insemination Database Application), for recording, analyzing and interpreting field and laboratory data. The second meeting was held in February 2000 in Kuala Lumpur, Malaysia, and the third meeting in February 2001 in Manila, the Philippines. These were the project review and planning meetings. The project was extended for a final two-year period (2003–2004) in order to consolidate the progress made and to permit wider dissemination of the outputs from the project, and the third project review and planning meeting was held in November 2002 in Hangzhou, People's Republic of China.

The objectives of the extended project were:

- Development and use of medicated and non-medicated UMB for better nutrition, and establishment of facilities and training of personnel at the pilot farms and national extension agencies in the use of block technology and radioimmunoassay (RIA) for improved reproductive management and early non-pregnancy diagnosis (N-PD);

- Identification, propagation and use of sources from unknown or lesser-known plants, adapted to the region, as low cost animal feeds;

- Establishment of regional capability for the production and distribution of RIA reagents; and

- Development and making available two customized database applications, AIDA and SPeRM (Semen Processing Records Management), for use by national livestock breeding and AI services to assist farmers in improving reproductive management.

The first two objectives were for the Animal Nutrition component and the last two for the Animal Reproduction component.

The following Regional Training Workshops were organized:

- *In vitro* Techniques for Feed Evaluation, 16–27 April 2001, Jakarta, Indonesia;

- The use of standardized and validated nuclear-based technologies, in particular those based on urinary purine derivatives, for measuring microbial protein supply in ruminants, 10–21 June 2002, Kuala Lumpur, Malaysia; and

- Nuclear and related methodologies for quantification of tannins in shrub and tree leaves, agro-industrial by-products and other new feed resources, 1–12 December 2003, Faisalabad, Pakistan.

A total of 49 researchers participated in, and six experts with a total of 80 man days were recruited for, these training workshops. In addition, expert missions were also fielded to assist the counterpart staff in the national UMB training workshops and other related workshops. Experts also provided technical advice to the participating groups on necessary improvements to the technical protocols.

Through the above mentioned training workshops, the following nuclear techniques were introduced in the participating laboratories: (a) the *in vitro* gas production method coupled with ^{15}N-based microbial mass quantification for feed evaluation, enabling characterization of feed resources based on the recent concepts of animal nutrition; (b) isotopically-derived, non-invasive, purine derivative methodologies for estimation of microbial protein supply to animals, enabling evaluation of nutritional status of animals, correction of nutritional deficiencies and development of appropriate feeding strategies; and (c) ^{125}I-BSA (bovine serum albumin) and ^{14}C-PEG (polyethylene glycol) tannin assays, enabling efficient utilization of tree and shrub foliage and agro-industrial by-products as animal feed.

The final meeting was held in Bangkok, Thailand from 11 to 15 October 2004. The objectives of this meeting were to review the results obtained during the full period of the project, including field and laboratory work, cost-benefit analyses and in-country training and education activities. Each PC was required to prepare a written report in the form of a scientific paper, which was reviewed, technically edited and formatted for publication. This publication contains papers for the Animal Nutrition component, which focused on: (i) development and use of non-medicated multi-nutrient blocks for correcting nutrient deficiencies; (ii) development and use of medicated multi-nutrient blocks for controlling intestinal parasites and for correcting nutrient deficiencies; and (iii) identification, propagation and use of lesser-known alternative feed resources. Research and Development work on multi-nutrient blocks (sections i and ii) is presented together in Part I. Part II of this TECDOC covers alternative feed resources (section iii). Results from the Animal Reproduction component of this Technical Cooperation project will be published in another TECDOC.

3. SYNTHESIS OF RESULTS

A summary of the results obtained from the project is given in Tables I–X. A synthesis of the results, for each of the three components is given below.

3.1. Urea-molasses multi-nutrient blocks

- A total of 42 formulations were developed across the 12 MSs. One to seven formulations per MS addressing local availability of block components or specific regional nutritional requirements were produced.

- A total of 353 farms (range 1–84) and 2592 dairy cattle/buffalo, sheep, beef cattle/heifers and goats were used across the 12 MSs for evaluation of blocks.

- Block consumption: (a) increased voluntary feed intake by up to 30%; milk production by 6 to 100%; milk fat by 0.1 to 0.3 percentage units; and live weight by up to 20% for dairy cattle; 30% for beef cattle, and 70% for sheep and goats; and (b) decreased time to 1st oestrus by 11 to 30 days in dairy cattle and buffalo; the intercalving interval by up to 60 days; and faecal worm-egg counts.

Urea-molasses multi-nutrient blocks have been found to be highly beneficial in all MSs. The cost : benefit analysis of block use in dairy cattle ranged from 1 : 1.2 to 1 : 9.3 across MSs, with the average benefit being 1 : 3.3. They increased dairy farmer income by 5 to 180% per cow per day with an average increase of 38% across the MSs. Income from beef cattle and small ruminants increased by up to 30% per animal.

3.2. Medicated blocks and herbal anthelmintics

- Medicated blocks containing fenbendazole were prepared in seven MSs and one MS (Pakistan) produced blocks with levamisole.

- Pineapple leaves, *Momordica charantina,* Neem*, Anona squamosa, Stellaria chameajasmae, Curcuma aeroginosa*, Kenaf and commercially produced herbal remedies were assessed in nine MSs, either as a bolus dose or after inclusion in blocks.

- A large number of farms (91) were involved in evaluations of these blocks in 11 MSs using 833 animals, including cattle, buffalo, goats and sheep. The blocks containing fenbendazole, albendazole and levamisole were highly effectively in reducing faecal egg counts (> 90% reduction).

- Pineapple leaf effectively reduced the faecal egg count by 80–90%, both as a bolus dose or when delivered in blocks. Momordica, Cucurma, Stellaria, Anona, Kenaf and Neem all showed anthelmintic activity with a range of faecal egg count reductions of 44–90%.

- Commercial herbal preparations were tested in China (anthelmintic) and India (anthelmintic, ecobolic). These were highly effective when delivered in blocks.

- Effective worm control increased live-weight gain by up to 500% in young beef cattle and 80% in sheep. In Malaysia, effective worm control decreased mortality to zero and increased the reproduction rate by 300%.

- Six MSs have extended medicated blocks use to more than 800 farmers using fenbendazole or pineapple leaf as the anthelmintic. The low cost of herbal remedies makes this a preferred option in Myanmar, Bangladesh and Vietnam.

- In China, Pakistan and Sri Lanka medicated block use has not progressed due to additional costs involved in this type of treatment compared to conventional use of effective commercial preparations.

- The cost : benefit ratios for medicated block use ranged from 1 : 1.3 to 1 : 7.8 across the MSs. Medicated block use resulted in an increase in farmer income per animal of 33–445%.

3.3. Unconventional, alternate and lesser-known feed resources

- A large number of plants and plant-derived materials (175) were evaluated *in vitro* with 3–40 plant materials assessed by each of 11 MSs. Of these. A total of 37 plant materials showed potential as novel feed resources.

- A total of 50 potential feeds were evaluated *in vivo* by 12 MSs and 39 of these showed potential as animal feed.

- Five MSs have introduced novel feeding practices to farmers. More than 2450 farmers have been involved in the use of novel feed resources in these five MSs, with the greatest adoption rates being in China, Thailand and Vietnam.

- The cost : benefit ratio of using these novel feed resources ranged from 1 : 1.2 to 1 : 11 and averaged 1 : 3.7. Through the use of these feed resources farmer income increased by 9–185%.

4. CONCLUSIONS

- All the objectives of the project have been achieved. In addition, the project has enhanced the capacity of MSs in using nuclear-based and related methodologies for nutritional evaluation of feed resources.

- The linkages between research institutions and universities with extension agencies, including cooperatives and non-governmental organizations (NGO), have further improved through the project activities. This will facilitate the transfer of technologies from 'Lab to Land'.

- Several MSs have transferred the block technology to private small-scale firms and cooperatives, which will help in sustaining the technology and at the same time in enhancing income of farmers and private entrepreneurs. Other mechanisms such as use of revolving funds, involvement of cooperatives and NGOs have also been put in place to sustain the technologies introduced through the project.

- Extensive work has been done in all participating MSs on the development and use of urea-molasses multi-nutrient blocks, medicated blocks, and feed resources that do not compete with human food and can be obtained from plants capable of growing in poor and degraded soils.

- All participating MSs have conducted economic analyses of all the interventions used.

5. RECOMMENDATIONS

- The country reports should be edited and published. Distribution and promotion of the results of this project to MSs should result in considerable spillover benefits of the results of this research and development work to other areas where similar problems inhibit ruminant production.

- The project has come up with proven technologies (listed above). All participating MSs should capitalize on this and support wider extension of these packages and sustain them for the development of the livestock industry.

- The project activities are fully complementary to national livestock nutrition and breeding improvement programmes in participating MSs. Excellent achievements made by participating groups in this project should be used for attracting additional funding from international sources, thereby enabling extension of the benefits to wider farming communities.

- Techniques such as the *in vitro* gas method coupled with ^{15}N microbial mass production for feed evaluation, purine derivative-based microbial protein supply methodologies, and tannin assays should be integrated into the routine feed evaluation approaches.

The project has substantially contributed towards improving livestock productivity and increasing the production of milk and meat, hence leading to enhanced income levels of farmers. Moreover, a close coordination between this project, national projects and coordinated research programmes has been established, several laboratories have received complementary assistance for upgrading their facilities and for consolidating their experimentation capabilities in the field. As a result of this, a new project was proposed and initiated for the 2005–2006 TC cycle. The focus is on improving livestock productivity through better nutritional strategies while conserving the environment.

TABLE I. DEVELOPMENT AND EVALUATION OF UREA-MOLASSES MULTI-NUTRIENT BLOCKS

	Number of Formulations	Number of Farms	Number of Animals	Duration (months)
Bangladesh	1	48	60	24
China	4	84	559	1.5
India	1	65	195	1–3
Indonesia	7	50	820	4
Malaysia	7	8	80	4
Mongolia	4	1	6	1
Myanmar	3	19	207	4
Pakistan	6	10	173	3–5
Philippines	2	9	81	42
Sri Lanka	4	30	250	18–36
Thailand	1	28	222	24
Vietnam	2	1	20	18

TABLE II. RESPONSE TO SUPPLEMENTATION OF MILK COWS WITH UREA-MOLASSES MULTI-NUTRIENT BLOCKS

	Increase in intake (%)	Increase in milk produced (%)	Decrease in time to 1st oestrus (d)	Decrease in intercalving interval (d)
Bangladesh	30	33	30	40
China	–	4	–	–
India	–	8	40	–
Indonesia	–	17	–	–
Malaysia	–	50–100	90	–
Mongolia	–	6	–	–
Myanmar	–	7	83	–
Pakistan	21	9	–	40–60
Philippines	–	26	–	17
Sri Lanka	20–30	21	30	30
Thailand	–	2	11	40
Vietnam	–	11	25	30

TABLE III. INTAKE AND EXTENT OF THE USE OF UREA-MOLASSES MULTI-NUTRIENT BLOCKS

	Block Intake (g/d)	Maximum amount of block used (Tonnes/year)	Maximum number of farmers using blocks (/year)
Bangladesh	–	2.7	40
China	400	471	3230

	Block Intake (g/d)	Maximum amount of block used (Tonnes/year)	Maximum number of farmers using blocks (/year)
India	500–700	18	500
Indonesia	–	139	1653
Malaysia	–	180	230
Mongolia	120	16	32
Myanmar	–	141	633
Pakistan	–	50	800
Philippines	–	4	120
Sri Lanka	–	59	937
Thailand	500–700	80	240
Vietnam	1000	102	279

TABLE IV. IMPACT OF FEEDING UREA-MOLASSES MULTI-NUTRIENT BLOCKS

	Benefit/cost	Increase in income (/cow/d)	% Increase in income (/cow/d)
Bangladesh	2.4	11 Taka	22
China	2.0–2.3	2.3–2.6 Yuan	15–30
India	3.0	5 Rs	5
Indonesia	1.6	1900 Rupiah	23
Malaysia	1.2–1.4	2.50 Ringgit	50
Mongolia	9.25	185 Tugrig	37
Myanmar	2.2	40.6 Kyat	11–27
Pakistan	4.0	–	10
Philippines	1.9	40 Peso	26
Sri Lanka	5.5–7.6	28 Rupee	22–35
Thailand	1.2	31 Baht	23
Vietnam	2.8	3 610 Dong	180

TABLE V. A SUMMARY OF THE EVALUATION OF MEDICATED MULTI-NUTRIENT BLOCKS AND HERBAL REMEDIES

	Types	Farms	Animals	Duration (months)
Bangladesh	Fenbendazole 3 herbals	15–40	18–50 heifers	24
China	1 herbal	1	24 sheep	3
India	Fenbendazole 1 herbal	12	31 buffalo	1 week
Indonesia	Albendazole 2 herbal	8	120 cattle	3
Malaysia	Fenbendazole 4 herbal	2	60 goats 40 sheep	4–6
Mongolia	2 herbal	1	12	3 weeks
Myanmar	Fenbendazole 2 herbal	14	298 beef cattle	1
Pakistan	Levamisole	4	60 sheep and goats	6
Philippines	Nil	–	–	–
Sri Lanka	Fenbendazole 2 molybdenum	3	48 goats	6
Thailand	Fenbendazole	5	46 heifers	4
Vietnam	Fenbendazole 1 herbal	2	44 heifers	3

TABLE VI. RESPONSES TO MEDICATED MULTI-NUTRIENT BLOCKS AND HERBAL REMEDIES

	Decrease in faecal egg counts (%)	Increase in live weight (%)	Other benefits
Bangladesh	Neem 44–62 Pineapple 62–85	15	26% increase in milk production
China	89	–	–
India	Fenbendazole 83–100 Wopell 80	–	–
Indonesia		–	–
Malaysia	50–98	30–80	Decrease in lamb/kid mortality
Mongolia		–	–
Myanmar	74–86	–	–
Pakistan	90	3	–
Philippines	–	–	–
Sri Lanka	50–90	–	Increase in packed cell volume and haemoglobin concentration
Thailand	100	70	–
Vietnam	75	Fenbendazole, 81 in dairy cattle Pineapple leaf block, 500 in beef cattle	–

TABLE VII. THE EXTENT OF USE OF MEDICATED BLOCKS

	Maximum used (Tonnes/year)	Maximum farmers (/year)	Comments
Bangladesh	0.5	40	–
China	–	–	Not taken further due to lower costs of oral drenches
India	0.2	–	Experimental assessment only
Indonesia	1.5	110	–
Malaysia	30	135	–
Mongolia	–	–	–
Myanmar	9.6	420	–
Pakistan	1.0	4	Not taken further due to lower costs of oral drenches
Philippines	–	–	–
Sri Lanka	–	–	Not taken further due to lower c osts of oral drenches
Thailand	6.6	35	–
Vietnam	21.3	56	–

TABLE VIII. IMPACT OF MEDICATED MULTI-NUTRIENT BLOCK FEEDING AND HERBAL ANTHELMINTICS

	Benefit/cost	Increase in income (/animal)	Increase in income (%/animal)
Bangladesh	3.0–5.1	Milk – 16 Taka/d	33
China	–	–	–
India	–	–	–
Indonesia	1.4–1.7	Milk – 1500–5300 Rupiah/d	17
Malaysia	7.8	Meat – 312 Ringgit (total)	445
Mongolia	–	–	–
Myanmar	–	–	–
Pakistan	–	–	–
Philippines	–	–	–
Sri Lanka	–	–	–
Thailand	1.3	Milk – 12 Baht/d	1
Vietnam	5.1 FBZ	Dairy – Fenbendazole 4700 Dong/d	147
	2.8 Pineapple	Beef – Pineapple 9760 Dong/d	121

TABLE IX. *IN VITRO* AND *IN VIVO* EVALUATION OF NOVEL FEED RESOURCES

	In vitro		*In vivo*	
	Number evaluated	Number of promising resources	Number evaluated	Number of promising resources
Bangladesh	15	4	3	3
China	10	1	5	1
India	23	7	4	3
Indonesia	9	4	3	Mixture
Malaysia	5	2	5	4
Mongolia	18	1	In progress	To be identified
Myanmar	18	4	4	3
Pakistan	40	9	10	1
Philippines	17	4	3	Mixture
Sri Lanka	–	–	8	8
Thailand	3	3	3	3
Vietnam	5	3	2	1

TABLE X. USE OF NOVEL FEED RESOURCES

	Technology transfer		Impact	
	Nunmber transferred	Number of farmers	Benefit/cost	Increase in income (/cow/d)
Bangladesh	3	48	9–11	157 Taka(39%)
China	5	860	4	–
India	–	–	–	–
Indonesia	–	–	–	–
Malaysia	2	8	1.2–1.3	–
Mongolia				
Myanmar			3.2–6.2	125–250 Kyat
Pakistan	6	4	In progress	In progress
Philippines	Mixture of 4	–	3	–
Sri Lanka	8	1	In progress	In progress
Thailand	3	634	1.1	13 Baht (9%)
Vietnam	1	902	1.5–2.4	1000–1500 Dong (159–185%)

PART I.
MULTI-NUTRIENT AND MEDICATED BLOCKS FOR RUMINANTS

IMPROVING ANIMAL PRODUCTIVITY AND REPRODUCTIVE EFFICIENCY: DEVELOPMENT AND TESTING MEDICATED UREA-MOLASSES MULTI-NUTRIENT BLOCKS IN RURAL FARMS OF BANGLADESH

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Abstract

Urea-molasses multi-nutient block (UMMB) is low-cost technology and has great potential to enhance the nutrition of ruminant livestock in Bangladesh and improve animal productivity. Where it is required, UMMB may also be formulated to include anthelmintic medication to control nematode parasites and further improve production. A series of studies was conducted to develop and extend these technologies to rural farmers of Bangladesh. By feeding UMMB to smallholder dairy cows in two areas it was found that live-weight (LW) and condition score tended to be improved and milk yield was increased by 32–33%. In a second experiment, growing calves belonging to rural farmers were given Albendazole (7.5 mg/kg), fresh pineapple leaf (1.6 g/kg LW) or fresh neem leaf (1 g/kg LW) in single as well as split doses. Faecal worm egg counts were reduced by all treatments but pineapple leaves showed higher efficacy (97%) than neem leaves (67%) and overall, divided doses had lower efficacy than the single dose. A third study was then conducted where UMMB, medicated UMMB (0.5 mg fenbendazole/kg block)) and unsupplemented controls were compared in lactating cows. Both treatments improved milk yield and live-weight gain ($P < 0.05$). The medicated UMMB reduced faecal worm egg counts to zero while the UMMB without medication also yielded a 25% reduction. An on-station study was then conducted where pineapple leaf UMMB and neem leaf UMMB were compared to unmedicated UMMB. The blocks were prepared and fed in split doses over five days to lactating cows. Supplementation of UMMB with pineapple had significantly ($P < 0.01$) higher efficacy in reducing faecal worm egg counts than UMMB with neem, which had a greater effect than unmedicated UMMB. Similar trends were also observed in improvements in milk yield, milk fat concentration and live-weight gain ($P < 0.05$). The latter study was then repeated on rural farms where treatment efficacy and production responses were again clearly demonstrated for the UMMB with herbal remedies included. Subsequent pilot farm studies have shown that the farmers are interested in adopting this technology since production benefits are self evident. Local NGOs and Government Livestock Extension workers have also been trained to further extend the use of this technology in Bangladesh.

1. INTRODUCTION

Due to the shortage of feeds for ruminant livestock and the pressure on land utilization for food crop production for human consumption it is highly important to provide rural farmers of Bangladesh with technologies that are low cost, easy to adopt and economically viable. During the past, research on the development of such technology has been conducted and progress has been made [1]. However, most of the technologies generated have been confined to use within the research stations and not transferred to the rural areas, where the majority of the potential end-user farmers live. Urea-molasses multi-nutrient block (UMMB) is one technology that has gained importance in feeding dairy cattle in this country. Research on the improvement of the productivity of livestock through the supplementary feeding of UMMB gave beneficial results [2, 3, 4] in terms of improved growth and milk production of cattle and buffalo. Despite these results, limited efforts [4] have been made to apply this technology on a larger scale in the rural areas of the country where substantial impact could be experienced in dairy production systems. Therefore, studies were undertaken to disseminate the UMMB technology to the rural farmers.

Gastrointestinal nematode (GIN) infection is a chronic problem that hinders the improvement of productivity of livestock and is frequently associated with the low nutritional status of animals in Bangladesh [5, 6]. Gastrointestinal nematode parasitism of ruminant livestock causes significant loss in production in many developing countries through mortality and reduced production of milk, meat and work potential [7, 8]. In situations where nutritional deficiencies are likely to exacerbate the detrimental effects of parasite infection, the use of low cost supplements such as UMMB can enhance the animals' ability to utilize the available diets and assist the animal to withstand infection [9]. In situations where treatment is necessary, UMMB can be modified to include an appropriate dose of anthelmintic. It has been suggested that medicated UMMB can form an integral part of strategic parasite control programme as well as will upgrade the nutritional status of animals [9].

In Bangladesh, chemical anthelmintics are expensive and not readily available in rural areas and there is the danger that with frequent use, resistance to the anthelmintic chemicals could occur, as has been shown elsewhere [10]. Alternatively, traditional knowledge indicates that there are many plants that have medicinal values. Some of these have anthelmintic effects on man and animals which can potentially be utilized for controlling parasites in livestock and thus improve productivity. The present studies were conducted to determine the efficacy of local herbal remedies for GIN control and to determine whether UMMB could be used as a carrier of commercial anthelmintics and herbal remedies to improve animal productivity.

2. MATERIALS AND METHODS

2.1. Effect of feeding UMMB on milk production and body condition of dairy cows of rural smallholders in Muktagacha and Fulbaria

2.1.1. Place of study, grouping of animals and diets

Separate studies were conducted at Muktagacha and Fulbaria Upazilas (sub-districts) of Mymensingh. Sixteen lactating dairy cows were selected in Muktagacha area and 14 from Fulbaria, based on their body weight, parity and stage of lactation. The animals in each location were randomly divided into two equal groups based on their live-weight. One group in each location was offered UMMB for 45 days while the other group was an unsupplemented control. All animals were fed a basal diet of rice straw and some cut grass.

2.1.2. Preparation and feeding of UMMB and data recording

The UMMB was made by the cold method [11] and was fed to the animals, in addition to the normal feeding, at 250 g/head/d. Live-weight, body condition score and daily milk yield of each animal were recorded.

2.1.3. Statistical analysis

Data for growth performance and milk yield were subjected to the paired T test and were analysed accordingly.

2.2. Study on the efficacy of two herbal anthelmintics in single and divided doses against gastrointestinal nematode infection in cattle

2.2.1. Study area, selection of animals and treatments

Two separate experiments (single dose and divided doses of anthelmintics) were carried out in growing cattle (about 8 months of age) in the villages of Muktagacha subdistrict, Mymensingh district. The animals were selected based on the severity of nematode infection (egg counts in their faeces) and divided into three groups each having 10 animals. Each group was then assigned to one of three anthelmintic treatments – neem leaves (*Azadirachta indica*), pineapple leaves (*Ananas comosus*) and Albendazole were tested.

2.2.2. Collection and processing of herbal anthelmintics

Pineapple leaves were collected, washed and chopped into pieces for feeding to the animals. Neem leaves were collected washed and water extracted using a pestle and mortar. The latter method was adopted since an initial attempt to feed neem leaves to the animals failed due to its bitter taste and the animals' refusal to eat it. However, this problem was overcome by extraction with water prior to oral drenching.

2.2.3. Feeding anthelmintics to animals and collection of faeces

For Experiment 1, water extracts of neem leaves were given to the animals by oral drenching, chopped pineapple leaves were mixed with concentrate feeds and fed to the animals, and Albendazole was given as a tablet (7.5 mg/kg live-weight (LW); Fenzol (250 mg, Ethical Drugs Ltd) was dosed to the animals directly. The amount of fresh neem (1.0 g/kg LW) and pineapple leaves (1.6 g/kg LW) were given to the animals in amounts equivalent to 200 mg/kg LW of dried leaves. All the anthelmintics were given to the animals in a single dose.

For Experiment 2, the same anthelmintics were fed to the animals in equal split doses (or a single dose) for three consecutive days. The daily doses were: neem leaves 0.35 g fresh leaves per kg LW, pineapple leaves 0.55 g fresh leaves per kg LW and Albendazole 2.5 mg per kg LW. Faeces from animals were collected on day 0, 7, 14 and 21 and examined for nematode egg counts using both Stoll's method as well as the McMaster counting technique [12].

2.2.4. Statistical analysis

Data for faecal egg count reduction (FECR %) values of different treatments were subjected to statistical analysis for a randomized block design.

2.3. Efficacy of non-medicated and medicated UMMB against nematode infection of cows on farm

2.3.1. Study place and animals

The research was carried out in the villages of Muktagacha sub-district. The experiment was conducted over 45 days with 12 lactating dairy cows. Animals were selected for the experiment based on milk production, stage of lactation and the GIN egg counts in their faeces. They were divided into three groups (A, B and C) with each group having four animals.

2.3.2. Preparation of medicated UMMB and feeding the animals

The UMMB was modified to medicated UMMB by adding 0.5 g fenbendazole/kg block during preparation. Group A was the control receiving neither UMMB nor any drug, Group B received UMMB with no drug and Group C received UMMB with fenbendazole.

The UMMB and medicated UMMB were fed to groups B and C, respectively at 250 g/d/cow. All groups received basal diets of rice straw, small amount of cut grass and rice polishings.

2.3.3. Parameters studied and chemical analyses

Live-weight, body condition score and milk yield were recorded for each cow. Milk samples were collected before the start and prior to the end of the experiment and analysed for milk protein and fat. Faecal samples were collected in the morning prior to block feeding and thereafter at day 7, 15, 30 and 45 of the experiment and were examined for GIN egg counts.

2.3.4. Statistical analysis

Data for weight gain and milk yield were adjusted for initial live-weight and for initial milk yield, respectively, as covariates and were analysed accordingly. However, data related to faecal egg counts, body condition score and milk composition were subjected to analysis of variance for a Randomized Complete Block Design (RBD).

2.4. An on-station study on the efficacy of two herbal anthelmintics in UMMB against gastrointestinal nematodes in lactating cows

2.4.1. Study place, selection and grouping of animals and their diets

The study was conducted in the Animal Nutrition field laboratory of Bangladesh Agricultural University, Bangladesh, for a period of 60 days. Nine dairy cows were selected based on the severity of nematode infection (300 or above eggs per g of faeces), and also on milk production and parity. The cows were allocated to three groups (A, B and C), each having three animals. Three rations were formulated with rice straw, green grass, wheat bran and mustard oil cake as the basal ingredients and were supplied twice daily (splitting the total feed into two equal portions) to the three groups. The herbal anthelmintics were added to the rations of two groups while the remaining group was the control (see below for details).

2.4.2. Preparation and feeding of herbal fortified UMMB

Leaves of the herbal anthelmintics were freeze-dried and ground and the required amount (200 mg/kg LW of cows) added to the ingredients of UMMB and mixed. Group A (control) received UMMB carrying no herbal anthelmintics. The UMMB containing pineapple leaves and those containing neem leaves were fed to the animals of group B and C respectively. Each block was weighing 2.5 kg and was fed to each cow for five days making the dose rate of 500 g/cow/d.

Collection of data and of faeces and examination for eggs, and Statistical analysis were as described above.

2.5. Supplementation of straw-based diets with UMMB carrying two herbal anthelmintics to improve milk production of dairy cows on-farm

2.5.1. Study area, selection animals and their diets

The work was carried out in the villages of Muktagacha sub-district. The experiment was conducted for a period of 60 days with 18 lactating dairy cows. Animals were selected based on milk production, stage of lactation and the GIN parasite egg counts in their faeces (300 or above eggs per g of faeces). They were divided into three equal groups based on their live-weight.

2.5.2. Preparation and feeding of herbal fortified UMMB

See section 2.4.2.

Collection of data and of faeces and examination for eggs, and Statistical analysis were as descrived above.

3. RESULTS

3.1. Effect of feeding UMMB on milk production and body condition of dairy cows of rural smallholders in Muktagacha and Fulbaria

The results of the studies are presented in Tables I and II, for Muktagacha and Fulbaria respectively. The results of the experiments in both areas showed similar trends in terms of milk yield, body weight gain and condition score. Although a small increase was observed in the UMMB fed animals compared to the non-fed groups, there was no significant difference in body condition score (BCS) of the cows between the UMMB supplemented groups and the non-supplemented groups. Body condition scores recorded on day 45 of the experiment showed that BCS tended to increase during the experiment in the UMMB groups whereas BCS remained static in of the non-supplemented groups. However, live-weight gain was significantly (P <0.05) higher in the supplemented group than the control (non-supplemented group) in Fulbaria (Table II). This was not the case in Muktagacha, where there was no significant effect of UMMB feeding on live-weight (LW) gain (Table I). Live-weight of animals of the unsupplemented group in both areas decreased compared to the UMMB fed group. In both areas, supplementation with UMMB significantly (P <0.05) increased milk production in the cows compared to the unsupplemented control cows.

TABLE I. MILK YIELD AND PERFORMANCE OF COWS FED ON DIETS SUPPLEMENTED WITH, OR WITHOUT, UREA-MOLASSES MULTI-NUTRIENT BLOCK (UMMB) IN MUKTAGACHA AREA (EXPERIMENT 1)

Parameter	Dietary groups #		SED	Significance	Increase %
	A	B			
Initial LW (kg)	249.4	235.1	–	–	
Final LW (kg)	249.0	237.2	–	–	
Average LW change (g/d)	–8.9	46.67	21.31	NS	
*Initial body condition score	3.60	3.55	0.485	NS	
Final body condition score	3.55	3.75	0.401	NS	
Initial milk yield (L/d)	4.50	4.45	–	–	
Final milk yield (L/d) on day 45	4.10[a]	5.46[b]	0.108	*	33.2

A = Unsupplemented control group; B = UMMB group

[a,b]Mean values having different superscripts in a row differ significantly

NS, not significant

*Body condition score, 1 = emaciated, 5 = overfat

TABLE II. MILK YIELD AND PERFORMANCE OF COWS FED ON DIETS SUPPLEMENTED WITH OR WITHOUT UREA-MOLASSES MULTI-NUTRIENT BLOCK (UMMB) IN FULBARIA AREA (EXPERIMENT 2)

Parameter	Dietary groups #		SED	Significance	% Increase
	A	B			
Initial LW (kg)	235.7	228.1	–	–	
Final LW (kg)	234.9	238.0	–	–	
Average LW change (g/d)	-17.78^{a}	51.6^{b}	12.28	*	
Initial body condition score	3.28	3.25	0.323	NS	
Final body condition score	3.20	3.45	0.379	NS	
Initial milk yield (L/d)	3.40	3.45	–	–	
Final milk yield (L/d) on day 45	3.00^{a}	3.98^{b}	0.212	*	32.7

A = Unsupplemented control group; B = UMMB group.
*Body condition score, 1 = emaciated, 5 = overfat
The values with different superscripts in a row differ significantly (*P* <0.05)

3.2. Medicated blocks and herbal anthelmintics

3.2.1. Efficacy of single dose application of herbal anthelmintics against nematode infection in cattle

Table III shows the faecal egg count reduction percentage (FECR %), of different treatments on different days in terms of controlling nematode parasites in cattle. On day seven the efficacy of Albendazole was significantly (*P* <0.01) higher than that of pineapple and neem leaves. On day 14, the FECR % values for Albendazole and pineapple were significantly (*P* <0.05) higher than neem leaves. Similar results were observed on day 21. These efficacy data of all three treatments clearly indicate that pineapple leaves are better herbal anthelmintics than neem leaves, however, the latter has moderate anthelmintic action in cattle.

TABLE III. FAECAL EGG COUNT REDUCTION VALUES (FECR %) OF NEMATODE PARASITES IN CATTLE GIVEN TWO HERBAL ANTHELMINTICS AND ALBENDZOLE IN SINGLE DOSE

Day	Faecal egg count reduction (%)			SED
	Neem leaves (*Azadirachta indica*)	Pineapple leaves (*Ananas comosus*)	Albendazole	
7	55.0^{b}	75.5^{b}	100.0^{a}	9.60
14	57.5^{b}	82.2^{a}	87.8^{a}	13.16
21	67.5^{b}	97.0^{a}	97.8^{a}	19.57

The values with different superscripts in a row differ significantly (*P* <0.05)

3.2.2. Efficacy of divided dose application of herbal anthelmintics against nematode infection in cattle

Table IV shows the overall efficacy of the different anthelmintic treatments over time against GIN parasites in cattle. The efficacy of Albendazole was the greatest on day seven but decreased on day 14 and again increased on day 21. The efficacy of both the herbal anthelmintics increased as the experiment progressed but the efficacy of pineapple leaves was higher than for neem leaves on each occasion.

TABLE IV. FAECAL EGG COUNT REDUCTION VALUES (FECR %) OF NEMATODE PARASITES IN CATTLE GIVEN TWO HERBAL ANTHELMINTICS AND ALBENDZOLE AT DIVIDED DOSES FOR THREE DAYS

	Faecal egg count reduction (%)			
Day	Neem leaves (*Azadirachta indica*)	Pineapple leaves (*Ananas comosus*)	Albendazole	SED
7	64.8	74.0	84.3	11.08
14	66.1^b	81.2^{ab}	97.5^a	15.93
21	71.2^b	92.1^a	92.1^a	9.96

The values with different superscripts in a row differ significantly (P <0.05)

3.3. Efficacy of non-medicated and medicated UMMB against nematode infection of cows

The faecal worm egg count (FEC) at different periods (Table V) showed that the medicated UMMB completely cleared the parasite eggs in animals by seven days and this was maintained throughout the experimental period. In contrast, the animals in the control group showed an increase in the FEC as the experiment progressed while the animals of the UMMB group showed a slight increase in egg counts up to the 15th day but thereafter the FEC declined by 2.35% and 25.0% at days 30 and 45 respectively. It is interesting to note that the animals fed UMMB without medication showed significantly lower (P <0.05) egg counts than those offered the unsupplemented control diet by the 45th day of experimentation.

TABLE V. EFFICACY OF MEDICATED UREA-MOLASSES MULTI-NUTRIENT BLOCK (UMMB) AGAINST GASTROINTESTINAL NEMATODES IN DAIRY COWS

Sample	*FEC of dietary groups			SED	Level of significance
	A#	B#	C#		
Initial	838	850	925		
7th day	888^a	900^a (–5.9%)	0^b (100%)	128.4	**
15th day	888^a	875^a (–2.9%)	0^b (100%)	105.2	**
30th day	1025^a	830^a (+2.4%)	0^b (100%)	103.9	**
45th day	1037.5^a	637.5^b (+25%)	0^c (100%)	96.8	**

A = Unsupplemented control group; B = UMMB group; C = medicated UMMB group. Values in the parentheses are the efficacy of the respective treatments.
The values with different superscripts in a row differ significantly (P <0)
** Indicates significant difference between treatments (P <0.01)
* FEC = faecal egg count

There was a significant (P <0.01) difference in live-weight gain between control and treated groups but no significant difference was found between UMMB and medicated UMMB groups (P >0.05) (Table VI). The highest live-weight gain (56.8 g/d) was recorded in the medicated UMMB group whereas the animals of the unsupplemented control group lost live-weight (–23.7 g/d). Although there were no significant differences in overall daily milk yield of cows fed the different dietary treatments, significant differences between treatments were observed when the data was analysed fortnightly. During the first fortnight, the average daily milk yield of all groups was similar but during the second and third fortnights animals supplemented with UMMB (P <0.05) and medicated UMMB (P <0.01) gave significantly more milk than the unsupplemented control group.

Milk composition at day 45 showed no significant effect of the different treatments although protein and fat percentages of milk of UMMB and medicated UMMB groups tended to be slightly higher than that of the unsupplemented control group.

TABLE VI. EFFECT OF UREA-MOLASSES MULTI-NUTRIENT BLOCK (UMMB) AND MEDICATED UMMB ON LIVE-WEIGHT, BODY CONDITION, MILK YIELD AND MILK COMPOSITION OF DAIRY COWS

Parameter	Dietary groups #			SED	Level of significance
	A	B	C		
Average LW change (g/d)	–23.68[a]	41.91[b]	56.78[b]	14.22	**
Initial milk yield (L/d)	2.50	2.50	2.50	–	–
Average milk yield (L/d)	2.29	2.81	2.97	0.412	NS
Milk yield in different periods (L/d):					
Day 1–15	2.49	2.56	2.56	0.040	NS
Day 16–30	2.38[a]	2.83[b]	2.93[b]	0.159	*
Day 31–45	2.00[a]	3.03[b]	3.42[b]	0.241	**
Initial milk protein (g/100 g)	3.90	3.88	3.90	0.08	NS
Milk protein on day 45 (g/100 g)	3.88	3.95	3.98	0.06	NS
Initial milk fat (g/100 g)	4.23	4.25	4.23	0.16	NS
Milk fat on day 45 (g/100 g)	4.43	4.60	4.75	0.19	NS

A = Unsupplemented control group; B = UMMB group; C = medicated UMMB group
* Indicates significant difference between groups (*P* <0.05).
** Indicates significant difference between groups (*P* <0.01)

3.4. Efficacy of herbal anthelmintics in divided doses with UMMB against nematode infection in milking cows on-station

The efficacy of different anthelmintic treatments in herbally fortified UMMB in terms of the faecal egg count reduction percentage (FECR %) in cows is shown in Table VII. It can be seen from the table that throughout the experimental period the efficacy of both the herbal anthelmintic groups was significantly (*P* <0.01) higher than that of the unmedicated UMMB control group. Among the herbal anthelmintic groups pineapple leaves gave significantly higher efficacy than neem leaves at every faecal collection. There also appeared to be a progressive increase in the efficacy of treatment over time

Table VIII shows that there were significant (*P* <0.05) effects of herbal anthelmintics on milk yield and live-weight gain of cows. The average daily milk yield was significantly (*P* <0.05) higher in animals of both pineapple and neem groups compared to the control group. Among the herbal anthelmintics groups, the use of pineapple leaves resulted in significantly (*P* <0.05) higher milk yield than neem leaves. There were no significant differences in milk protein content between the three treatments, however, pineapple leaves gave higher (*P* <0.05) fat content of milk with the control group having the lowest values for both fat and protein contents.

3.5. Efficacy of herbal anthelmintics in divided doses with UMMB against nematode infection in milking cows on-farm

The efficacy of different anthelmintic treatments in herbally fortified UMMB in terms of the faecal egg count reduction percentage (FECR %) in calves is shown in Table IX. Throughout the experimental period pineapple leaf gave significantly *(P* <0.01) higher efficacy values than neem leaf and the control group. However, neem leaves also resulted in improved FECR % (*P* <0.01) than the control diet. The data also showed that there was a progressive increase in the efficacy of treatments over time and greatest efficacy was at day 60 in all cases.

TABLE VII. EFFICACY (FAECAL EGG COUNT [EGGS PER g, EPG] REDUCTION, FECR %) OF HERBAL ANTHELMINTICS IN DIVIDED DOSES WITH UREA-MOLASSES MULTI-NITRIENT BLOCK (UMMB) AGAINST NEMATODE INFECTION OF LACTATING COWS ON-STATION

Animal Group	Dewormer	Initial EPG	FECR (%) post-treatment on day				
			7	15	30	45	60
A	Only UMMB	490	–2.55[a]	4.65[a]	9.45[a]	18.21[a]	18.44[a]
B	UMMB with neem leaves	500	45.43[b]	51.36[b]	56.79[b]	60.29[b]	63.45[b]
C	UMMB with pineapple leaves	480	62.45[c]	71.67[c]	77.33[c]	82.45[c]	84.31[c]
SED		38.86	6.23	9.58	7.56	7.59	11.51
Level of significance		NS	**	**	**	**	**

** Indicates significant difference between groups (*P* <0.01); NS, non significant

TABLE VIII. EFFECT OF HERBAL ANTHELMINTICS IN SPLIT DOSES WITH UREA-MOLASSES MULTI-NUTRIENT BLOCK (UMMB) ON MILK YIELD AND COMPOSITION OF DAIRY COWS ON-STATION

Parameter	Dietary groups #			SED	Level of significance
	A	B	C		
Average LW change (g/d)	71.91[a]	82.68[a]	96.78[b]	14.22	*
Initial average milk yield (L/d)	4.05	4.10	4.00	–	–
Average final milk yield (L/d)	4.75[a]	5.10[b]	5.45[c]	0.28	*
Initial milk protein (g/100 g)	3.81	3.80	3.85	0.05	NS
Milk protein on day 60 (g/100 g)	3.93	3.89	3.98	0.08	NS
Initial milk fat (g/100 g)	4.30	4.31	4.30	0.12	NS
Milk fat on day 60 (g/100 g)	4.60[a]	4.72[a]	4.84[b]	0.10	*

A = Control group (only UMMB); B = UMMB + neem leaves group; C = UMMB + pineapple leaves group;
* Indicates significant difference between groups (*P* <0.05); NS, not significant

TABLE IX. EFFICACY (FAECAL EGG COUNT [EGGS PER g, EPG] REDUCTION, FECR %) OF HERBAL ANTHELMINTICS IN SPLIT DOSES WITH UREA-MOLASSES MULTI-NUTRIENT BLOCK (UMMB) AGAINST NEMATODE INFECTION OF LACTATING COWS ON-FARM

Animal Group	Dewormer	Initial EPG	FECR (%) at post-treatment on day				
			7	15	30	45	60
A	Only UMMB	600	1.60[a]	6.55[a]	12.63[a]	20.05[a]	20.12[a]
B	UMMB with neem leaves	550	43.63[b]	52.55[b]	55.80[b]	59.11[b]	61.46[b]
C	UMMB with pineapple leaves	630	61.65[c]	69.84[c]	79.32[c]	83.55[c]	85.31[c]
SED		41.54	5.83	8.92	5.90	7.98	10.23
Level of significance		NS	**	**	**	**	**

** Indicates significant difference between groups (*P* <0.01)

Table X shows that there were significant (P <0.01) effects of herbal anthelmintics in split doses on live-weight gain of the animals and similar results were found for milk production. The average daily milk yield was significantly (P <0.05) higher in animals of both pineapple and neem groups than that of the control group. Again, pineapple leaves treatment gave significantly (P <0.05) higher milk production than that of neem leaves. Milk composition was not significantly affected by herbal treatments but tended to be higher when compared to control.

TABLE X. EFFECT OF HERBAL ANTHELMINTICS IN DIVIDED DOSES WITH UREA-MOLASES MULTI-NUTRIENT BLOCK (UMMB) ON MILK YIELD AND COMPOSITION OF DAIRY COWS ON-FARM

Parameter	Dietary groups #			SED	Level of significance
	A	B	C		
LW change (g/d)	45.41[a]	59.87[b]	77.67[b]	14.22	**
Initial milk yield (L/d)	3.40	3.45	3.40	–	–
Final milk yield (L/d)	4.15[a]	4.35[a]	4.75[b]	0.31	*
Initial milk protein (g/100 g)	3.80	3.83	3.87	0.07	NS
Milk protein on day 60 (g/100 g)	3.85	3.90	3.95	0.08	NS
Initial milk fat (g/100 g)	4.33	4.35	4.23	0.17	NS
Milk fat on day 60 (g/100 g)	4.43	4.65	4.67	0.20	NS

A = Control (only UMMB); B = UMMB + neem leaves; C = UMMB + pineapple leaves.
* Indicates significant difference between groups (P <0.05)
**Indicates significant difference between groups (P <0.01)
NS, not significant

4. DISCUSSION

4.1. Effect of feeding UMMB on milk production and body condition of dairy cows of rural smallholders in Muktagacha and Fulbaria

Several studies in Bangladesh have shown that supplementation of straw-based diets with UMMB increases the live-weight gain of growing calves and milk production of dairy cows and buffalo [2, 4]. In the present study, experiments in two areas showed that UMMB feeding significantly increased milk production and live-weight gain of cattle. The increase in body condition score of the animals due to block feeding, although not statistically significant, also indicates that UMMB has positive effects on the general health of the animals. Further work with a greater number of animals should confirm this. In addition, in many situations we cannot anticipate an increase in body condition score simultaneously with a substantial increase in milk yield. This is because there will be partitioning of the additional nutrients generated by UMMB use between milk synthesis and live-weight gain and the greater part of the nutrients would be expected to be diverted to milk production. In both studies, milk production was significantly increased by 32–33% with UMMB feeding. Of primary importance to this study, was that all the farmers involved in the trials spontaneously reported that the feeding of UMMB as a supplement to normal diets increased the health and body condition of growing calves and the body condition and milk production of dairy cows.

4.2. Study on the efficacy of two herbal anthelmintics in single and divided doses against gastrointestinal nematode infection in cattle

The efficacy results from this experiment indicate that single doses of Albendazole and both herbal remedies (i.e. pineapple and neem leaves) are effective in controlling GIN infection in cattle. Between the two herbal remedies, neem leaves were moderately effective and the pineapple leaves were highly effective in controlling GIN. Compared to Albendazole, neem leaves and pineapple leaves were not as effective in reducing egg burdens of the animals within seven days of administration but by three weeks after dosing pineapple leaf was as effective as Albendazole. A similar level of efficacy for neem leaves has been previously observed on day 21 in goats [13] while the observed 98% efficacy of a single dose with pineapple leaves at 200 mg/kg live-weight accords with previous findings for cattle in the Philippines [14].

When Albendazole and the herbal remedies were administered in split doses, the efficacy was lower than that found in a single dose. For Albendazole this is probably due to the sub-therapeutic level of the drug in the dosing regimen used and such an approach is not recommended unless low level dosing is continued for sufficient time for therapeutic efficacy to occur. In contrast, this seems to be not true in case of the herbal remedies where the efficacies were similar to those for the single dose.

4.3. Efficacy of UMMB and medicated UMMB against nematode infection of cows

Faecal worm egg counts during the experiment indicate that the UMMB medicated with fenbendazole (0.5 g/kg block) was highly effective for the treatment as well as prevention of parasitic reinfection in dairy cows. It was also observed that use of UMMB without medication resulted in a reduction (25%) in faecal worm egg counts over time. Although there was no significant increase in total milk yield at the end of the study after UMMB and medicated UMMB treatment, closer analysis showed that there was a significant increase during the 2nd and 3rd fortnights. The lack of a significant increase in total milk yield is probably due to the high SED value, resulting from the small group sizes used for this experiment which was difficult to avoid in this on-farm study. The effect of medication on live-weight gain and milk production tended to be greater than with UMMB alone, but was not statistically significant in this study. We could expect a higher milk yield and live-weight gain in the medicated UMMB group as the GIN infection would be reduced and the availability of nutrients for milk production and growth increased. Further studies involving greater numbers of animals are required to fully evaluate this possibility.

4.4. Efficacy of herbal anthelmintics in divided doses with UMMB against nematode infection in milking cows on-station

Both herbal remedies were effective in reducing faecal worm egg counts when incorporated into UMMB and fed to dairy cows. The efficacy of pineapple leaf UMMB was significantly higher than neem leaf UMMB throughout the study indicating that it is more effective in controlling GI nematodes in lactating cows. This accord with the findings reported above for single doses with these same herbal remedies. It is also interesting to note that the UMMB without medication showed some effects in reducing faecal worm egg counts. This finding is supported by previous work that showed urea supplementation had some effects in reducing nematode burdens in sheep through improved immunity resulting from enhanced rumen function and increased nutrient availability [15]

Both the herbal remedies when incorporated into UMMB significantly increased milk yield and live-weight of animals compared to non-medicated UMMB. This is probably because the herbal remedies reduced the nematode burden in the gastrointestinal tract of the cows as previously observed for single doses with the same plant materials [13, 14], Once the worm burden is removed more nutrients are available to the animals for productive purposes [16, 17] and milk composition and yield and live-weight gain can be improved.

4.5. Efficacy of herbal anthelmintics in divided doses with UMMB against nematode infection in milking cows on-farm

The efficacy of herbal anthelmintics on the GIN of cows under rural conditions was similar to that described above. The pineapple leaf containing UMMB were more effective in controlling nematodes in cows than neem leaf containing UMMB. For milk production and weight gain, the herbal remedies incorporated into UMMB again significantly increased milk yield and live-weight of animals compared to non-medicated UMMB. The underlying reasons for these responses to treatment have been discussed above.

5. COST-BENEFIT OF NON-MEDICATED AND MEDICATED UMMB STUDIES

The cost-benefit ratios from the experiments with feeding UMMB and medicated UMMB to dairy cows on-farm were calculated and are shown in Table XI. It is clear from this table that feeding both types of UMMB to dairy cows is cost-effective. By feeding non-medicated UMMB to lactating cows an additional profit of Tk. 9.14/d was generated from 0.75 L of milk per day when compared to the unsupplemented control group. Feeding medicated UMMB prepared with pineapple and neem leaves increased net profits by 122% and 33%, respectively. The experiment also shows that although the efficacy of the drug Albendazole is 97 to 100%, the cost of this treatment exceeded the benefits generated in extra milk production. These cost : benefit analyses clearly indicate that feeding medicated UMMB containing herbal anthelmintics to dairy cows under rural condition is more profitable than non-medicated UMMB and medicated UMMB containing Albendazole.

TABLE XI. COST AND NET PROFIT FROM HERBALLY FORTIFIED UREA-MOLASSES MULTI-NUTRIENT BLOCK (UMMB) SUPPLEMENTS TO LACTATING COWS IN RURAL FARMS

Parameters	Without UMMB	With UMMB	UMMB with neem leaves	UMMB with pineapple leaves	UMMB with Albendazole
Initial milk yield (L/cow/d)	3.40	3.40	3.45	3.40	3.40
Final milk yield (L/cow/d)	3.00	4.15	4.35	4.75	4.90
Additional milk (L/cow/d)	–	0.75	0.90	1.35	1.50
Value of additional milk (Tk./cow/d)	–	13.50	16.20	24.3	27.00
Cost of UMMB/medication UMMB for additional milk (Tk./d/cow)	–	4.00	4.00	4.00	4.00
Cost of Albendazole (Tk/dose)	–	–	–	–	20.00
Net profit	–	9.14	12.20	20.30	3.00
Cost **:** benefit ratio	–	1 : 2.4	1 : 3.0	1 : 5.1	1 : 0.75

Note: Cost per kg UMMB was Tk. 8.00, price of per L of milk was Tk. 18.00 and price of one dose of Albendazole was Tk. 20.00

6. IMPACT GENERATED BY THE ADOPTION OF MEDICATED UMMB IN RURAL FARMS AND THE MECHANISM ADOPTED TO MAKE IT SUSTAINABLE

Information on this technology was disseminated in the villages of Muktagacha subdistrict of Mymensingh and Delduar sub-district of Tangail. Sixteen pilot farms in each area (32 farms in total) were included in the study. The farmers attended a field day and were lectured and given demonstrations on UMMB preparation, medicated UMMB preparation and the benefits of herbal anthelmintics in controlling GIN parasites in cattle. Initially, to get them started, the farmers were supplied with previously prepared medicated UMMB. The herbal anthelmintics were supplied to them during the field day demonstrations and later they were shown how to collect and prepare and mix the herbal remedies with the UMMB. Demonstrations on the feeding of UMMB and recording of data were also given with follow-up monitoring over time. A few leading farmers from the pilot farms were considered as the central persons to disseminate the UMMB technology to other farmers. This was done through a number of practical demonstrations on the preparation of UMMB at the premises of both the potential and experienced pilot farmers. During these demonstrations, a farmer was asked to give a talk on the benefits he derived from adopting this technology followed by a demonstration of UMMB and medicated UMMB preparation for the other farmers.

The farmers have reported that medicated UMMB increased milk yield by more than 1.0 kg per day, the animal's feed intake was increased and overall health was improved. On seeing the benefits obtained a few neighbouring farmers have shown interest and have contacted us to get advice in preparing and feeding the medicated block to their cows. In addition, one farmer in each area has volunteered to prepare medicated UMMB to sell to other farmers who are regularly feeding it to their animals.

Leaflets and folders were distributed in the local language to the pilot-project farmers as well as to other interested farmers. The folders and leaflets describe how to prepare and feed UMMB and medicated UMMB to cattle and the potential benefits to be derived from their use. We initially started with 16 pilot farms but now the technology has been disseminated to some 50 farmers in each of the target areas.

We have also held several field demonstrations and distributed leaflets among the farmers and NGOs on the preparation and feeding to animals of UMMB and medicated UMMB. Training was also given to the NGO field workers and Livestock Extension workers on the preparation and feeding of medicated blocks to livestock so that they can instruct farmers and assist in the propagation of this technology.

7. CONCLUSIONS

Supplementation with UMMB to lactating cows on a straw based diet on rural farms improved live-weight and body condition score and increased milk yield. The efficacy of herbal anthelmintics was compared to Albendazole. Pineapple leaves showed greater efficacy than neem leaves whether delivered as a single or divided dose. On the Research Station, delivery of these herbal remedies in medicated UMMB also resulted in substantial reductions in faecal worm egg counts and increased milk production and live-weight gain in dairy cows. In this study UMMB with pineapple leaf had significantly higher efficacy than UMMB with neem leaf. This evaluation of herbal remedies in UMMB was repeated on-farm where similar results were observed. Feeding herbal fortified UMMB to lactating cows increased weight gain and milk yield and the farmers readily accepted the technology and measures have been taken to extend its use in rural areas of Bangladesh.

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EFFECTS OF UREA-MOLASSES MULTI-NUTRIENT BLOCK (UMMB) ON CATTLE/YAK PRODUCTION AND MEDICATED UMMB (MUMB) ON CONTROL OF PARASITES IN SHEEP IN GANSU PROVINCE, CHINA

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Abstract

Urea-molasses multi-nutrient blocks (UMMB) were prepared and evaluation trials conducted in Gansu Province, China. Supplementation with UMMB had a positive effect on animal performace. In Jiuquan, cross-bred beef cattle (local X Simmental) aged 1.5 years were offered UMMB during a 45 day fattening period. After the fattening period, each animal was worth an extra 80.8 Yuan of net profit from the additional weight gain and the cost/benefit ratio was increased by more than four times. A production increase of smaller magnitude was evident in a trial in Linxia with chauri (cattle X yak), aged from 8 to 12 years, and the cost/benefit ratio was 1 : 2.3. Another trial was conducted in dairy cows (cross-bred local X Friesian Holstein) in Yunchang, in 2000, where UMMB supplementation resulted in a significant increase in milk production with a cost/benefit ratio of 1 : 5.6. Detailed studies on rumen NH_3–N levels were conducted in cannulated yak before and after eating UMMB and the dynamic concentration of NH_3–N level increased by two to five times when UMMB was available. A trial with UMMB containing herbal anthelmintic medication was carried out in sheep in Linxia and Yunchang and it was shown that this treatment was as effective as the conventional treatment with albendazole. Economic evaluation of this treatment showed that the cost of medicinal herbs was four times that of chemical anthelmintics to control parasites and, hence, this method is not likely to be adopted by smallholder farmers in this area of China.

1. INTRODUCTION

Gansu Province, with 454 000 square km of land (of which 3 486 167 ha are arable), is located between the Tibetan Plateau, Loess Plateau and the Western Desert in China. The rainfall ranges from 500 mm in the south to 50 mm in the north-west. The average temperature is 12°C with a maximum of 33°C and a minimum of –25°C. Its unique climatic and geographical conditions represent almost all situations in the neighboring provinces. Traditionally, Gansu is an agro-pastoral zone of China where farmers raise ruminants for meat, milk, wool and draught power. Livestock frequently provides the main cash income, especially in recent years since the price of cereal grain has declined. In addition, the cost of poultry and pig production has also declined over time while the price of milk and cattle and sheep meat has remained stable, and hence more and more farmers are switching to raising cattle and sheep to boost their income.

According to statistics from the Agriculture Ministry of Gansu, 1.2 and 0.51 million ha of arable land are used to grow wheat and maize, respectively [1]. This results in a large amount of wheat and maize straw. The cattle and sheep industries almost totally depend on these roughages for fodder. The populations of cattle and sheep in 2003 were 3.7 and 12.8 million respectively (Gansu Agricultural Yearbook Editorial Committee, 2003). These ruminants are grazed on natural grassland in the pastoral area and cereal based fodder (including maize silage, maize straw and wheat straw) in the cropping areas. In the last decade, the government has encouraged farmers to raise cattle in order to reduce poverty and to fully utilize crop residues. However, the productivity of ruminant livestock has been restricted by the feed supply since the basal diet of most cattle and sheep almost totally consists of roughage. To improve productivity and profits, farmers have used increasing amounts of cereal grain based concentrates for meat and milk production but this has introduced competition since grain is used for human consumption. In contrast, 6.3 million tons of maize straw and 1.1 million tons of wheat straw are produced annually and are not used efficiently. The Government has encouraged farmers to develop the so-called 'straw-animal-industry' for utilizing the straw more efficiently. Under this initiative, farmers are eager to obtain new technologies for roughage and crop residue utilization. Previous work in China and other developing countries has shown that urea-molasses multi-nutrient blocks (UMMB) are an efficient and effective means of nitrogen supplementation.

Livestock production in Gansu still suffers from parasitic diseases although recommendations for preventative measures are well developed and parasite control is already practiced. Recently, China has become a World Trade Organization member and scientists, government policy makers and farmers are becoming more concerned about drug residues in animal products for international markets since chemical medicines are used for parasite control. Based on investigations conducted by the Veterinary Medicine Service of Gansu Province, the Institute of Veterinary Medicine of the Chinese Agricultural Academy, Gansu Agricultural University and local Institutes of Veterinary and Animal Husbandry in some prefectures, the major species and infection rate of helminth parasites of sheep remain high. Compared with sheep, the infection rate of cattle with parasitic helminths is much lower. The parasite species distribution and infection rate for both species of host tends to vary greatly between regions.

The seasonal influences on nematode infections have been studied through post-mortem analyses and faecal egg counts [2]. The results indicate that the rate of infection of adult sheep appears greatest in spring commencing in March or April, the peak of infection occurs from April to June and then decreases after July but a small rise in infection may also occur in autumn (from August to October). The infection rate is low in winter. For one-year-old lambs, or younger, the situation is different from the adult. The infection rate of *Dictyocaulus* spp. is highest in spring (April to May), but for the other nematodes the peak of infection appears to occur in summer (from July to August). Infection rates of lambs are low in winter. The infection level of cattle is generally much lower than sheep. For both species, the infection rate of younger animals is greater and more severe than in adults due to lower level of resistance to infection.

In current government disease prevention strategies, animals should be treated with anthelmintic medicine (albendazole, 10–20 mg/kg LW) twice a year (late autumn and early spring). The cost of medicine is one Yuan per sheep unit per year and four Yuan per cattle unit per year. In 1984, the sheep and cattle in Xiahe were treated with albendazole and the adult sheep survival rate was increased by 4.5% and lamb survival rate was increased by 20.7% [3]. Sheep mortality can be more than 10% in epidemic years [3]. It has also been shown that the working ability of severely infected draught cattle can be reduced by 33 to 50% and their working life reduced by three to five years [4]. It has been estimated that the annual economic loss caused by parasites is 15% to 20% of total livestock production in parasite infected areas of Gansu [3].

Traditionally, the most common herbs used for parasite control are *Areca catechu, Cyrtomium fortunei, Quisqualis indica, Rheum officinale, Gleditsia sinensis, Salix cupularis, Milytta lapidescens, Melia toosenda, Cucurbita moschate* and *Carpesium abrotanoides*. A number of these herbs are selected and combined into one dose and crushed into powder, made into a solution with water and then used as a drench. Normally one dose costs two Yuan for sheep and six Yuan for cattle. Historically, this type of treatment has played an important role in veterinary practice but no publications are available that provide details of efficacy of herbal anthelmintic treatments. More recently, application of traditional remedies appears to be declining due to the low price and convenience of albendazole and other commercially available anthelmintics.

The present work set out to accurately determine the benefits of UMMB use in Gansu Province in order to provide information for wider promotion of this technique to farmers. In addition, research was conducted on providing anthelmintic medication in UMMB in local production systems.

2. MATERIALS AND METHODS

2.1. Supplementation with UMMB

2.1.1. UMMB

Animals were offered UMMB as a supplement at an average of 0.5 kg/d. The ingredients and chemical composition of the block are shown in Tables I and II.

The UMMB was made by the following procedure: a) the salt, bentonite, rapeseed cake, sesame cake, wheat bran, maize flour and bone meal were mixed in a mechanized mixer; b) at the same time, the urea and water were put into a pan for heating to form the urea solution; c) the coarse wheat flour was put into another pan and water added; d) the dampened wheat flour was added to the urea solution and stirred into a fine paste; e) the paste and molasses were put into the mixer with the other ingredients; f) after mixing, the mixure was put into the mould to press. Each block weighed 5 kg. The procedure for making medicated blocks (MUMB) was same as for UMMB, except that albendazole was added before the first mixing, and the finished blocks weighed 1 kg.

TABLE I. INGREDIENTS AND THE COST OF UMMB

Ingredients	Proportion (%)	Price (Yuan/kg)*
Molasses	10.0	1.10
Urea	10.0	1.20
Salt	7.0	1.00
Bentonite	30.0	0.30
Rape seeds cake	12.5	1.20
Sesame cake	12.5	1.20
Wheat bran	4.0	0.60
Maize	8.0	0.90
Bone meal	3.0	2.00
Coarse wheat flour	3.0	1.00

*US$ 1 = 8.261Yuan

TABLE II. CHEMICAL COMPOSITION (g/kg DRY MATTER) OF THE UREA-MOLASSES MULTI-NUTRIENT BLOCK

Crude protein	Crude fat	Phosphorous	Calcium
360.7	10.6	12.4	26.5

2.1.2. Trials

Trial 1

Twelve cross-bred beef cattle (local cattle x Simmental), of 1.5 years of age, were selected for fattening trial from 22 December 1999 to 6 January 2000 in Jiuquan, Gansu. The animals were divided into two groups on a live-weight basis, six as an unsupplemented control and six offered access to UMMB at 0.5 kg/head/d. The basal diet was 10 kg of wheat straw and 1 kg of maize flour per head per day. Body weight was recorded at the start and finish of the trial.

Trial 2

A trial was arranged to monitor the effect of UMMB in the beef production system in Linxia, Gansu, where farmers in the agro-pastoral area collect old cull chauris (cross-breds between yak and cattle) from the pastoral area for fattening prior to sale for slaughter. Thirty chauri, aged between 8 and 12 years, were divided into two groups on a live-weight basis, 15 as an unsupplemented control and 15 supplemented with 0.5 kg/head/d UMMB for 60 days, from 6 January 1999 to 6 March 2000. The basal diet was 10 kg of wheat straw and 1.7 kg of maize flour per head per day. Body weight was recorded at the start and finish of the trial.

Trial 3

Eight cross-bred dairy cows (local x Friesian Holstein), four years of age, were selected for trial from 25 September to 5 October 5 2000 in Yunchang, Gansu. Four cows were used as an unsupplemented control and four were supplemented with UMMB at 0.5 kg/head/d. The basal diet was 10 kg of maize silage and 2 kg of maize flour per head per day. Milk yield was recorded for the 15 days of the trial.

Trial 4

To investiagte the rumen NH_3–N level in yak, with and without UMMB, research was conducted at the Alpine Grassland Station of Gansu Agricultural University in December 1999. After recovery from surgical rumen cannulation, 3 4–year-old yaks were grazed freely on grassland and supplemented with 10 kg of oats per head per day. Rumen liquor samples were then extracted through the cannula of each yak at two hourly intervals for 24 h for spectrometric measurement of NH_3–N. The yaks were then given 0.5 kg of UMMB per head per day for seven days before the rumen liquor was again sampled at two hourly intervals for 24 h. *Ad libitum* water was offered twice daily throughout the experiment.

2.2. Supplementation with MUMB

2.2.1. Animals

Twenty-four sheep were selected in each of Linxia and Yunchang for testing the efficiency of medicated block and chemical medicines for nematode parasite control. The sheep were divided into two groups. One group was given albendazole tablets (20 mg/kg live-weight, Kangruqing, made by Jiangsu Wujing Animal Medicine Factory) and the other group was offered 200 g/head medicated block containing herbal medicine (molasses 40%, rapeseed cake 20%, coarse wheat flour 20%, and herbal medicine 20%). The usual dose of the herbal remedy is about 42 g, and includes *Areca catechu* 6 g; *Cyrtomium fortunei* 8 g; *Quisqualis indica* 6 g; *Milytta lapidescens* 6 g; *Carpesium abrotanoides* 8 g; *Cnidium monnieri* 8 g. This prescription was determined, through discussion between the parasitologist from Gansu Agricultural University and the veterinarians from the local animal production services, based on the principles of traditional Chinese veterinary and medicine theory. All animals were fastened for 24 h before treatment. Faecal nematode egg counts conducted before and 24, 48 and 72 h after treatment were used to test determine efficacy of treatment.

3. RESULTS

3.1. Supplementation with UMMB

Trial 1

The results from Jiuquan are shown in Table III and indicate a significant difference in live-weight gain between control and UMMB treatment (P <0.01). By the end of the experiment, the live-weight gain of animals fed with UMMB was 17.6 kg greater (130.4% higher) than those without UMMB. Compared to the control, the farmer using UMMB could make an extra 80.8 Yuan of net profit from each animal after the 45 day fattening period with a very attractive cost/benefit ratio being shown.

TABLE III. EFFECT OF UREA-MOLASSES MULTI-NUTRIENT BLOCK (UMMB) ON BEEF CATTLE IN JIUQUAN

Group	No. of animal	Initial weight (kg)	Final weight (kg)	Weight gain (kg)	Daily gain (kg/d)
Control	6	214.5 ± 27.8	228.0 ± 26.1	13.5 ± 1.8	0.300 ± 0.040
UMMB	6	220.9 ± 31.7	252.0 ± 28.7	31.1 ± 4.1**	0.691 ± 0.092*
Cost/benefit assessment:					
	Cost of diet (Yuan/d)		Increased Profit (Yuan/d)		Cost : benefit
*Control	2.00		1.800		1 : 0.90
UMMB	0.55		2.346		1 : 4.27

* Indicates a significant difference between groups (P <0.01).

**Control diet = 1 kg maize flour × 1.0 Yuan/kg + 10 kg wheat straw × 0.1 Yuan/kg

Cost of UMMB = 1.1 Yuan/kg × 0.5 kg; price of LW = 6 Yuan/kg

Trial 2

Table IV indicates that the increase in live-weight gain due to UMMB use was not as high as that in Jiuquan (see above) although the effect of UMMB was significant (P <0.01). This difference in treatment effects may be because the animals used were much older than those in Jiuquan. In spite of that, the net profit with UMMB was 67.7 Yuan more than with the control diet and the cost/benefit ratio increased by 2.3 times.

TABLE IV. EFFECT OF UREA-MOLASSES MULTI-NUTRIENT BLOCK (UMMB) ON CHAURI (YAK × CATTLE), LINXIA

Group	No. of animal	Initial weight (kg)	Final weight (kg)	Weight gain (kg)	Daily gain (kg/d)
Control	15	424.6 ± 15.7	464.9 ± 12.8	40.3 ± 5.4	0.672 ± 0.090
UMMB	15	422.6 ± 16.5	480.2 ± 16.2	57.6 ±4.1**	0.960 ± 0.068*
Cost/benefit assessment:					
	Cost of diet (Yuan/d)		Increased Profit (Yuan/d)		Cost : benefit
Control	3.28		4.032		1 : 1.23
UMMB	0.60		1.728		1 : 2.88

* Indicates a significant difference between groups (P <0.01).
**Control diet = 1.75 kg concentrate × 1.3 Yuan/kg + 10 kg wheat straw × 0.1 Yuan/kg
Cost of UMMB = 1.2 Yuan/kg × 0.5 kg; sale price, per kg, 6 Yuan/kg

Trial 3

Compared with the beef cattle, the dairy cattle showed a greater response to UMMB supplementation (Table V). The daily milk yield was increased by 1.2 kg per day per head and the cost/benefit ratio was the highest in this trial.

TABLE V. EFFECT OF UREA-MOLASSES MULTI-NUTRIENT BLOCK (UMMB) SUPPLEMENTATION ON MILK YIELD OF COWS IN YUNCHANG

	Milk yield (kg/d)	
Control	23.4 ± 0.57	
UMMB	24.6 ± 0.29*	
Cost/benefit assessment:		
Cost of diet (Yuan/d)	Increased Profit (Yuan/d)	Cost : benefit
UMMB 0.6	3.36	1 : 5.6

* Indicates a significant difference between groups (P <0.01).
Control diet = 5 kg concentrate × 1.3 Yuan/kg + 20 kg maize silage × 0.8 Yuan/kg
Cost of UMMB = 1.2 Yuan/kg × 0.5 kg; Price of milk = 2.8 Yuan/kg

Trial 4

The concentrations of NH_3–N in yak rumen over 24 h with and without UMMB are shown in Table VI. The NH_3–N levels were increased by two to five times with UMMB supplementation, which explains why the production performance of UMMB treated animals in the above trials markedly improved over their respective controls.

TABLE VI. THE EFFECT OF UREA-MOLASSES MULTI-NUTRIENT BLOCK (UMMB) ON NH_3–N LEVEL IN YAK RUMEN (mg/L)

Time	Without UMMB		With UMMB	
	Average	SD	Average	SD
08:00	4.09	± 1.04	10.44**	± 0.31
10:00	5.22	± 0.29	11.97**	± 0.47
12:00	5.94	± 0.46	13.77**	± 0.08
14:00	4.31	± 0.60	12.77**	± 0.51
16:00	2.73	± 0.32	10.77**	± 0.79
18:00	5.69	± 0.37	11.49**	± 0.26
20:00	4.14	± 0.41	11.88**	± 0.64
22:00	3.52	± 0.38	11.21**	± 0.12
00:00	2.35	± 0.50	9.14**	± 0.46
02:00	1.58	± 0.26	6.16**	± 0.72
04:00	2.21	± 0.48	5.02**	± 0.55
06:00	3.09	± 0.25	3.43*	± 0.25

* Indicates a significant difference between groups ($P < 0.05$)
**Indicates a significant difference between groups ($P < 0.01$)

3.2. Parasite control through supplementation with MUMB

The results are given in Table VII.

TABLE VII. THE EFFECT OF ANTHELMINITIC TREATMENT

Location	Group	Treatment	Eggs/g faeces (EPG)			
			Before treatment	After treatment		
				24 h	48 h	72 h
Yunchang	A	Albendazole tablet	1590 ± 112	75 ± 30	33 ± 19	33 ± 19
	B	Medicated block	1600 ± 91	83 ± 30	33 ± 19	25 ± 13
Linxia	A	Albendazole tablet	1183 ± 104	242 ± 61	333 ± 93	67 ± 23
	B	Medicated block	1325 ± 127	650 ± 90	375 ± 69	100 ± 33

Number of animals in each group = 12

There was no consistent difference between the albendazole and medicated block treatments which means that the medicated block could possibly replace albendazole. However, the cost of the medicated block (herbal medicine) is 2 Yuan and this is four times the cost of albendazole tablets (0.5 Yuan per dose). The effect of both anthelmintic treatments appeared to be different between the two locations with a greater effect at Yunchang. The body conditions of animals in the two locations also differed.

4. DISCUSSION

4.1. Formula of UMMB

The UMMB formula tested was shown to be suitable for use in the production systems for which it was designed. Extension workers have suggested that the above-mentioned formula can be modified according to the available feed resources in different areas with little impact on the provision of essential nutrients. For example, the proportion of rapeseed cake and sesame cake could be reduced in areas where these residues have been supplied to animals as a component in the basal diet. In other locations where molasses is not readily available, the molasses could be replaced by wheat flour to provide a digestible energy source. Micro-elements, such as Se, which are lacking in the soil and locally available feeds in certain areas, could also be added. It was shown that the formulation can also be used to carry medication to control parasites if required.

A wooden box can be adapted to control block intake if required. This has been shown to work on the demonstration farms in Yunchang during training workshops for extension workers. We also suggested to trainees to use other containers according to availability. Another solution is to reduce the amount of block offered to an amount that can be consumed within one day.

4.2. Procedure of UMMB making

In Jiuquan, farmers prefer blocks of smaller size and regular shape. For this reason, we have suggested to reduce the block size to 3.5 kg, or smaller. Regarding the problem of some blocks splitting after manufacture and storage, the heated urea solution should be put into the wheat flour slowly with rapid stirring of the mixture in order to make a good paste. Based on our experience, the molasses can be totally replaced by wheat flour (use 0.5 kg of wheat flour to replace 1 kg of molasses) if required.

4.3. Production benefit of UMMB use

The benefit from UMMB supplementation was satisfactory with both dairy cattle, beef cattle and chauri, the cost : benefit ratio being 1 : 5.6, 1 : 4.27 and 1 : 2.88 for each group respectively. These results were similar to those obtained for white yak (1 : 3.5) and black yak (1 : 2.11) grazing on alpine grassland [4]. The benefits may be due to the increased NH_3–N level in the rumen.

It is noted that the benefit of UMMB supplementation in dairy cattle is much higher than beef and chauri and farmers have recognized this. This indicates targeting this technology initially at dairy farmers.

4.4. Parasitic load

Due to the effort made by the Government in the recent years, the major pathogenic helminth parasites in most areas have been controlled, especially on the large-scale farms. Most farmers have realized the effect of parasites on animal production and have been trained to use chemical medicine to control nematode parasites. Some farmers also have the knowledge to use locally available herbal medicines. However, animal production still suffers from parasites in the remote/pastoral areas of Western China. In these areas, the livestock of small householders/herders are frequently affected by parasites and feed shortages because it is difficult to access the local animal production service network and other resources like education and marketing.

During our project work, it was difficult to find infected sheep to be used for anthelmintic treatments in large-scale family farms and on smallholdings in developed areas, so all sheep used in this study were from more remote areas. It is suggested that future work on parasite control should, therefore, focus on the more remote pastoral areas.

4.5. Medicated blocks

In order to make the medicated blocks attractive for the animals to eat, herbs frequently used in the typical prescription were those without a strong smell. The prepared MUMB were still not very attractive to the animals and some cereal was placed on top of the blocks to persuade the animals to consume them.

The economic evaluation for anthelmintic treatment is difficult since the animals raised in the developed areas were recently treated with chemical medicine so a comparison was not possible. However, in the remote areas animals are frequently moved off-farm, either for sale or for slaughter. For the purpose of the trial, we carried out whole family farm experiments (all sheep on the farm received the same treatment). Two family sheep farms were selected and one of them was used as a control (only given albendazole tablets), another represented a treatment (given MUMB containing albendazole, the MUMB was replaced by UMMB after five days, the intake of albendazole was twice that of the control). The faecal egg counts were similar on both farms suggesting that both albendazole tablets and MUMB, containing albendazole, are suitable approaches for parasite control.

5. CONCLUSIONS

The urea-molasses multi-nutrient block (UMMB) technique was developed and demonstrated under IAEA projects RAS/5/030 and lately RAS/5/035 in Gansu Province. Through the demonstrations and recording of production benefits, farmers have realized that UMMB supplementation is efficient for cattle or yak supplementation and it increases the productivity and the profit. Incorporation of anthelmintic medications into the UMMB led to successful control of nematode parasites but conventional chemical treatments are more likely to be practiced due to their substantially lower cost.

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REPRODUCTIVE PERFORMANCE OF DAIRY BUFFALO RECEIVING SUPPLEMENTS OF UREA-MOLASSES MULTI-NUTRIENT BLOCK (UMMB)

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Abstract

Buffalo are the predominant dairy animal in India. However, poor nutrition limits their productive and reproductive efficiency. The effects of supplementary feeding of urea-molasses multi-nutrient blocks (UMMB) prepared by an easy 'cold method' were assessed during different phases of reproduction in dairy buffalo. Supplementary feeding during the pre-partum period improved post-partum reproductive efficiency in terms of days to first oestrus (34 vs 48 d) and conception rates (30% vs 0%) when compared to unsupplemented controls. The effects of UMMB supplementary feeding were more pronounced in buffalo kept in rural areas by marginal farmers than in those kept on organized farms, due to the differences in the basal diet in each system. Pre-partum UMMB supplementation also improved the post-partum milk yield. Supplementation with UMMB in buffalo calving at a young age induced a higher proportion (71% vs 14%) to exhibit oestrus during the first 50 days post-partum, compared to unsupplemented controls. Milk yield was greater and peak milk yield was maintained for a longer duration with UMMB supplementation during the post-partum period. Supplementation with UMMB for 30 days in buffalo with delayed onset of puberty induced oestrus in 33% of heifers during the summer season and in 93% of the heifers during the winter season. Similarly, in anoestrus adult buffalo, UMMB supplementation induced ovarian activity in 40% of buffalo during the summer season and in 90% buffalo during the winter season. In addition, UMMB supplementation was shown to increase the effect of pregnant mare serum gonadotropin (PMSG) used for induction of oestrus in anoestrus and delayed pubertal buffalo. Medicated blocks could be successfully used for easy dispensing of herbal drugs to decrease placenta retention or reduce nematode parasite burdens in buffalo. Overall, UMMB supplementation improved milk production and reproductive efficiency in dairy buffalo and could be easily adopted by marginal farmers.

1. INTRODUCTION

Buffalo are an integral part of agriculture in South Eastern Asia and this species of livestock contributes significantly to the economy and social status of its farmers. However, inadequate nutrition is one of the factors that frequently limits the full utilization of the productive and reproductive potential of this species in this region. It has been estimated that India is deficient in green fodder by 30% for ruminant livestock but produces 360 million tons of agricultural by-products annually. Developing alternate feeding strategies for ruminant production based on agro-industrial wastes is, therefore, of prime importance. Until recently, most of the prescribed supplementary feeding regimes have been unsustainable, being too expensive, cumbersome to prepare and/or inconsistent in their effects on production and fertility. The other major problem for the buffalo is that it often suffers from delayed onset of puberty, poor oestrus expression or long post-partum ovarian quiescence causing substantial economic losses to the Indian dairy industry. Some of these ailments can be avoided or treated by use of indigenous and/or easily available medications. Dispensing these, however, is cumbersome and is often neglected for this reason. An easy method of administering these medicines over a period of time, therefore, needs to be devised to increase their application by farmers in order to derive optimum reproductive returns.

The objectives of the present work were: (a) to develop a urea-molasses multi-nutrient block (UMMB) based on locally available agro-industrial wastes that is economic, adaptable and easily prepared by farmers; (b) to assess the effect of UMMB supplementary feeding on production and reproduction in buffalo; (c) to formulate medicated urea-molasses multi-nutrient blocks (MUMB); and (d) promote wider dissemination of UMMB and MUMB technology to the end-user farmers.

2. MATERIALS AND METHODS

2.1. Preparation of UMMB by a 'Cold Process' using different formulations

Five formulations (I–V) were tested for production of blocks using locally available agro-industrial by-products in Punjab, India (Table I).

TABLE I FORMULATIONS USED FOR PREPARING UREA-MOLASSES MULTI-NUTRIENT BLOCKS

Ingredients	Formulation				
(on percentage basis)	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

For preparation of the blocks, urea and molasses were mixed together by stirring and then left for 24 h. Common salt was mixed with cement, before mixing with other dry ingredients, to give a uniform distribution in the whole premix. The urea-molasses mixture was poured into the premix of the dry ingredients, prepared on a polythene sheet or in an iron pan, and mixed thoroughly. One or 2.0 kg of the semi-solid mixture was then put in an iron frame (9" x 3" x 3"), covered with an iron or wooden sheet (that fitted well into the iron frame) and pressed for 20–30 seconds under the pressure of an adult foot (adult = person weighing 60–70 kg). The iron case was then pulled out leaving the pressed UMMB on the polythene sheet. The UMMBs were left at room temperature for drying so as to be hard enough for handling, transport and feeding.

The urea-molasses multi-nutrient blocks were also prepared by a 'Hot Process' [1] for comparative purposes. Twenty blocks from both the cold formulation and hot process were observed daily for their quality, texture, brittleness and any gross deterioration. Ten blocks of each category were left on shelves in a room to study their keeping quality and the rest were offered to buffalo to study their acceptability and effects on production.

2.2. Acceptability and average consumption of UMMB

A 2 kg block of UMMB was left in the manger of each buffalo for 24 h and the consumption was calculated by weighing the residue.

2.3. Effect of supplementary UMMB feeding on production and reproduction in dairy buffalo

2.3.1. Effect of pre-partum UMMB supplementation on post-partum reproduction and production

Ten Murrah buffalo (2^{nd}–5^{th} gestation) kept at an organized dairy farm, and expected to calve in the months of September and October, were offered UMMB supplementary feeding for 60–88 days pre-parturition. A 2 kg UMMB was offered to each animal daily and the intake was calculated from the residue after 24 h. Five non-supplemented buffalo were kept on a routine conventional diet as controls. The basal diet included 30–40 kg /animal/d green fodder (pearl millet, sorghum or barseem) along with 2 kg of an unspecified concentrate mixture. Observations on live weight (electronic scale; range 0–1000 kg), body condition score (BCS; 1–5 point scale) [2] and heart girth (using a Weigh Band; Dalton Supplies Ltd. Nettlebed, Henley-on-Thames, Oxon) were made at weekly intervals from the start of the UMMB supplementation until 60 days after parturition. The buffalo were observed twice daily by an attendant and placed with a teaser bull for determination of oestrus activity. Venous blood samples were collected at weekly intervals for progesterone estimations for 60 days post-partum. Daily milk yield of the animals during this period was recorded.

A similar experiment was undertaken on buffalo expected to calve in the summer months (June–July), in a rural area where 11 buffalo were supplemented with UMMB and seven were kept on a routine diet consisting of 20–30 kg /head/d mature barseem, sorgum or pearl millet. However, since the period of study also covered a two month ‘fodder-lean period’ each animal was exposed to a basal diet of approximately 2 kg wheat straw with 0.5–2 kg concentrates for a period of 1–2 months during the study. The UMMB intake, BCS and oestrus activity were recorded as at the established farms, but no teaser bulls were available in the rural areas

2.3.2. Effect of post-partum UMMB supplementary feeding on onset of ovarian activity

Fourteen freshly calved Murrah buffalo belonging to smallholder dairy farmers were offered UMMB from parturition until 60 days post-partum. Seven buffalo were kept as non-supplemented controls. Observations on daily UMMB intake, milk yield and oestrus activity were made by the farmers. Body weight was calculated using Shaefer’s formula from heart girth measured at weekly intervals. Blood samples were collected on 0, 15, 30 and 45 days post-partum for biochemical and endocrine analysis for free fatty acids, glucose, insulin and progesterone.

2.3.3. Effect of UMMB supplementary feeding in anoestrus buffalo

The study was conducted on 40 true anoestrus buffalo, both during a low breeding season (May and June) and peak breeding season (September–October). These buffalo had smooth ovaries and serum progesterone concentrations of less than 1.0 ng/mL. In September and October, the buffalo were given conventional feeding comprising a limited quantity of green fodder (Bazra, Maize or Sorghum; 10–20 kg/head/d) and *ad libitum* wheat straw, occasionally supplemented with 1–2 kg of home made non-specific concentrates. During summer months (May–June), 5–10 kg mature barseem and 2–4 kg wheat straw were fed to each buffalo. The buffalo were subjected to bathing under tap water and/or wallowing in a local pond once daily during the summer months.

The buffalo were supplemented with UMMB for 30 days. Ten anoestrus buffalo kept on routine feeding served as unsupplemented controls. Observations on oestrus activity and milk yield were made by the farmers and the animals in heat were served naturally. Pregnancy diagnosis was made by rectal palpation of genitalia two months after supplementation began. Blood glucose, total plasma proteins, blood urea nitrogen and creatinine were estimated from samples taken at weekly intervals during the period of supplementation.

2.3.4. Effect of a UMMB supplement on the age of puberty

Twenty-seven non-cycling, delayed pubertal Murrah buffalo heifers (age >36 months, body weight >300 kg) reared by marginal farmers were supplemented with *ad libitum* UMMB for 56 days in summer (July–August, n = 27) and winter (November–December). Daily intake of UMMB, changes in body weight and onset of oestrus activity were recorded.

The animals not showing oestrus within 28 days from the start of UMMB supplementation were injected with 750 mg progesterone (Proluton depot, German Remedies) thrice at intervals of 72 h, followed by 500 IU of pregnant mare serum gonadotropin (PMSG; Folligon Intervet Holland) within 72 h of the last progesterone injection. Heifers that were then detected to be in oestrus were mated naturally.

2.4. Preparation and supplementation of medicated blocks

The UMMBs prepared were medicated using either a herbal ecobolic drug, (Replanta, Indian Herbs, Saharanpur India), a herbal anthelmintic drug (Wopell, Indian Herbs, Saharanpur India) or fenbendazole (Panacur, Intervet Holland). These drugs were added to the normal formulation of UMMB at the rate of 4%, 10% and 50 g/100 kg, respectively. Replanta enriched blocks were fed for seven days starting immediately after parturition to buffalo already on UMMB supplementation. Wopell and Panacur medicated blocks were fed for a week each to nine and eleven buffalo, positive for strongyle infection, respectively.

For comparative studies, conventional feeding of Replanta powder, 50 g daily for six days to six recently calved buffalo, Wopell, 8.0 g daily for seven days to four strongyle positive sheep and fenbedazole 1.5 g bolus once to 11 strongyle positive buffalo, were used as controls.

2.5. Prevalence of gastrointestinal parasites

A survey for prevalence of gastrointestinal parasites in ruminant livestock was carried out from August 2001 to August 2004.

3. RESULTS

3.1. Preparation of acceptable UMMB

Blocks prepared using the formulation containing 35% molasses, 10% urea, 16% oiled and 17% de-oiled rice bran, 10% ground nut cake, 10% cement and 2% salt (Table I, formulation V), were found best for feeding, being relatively easier to prepare, lesser brittle and requiring a relatively short time (3–5 d) to dry. The ‘hot process’, however, required higher initial costs for installation of necessary infrastructure, including a furnace, a hydrolic process etc., than the ‘cold process’which does not require any expensive equipment. Blocks prepared with 40% molasses remained soft and unfit for licking. Blocks with 33% de-oiled rice bran were brittle and blocks with 33% oiled rice bran were difficult to prepare due to the sticky nature of the material. Blocks weighing 1.0 kg had a greater tendency to break than

2 kg blocks. Blocks prepared from formulation by the 'cold process' were, therefore, adopted for subsequent studies.

No apparent deterioration of the blocks was noticed when they were kept indoors under dry conditions for up to 14 months. A few blocks, however, exhibited growth of surface mucous during the rainy season.

The proximate analysis of the selected UMMB formulation was conducted immediately after preparation and after storage for 14 months. On a dry matter basis crude protein, neutral detergent fiber, cellulose, ether extract and ash were 418.4, 265.0, 41.0, 7.5 and 274.7 g/kg, for freshly manufactured UMMB, and 413.0, 270.0, 55.0, 10.0 and 267.5 g/kg, for stored UMMB, respectively.

3.2. Acceptability and average consumption of UMMB

All buffalo offered UMMB ate it**.** A large proportion of the buffalo (46%) had a tendency to bite and eat the blocks during the first week of study, but this declined to only 5% of buffalo after four weeks. The daily average UMMB consumption by each animal was 600 g. A few recently calved buffalo had an initial daily UMMB intake of only 50–100 g but this increased to 500–700 g within two weeks of supplementation.

3.3. Effect of supplementary UMMB feeding on production and reproduction in buffalo

3.3.1. Effect of pre-partum UMMB supplementary feeding on post-partum reproduction

The voluntary average daily intake of UMMB recorded in this study was 674.13 ± 16.49 g at the organized farm. Changes in body weight, BCS and heart girth at different stages during the study period are given in Table II. Body weight gain during the pre-partum period tended to be higher in the supplemented buffalo ($P > 0.05$) than in the controls. All buffalo lost body weight during the two months post-partum. However, supplemented buffalo lost less weight than the controls during the first month but lost more during the second month post-partum. Average BCS at the start of the study was similar in both groups and increased by the time of parturition. A significant ($P < 0.05$) loss in BCS was observed at parturition in all buffalo and this decline continued for the next two months post-partum. The cumulative loss in BCS during the first month post-partum was lower in the supplemented than in the control group. Of the 15 buffalo, nine calved with a BCS (1 = emaciated; 5 = over-fat) of less than 4.0 and in six the BCS was more than 4.0. None of the buffalo suffered from any clinical metabolic disease after parturition. Changes in heart girth showed a similar trend to body weight and BCS during the pre-partum and post-partum periods.

Average milk production in the first 30 days of lactation in UMMB supplemented buffalo tended to be higher than in the corresponding controls. On average, supplemented buffalo produced 88 kg more milk during the first two months compared to the unsupplemented controls.

The supplemented and control buffalo exhibited first behavioral oestrus at 24.0 (range = l5–45) and 24.4 (range = 15–40) days post-partum respectively. As evidenced by elevated plasma progesterone concentrations (>1.0 ng/mL), 9/10 (90%) and 4/5 (80%), buffalo in the respective groups came into ovulatory oestrus at 34 (range, 23–49) days and 48 (range, 34–57) days post-partum (Table III).

TABLE II. BODY WEIGHT, BODY CONDITION SCORE (BCS) AND MILK PRODUCTION OF BUFFALO AFTER PRE-PARTUM SUPPLEMENTARY FEEDING WITH UREA-MOLASSES MULTI-NUTRIENT BLOCK

Parameter	Treatment	Initial	At parturition	30 d Post-partum	60 d Post-partum
Body weight (kg)	Supplemented	603.50 ± 19.37	644.00 ± 18.59	550.00 ± 17.45	529.20 ± 17.44
	Control	601.80 ± 55.41	637.80 ± 51.86	537.00 ± 34.75	533.60 ± 36.32
BCS *(Scale 1–5)	Supplemented	3.50 ± 0.05	3.80 ± 0.09	3.00 ± 0.07	2.88 ± 0.07
	Control	3.50 ± 0.10	3.75 ± 0.01	2.93 ± 0.15	2.87 ± 0.12
Girth (cms)	Supplemented	209.40 ± 2.25	214.50 ± 1.80	208.66 ± 2.12	205.30 ± 1.86
	Control	208.00 ± 8.10	213.60 ± 7.81	208.00 ± 4.84	205.40 ± 5.46
Milk Yield (kg)	Supplemented (n = 5)			262.20 ± 13.67	578.10 ± 29.17
	Control (n = 4)			232.84 ± 22.86	490.10 ± 33.62

*BCS scale, 1 = emaciated, 5 = over-fat

TABLE III. OBSERVATIONS RELATED TO ONSET OF OESTRUS IN POST-PARTUM BUFFALO AFTER PRE-PARTUM SUPPLEMENTATION WITH UREA-MOLASSES MULTI-NITRIENT BLOCK

Group	Days to 1st observed heat	Days to first ovulatory heat	Incidence of silent estrus	Anoestrus Up to 60 d
Supplemented (n = 10)	24.00 ± 3.17 (n = 10)	34.33 ± 2.56 (n = 9)	11% (n = 1)	10% (n = 1)
Control (n = 5)	24.40 ± 5.67 (n = 5)	48.25 ± 5.25 (n = 4)	75% (n = 3)	20% (n = 1)

The first oestrus in 1 (11%) and 3 (75%) buffalo in the supplemented and control groups, respectively, was silent. One buffalo in each group remained acyclic during the post-partum period. A higher proportion of the supplemented than of unsupplemented buffalo (80% vs 60%) were fit for breeding within 60 days post-partum, as diagnosed by the good quality vaginal mucus and uterine tone. The conception rate in the supplemented buffalo was noticeably higher (30% vs 0%) during first 70 days post-partum.

In the rural areas, the average UMMB intake was 627.51 ± 33.96 g. The average BCS of pre-partum buffalo was 2.67 and 2.60 at the start of the UMMB supplementation period and 3.04 and 2.64 at calving in supplemented and control buffalo respectively. Sixty seven % (7/11) of supplemented and 14.5% (1/7) of control buffalo showed observed heat within 60 days post-partum. All the buffalo in the supplemented and only 43% in the control group experienced their first oestrus within 90 days post-partum. Average interval to first oestrus in the supplemented and control buffalo was 56 ± 6.0 and 62 ± 25 days respectively.

The biochemical parameters blood glucose, total proteins and blood urea nitrogen remained within the normal physiological range in both groups throughout the study.

3.3.2. Effect of post-partum UMMB supplementary feeding on the onset of ovarian activity

The daily intake of UMMB varied between 700 and 800 g with an intake of 50–400 g during the first week. The percentage body weight loss was greater in unsupplemented (0.53

to 3.9%) than in supplemented (0.02% to 3.0%) buffalo over the 60 days post-partum. In addition, supplemented buffalo started gaining body weight earlier than the unsupplemented controls (5th vs 7th week). A higher proportion of supplemented buffalo (71%) displayed oestrus within 50 days post-partum compared to only 14% in the controls. Supplemented buffalo yielded more milk (8.91 ± 0.23 vs 8.25 ± 0.23 kg/d) than the controls over the period of UMMB supplementation. Free fatty acid concentrations remained lower (41.60 ± 0.66 vs. 48.68 ± 0.86 mg/dL) in the supplemented buffalo than the controls. Blood glucose (51.7 ± 1.25 vs. 42.6 ± 1.03 mg/dL) and insulin (45.41 ± 0.92 vs. 39.26 ± 0.77 units/mL) concentrations were higher in supplemented than in the unsupplemented buffalo.

3.3.3. Effect of UMMB supplementary feeding in anoestrus buffalo

Average daily intake of UMMB by individual buffalo was 600 g. More summer anoestrus buffalo exhibited fertile oestrus within 30 days compared to the unsupplemented controls (40% vs. 10%, respectively). Responses of anoestrus buffalo to UMMB supplementation during the peak breeding period (September–October) were much higher (90% at 60 d). An increase in feed intake (20–25%), daily milk yield (8%) and milk fat (0.5%) concentration was observed in the supplemented buffalo compared to the controls. Blood glucose, total plasma proteins, blood urea nitrogen and creatinine concentrations remained in the normal physiological limits in both groups during the period of observations.

3.3.4. Effect of UMMB supplementation on the age of puberty in dairy buffalo

One month of UMMB supplementary feeding induced fertile oestrus in 60% of delayed pubertal buffalo heifers. Daily intake of UMMB was 600 g. While only 33% of the heifers exhibited oestrus symptoms within one month of receiving UMMB during the summer months, 93% of the heifers came into oestrus within one month of receiving UMMB during the winter months. The symptoms of oestrus were more prominent in supplemented than unsupplemented controls. A higher proportion of the supplemented buffalo displayed oestrus (100% vs 36%) and had higher conception rates (100% vs 25%) than the unsupplemented controls after the hormone treatment.

3.4. Effect of medicated blocks

Supplementary feeding recently calved buffalo with UMMB medicated with Replanta decreased the time for shedding of placenta (5.75 ± 0.62 vs 4.40 ± 0.50 h) and the days to first post-partum oestrus (42.5 ± 4.5 vs 36 ± 0.39 h) for treated and control buffalo, respectively. Replanta-medicated supplement increased the amount of lotia, the post-partum uterine discharge and improved the quality of subsequent oestrus. The results for the Replanta-medicated supplement were comparable to results from feeding of Replanta powder (shedding of placenta 4.04 ± 0.74 h, days to first oestrus 37.4 ± 2.84 d).

Feeding Wopell 8.0 g daily reduced the strogyles eggs in faeces (eggs per g, epg) epg in sheep from 16 000 to 5000 by day six of the treatment. The reduction in the epg was evident on the second day of the treatment. The treatment, however, did not completely clear the eggs during the course of this treatment of seven days. Wopell fed in MUMB, however, cleared all the eggs in 80% of the buffalo during the same period. Fenbendazole treatment, fed either as a bolus or in MUMB had similar effect and cleared eggs in 66–100% buffalo in the field trials.

3.5. Prevalence of gastrointestinal parasites

During the period August 2000 to August 2004, a total of 3757 faecal samples of ruminants (926 cattle, 1949 buffalo, 618 sheep and 264 goats) were examined for gastrointestinal helminth infections, from which 11.9% (106 cattle, 133 buffalo, 147 sheep and 48 goats) samples were found positive for strongyle nematode infection. The highest infection rate was seen during the months of November followed by October and the lowest was in the month of August. This suggests a seasonal variation with increased prevalence in the post-monsoon period. Similarly, the incidence of paramphistomosis was highest during and after monsoon (8.5%) followed by the summer (2.9%) and winter months (0.63%). Epidemiologically, the highest incidence varied between the districts of the Punjab state, from 9.0% to 19.4%. In delayed pubertal buffalo heifers (n = 90), peri-parturient buffalo (n = 72) and anoestrus buffalo (n = 200), the incidence recorded was 3.3%, 2.7% and nil respectively.

4. DISCUSSION

4.1. UMMB preparation by the 'Cold Process'

The use of UMMB in India has been known since early 1980's [3]. However, the hot preparation process used in much of the early work involved high initial costs, cumbersome procedures and significant labour requirements that limited the acceptance of UMMB. Further, these blocks were highly hygroscopic and had a shorter shelf-life than those prepared by the cold process [3, 4]. The present studies have developed practical, low-cost methods for UMMB preparation that can be used by smallholder farmers and, hence, are more readily adopted.

4.2. Benefits of UMMB supplementary feeding

During the pre-partum UMMB supplementary feeding period, the supplemented buffalo gained more weight and lost less during early post-partum period, compared to the control group. Similar trends in body weight changes following concentrate-based pre-partum supplementary feeding have been reported in cattle [5] and in buffalo [6]. In the rural studies, the improvement in BCS of UMMB supplemented buffalo over their control counterparts was greater than in the studies undertaken in the organized farms. This is could be attributed to the better basal diet available at the organized farms than is usually the case in rural villages. The interval to first oestrus, however, was much higher in rural buffalo (56 and 62 d) compared to that in buffalo at organized farms (average 24 d). Poor heat detection in the absence of teaser bulls, summer stress and/or poor basic feeding could be responsible for this delay in onset of ovarian activity in rural buffalo. Long post-partum anoestrus periods have been previously observed in poorly managed buffalo [7, 8].

The degree of weight loss during the first post-partum month appeared to have a substantial bearing on post-partum ovarian activity. Buffalo losing less weight in the first month ovulated earlier (34 vs 48 d) despite having lost more weight during the second month post-partum. It has been observed previously that Holstein dairy cows that lost more weight during first two weeks of lactation had delayed ovarian activity whereas weight lost between the third and ninth week was similar in animals having early or delayed ovarian activity [9]. Body condition score started declining at parturition in all the buffalo and continued over the next two months. *Bos indicus*-cross cows supplemented with urea-molasses during late pregnancy had shorter service periods although no apparent changes occurred in BCS and body weight around the time of parturition [10].

In the present study, nine buffalo calved with a BCS of more than 4.0, but none of these suffered from any metabolic disorder. Gaining BCS in the pre-partum dry period is harmless provided animals are not over conditioned [11]. While some workers [12] observed no adverse effect in cows calving with BCS between 4 and 5, others [13, 14] cautioned against over-conditioning during the pre-partum period for fear of increasing the prevalence of metabolic disorders post-partum.

High milk production often leads to negative energy balance in the early post-partum period leading to delays in the onset of subsequent ovarian activity [15]. Improvement of energy balance provides an important signal for initiation of ovarian activity [9]. In the present study, supplementary UMMB feeding to post-partum buffalo appeared to lower the extent and duration of negative energy balance in the post-partum period thereby helping early onset of post-partum ovarian activity. In cross-bred dairy cows in Vietnam, supplementary feeding with UMMB shortened the calving to first oestrus interval (110 vs 135 d) and calving to conception interval (121 vs 152 d) [16].

Deficiencies of energy, protein and minerals in diets are the established causes of prolonged anoestrus in cattle and buffalo [17, 18]. Negative energy balance (NEB) decreases LH pulse frequency, diameter of dominant follicle, insulin like growth factor (IGF–I), glucose and insulin concentrations and increases loss of BCS. This in turn results in higher incidence of anoestrus [14]. The UMMB is a good source of several nutrients [4]. Therapeutic effects of UMMB supplementation in anoestrus buffalo in the present study were greater during the breeding season than in the non-breeding season. Factors other than nutrition, for example heat stress and longer day length, could be responsible for such differences. Initial BCS appeared to affect the induction of oestrus following UMMB supplementation. The response of UMMB supplementation for 30 days was greater in buffalo with a BCS of over 3.0 than in buffalo with a BCS of under 3.0. The buffalo with very poor BCS (less than 2.0) and over conditioned buffalo (BCS over 4.0) did not respond during the 30 days UMMB supplementation period.

In the various studies reported here, UMMB supplemented buffalo produced more milk than the controls. The reproductive performance of UMMB supplemented buffalo post-partum was also better than their un-supplemented counterparts. Previously, reproductive performance was found to be positively correlated to productive performance in Holstein dairy cattle [9, 11]. In contrast, other workers found a negative correlation between milk yield and reproductive performance post-partum [12]. High yielding cows may be healthier than low yielding cows because they normally are looked after better and receive a better diet than the low yielders.

4.3. Biochemical Changes in Blood

The lower concentrations of free fatty acids and higher glucose concentrations were indicative of better energy balance in supplemented post-partum buffalo, compared to the controls. The UMMB fed buffalo appeared to have reduced mobilization of adipose tissue resulting in decreased levels of free fatty acids [19]. Blood urea nitrogen (BUN) concentrations remained within the normal physiological limits in the various experiments. Previous work has established that BUN levels are influenced by the amount of crude protein intake, degradability of protein, energy intake and time of sampling post-feeding [20]. Excessive levels of crude protein in the diet elevated BUN levels, altered uterine pH and reduced fertility in dairy cows [14, 20, 21] and buffalo [22]. A lack of BUN elevation suggests that there were no related harmful effects of UMMB supplementation in the current studies.

In anoestrus buffalo, the BUN concentrations at the start of the study (in May) were similar in both the groups of buffalo but this decreased significantly ($P < 0.05$) by day 30 in the UMMB supplemented buffalo and by day 45 in the controls. An early reduction in BUN concentrations in UMMB fed buffalo is suggestive of improved nutritional status and reduced muscle catabolism, together with improvement in the environmental conditions. The pattern of changes in plasma creatinine levels was similar to that of BUN during supplementation with UMMB but were not significant and fodder availability was minimal which might have exposed the animals to high muscle catabolism and elevated BUN [23, 24].

The blood insulin levels observed in the present studies were within the physiological limits and remained unaffected by UMMB supplementation. There were no differences in plasma concentration of insulin in buffalo that resumed cyclicity (6.842 ± 1.700 μU/mL) or remained anoestrus (6.009 ± 1.248 μU/mL) after UMMB supplementation. Plasma insulin levels vary depending upon glucose concentration in the blood, as it is the most important stimulus for insulin secretion [25]. A lack of appreciable changes in insulin could be the result of almost constant blood glucose concentration in the buffalo under study.

4.4. Medicated Blocks

Most ecobolics used in veterinary practice to induce an early uterine involution and timely onset of ovarian activity are injectable pharmaceutical preparations which are expensive and tedious to be used as routine under field conditions. Replenta, an indigenous herbal preparation when fed as powder or blended in UMMB, enhanced the uterine involution and subsequent ovarian activity, which are the direct expressions of future fertility of an animal. Incorporation of Replenta in UMMB, however, had the advantage of easy, hastle free feeding and least wastage over feeding it orally.

Feeding of Wopell powder significantly reduced the helminths' epg but failed to totally eliminate the infection during a six-day daily treatment in sheep. The MUMB containing Wopell, however, was effective in totally eliminating the infection in 80% buffalo with a treatment of the same duration. Feeding Wopell as MUMB, therefore, appears to be a better choice, at least for buffalo. Similar evidence in sheep, however, needs to be developed.

Fenbendazole given as a bolus or as MUMB was equally effective as an anthemintic treatment, although as MUMB it required to be given over a longer duration. The latter, however, has the advantage of easy administration and has prolonged protection from the repeated infection, especially, in grazing animals.

5. SUMMARY OF TRAINING AND EXTENSION ACTIVITIES

Over the last four years more than 200 veterinarians, 20 veterinary pharmacists and 900 farmers have been given training on production and utilization of UMMB. At the national level more than 31 scientists from other universities have been shown the production of UMMB. In addition, the work done on UMMB has been presented at two national and two international conferences held in India

Linkages have been established with the Government of Punjab, Animal Husbandry Department where 15 veterinary officers were involved in the selection of progressive farmers for the establishment of pilot farms, to hold demonstrations for UMMB production and to guide the farmers in routine use of UMMB. Twelve people involved in procurement of milk and 11 elected groups at the village level were involved in the implementation of the project. Financial help was provided by the Government of India through the National Agricultural

Technology Project. The Indian Council of Agricultural Research has funded the Center of Advanced studies in our department and has helped in extending the technology at national level.

6. CONCLUSIONS

Urea-molasses multi-nutrient blocks prepared by the cold method were economical and easily adoptable by marginal farmers. Supplementation with UMMB improved milk production and reproductive efficiency when offered during the pre-partum period, post-partum period or in late lactation to anoestrus buffalo. Use of UMMB was also shown to induce ovarian activity in delayed pubertal buffalo. Preliminary studies indicate that UMMB may be used effectively for easy dispensing of herbal drugs.

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DEVELOPMENT AND UTILIZATION OF UREA-MOLASSES MULTI-NUTRIENT BLOCKS (UMMB) AND MEDICATED MULTI-NUTRIENT BLOCKS (MUMB) AS SUPPLEMENTS FOR RUMINANTS IN MALAYSIA

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Abstract

This paper reviews the development and utilization of urea-molasses multi-nutrient blocks (UMMB) and medicated urea-molasses multi-nutrient blocks (MUMB) as nutrient supplements and as carriers for controlling parasites. Experiments carried out with dairy cows clearly indicated the positive impact of UMMB and MUMB on milk yield, reproduction and body condition score (BCS). Improvements in milk yield of dairy animals due to UMMB supplementation were shown to be between 80 and 100% and the supplementation reduced the use of concentrate feeds in daily feeding by 30%. Cost to benefit ratios of between 1 : 2 and 1 : 1.8 were recorded from the dairy experiments. This paper also highlights the potential use of MUMB and herbal-based products for the control of parasites in ruminants, notably goats and sheep. Kenaf *(Hibiscus cannabinus)* and neem *(Azadirachta indica)* are two plant species of interest for parasite control. Recommendations on future work on the development, utilization and promotion of UMMB, MUMB and herbal-based products in Malaysia are discussed.

1. INTRODUCTION

Deficiencies and imbalances of nutrients are major factors limiting ruminant production in Malaysia [1]. These factors contribute to the poor performance of the animals, which are linked to poor appetite, poor body conformation, lower growth rate, low fertility, non-infectious abortion, increased interval between parturitions and lameness. These problems are commonly observed in ruminants raised by smallholders, especially beef cattle, dairy cattle and goats.

In small ruminants in particular, deficiencies and imbalances of nutrients are closely associated with helminthosis [2] which is one of the most important diseases limiting small ruminant productivity, especially of young stock. Nematode parasite infections can cause anorexia, poor digestion and malabsorption of feed, gastrointestinal loss of endogenous protein and repartitioning of nutrients towards the initiation of the immune response in animals. Over 90% of the endoparasitism cases in small ruminants in Malaysia are due to *Haemonchus contortus* [3, 4]. In hot and wet tropical climates these parasites cause high mortality and production losses and have led to heavy use of anthelmintics in many areas.

This paper summarizes the work undertaken throughout the project period (1999–2004) on the introduction of improved feeding strategies based on strategic supplementation using locally available feed resources. The overall objectives of the project were: (i) to promote the use of urea-molasses multi-nutrient blocks (UMMB) as nutrient supplements for improving meat and milk production under smallholders condition; and, (ii) to utilize medicated UMMB (MUMB) and herbal-based medicines for parasite control as well as increasing productivity of ruminants.

2. MATERIALS AND METHODS

2.1. Selection of pilot farms, experimentation and transfer of technology

Formulations of UMMB and MUMB have been previously described [2]. Eleven pilot farms were selected for the UMMB promotion through on-farm feeding trials (Table I). The farms were selected as model farms to disseminate the UMMB and MUMB technologies to the smallholders in the surrounding areas. Apart from these farms, promotions were also held at the government and private livestock farms, including farms under the Federal Land Development Authority (FELDA) and the Rubber Industry Smallholders Development Authority (RISDA).

TABLE I. LOCATION OF PILOT FARMS FOR UREA-MOLASSES MULTI-NUTRIENT BLOCK (UMMB) PROMOTION

State	Region covered in Malaysia	Location of the farm (Village/District)	Species	Experiment No. (refer to text)
Kedah	North-West	Kampong Ganding, Kota Setar	Dairy cows (9 Sahiwal-Friesian)	2.1.1.
Kelantan	North-East	Kampong Beris Lalang	Sheep (20 Dorset X Malin)	2.1.2.
Kedah	North-West	Kampong Ganding, Kota Setar	Dairy cows (10 Sahiwal Friesian)	2.1.3.
Kedah	North-West	Kampong Ganding, Kota Setar	Dairy cows (8 Sahiwal-Friesian)	2.1.4.
Selangor	Central	Sepang	Sheep (58 Siamese long tail X Cameroon)	2.1.5.
Terengganu	North-East	Marang	Boer cross-bred goats(40)	2.1.6.
Penang	West	Kampong Permatang Ara	Goats, Saanen, mix (10)	In progress 2.1.7.
Kedah	North-West	Kuala Nerang	Goats, mix breed, (37)	In progress 2.1.7.

The experiments were conducted at the pilot farms to show the benefits of UMMB or MUMB supplementation on the performance of the animals, particularly in terms of productivity improvement and the overall cost to benefit ratio. Apart from demonstrations in the making of UMMB or MUMB at MARDI stations and on-farm studies, dissemination activities also included free distribution of UMMB and MUMB in selected areas and expositions of the products at the annual agricultural shows held in every state. Other methods of dissemination included promotion through print, radio and television campaigns.

2.1.1. Effect of UMMB supplementation on infertile dairy cows

An experiment was carried out on nine infertile Sahiwal-Friesian dairy cows raised by a smallholder farmer. There was no record of heat occurrence in these animals during the previous 1–2 years. Poor body condition, lameness and stillbirths were also reported in the previous batches of cattle reared. All animals were given 4 kg UMMB every week for 16 weeks. Intake of UMMB, heart girth and body condition score (BCS) were recorded weekly. Date of heat occurrence and date of the application of artificial insemination (AI) were also recorded. Pregnancy diagnosis was carried out four months after the last artificial insemination.

2.1.2. Effect of MUMB supplementation on the performance of growing sheep

Twenty young female Dorset X Malin sheep of six months of age and averaging 17.8 kg live-weight were divided into two groups of 10 animals based on live-weight. Group 1 was supplemented with MUMB while Group 2 was not supplemented (control group). The animals were fed grasses (cut-and-carry) with a small amount of palm kernel cake (PKC). Salt lick was not provided. The animals, having low appetites, were in poor body condition. The effect of MUMB supplementation on the performance of the sheep was monitored for 26 weeks.

2.1.3. Effect of UMMB supplementation on milk yield and heat occurrence in low yielding dairy cows

Ten Sahiwal-Friesian dairy cows were divided into two groups of five cows each based on age. The first group acted as a control and the second group was supplemented with UMMB. Each animal in the treatment group was given 4 kg UMMB per week. The block was initially immersed in drinking water to make it less hard before placing in the feeding trough. It is a common practise for the farmers in this village to soften the block as they believe softer blocks are preferred by their animals. Intake of the block, milk yield (by difference), body condition scores (BCS) and heat occurrence were recorded over 120 days. The basal feeding regime was that which the farmer had routinely practiced. The diets used throughout the trial consisted of Napier grass, PKC, soya bean waste and rice straw. Effects of UMMB supplementation on milk yield and other related parameters were studied.

2.1.4. Effect of UMMB supplementation on milk yield in low yielding dairy cows

Eight Sahiwal-Friesian dairy cows were divided into two groups of four cows each. The first group acted as a control and the second group was supplemented with UMMB. Each animal in the treatment group was given 4 kg UMMB per week. The block was immersed in the drinking water for a few minutes and it was then placed in the feeding trough for the animals to lick. Intake of the block, milk-yield (by difference) and BCS (scale of 1 to 5, 1 = very thin; 5 = overfat) were recorded. The experimental duration was 120 days. Feeding regime was as practiced by the farmer. The diets used throughout the trial consisted of Napier grass (usually fed between 13 and 20 kg/head/d), PKC, rice bran, soya bean waste and rice straw. The effect of UMMB supplementation on milk yield was evaluated.

2.1.5. *Feeding MUMB to hair-sheep cross-breds under intensive and semi-intensive systems*

Sheep of mixed sex and one to three years of age (Cameroon Hair sheep males x Thai Long Tail ewes and their offspring) were selected and placed in two locations to represent an intensive system (reared in a shed in the University of Malaya's experimental farm) and a semi-intensive system at the farmer level (in Sepang, Selangor). In the semi-intensive system, 14 sheep were in the control group and 17 sheep in the MUMB-treatment group and all sheep were allowed to graze in a rubber plantation from 9:00 a.m. to 6:00 p.m. daily. Under the intensive system, 13 sheep were placed in the control pens and 14 sheep in the MUMB-treatment pens. For all sheep access to the MUMB was allowed for two hours daily in the evening, after fodder was given or after grazing and supplementary concentrate pellets were provided for the two systems respectively. Only one block was given per pen, and this was replaced with a fresh block when it had been completely consumed, usually after a week. All sheep were drenched to remove the adult worms at the start of the study, and MUMB was introduced two weeks after deworming for the treated groups only. In the first and second weeks, and subsequently thereafter once every month, faecal samples were collected. Live-weights were recorded individually at the end of each month for the six months of the trial. Standard procedures for the faecal egg count (average count of all sheep per treatment) and worm species identification were performed at the Regional Veterinary Laboratory, Ipoh Perak.

2.1.6. Feeding a liquid supplement on the growth performance of goats

Forty local Boer cross-bred female goats were randomly divided into five groups based on live-weight. Animals in group A were fed a liquid supplement mixture (MOLIF) which contained molasses (95.5%), urea (2.5%), zeolite (1%) and a mineral premix (1%). Apart from MOLIF, Group B animals were fed a mineral mixture (MMZ) which contained Mn, Fe, Zn, Co, Ca and Na plus polyethylene glycol (PEG, MW 4000). The PEG was added at the rate of 7% of the total mixture. It was purposely used as an anti-mould and emulsying agent in the formulation. Group C were fed MOLIF plus MMZ with a by-pass fat (BPF) without PEG and Group D animals were fed MOLIF plus MMZ without PEG and BPF. All animals were fed pelleted complete diets based on OPF (included at 30% of the diet) at the rate of 3.5% of mean live-weight. These animals were purposely fed less than the targeted dry matter intake of about 4.0–4.5% of mean live-weight. Sufficient MOLIF mixture was prepared for a 40-day supply, and was fed at 30 g/animal/d in 3 L of drinking water. By-pass fat was in the form of powder which was commercially produced based on oil palm derivatives. Changes in live-weight of the animals were recorded over a four month period.

2.1.7. Experiments in progress

Two short-term on-farm experiments on the evaluation of UMMB and a liquid formulation are being conducted in goats on two farms. The first experiment is comprized of 10 Saanen goats while the second experiment is being conducted on grazing goats of mixed breeds (n = 37) raised in orchards. A formulated UMMB is tested on the first farm while a liquid supplement is evaluated on the second farm. The choice of supplementation is based on farmer's preference. Total consumption of UMMB and liquid supplement as well as the effect of both supplements on intake and rate of growth are being monitored.

2.2. Experimentation on potential herbal medicines for parasite control

2.2.1. Proximate and tannin analysis of potentially useful plants for parasite control

Leaves from oil palm fronds (OPF; *Elaeis guinensis*), Kenaf (*Hibiscus cannabinus*), leucaena (*Leucaena leucocephala*), jackfruit (*Artocarpus heterophyllus*), neem (*Azadirachta indica)* and mango (*Mangifera* spp.) were analysed for proximate analyses (1). Tannin content was analysed by Folin and Dennis method [4]. Jackfruit, neem and mango leaves are commonly used by smallholders for controlling parasites in goats and sheep in Malaysia.

2.2.2. Effect of neem supplementation on faecal egg counts in growing sheep

The experiment was carried out in a smallholder sheep and goat farm having a total of 50 animals. Fifteen Siamese long tails, between 8 and 18 months of age, were selected and monitored for faecal egg counts for a period of one month. Faecal samples were taken daily for the first week and once a week thereafter for one month. All the animals were grazed for about five hours a day on local pastures surrounding the shed, and given *ad libitum* fresh neem leaves daily in the pen for the duration of the trial. In addition to this they received some concentrates, mainly a mixture of PKC, rice bran and brewers grain and given water in the pen.

2.2.3. Effect of Kenaf and bio-oil on the faecal egg counts in growing goats

Three groups of five growing goats were either fed: a complete pelleted diet containing Kenaf at 45% level of inclusion (Group 1); drenched with bio-oil at the dose rate of 1 mL/head/d (Group 2); or remained an untreated control (Group 3). Complete diets in Groups 2 and 3 contained OPF, which was included at 35% of the diet. The diets for all groups were iso-nitrogenous and isocaloric with crude protein (CP) and energy contents of 141 g/kg dry matter (DM) and 9.60 MJ/kg respectively. The effect of treatments on the faecal egg count were studied. Bio-oil was produced by a pyrolysis process (heating in an enclosed system at a very high temperature) and agricultural wastes like oil palm trunks and rubber wood were used as feedstock. Bio-oil was produced by a local supplier using a simple pyrolysis process where agricultural wastes and crop residues were used as feedstock.

2.2.4. Effect of feeding Sentang (Azadirachta excelsa) leaves on the faecal egg counts in growing goats

Fifteen Boer cross-bred goats, between 4 and 5 months of age and about 30 kg live-weight, were randomly divided into three groups of five animals based on live-weight. The animals were fed a mixture of corn silage and concentrate. The treatments for the respective groups were; (i) control (no Sentang); (ii) fresh Sentang leaves; and, (iii) Sentang leaves in the form of powder (both given at the equivalent rate of 2 g/kg live-weight). The Sentang was collected at the Forestry Research Institute of Malaysia (FRIM). All animals were challenged with a single dose of 2000 infective *Haemonchus concortus* larvae before the commencement of the trial. Faecal egg counts of individual sheep were determined at weekly intervals for five weeks after the parasite challenge

2.3. Data analysis

The experiments carried out at the pilot farms were limited in terms of animal numbers and statistical evaluation was, therefore, limited in some instances. Where possible, the *Student's t-test* to compare differences in mean values of production parameters, in treatment and control groups or analysis of variance (ANOVA) were used to test differences in means using the linear model procedure depending on dependent variables.

3. RESULTS

Out of eight experiments held at the pilot-farms, six were completed while two are in progress (Table I).

3.1. Trials on pilot farms

3.1.1. Effect of UMMB supplementation on infertile dairy cows

Table II shows the pregnancy record of the infertile dairy cows while Table III shows intake of the blocks and BCS of the animals. The mean change in heart girth measurement and body score for the animals during the trial period were 6.51 cm.

TABLE II. PREGNANCY RECORD OF THE INFERTILE DAIRY COWS (N = 9)

Animal no.	Total heats detected	Date of last heat detected	No of AI used	Date of last AI	Pregnancy Diagnosis	Notes
523	1	23.3.99	1	23.3.99	Negative	
G 20	5	15.9.99	1	12.7.99	Negative	
G 04	3	18.4.99	2	18.4.99	Negative	
H 1060	4	12.6.99	1	22.4.99	Negative	
488	1	19.7.99	1	10.1.99	Positive	Pregnant
415	2	26.4.99	2	26.4.99	Negative	
421	2	15.9.99	2	15.9.99	Negative	
498	4	19.7.99	3	19.7.99	Negative	
552	2	15.9.99	2	15.9.99	Negative	

AI = artificial insemination

TABLE III. INTAKE OF UREA-MOLASSES MULTI-NUTRIENT BLOCK (UMMB) AND BODY CONDITION SCORE (BCS) OF INFERTILE DAIRY COWS

Animal no.	UMMB intake (kg/week)	Initial heart girth (cm)	Final heart girth (cm)	Initial BCS*	Final BCS
523	3.9	151.5	164.5	1.5	2.0
G 20	4.0	162.0	170.5	3.0	3.0
G 04	4.0	159.0	172.5	3.5	3.0
H 1060	4.0	159.0	166.5	3.0	3.0
488	4.0	145.0	157.0	4.0	3.0
415	4.0	156.0	159.0	3.0	2.5
421	4.0	148.0	152.0	2.5	2.5
498	4.0	176.0	172.0	2.5	3.5
552	4.0	154.0	156.0	3.5	2.5

*BCS on a scale of 1 to 5, 1 = very thin, 5 + over fat,

3.1.2. Effect of MUMB supplementation on the performance of growing sheep

Table IV shows the effect of MUMB supplementation on the appetite and rate of growth of sheep. The overall live-weight (LW) gains to feed cost ratios achieved from this experiment were 0.86 : 1 and 2.78 : 1 for MUMB and the control group respectively. A more positive impact of treatment was shown by the increased reproduction rate and lamb survival of MUMB treated sheep.

3.1.3. Effect of UMMB supplementation on milk yield and heat occurrence in low yielding dairy cows

The effects of UMMB supplementation on milk yield, body condition and heat occurrence of low yielding cows are shown in Table V. The body condition of the treatment group was generally better than those of the control. There was no explanation with regard to these differences as the animals were randomly selected based on age.

TABLE IV. EFFECT OF MEDICATED UREA-MOLASSES BLOCK (MUMB) SUPPLEMENTATION ON THE PERFORMANCE OF DORSET X MALIN CROSS-BRED SHEEP

Parameters	Group 1 (Control)	Group 2 (MUMB)
Initial LW (kg)	17.8	17.8
Mean LW (kg)	22.8	27.3
LW change (kg)	5.0	9.5
MUMB intake (g/d)	–	89
Body condition score*	Poor	Excellent
Appetite	Poor	Improved
Lambs born	2	8
Mortality of lamb	2	0
LW gain (g/d)	27.5	150.0
Cost of feed (RM) +	58.09	58.1
Cost of MUMB (RM)+	–	40.5
Overall cost of feed / d (RM) +	58.09	98.1
Gain/Feed cost	0.86	2.78

*BCS on a scale of 1 to 5, 1 = very thin, 5 + over fat.
+ Cost of grasses (cut and carry) not included (US$ 1 = RM 3.8)

TABLE V. EFFECT OF UREA-MOLASSES MULTI-NUTRIENT BLOCK (UMMB) SUPPLEMENTATION ON MILK YIELD AND HEAT OCCURENCE IN LOW YIELDING DAIRY COWS OVER 120 DAYS

	Control (n = 5)	UMMB (n = 5)
LW		
Initial LW (kg)	337.4	401.6
Final LW (kg)	400.8	439.4
LW change(kg)	63.4	37.8
UMMB Intake		
Total intake (kg)	0	78.97
Mean intake (g/d)	0	570
Milk Yield		
Total milk yield (L over 120 d)	552	1128
Mean milk yield (L/d)	4.6	9.4
Body Condition and Heat Occurrence (++)		
Initial heart girth (cm)	158	170.2
Final heart girth (cm)	170.2	175.9
Initial body condition score* (BCS, see text)	2.50	3.70
Final body condition score	2.25	2.90
Heat occurrence after calving (%)	20	80
Costing*		
Total feed cost/head (RM/d)	1.28	1.28
Cost of UMMB /head (RM/d)	0	1.41
Total feed cost (RM)	153.60	322.80
Cost of milk @RM 1.30/L (purchased by the MCC#)	717.60	1466.40
Gross profit (120 d) (RM)	564.00	1143.60
Net profit (RM)		579.60

Notes: ++ Resumption of post ovarian activity in the UMMB supplemented animals within 74–121 days of calving.
*BCS on a scale of 1 to 5, 1 = very thin, 5 + over fat.
MCC: Milk collecting centre, *US$ 1: RM 3.8

3.1.4. Effect of UMMB supplementation on milk yield in low yielding dairy cows

The effect of UMMB supplementation on milk yield, body condition and heat occurrence of poor yielding cows is shown in Table VI.

TABLE VI. EFFECT OF UREA-MOLASSES MULTI-NUTRIENT BLOCK (UMMB) SUPPLEMENTATION ON MILK YIELD IN LOW YIELDING DAIRY COWS

	Control (n = 4)	UMMB (n = 4)
LW		
Initial LW (kg)	330.0	396.0
Final LW (kg)	398.3	428.3
LW change(kg)	68.3	32.3
UMMB Intake		
Total intake (kg)	0	79.6
Mean intake (g/d)	0	0.620
Milk Yield		
Total milk yield (L over 120 d)	540	1026
Mean milk yield (L/d)	4.5	8.55
Costing*		
Total feed cost/head (RM/d)	1.30	1.30
Cost of UMMB /head (RM/d)	0	1.41
Total feed cost (RM)	156.0	325.20
Cost of mMilk @RM1.30/L (purchased by the MCC#)	702.00	1333.8
Gross profit (120 d) (RM)	546	1008.6
Net profit (RM)		462.60

Notes: # MCC: Milk collecting Centre.
*US$ 1 : RM 3.8

3.1.5. Feeding MUMB to hair-sheep cross-breds under intensive and semi-intensive systems

Effects of feeding MUMB on faecal egg count of cross-bred sheep raised under intensive and semi-intensive systems are shown in Table VII, while the effects of MUMB supplementation on their growth rate are shown in Table VIII.

TABLE VII. EFFECTS OF MEDICATED UREA MULTI-NUTRIENT BLOCK (MUMB) ON FAECAL EGG COUNTS (EGGS/G FAECES) OF CROSS-BRED SHEEP UNDER INTENSIVE AND SEMI-INTENSIVE SYSTEMS

Period of sample collection	Management system*			
	Intensive		Semi-intensive	
	Control	MUMB	Control	MUMB
Month 1				
0 week before dosing	483	675	639	523
2nd week after dosing	217	292	178	188
Month 2 (after dosing)	175	158	167	150
Month 3	192	183	189	173
Month 4	258	158	217	211
Month 5	392	192	361	203
Month 6	483[a]	183[b]	530[a]	239[b]

Notes: *A pair of means in a row (within a management system) with different superscript letters were significantly different (P <0.05)

TABLE VIII. EFFECT OF MEDICATED UREA MULTI-NUTRIENT BLOCK (MUMB) SUPPLEMENTATION ON LIVE-WEIGHT GAIN OF HAIR SHEEP

	Management system*			
	Intensive		Semi-intensive	
	Control	MUMB	Control	MUMB
Initial weight, kg	34.4	33.7	25.2	27.5
Final weight, kg (at 6 month)	35.0	35.9	27.5	30.6
Weight increment, kg	0.57^{a}	1.87^{b}	2.23^{a}	3.17^{b}

*A pair of means in a row (within a management system) with different superscript letters were significantly different (P <0.05)

3.1.6. Feeding a liquid supplement on the growth performance of goats

Table IX shows the effect of a formulated liquid supplement on the growth rate of local cross-bred goats. Mean dry matter intake (g/d) of all animals were surprisingly lower than the amount expected to be consumed. There is no explanation to the depression of intake as the feed was properly processed and stored before transporting to the farm.

TABLE IX. EFFECT OF A FORMULATED LIQUID SUPPLEMENT ON THE GROWTH RATE OF LOCAL CROSS-BRED GOATS

Treatment	Initial LW (LW, kg)	Final LW (kg)	Average daily gain (g/d)	Dry matter intake (DMI, kg)
A (Control)*	11.4	15.6	33	0.12
B (PEG)**	12.3	16.1	34	0.14
C (BPF)*	14.3	19.0	42	0.16
D (Mineral)	13.1	18.3	42	0.14
E (PEG+BPF)	12.8	16.7	44	0.14

Notes: **PEG: Propylene glycole, BPF: By-pass fat

*The basal diet contained 14% Crude protein, 24.1% Crude fibre, 3.2% ether extract, 7.9 % ash and the calculated ME was 8.25 MJ/kg

3.2. Experimentation on potential herbal medicines for parasite control

The experiments on potential herbal medicines were carried out on selected plant species only. These results are considered preliminary and studies are in progress at MARDI goat and sheep farms.

3.2.1. Proximate and tannin analysis of potentially useful plants for parasite control

Kenaf and Leucaena are known to contain high amounts of crude protein which are thought to have an indirect effect on parasite control, particularly in grazing goats and sheep. It is of interest to evaluate OPF and neem as both plants are easily available and have been used for feeding ruminants. Table X shows the nutritive value of selected plant species for parasite control.

TABLE X. NUTRITIVE VALUE OF SELECTED PLANTS FOR ANTHELMINTIC STUDIES (g/kg DM)

	Oil palm fronds	Kenaf *(Hibiscus cannabinus)*	Leucaena *(Leucaena leucocephala)*	Jackfruit (*Artocarpus heterophyllus)*	Neem *(Azadirachta indica)*	Mango (*Mangifera spp)*
CP	68.0	210	271	79	156	110
CF	385	–	124	169	–	167
NFE	474	–	360	415	–	626
EE	21	23.1	54.1	53	–	44
ADF	556	332	–	–	225	–
NDF	787	478	–	–	248	–
Ash	32	104	61	284	–	53
ME (MJ/kg)	1.35	6.98	–	–	–	6.0
Ca	3.6	9.2	4.7	79	–	14.3
P	0.7	1.6	1.6	–	–	1.1
Mg	1.0	–	0.16	–	–	1.8
Cu (ppm)	2.1	–	15	–	–	7
Tannins (mg/g) [+]	12.9–23.2	1.67–1.97	3.63–3.80	–	–	–

Chemical constituents (g/kg dry matter): CP = Crude protein, CF = Crude fibre, NFE = Nitrogen free extract, EE = Ether extract, ADF = Acid detergent fibre, NDF = Neutral detergent fibre, ME = Metabolizable energy, + = Tannic acid equivalent (analysed by Folin and Dennis method)

3.2.2. Effect of neem supplementation on faecal egg counts in growing sheep

Table XI shows mean faecal egg counts of 15 sheep fed *ad libitum* with neem leaves over a period of 30 days. On observing the eating habits of the sheep, it was noted that they finished about 300 g/head/d, approximately 90% of all leaves fed, and left the stem.

TABLE XI: MEAN FAECAL EGG COUNT OF 15 SHEEP FED *AD LIBITUM* NEEM LEAVES OVER A PERIOD OF 30 DAYS

Day	Eggs per gram of faeces
(Pre-treatment) 0	3200
1	3620
2	3754
3	1477
4	3507
5	2085
9	1808
17	1286
23	1575
30	708

3.2.3. Effect of Kenaf and bio-oil on the faecal egg counts in growing goats

Figures 1 and 2 show the effect of Kenaf and bio-oil on faecal egg counts of infected sheep.

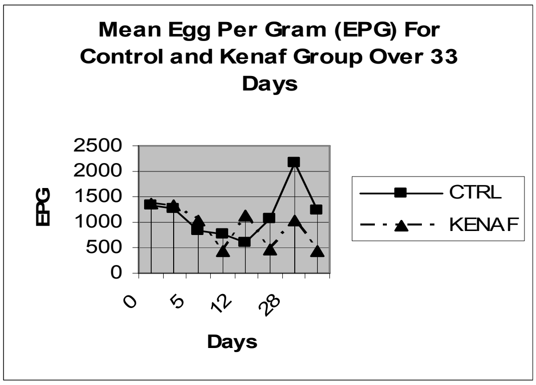

FIG. 1. Effect of Kenaf on faecal egg count of Infected Sheep.

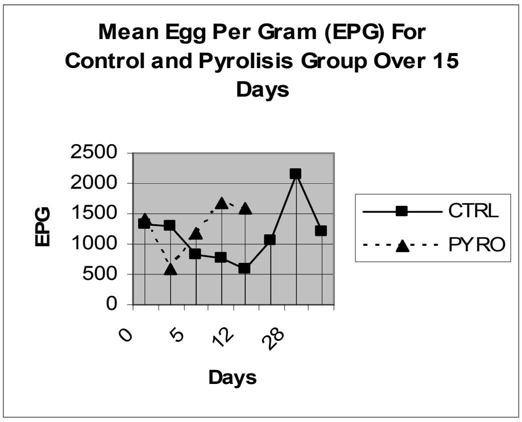

FIG. 2. Effect of "Bio-oil" (pyrolysis) on faecal egg count of Infected Sheep.

3.2.4. Effect of feeding Sentang (Azadirachta excelsa) leaves on the faecal egg counts in growing goats

There were no significant differences on intake of the diets. Table XII shows the effect of feeding Sentang leaves on faecal egg count of cross-bred Boer goats.

TABLE XII. EFFECT OF FEEDING SENTANG LEAVES ON THE FAECAL EGG COUNTS OF BOER CROSS GOATS

Treatment	Mean faecal egg count (per g faeces)							
	Days post treatment							
	3	6	8	10	13	16	20	36
Control	2286	1032	1985	2203	2461	3840	5640	2222
Fresh leaves	2737	1899	2684	2632	2658	3483	3879	2240
Leaf powder	2336	1034	1990	2704	2943	4152	5699	2281

There was no significant effect of Sentang leaves on the faecal egg count of Boer cross-bred goats between treatments. In general, the faecal egg count was high in all groups.

4. DISCUSSION

4.1. Effects of supplementation with UMMB and MUMB

4.1.1. Effect of UMMB supplementation on the infertile dairy cows

All of the infertile animals in experiment 2.1.1 came to heat within 5–8 weeks of receiving UMMB supplementation. Improvements in heart girth were seen in most of the animals but these were not reflected in improved BCS, which declined from an average of 2.9 to 2.7 during the trial. Based on the AI service and heat record, it seemed that ovarian cyclicity occurred in the animals and this could be improved by the UMMB supplementation. Two of the animals became pregnant during the trial although one of them subsequently aborted. The effect of UMMB supplementation on the fertility of the animals could not be seen clearly in this experiment as calving dates were not available for detailed interpretation and an untreated control group was not available for comparison. Limited dry matter intake and poor quality of diet may have contributed to anoestrus in the trial animals and this was possibly rectified by UMMB supplementation.

4.1.2. Effect of MUMB supplementation on the performance of growing sheep

The overall gain : feed cost ratios for MUMB and control groups were 0.86 : 1 and 2.78 : 1 respectively, which indicates that feeding MUMB is not profitable for live-weight gain alone. Of greater importance than improved appetite and body condition was the substantial impact of MUMB on reproduction rate since eight lambs were born in the MUMB group and all survived, whereas neither of the two lambs born in the control group survived. It is evident that good nutrition through MUMB supplementation had improved the rate of growth and general health of the animals and improved reproductive performance. These results are similar to those reported in earlier experiments [5]. The benefits of MUMB supplementation are generally related to better appetite, improved body condition and reduction in animal mortality, resulting in higher sales and higher income to the smallholders [6]. Fenbendazole (FBZ) is the chemical of choice to be used as an anthelmintic agent for parasitic control in MUMB in Malaysia, often included at the rate of 0.05% of the total weight of MUMB. At least 1 g MUMB/kg LW/d is required to maintain a low faecal egg count and at the same time it improves live-weight gain. However, from our experience, for MUMB to be effective, initial drenching is required to remove existing parasite burdens [7]. In the current experiment not all worms were removed by initial treatment as indicated by positive faecal egg counts at two weeks post-dosing. Where anthelmintics have been frequently used, resistance is emerging as a major problem in Malaysia [8, 9, 10, 11]. This issue needs to be considered also when MUMB is used as a carrier for controlling parasites in ruminants.

4.1.3. Effect of UMMB supplementation on milk yield and heat occurrence in low yielding dairy cows

Significant benefits of UMMB supplementation on milk yield of dairy cattle have been shown in experiment 2.1.3 and 2.1.4 carried out at two farms. The net profit of using UMMB in these two farms was between RM 462.60 and RM 579 over the 120-d experimental period. The UMMB supplementation had improved the yield of milk in both experiments by around 90%. The infertility and low milk yields in dairy cows under the smallholder system is mainly attributed to poor nutrition. As shown in these experiments, the cost to benefit ratios are in the range of 1 : 1 to 1.2 : 1, while reduction in the use of concentrate and feed cost is between 25 and 30%.

Of additional benefit, the recording systems in both farms were improved after the implementation of the project. The recordings were mainly related to feeding and farm management. Examples of the records now being kept are; type of feed given, total feed intake, total feed residues, live-weight changes (based on heart girth measurement), milk yield (weight by difference), milk quality (hygiene, microbial count and solid-not-fat content), health record, heat symptoms and date of insemination. The farmer's knowledge on the importance of good nutrition and feeding values of local feed resources were extended and subsequent discussions between smallholders and extension workers have been more open with more active participation of the farmers. Another impact observed was the increased use of locally available agricultural by-products as feeds for dairy cows, particularly rice straw and soyabean waste.

Under the Malaysian dairy smallholder system, UMMB responses on the performance of the animals are immediate, simply because the animals are intensively fed and easily managed. Improvement in block intake and milk yield is commonly seen when low quality feed resources (for example crop residues) are utilized for dairy feeding.

4.1.4. Feeding MUMB to hair-sheep cross-breds under intensive and semi-intensive systems

The faecal egg counts (FEC) indicated that MUMB was effective in sustaining low worm burden regardless of rearing system, and species identification showed helminthiasis was dominated by *Strongylus spp* [12]. The results also suggest a gradual build up of worm burdens which culminated at six months after drenching. Although live-weights within treatment appeared to be similar, because the initial weights of the sheep were close to their expected mature weights, gains in weight after six months show significant differences. Provision of MUMB tended to result in higher live-weight gains after six months of feeding. Based on weekly estimation of one MUMB per pen, each sheep ate a minimum of 84 g MUMB/d, which supplied an equivalent dose of 42 mg FBZ/head/d. Although this was below the recommended dose of 5 mg/kg LW, the effectiveness of medicated MUMB was evident as suggested by low FEC throughout the six-months of observation [13].

4.1.5. Feeding a liquid supplement on the growth performance of goats

This experiment was carried out to study the effect of formulated liquid supplements on the rate of growth of cross-bred goats raised by a smallholder. An earlier experiment carried at the MARDI Station, Serdang, Selangor revealed that addition of PEG and a by-pass fat (BPF) markedly increased the rate of growth of lambs fed on OPF based diets. The on-farm experiment was, therefore, conducted in order to convince smallholders about the advantages of liquid supplementation. Liquid supplementation was used instead of UMMB as the former was easier to handle, cheaper and can be supplemented through drinking water. Results of the experiment indicated that under the condition of the trial, there was no significant benefit of liquid supplement to the goats. It is likely that the response to supplementation could not be translated into better performance as the basal diet used in this experiment was already adequate in nutrients, particularly protein. It appears that addition of PEG in the formulation seems to be poorly related to live-weight gain compared to BPF. Though insignificant, the response of the latter is equivalent to the addition of extra minerals.

4.2. Experimentation on potential herbal medicines for parasite control

4.2.1. Proximate analysis of potentially useful plants for parasite control

Nutritive values of selected local feed resources thought to be effective in controlling parasites indicated that the CP content in the OPF, Kenaf, *leucaena*, jackfruit, neem and mango were 68, 210, 271, 79, 15 and 11 g/kg DM respectively. Fresh jackfruit leaves are commonly used by farmers in the villages for parasite control [13]. An assessment of its nutritive value indicated a DCP and total digestible nutrients (TDN) content of 26 g/kg DM and 21.4% respectively [4]. The effectiveness of Kenaf and *leucaena* in controlling parasites in ruminant animals could possibly be indirect and is likely to be associated with a higher CP content. The tannin concentrations (as tannic acid) in OPF, Kenaf and *leucaena* as determined by Folin and Dennis indicator method were in the ranges of 12.9–23.2, 1.67–1.97 and 3.63–3.80 mg/g respectively. The possible role of tannins in parasitic control merits a more detailed investigation as a positive link exists between ruminal protein degradation and decrease in parasitic load [14, 15, 16, 17].

4.2.2. Effect of neem supplementation on faecal egg counts in growing sheep

The faecal egg counts/g (epg) during the first week (3200–3754 epg) did not show a marked reduction except for the 3rd day (1477 epg). This could be because animals were acclimatizing to the flavour of neem leaves and hence were not eating much. However, from the 2nd week onwards, there was a significant reduction in egg counts suggesting the reduction of the parasite burden in sheep. After 30 days of feeding neem, the mean egg count was reduced to about 700 epg, which was an 82% reduction. It is important to note here that these results were, however, inconclusive because of the absence of the control group. Lowered faecal egg counts in sheep fed *ad libitum* neem leaves, are likely to be associated with improved nutrition due to neem feeding. Neem may contain anti-parasitic activity as has been suggested earlier [14, 18]. As neem is readily available in the tropics, it would be practical in terms of cost and usage to use it for improving nutritional status of the animals, particularly under the smallholder system. Further studies are required in order to understand the possible effect of neem for parasite control. Additionally, as deformed eggs were also found in the faeces of neem-fed sheep [19], studies are required to confirm whether there exist direct anthelmintic/ovicidal/larvacidal effects attributable to neem.

4.2.3. Effect of Kenaf and bio-oil on the faecal egg count in growing goats

Over a 33-day experimental period, Kenaf was observed to decrease the faecal egg count by 69% compared to the control group (Fig. 1). It is likely that the reduction in faecal egg count is due to increased protein intake in the Kenaf-fed group compared to the control [20]. Though 'bio-oil' was reported to be effective in reducing parasites under the smallholder system in two sheep farms in the Northern region, this was not shown in the present experiment up to the point of early termination (due to the animals being attacked by stray dogs). A longer-term experiment is presently in progress to study the effect of bio-oil as an anthelminthic agent in sheep.

4.2.4. Effect of feeding Sentang (Azadirachta excelsa) leaves on the faecal egg count in growing goats

Sentang is a potential plant for soft wood timber production in Malaysia. It is of the same genus as neem (*Azadirachta indica),* and was, therefore, considered as a potential plant to control parasites in ruminant animals. This trial was carried out to investigate whether Sentang has anthelmintic properties. Under the condition of the trial, it was found that Sentang is ineffective in controlling parasites. More studies on the possible use of Sentang leaves as a ruminant feed are required.

5. CONCLUSIONS

Nutrient deficiencies (particularly protein, energy and minerals) and parasite infestations are common in ruminant livestock raised by smallholders. Poor performance in terms of growth rate, milk yield and reproduction, and heavy mortality in young animals are factors limiting farmer's income. Limitations are generally attributed to poor nutrition of the animals as well as to poor understanding of the farmers of overall nutrition and feeding. The use of UMMB and MUMB has been shown to be practical and effective in overcoming nutritional problems in sheep, goats, beef and dairy cattle in Malaysia. The cost to benefit ratio from UMMB or MUMB feeding depends greatly on the type of basal diets consumed, species of ruminants and the extent of nutrient deficiencies or imbalances in livestock. Like UMMB, MUMB can be utilized as a nutrient supplement and has the added benefit as a potential carrier for parasite control agents in grazing animals, especially sheep and goats [8]. Strategies to make UMMB and MUMB sustainable in Malaysia include intensification of extension activities to promote their utilization, development of suitable UMMB formulations for the plantation environment and improvement on productive and reproductive parameters of ruminants under the plantation system. Previous experiments carried out on grazing and pen-fed sheep and goats showed that the consumption of the blocks was less than the targeted intake of 100 g/head/d [8]. In certain circumstances, live-weight gain of PKC supplemented animals was better that those consuming UMMB or MUMB. One of the main by-products of oil palm industry, PKC, is easily and cheaply available in Malaysia and this partly contributes to the slow adoption of UMMB or MUMB technology amongst the smallholders.

Additionally, from our survey, the salt block is still preferred over UMMB by 80% of dairy farmers and private sector farmers. The main reason is the ease of handling of salt-blocks compared to UMMB or MUMB, especially in terms of hardness and easiness of delivery. In contrast, most small farmers with sheep and goat ventures expressed preference for UMMB over the salt-block, especially if UMMB can be hung for feeding like the latter. A more resistant or robust type of UMMB formulation is, therefore, required for future applications under Malaysian conditions. This accords with government policy as larger-scale small ruminant operations are being encouraged, particularly by integration of livestock under plantation crops. Hence, activities for UMMB or MUMB promotion will be further extended to livestock related government and private farms where it is estimated that about 62 000 head of beef cattle will be raised in the plantation environments and the need for UMMB supplementation is frequently justified.

Apart from UMMB and MUMB, there is a need to conduct research to characterize potential plant-based materials for parasite control. Basic data on the nutritive and feeding values of selected feed resources like Kenaf, neem and OPF are available but detailed investigations are needed to understand their roles in parasite control. There are data available on neem from many countries (for example India and Pakistan), but the use of neem for livestock feeding is still new in Malaysia. A longer-term experiment is currently in progress at UPM to further evaluate Sentang *(Azadirachta excelsa)* for parasite control. Other local plants worth considering for parasitic control are *Gliricidia sepium*, *Sesbania sesban,* Angsana *(Pterocarpus indicus)*, Ludai *(S. baccatum)*, Memaya *(Sapium discolor),* Kesiar *(Streplus asper)* and Ficus *(Ficus spp)* [5, 21]. The active components of some of these species are currently being investigated. Apart from tannins, forages containing saponins were also known to impact on parasite infections in sheep [5, 22]. Separation of the nutritional impacts of these plants on immunity and direct anthelmintic effects of plant derived compounds should also be estimated where possible.

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IMPROVEMENT OF ANIMAL PRODUCTIVITY THROUGH SUPPLEMENTARY FEEDING WITH UREA-MINERAL BLOCKS (UMB) IN MONGOLIA

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Abstract

The predominant feed resource available for ruminant production in Mongolia is low quality fibrous forages, which sometimes lack essential nutrients for optimal growth and production of livestock. Four formulations of urea-mineral block (UMB) were developed and tested with locally available low quality forages. In dairy cattle, the average daily intake of one of these formulations (1) was 121 g and consumption resulted in an increase in the daily milk yield of 0.3 L/cow, with a cost : benefit ratio of 1 : 8.2. Training and extension activities are presently underway to extend this technology to ruminant-livestock keepers. A medicated block containing the plant *Stelleria chamaejasme* was also developed for use in sheep, resulting in substantial reductions in cestode egg counts in the faeces. Validation of these results will be necessary before recommendations for use can be made to farmers.

1. INTRODUCTION

Native pastures, spread over approximately 129 million hectares, are the main source of feed for ruminants in Mongolia, these pastures providing about 98% of the total available feed resources [1]. Animal production in Mongolia is constrained by the low quality of these forages and local deficiencies in nutrient availability. Decreasing areas under pastures warrant the development of supplementary feeding strategies for improvement of animal production. Among various supplementary feeding technologies, urea-molasses multi-nutrient blocks have the advantage of being easy to produce and store, and are readily eaten by livestock in most production systems. Their use has also been proved to be economically beneficial in many regions [2, 3]. Due to the non-availability of molasses in Mongolia, urea-mineral blocks (UMB) have been prepared [2] to improve the nutritional status of livestock.

Parasitic infestation frequently reduces growth and decreases the meat and wool production of sheep in Mongolia [4]. Gastrointestinal parasites of sheep can be eliminated by the use of commercial anthelmintic chemicals; however, re-infection from the infected pastures after anthelmintic treatment is common, making regular deworming necessary. Many plants found in Mongolia are known to have antiparasitic properties [1, 5]. Being eco-friendly, these plants can be used regularly for control of parasites in sheep. *Stelleria chamaejasme,* a xerophyte plant, is known to have antiparasitic properties [5].

In this paper, the formulation, preparation and application of UMB and the latest results of research to determine the impact of supplementation with UMB on milk production in cattle are described**.** In addition, a study comparing the anthelmintic efficacy in sheep of UMB with added *S. chamaejasme*, alone or in combination with copper sulphate, is reported.

2. MATERIALS AND METHODS

2.1. Preparation of urea-mineral blocks (UMB) for supplementation of dairy cows

2.1.1. Formulation and preparation of UMB

The UMB were prepared using four formulations as shown in Table I.

TABLE I. PROPORTION OF INGREDIENTS (% OF DRY MATTER) USED FOR PREPARATION OF UREA-MINERAL BLOCKS

Ingredients	Formulations			
	1	2	3	4
Urtica*	–	5	–	–
Natural sodium sulphate salt	64	–	–	57
Common salt	10	30	30	
Wheat bran	10	45	50	15
Urea	5	5	5	5
Wheat flour	6	8	8	15
Local yellow clay		–		5
Cement	5	7	7	3

* Dried leaf of *Urtica hyperborean*

All ingredients were weighed prior to commencing mixing. The cement and urea were mixed with 130–170 mL water (or alcohol fermentation waste) and thoroughly stirred with a shovel before adding the salt. Wheat bran and then the other ingredients were added. The mixture was mixed thoroughly before being placed in a polyethylene bag, which was put into a mould and pressed for 3–5 min. Blocks of 3.5–4.5 kg with diameter of 20 cm and height 13–16 cm were prepared. Before feeding, the blocks were air dried for 10–14 days, by which time only 15–18% moisture remained. The blocks were then stored until feeding. Chemical composition of the UMBs and the raw materials used was estimated by the method of the Association of Official Analytical Chemists [6, 7].

2.1.2. Supplementation of dairy cattle with UMMB

Six Mongolian x Friesian-Holstein cross-bred cows, of 280–300 kg live weight and in their second lactation, were selected for assessing the effect of supplementary feeding with UMB (Formulation 1) on milk production. The cows were grazed in a grass-forb pasture and offered hay (3 kg/head/d). Three cows were supplemented with UMB for 30 days, while the remaining three were kept as unsupplemented controls. Daily feed intake of the cows was recorded. Milk yields of treated and control cows were compared in three periods (days 1–10, 11–20 and 21–30) after the introduction of the UMB supplement.

2.2. Impact of medicated UMB (MUMB) as an anthelmintic for sheep

2.2.1. Development and use of medicated blocks (MUMB)

Medicated UMB (MUMB) were prepared by incorporating air-dried powdered leaves of *S. chamaejasme* alone (Type 1) or *S. chamaejasme* together with copper sulphate (Type 2) into the UMB. The composition of these blocks is given in Table II.

TABLE II. INGREDIENTS (% OF DRY MATTER) IN MEDICATED UREA-MOLASSES MULTI-NUTRIENT BLOCKS (MUMB)

Block	Type 1	Type 2
Common salt	40	40
Wheat bran	32	32
Wheat flour	7	7
Stelleria chamaejasme	8	4
Cement	10	10
Urea	3	3
Copper sulphate		4

2.2.2. *Supplementation of sheep with MUMB*

This study was carried out during the months of February to March, 2004. Twelve sheep, aged 15 to 18 months, and naturally infected with *Moniezia* spp. were allocated to three equal groups (average live weight 32 kg). Sheep in Group 1 (n = 4) received a supplement of Type 1 MUMB enriched with *S. chamaejasme*, alone; Group 2 sheep (n = 4) were received a supplement of Type 2 MUMB containing *S. chamaejasme* and copper sulphate; Group 3 sheep (n = 4) remained as unsupplemented controls. The sheep were housed in a barn and fed with grass hay for the duration of the trial. Block intakes were recorded daily. Faecal samples were collected before supplementation commenced and at weekly intervals thereafter. Individual faecal worm egg counts were estimated by using a standard flotation method [8].

3. RESULTS

3.1. Urea mineral blocks (UMB)

3.1.1. *Characteristics of UMB*

Physical characteristics of the blocks prepared by different formulations were compared. Five per cent cement gave adequate hardness when used with 10% wheat bran. When wheat bran was used in higher proportions (45–50%), a higher amount of cement had to be used to attain the required texture for the blocks. Strength percentage using different binders is given in Table III.

TABLE III. SELECTION OF BINDING MATERIALS FOR UREA-MINERAL BLOCKS

	Binding material (%)		Strength (%)
Formulations	Yellow clay	Cement	
1		5	97.3
2		7	98.7
3		7	98.6
4	5	3	98.2

Chemical composition of the ingredients used and the UMB is given in Tables IV and V respectively.

TABLE IV. DRY MATTER (DM, g/kg) AND CHEMICAL COMPOSITION (g/kg DM) OF RAW MATERIALS USED IN THE PREPARATION OF UREA-MINERAL BLOCKS

Feed raw materials	Dry matter	Organic matter	Crude protein	Crude fat	Crude fibre	Ash
Wheat bran	967.7	907.2	174.0	43.2	69.1	54.1
Dried residue of alcohol processing	968.2	946.3	260.0	64.5	135.9	22.2
Wheat flour (second grade)	963.0	953.4	125.0	17.0	5.5	9.6

TABLE V. CHEMICAL COMPOSITION (g/kg DRY MATER) OF THE UREA MINERAL BLOCKS

Block formulation	Organic matter	Crude protein	Ether extract	Crude fibre	Ash
1.	230	210	9	6	770
2.	633	336	13	12	367
3	642	321	12	11	358
4	355	295	06	6	645

3.1.2. Supplementation of dairy cows

Average daily intake of UMB (Formulation 1) per cow was 121 g (Table VI). Milk yield of the cows is given in Table VII. Average daily milk yield of the supplemented cows was 6.5 L compared to 6.1 L of the un-supplemented cows. Economic analysis of UMB supplementation is shown in Table VIII. The cost : benefit ratio of UMB supplementation based on daily milk production was calculated to be 1: 8.2.

TABLE VI. DAILY INTAKE (kg) OF UREA-MINERAL BLOCKS (UMB, FORMULATION 1) BY INDIVIDUAL COWS

Cow No.	Daily UMB intake	Monthly UMB intake
1	0.110 ± 0.099	3.31
2	0.131 ± 0.18	3.95
3	0.124 ± 0.21	3.74

TABLE VII. DAILY MILK PRODUCTION (L) OF INDIVIDUAL COWS, EITHER SUPPLEMENTED WITH UREA-MINERAL BLOCK (UMB, FORMULATION 1) OR UNSUPPLEMENTED

Treatment	Cow No.	Initial daily yield	Milk yield (days 1–10)	Milk yield (days 11–20)	Milk yield (days 21–30)	Average milk yield (days 1–30)
UMB supplemented	1	6.0	6.1	6.15	6.2	6.15 ± 0.02
	2	6.2	6.7	6.9	7.0	6.86 ± 0.02
	3	6.1	6.0	6.3	6.9	6.4 ± 0.07
Unsupplemented	4	5.9	5.85	6.0	5.8	5.88 ± 0.10
	5	6.1	6.0	6.15	6.1	6.08 ± 0.07
	6	6.2	6.2	6.1	6.1	6.1 ± 0.05

TABLE VIII. ECONOMIC ANALYSIS OF MILK PRODUCTION FROM DAIRY COWS SUPPLEMENTED WITH UREA-MINERAL BLOCK (UMB) OR UNSUPPLEMENTED (1US$ = 1200 TUGRIGS)

	Supplemented	Unsupplemented
Daily milk yield (L/cow)	6.47	6.1
UMB cost (Tugrigs/d)	20	–
Hay cost (Tugrigs/d)	560	560
Total cost of feed eaten by cows Tugrigs/d) (A)	580	560
Sale price of milk (Tugrigs/L)	500	500
Gross profit (B)	3235	3050
Net profit (B – A)	2655	2490
Value of extra milk	165	

3.2. Supplementation of sheep with MUMB

3.2.1. Characteristics and intake of MUMB

Chemical composition of the medicated blocks is given in Table IX. Consumption of the Type 1 block was higher in the experimental period than in the preliminary period. However, intake of the Type 2 block was lower than that of the Type 1 block in both periods, and declined during the experimental period (Table X).

TABLE IX. CHEMICAL COMPOSITION OF MEDICATED UREA-MOLASSES MULTI-NUTRIENT BLOCKS (TYPES 1 AND 2,)

Chemical components (g/kg dry matter)	Type 1	Type 2
Crude Protein	233	228
Ether extract	16	16
Crude fibre	59	51
Ash	484	535

TABLE X. INTAKE OF MEDICATED UREA-MINERAL BLOCKS (MUMB, TYPES 1 AND 2) BY SHEEP

Blocks	Intake of medicated feed blocks (g/head/d)	
	Period of experiment	
	Preliminary period (7 d)	Experimental period (7 d)
Type 1 (containing *Stelleria chamaejasme)*	60	72.5
Type 2. (Block containing copper sulphate and *Stelleria chamaejasme*)	34	16

Over the experimental period both types of MUMB were found to decrease faecal egg numbers compared to the control group. Unfortunately, quantitative data could not be provided because of unforeseen circumstances.

4. DISCUSSION

4.1. Urea mineral blocks

Urea-molasses blocks have been proven to be highly beneficial in areas where low quality forages are the predominant feed resource [2]. In Mongolia, molasses is not readily available and blocks were prepared using other sources of fermentable energy. The present study showed that a number of formulations could be used to successfully prepare blocks, and these blocks were readily consumed by ruminant livestock. If necessary, blocks can be tailor-made for particular locations to compensate for nutrient deficiencies. For example, the blocks having high concentrations of salt could be successfully used in the mountainous areas where salt is deficient. Studies have shown that blocks having lower concentrations of salt were most readily consumed. In the studies described, UMB supplementation improved the milk yield of the cows and this technology was found to be cost effective. Further studies will be necessary to determine the potential level of benefits obtainable in Mongolia's ruminant livestock industry. A programme of training and extension activities has been commenced for this purpose.

4.2. Medicated UMB

Urea mineral blocks can be used to deliver compounds other than essential or deficient nutrients. Previous work has established that UMB can successfully deliver anthelmintic chemicals and assist in the control of nematode parasites [9, 10]. Commercial anthelmintics are not often used in Mongolia due to their relatively high cost and low accessibility. *Stelleria chamaejasme* has anthelmintic properties and, although it is considered poisonous for human beings, there are no reports of livestock poisoning after its consumption [11]. In the present study, UMB prepared with *S. chamaejasme* alone or with *S. chamaejasme* combined with copper sulphate, were both effective in controlling *Moniezia* spp. and *Thysaniezia* spp. endoparasites of sheep. Due to lack of quantitative data, it is recommended that these studies need to be repeated.

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EVALUATION OF UREA-MOLASSES MULTI-NUTRIENT BLOCKS AS A FEED SUPPLEMENT FOR CATTLE PRODUCTION AND AS A CARRIER FOR ANTHELMINTIC MEDICATION IN MYANMAR

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Abstract

Dairy and beef production in Myanmar is expanding, due to increasing demands from a growing population but animal productivity, is often low due to inadequate nutritional resources. The benefits of feeding different formulations of urea-molasses multi-nutrient blocks (UMMB) to dairy and beef cattle were investigated before attempting to transfer this feed supplementation technology to farmers. Several studies indicated that supplementation with UMMB resulted in increased milk production, improved live-weight gain and intake of the available feeds, Supplementation with UMMB was cost effective with a cost : benefit ratio of more than 1 : 2. In addition, supplementation with UMMB resulted in a substantial reduction in the calving to first service interval, calving to conception interval and the number of services per conception. The time to first oestrus for dairy heifers was also reduced. UMMB will, therefore, have a substantial impact on dairy and beef cattle production once this technology is passed on to farmers.

Infection with gastrointestinal nematode parasites is frequently a problem in cattle production in tropical areas where commercial anthelmintics are not often used due to their high cost and/or unavailability. Three local herbal remedies, leaves of *Ananas comosus, Momordica charantia* and *Anona squamosa* were assessed for their anthelmintic efficacy. All three plants reduced faecal worm egg counts of infected cattle after weekly bolus doses for at least two weeks. Comparison of bolus doses with *A. comosus* or *M. charantia* with albendazole showed similar levels of efficacy (94%) in reducing faecal worm egg counts. Assessment of these plants after inclusion in UMMB showed similar efficacy (>79%) to UMMB containing fenbendazole (89%) and suggests further work be conducted to confirm dose rates and benefits of treatment before introduction for on-farm application.

1. INTRODUCTION

Small-scale dairy farming is the predominant system of milk production in Myanmar. The demand for milk is increasing as a result of greater urbanization and to cater for the demands of an increasing population. Dairy farming also provides additional income to peri-urban farmers particularly in the central region of Myanmar. Among the many problems faced by dairy farmers, scarcity and high price of feed ingredients is considered to be the major constraint Availability of grazing land for ruminant animals has become restricted, as a result of the increasing human population, urbanization, industrialization and increasing demand for utilization of agricultural land for production. The present national herd of 13.1 million head of cattle and buffaloes are mainly grazed on natural grassland during the monsoon (June–September) and they are fed with crop residues and agro-industrial by-products during the dry season (February–May). Frequently, both the quality and quantity of feed is low especially during the dry season.

Urea-molasses multi-nutrient blocks (UMMB) have been shown to be an effective means of increasing productivity of ruminant livestock fed roughage based diets [1, 2]. The objective of the current project was to investigate the benefits of feeding different types and formulations of UMMB to dairy and beef cattle in Myanmar and to transfer this feed supplementation technology to farmers.

The climatic conditions in a tropical country like Myanmar favour a high incidence of gastrointestinal nematode (GIN) parasite infection in cattle [3, 4, 5] that may cause substantial losses in production [6]. To combat this problem, indigenous medicinal plants have been used for centuries throughout Myanmar to treat animals and currently the majority of farmers rely on traditional herbal remedies when their animals become sick, as they are cheap and readily available and their traditional use is widely accepted. Researchers have reported that low level daily dose of fenbendazole (FBZ), incorporated in UMMB, controls GIN. The current study evaluated the efficacy of herbal medicine in comparison with commercial anthelmintics. In addition, research was conducted to develop a means of controlling nematode parasites through the strategic use of UMMB containing anthelmintics or herbal remedies in production systems where UMMB is regularly used.

2. MATERIALS AND METHODS

Formulas of UMMB prepared and used in the trials are shown in Table I, and Table II shows their chemical analysis as estimated according the AOAC [7].

2.1. Effect of UMMB on animal production and reproduction 1999–2004

2.1.1. Studies carried out during 1999 and 2000

STUDY 1

UMMB–1 (see Table I) was offered to 11 cows and four heifers at the rate of 0.5 kg/head/d for 180 days while another 12 cows and eight heifers were unsupplemented controls. Productive and reproductive parameters were recorded for individual animals every second week. Similarly, 13 growing calves were offered UMMB–1 for 180 days at 0.5 kg/head/d while another nine calves were un-supplemented controls. Live-weight was recorded each week during the trial.

STUDY 2

In Mandalay, 23 Friesian-Holstein cross-bred milking cows were divided into two groups basic on milk production. Fifteen cows were offered UMMB–1 at 0.5 kg/head/d for 12 weeks while the other eight cows acted were unsupplemented controls. Productive and reproductive parameters were recorded for individual animals every second week.

STUDY 3

A study was conducted in two villages where 23 cows were offered UMMB–1 at 0.5 kg/head/d in Tharyaraye village and another 23 cows were unsupplemented controls in Shardaw village. Studies commenced 10 days before calving and finished at 105 days after calving. Calving to first service and conception intervals were recorded for each animal.

STUDY 4

At Shwepazon farm (medium scale), 10 cows, between the 1st and 4th parity, that calved from September to October 1999, were randomly divided into two groups. All post-partum cows were offered 2 kg sesame cake and *ad libitum* chopped rice straw with grass. One group was offered UMMB–1 from the 8th month of pregnancy for 12 months at the rate of 0.3 kg/cow/d. Daily milk production was recorded. At the same farm, 12 Friesian-Holstein cross-bred calves were randomly allocated into two groups. All the calves were offered the same basal ration of 0.8 kg sesame cake with *ad libitum* chopped straw. One group was offered UMMB–1 at the rate of 0.3 kg/calf/d while the other group was the un-supplemented control. Daily feed intake, weekly body weight change and body condition score were recorded for seven months.

2.1.2. Studies carried out during 2001 and 2002

STUDY 1

Eighteen Friesian-Holstein cross-bred cows, between the 1st to 5th parity and that had calved within four weeks of starting the experiment, were randomly divided into three groups. Cows were given concentrate (60% sesame cake + 40% pea bran) at 1 percent body weight plus a limited amount of cut grass (8 kg) and *ad libitum* chopped rice straw. UMMB–2 (see Table I) was offered to group A cows at 0.5 g/head/d for 119 days; UMMB–3 was offered to group B cows at 0.5 g/head/d for 119 days; and group C cows were an unsupplemented control. Daily feed intake, milk production and weekly body weight changes were recorded. Post-partum ovarian changes were determined from 10 mL samples of milk by using the radioimmunology assay (RIA) method. A randomized complete block design was used in this experiment.

STUDY 2

A total of 109 cows (67 cows in three pilot farms at Mandalay and 42 cows in three pilot farms at Yangon) were used for the trial. All the animals were between the 1st and 7th parity and treatment was started 10 days before calving and continued for 180 days after calving. The cows were randomly allocated into two groups on each farm. One group was offered UMMB–1 at 0.5 kg/d/cow while the other group was an unsupplemented control. Feed intake, milk production, body weight and reproductive performance were recorded for individual cows.

2.1.3. Studies carried out during 2003 and 2004

Studies were conducted at four villages in the Mandalay region. Sites I, II and III were small-scale dairy systems with the cows kept under intensive feeding. Site IV was median scale and the cows were kept under an intensive feeding system. Across the villages 195 lactating cows and 58 dairy breed heifers were randomly divided into two groups. One group was offered UMMB–1 at 5 kg/head/week for 180 days while the other group was a control (without supplement). Milk yield and feed intake were recorded daily. Body weight of the cows was estimated by heart girth measurement and body condition score was recorded. Data were statistically analysed by standard methods [8]. The cost : benefit ratio was calculated to assess the economical profitability of UMMB supplementation.

TABLE I. FORMULATIONS OF UREA-MOLASSES MULTI-NUTRIENT BLOCK (UMMB)

Ingredient (%)	UMMB–1	UMMB–2	UMMB–3
Molasses	35	30	30
Urea	12	8	12
Rice bran	33	40	38
Lime	10	17	15
Cement	5	–	–
Salt	5	5	5

TABLE II. CHEMICAL COMPOSITION (g/kg) OF UREA-MOLASSES MULTI-NUTRIENT BLOCK (UMMB) (DRY MATTER [DM] BASIS)

Description	DM*	Crude protein	Crude fibre	Ether extract	Ash
UMMB–1	802	289	19	29	267
UMMB–2	880	221	25	25	250
UMMB–3	891	336	17	3	207

*g/kg

2.2. Development and use of medicated blocks

2.2.1. *Efficacy of herbal remedies in young cattle*

Dried leaf powder of *Anonas comosus* (pineapple), *Anona squamosa* (custard apple) and *Momordica charantia* (bitter gourd) were tested from June to September 2002. In each of three regions, 40 calves with positive faecal worm egg counts (FEC) were randomly divided into four equal groups and treated as shown in Table III Treatment was by oral dosing with 2 g/kg LW of a herbal bolus prepared by mixing 1kg leaf powder with an equal amount of molasses. Individual FEC were estimated using the McMaster method [9] at the start of the trial (Day 0) and weekly for seven weeks. The *Student's-t* test was used for comparisons of FEC between groups.

TABLE III. EXPERIMENTAL ANIMALS AND TREATMENTS USED IN EXPERIMENT 2.2.1.

Treatment group	Frequency of feeding	No. of experimental animals and herbal plant offered		
		Region I *Anona squamosa*	Region II *Momordica charantia*	Region III *Anonas comosus*
A	Once	10	10	10
B	Twice	10	10	10
C	Thrice	10	10	10
D	Control	10	10	10

2.2.2. *Comparative efficacy of herbal remedies with albendazole*

In Tadau Township during November–December 2002, 40 young cattle with positive FEC were divided into four equal groups (on the basis of FEC). Groups A, B and C were given *M. charantia, A. comosus* and albendazole (Benezal, Ireland) respectively. For Groups A and B, the herbals (as prepared above) were given at 2 g/kg LW at weekly intervals for five consecutive weeks. Group C was given a single dose of 5 mg/kg BW at Day 0 only. Group D remained an untreated control group. Faecal collection and FEC were carried out at weekly intervals from Day 0 for five weeks. The comparative reduction of weekly mean FEC of the four groups was analysed by the F test. Percentage FEC reduction was analysed by a simple comparison of geometric means of pre-treatment FEC with weekly post-treatment FEC of treated groups.

2.2.3. *Inclusion of Anonas comosus (pineapple) leaf in UMMB*

At Myabayin dairy farm, Kyaukse Township during June and July 2003, 20 calves, with a live-weight of 50–100 kg and with positive faecal worm egg counts, were divided into two groups. Group A was given medicated UMMB (MUMB) containing pineapple leaf (included in the block at 35%) at the rate of 0.1 kg/d for 14 days, and Group B was given UMMB at the same rate. Faecal collection for FEC was carried out at weekly intervals from day 0 for three weeks.

2.2.4. Field efficacy of herbal remedies in UMMB

In Sinkyone village, Tadau Township during November to December 2003, 20 calves, between 4 and 10 months-of-age, with a live-weight between 50 and100 kg, were randomly divided into four groups of five animals each. The composition of the MUMB tested is given in Table IV Group A (*A. comosus*) and Group B (*M. charantina*) calves were given their respective herbal MUMB, while Group C calves received UMMB containing 0.5 g/kg fenbendazole (FBZ; Hunter 22%, Anupco). The MUMB was fed to the animals throughout the experimental period. Group D acted as an untreated control, receiving UMMB without medication. Groups A and B were given 1 kg of their respective MUMB each week during the three weeks of the experiment while treatment C was given 1 kg FBZ MUMB for only one week. Daily dosage of all blocks was 0.25 kg/calf/d. Faecal collection for FEC was carried out weekly.

TABLE IV. COMPOSITION (%) OF UREA-MOLASSES MULTI-NUTRIENT BLOCK (UMMB) AND MEDICATED UMMB (MUMB) USED IN EXPERIMENT 2.2.4 (SEE TEXT)

Ingredients	Treatment group			
	A (MUMB)	B (MUMB)	C (MUMB)	D (UMMB)
Molasses	35	35	35	35
A. comosus leaf powder	35	–	–	–
M. charantia leaf powder	–	35	–	–
Febendazole	–	–	500 mg	–
Rice bran	15	15	50	50
Lime	2	2	2	2
Cement	8	8	8	8
Salt	5	5	5	5

* Except for Fenbendazole; block was fed at the rate of 0.25 kg/head/d

3. RESULTS

3.1. Effect of UMMB on animal production and reproduction (1999–2004)

3.1.1. Studies carried out during 1999 and 2000

Results from the four studies are summarized in Tables V and VI. Supplementation with UMMB increased milk production by 15–38% with the greater increase occurring in the Mandalay area. Supplementation with UMMB had no effect on body condition score at any site but increased live-weight gain in heifers at Yangon by >500% and in calves by 15–29%, with the greatest increase at Shwepazo. Use of UMMB showed no impact on calving to 1st service interval at Yangon but substantially reduced this interval at Tharyaraye when compared to Shardaw. Conception rate at 1st service was significantly increased at Yangon and the number of services per conception in both heifers and cows was reduced.

3.1.2. Studies carried out during 2001 and 2002

The productive and reproductive efficiency of supplementation with UMMB–2, and UMMB–3 compared to the un-supplemented control group are shown in Table VII. Body weight loss during the study tended to be lower in the UMMB–2 and UMMB–3 groups but this difference was not significant ($P > 0.05$). Values for mean feed intake and milk production tended to be greater in the UMMB–2 and UMMB–3 groups but these differences were not significant ($P > 0.05$). Calving to 1st post-partum oestrus and calving to 1st service intervals were, however, significantly lower ($P < 0.05$) in the groups offered UMMB. Use of UMMB also increased the percentage of cows pregnant after the first service. Effects of UMMB on the productive and reproductive efficiency at the six pilot farms are shown in Tables VIII and IX. On average feed intake was increased by 4% and milk production by 5% after UMMB was offered on the pilot farms. Use of UMMB also tended to increase the number of pregnancies at first service and reduce the number of services per conception on these farms. Cost to benefit ratios for UMMB use on the pilot farms are shown in Table X and indicate a positive return of investment for the UMMB supplement.

3.1.3. Studies carried out during 2003 and 2004

As shown in Table XI, the average milk yield of cows supplemented with UMMB was 5% higher (P <0.05) than the control group over the 180-day study period. There was no effect of UMMB on body condition score but age at 1st service was reduced by an average of 16 days in UMMB treated heifers. Cost to benefit calculations for this study are shown in (Table XII) and indicate that there was an average 113% return on investment from feeding UMMB.

TABLE V. EFFECTS OF UREA-MOLASSES MULTI-NUTRIENT BLOCK (UMMB) ON PRODUCTIVE AND REPRODUCTIVE PRERFORMANCE IN COWS, HEIFERS AND CALVES IN YANGON AND MANDALAY

Description	UMMB	Control
Milk yield L/head/d		
Yangon	9.9 ± 1.99^{b} (n = 11)	8.4 ± 1.95^{b} (n = 12)
Mandalay	15.2 ± 1.5^{b} (n = 15)	11.0 ± 2.5^{b} (n = 8)
Shwepazon	10.6 ± 2.58^{b} (n = 5)	9.2 ± 1.74^{b} (n = 5)
Body Condition Score[1]		
Cows (Yangon)	3^{a} (n = 11)	3^{a} (n = 12)
Cows (Mandalay)	3^{a} (n = 15)	3^{a} (n = 8)
Heifers (Yangon)	3.4^{a} (n = 4)	3.3^{a} (n = 8)
Calves (Yangon)	3.3^{a} (n = 13)	3.3^{a} (n = 9)
Body weight gain kg/head/d		
Heifers (Yangon)	0.12 ± 3.4^{a} (n = 4)	0.02 ± 3.8^{a} (n = 8)
Calves (Yangon)	0.45 ± 6.3^{a} (n = 13)	0.39 ± 4.1^{a} (n = 9)
Calves (Shwepazon)	0.27 ± 2.41 (n = 6)^{b}	0.21 ± 2.3^{b} (n = 6)

Within rows values with dfferent superscripts differ (P <0.05)
[1]Body condition score 1 = very thin, 5 = overfat

TABLE VI. EFFECTS OF UREA-MOLASSES MULTI-NUTRIENT BLOCK (UMMB) ON REPRODUCTIVE PERFORMANCE OF COWS AND HEIFERS IN YANGON AND MANDALAY

Description	UMMB	Control	P value
Calving to 1st service interval (d)			
Cow (Yangon)	87 ± 9.6 (11)	86 ± 14.6 (12)	NS
Cows (Tharyaraye, Shardaw)	78.1 ± 7.9 (23)	95.4 ± 6.4 (23)	<0.01
Conception rate at 1st service (%)			
Cows (Yangon)	45.5 (11)	36 (12)	<0.05
Heifer (Yangon)	50 (4)	25 (8)	<0.05
Calving to conception interval (d)			
Cows (Tharyaraye, Shardaw)	115.2 ± 14 (23)	119.6 ± 12.7 (23)	<0.05
Service per conception			
Cow (Yangon)	2.1 (11)	2.7 (12)	<0.05
Heifer	2 (4)	4 (8)	NS

NS, not significant
Values between the brackets are number of cows

TABLE VII. PRODUCTIVE AND REPRODUCTIVE PERFORMANCE OF COWS RECEIVING UMMB–2, UMMB–3 AND WITHOUT UREA-MOLASSES MULTI-NUTRIENT BLOCK (UMMB) (2.1.2., STUDY 1)

Description	UMMB (2)*	UMMB (3)*	Without UMMB	*P* value
No of cows	6	6	6	
Calving to 1st oestrus (d)	78.2 ± 17.9	60.7 ± 20.6	92.4 ± 16.1	<0.05
Body weight changes (kg)	19.1 ± 6.6	18.1 ± 5.2	22.2 ± 7.1	NS
Feed intake(kg DM/d/cow)	14.1 ± 2.2	14.2 ± 2.35	13.7 ± 1.6	NS
Milk production (L/head/d)	10.6 ± 2.34	11.9 ± 1.63	10.3 ± 1.8	NS
Calving to first service(d)	97.1 ± 8.3	81.0 ± 11.5	112.3 ± 8.9	<0.05
Service per conception	1.9	1.8	2	NS
1st service conception (%)	66.1	66.6	50.4	NS

NS: not significant
* See text for details

TABLE VIII. FEED INTAKE AND MILK PRODUCTION OF COWS WITH AND WITHOUT UREA-MOLASSES MULTI-NUTRIENT BLOCK (UMMB) ON THE SIX PILOT FAMS (2.1.2., STUDY 2)

Item	Feed intake kg DM/head/d			Milk production L/head/d		
	UMMB	Control	*P* value	UMMB	Control	*P* value
Farm–1 (n = 21)	14.5 ± 3.1	14.3 ± 2.8	NS	19.4 ± 4.1	18.4 ± 3.6	<0.05
Farm–2 (n = 24)	12.8 ± 4.2	12.1 ± 3.2	<0.05	12.3 ± 2.8	11.0 ± 3.1	<0.05
Farm–3 (n = 22)	13.6 ± 3.3	13.1 ± 2.6	<0.05	14.6 ± 2.9	13.9 ± 3.5	<0.05
Farm–4 (n = 14)	11.4 ± 2.8	11.2 ± 2.5	NS	13.7 ± 3.3	12.7 ± 2.7	<0.05
Farm–5 (n = 12)	10.6 ± 3.5	9.9 ± 3.2	<0.05	12.7 ± 3.5	12.4 ± 2.9	NS
Farm–6 (n = 16)	10.8 ± 4.1	10.4 ± 2.7	NS	13.3 ± 2.8	13.0 ± 3.1	NS
Mean	12.3	11.8		14.3	13.6	

NS, not significant

TABLE IX. EFFECTS OF UREA-MOLASSES MULTI-NUTRIENT BLOCK (UMMB) ON REPRODUCTIVE PERFORMANCE OF COWS ON SIX PILOT FARMS (2.1.2., STUDY 2)

Farm	Calving to 1st estrus (d)		1st service conception (%)		Service per conception	
	UMMB	Control	UMMB	Control	UMMB	Control
Farm-1	99.2 ± 3.4[a]	101.2 ± 4[b]	50[c]	42.9[d]	1.9[e]	2.1[f]
Farm-2	117.9 ± 4[a]	119.2 ± 4[b]	47	45.7	2.1	2.3
Farm-3	111.2 ± 5[a]	113.9 ± 5[b]	80	75	1.2	1.4
Farm-4	107.2 ± 4[a]	109.3 ± 5[b]	32	28	2.9	3.1
Farm-5	124.3 ± 7	125.1 ± 5.3	41	39	2.5	2.7
Farm-6	142.5 ± 8	142.9 ± 4	45	43.3	2.1	2.5

Within rows values with different superscripts differ (*P* <0.05)

TABLE X. COST : BENEFIT CALCULATIONS OF SUPPLEMENTATION WITH UREA-MOLASSES MULTI-NUTRIENT BLOCK (UMMB) ON PILOT FARMS (2.1.2., STUDY 2)

Description	Extra milk production L/head/d	Cost of UMMB k/head/d	Value of extra milk k/head/d	Cost **:** Benefit
Farm (1)	1.0	35	75	1 **:** 2.2
Farm (2)	1.3	35	96	1 **:** 2.7
Farm (3)	0.6	35	40	1 **:** 1.1
Farm (4)	1.0	25	82	1 **:** 3
Farm (5)	0.4	25	63	1 **:** 2.5
Farm (6)	0.3	25	53	1 **:** 2.1

TABLE XI. EFFECT OF SUPPLEMENTATION WITH UREA-MOLASSES MULTI-NUTRIENT BLOCK (UMMB) ON MILK YIELD BODY CONDITION SCORE (BCS) AND HEIFER AGE AT FIRST SERVICE

Place	Treatment	Milk production (L/head/d)	BCS*	Age of heifers at 1st service (d)
Site I	UMMB (n = 23)	10.6 ± 0.5^{a}	2.8	689.4 ± 70.6 (n = 5) [b]
	Control (n = 19)	10.2 ± 0.6^{a}	2.8	700.5 ± 78.1(n = 4) [b]
Site II	UMMB (n = 21)	10.3 ± 0.4^{a}	2.8	691.8 ± 69.8 (n = 5)
	Control (n = 21)	9.8 ± 0.7^{a}	2.8	703.3 ± 78.8 (n = 4)
Site III	UMMB (n = 27)	8.3 ± 0.8^{a}	2.5	725.2 ± 93.4 (n = 10) [b]
	Control (n = 29)	7.8 ± 0.7^{a}	2.5	759.4 ± 121.9 (n = 8) [b]
Site IV	UMMB (n = 27)	11.5 ± 0.6	3	739.8 ± 96.2 (n = 12) [b]
	Control (n = 28)	11.1 ± 0.5	3	756.8 ± 135.7 (n = 11) [b]

Within rows values with different superscripts differ (P <0.05)
*BGS, 1 = very thin, 5 = overfat

TABLE XII. COSTS : BENEFIT OF SUPPLEMENTATION WITH UREA-MOLASSES MULTI-NUTRIENT BLOCK (UMMB)

Description	Extra milk production L/head/d	Cost of UMMB kyats/head/d	Value of extra-milk kyats/head/d	Cost : Benefit
Site–I	0.4	27	49	1 **:** 1.8
Site–II	0.5	27	65	1 **:** 24
Site–III	0.5	27	61	1 **:** 2.3
Site–IV	0.4	27	54	1 **:** 2

3.2. Development and usage of medicated block

3.2.1. Experiment 1

Though the total egg counts at the end of the experiment showed 50%, 82.6% and 87.9% reductions in Groups A, B and C respectively, when compared with the egg counts before the treatment with *A. squamosa*, it was observed that significant difference were only observed on day 28, 35, 42, and 49. A similar pattern was observed in Group B, with significant difference observed on day 21, 28. 35, 42, and 47 when compared with the pretreatment egg counts. Group C showed significant differences from day 14 onwards when comparing with the pretreatment egg counts but no significant differences were observed throughout the experiment when compared with the controls (Fig. 1).

With *M. charantia,* Group A did not show any significant difference compared to the FEC of controls and those taken in the pretreatment period. In Group B, it was found that significant differences ($P > 0.05$) were observed throughout the experiment compared with FEC in the pretreatment period, but there was a significant difference after three weeks of treatment. Group C clearly showed significant FEC reductions when comparing the egg count taken in the pretreatment period, and FEC for this group were lower than those of the control group throughout (Fig. 2). When Group A received (*A. comosus*) FEC were lower throughout the experimental period, compared to the preexperimental period, although this group and the controls differed only on day 28 of the treatment period. However, Group B and Group C showed significant FEC reductions throughout the experiment compared to both pretreatment values and the control group (Fig. 3).

3.2.2. Experiment 2

The percentage reduction of faecal worm egg counts and geometric mean worm egg counts pretreatment and weekly, post-treatment, are shown in Table XIII. The comparative efficacy of the two selected herbal plants and albendazole indicated that a single oral treatment of albendazole at 5 mg/kg body weight significantly reduced the faecal worm egg count from one week after the treatment to the end of the experimental period ($P < 0.01$) when compared with the control. Similarly, *A. comosus* reduced FEC after the first and second weekly treatments ($P < 0.05$), and this was further reduced after the third treatment ($P < 0.01$). Treatment with one dose of *M. charantia,* however, did not significantly reduce FEC but after two treatments at weekly intervals a significant egg reduction was observed ($P < 0.05$) and a further reduction was observed after three treatments ($P < 0.01$).

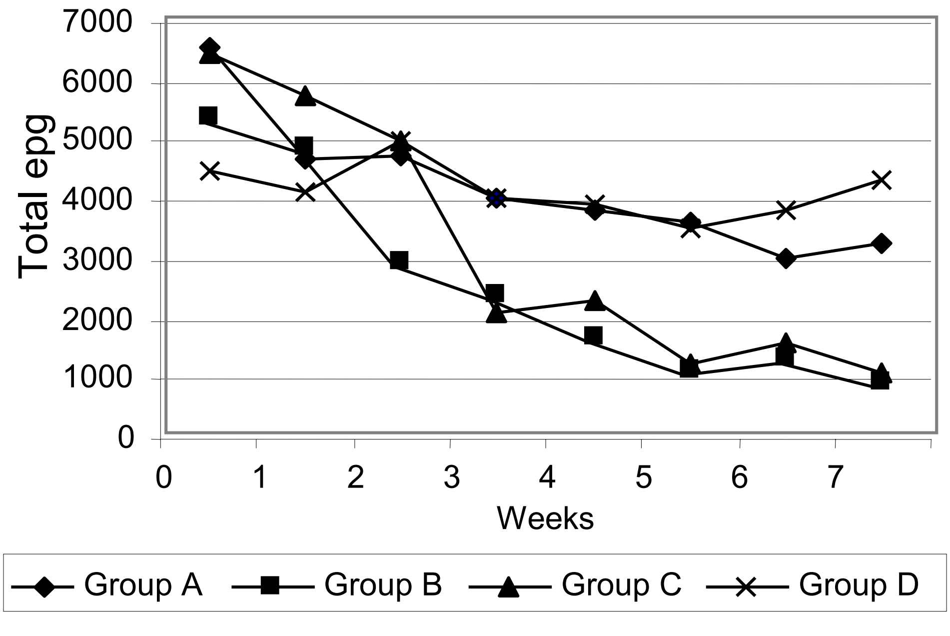

FIG. 1. Changes in weekly faecal eggs per gram (epg) in calves treated with Anona.

TABLE XIII. GEOMETRIC MEAN PRETREATMENT AND POST-TREATMENT WEEKLY, FOR FIVE WEEKS, OF FAECAL WORM EGG COUNTS (EPG) OF FOUR EXPERIMENTAL GROUPS OF CALVES GIVEN *MOMORDICA CHARANTIA, ANONAS COMOSUS*, ALBENDAZOLE OR NOT TREATED

Exp. group	Mean EPG						Percentage reduction of EPG
	Pre-treatment	Post-treatment					
		1^{st} w	2^{nd} w	3^{rd} w	4^{th} w	5^{th} w	
A (*M. charantia*)	280.7	108.0	35.2	13.1	17.9	6.9	94.0
B (*A. comosus*)	253.6	66.7^{b}	143.3^{b}	26.5^{a}	24.7^{a}	10.2^{a}	96.0
C (albendazole)	288.4	1.7^{a}	0	0	0	0	100
D (Control)	242.7	201.4	82.0	72.8	149.7	147.6	38.4

Within rows values with different superscripts differ (*P* <0.05)

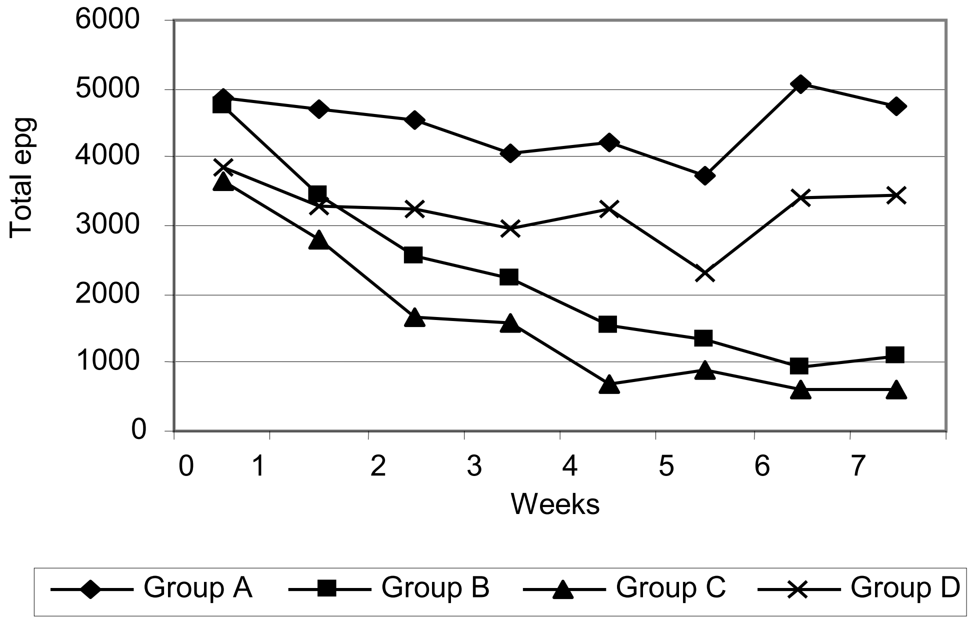

FIG. 2. Changes in weekly faecal eggs per gram (epg) in calves treated with Momordica charantia.

3.2.3. Experiment 3

Mean weekly pre-treatment and post-treatment faecal worm egg counts are shown in Table XIV. Treatment with UMMB containing A. comosus resulted in a reduction in faecal worm egg counts by 60–65% compared to the control groups receiving UMMB alone.

3.2.4. Experiment 4

Mean weekly pretreatment and post-treatment faecal worm egg counts are shown in Table XV. All three medicated block formulations reduced faecal worm egg counts to a similar level by two weeks after commencing treatment.

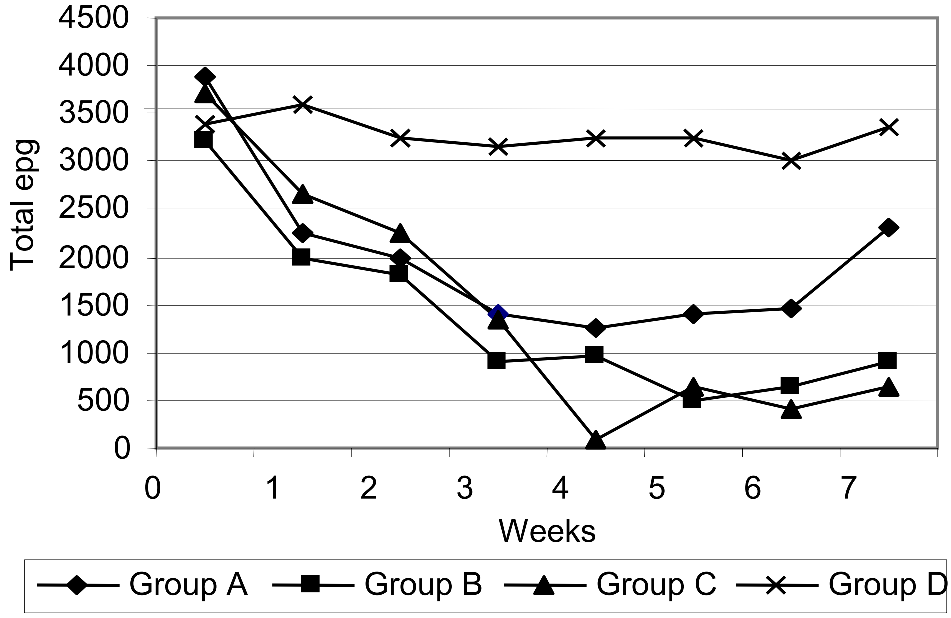

FIG. 3. Changes in weekly faecal eggs per gramme (epg) in calves treated with Anonas comosus.

TABLE XIV. PRETREATMENT AND POST-TREATMENT WEEKLY FAECAL WORM EGG COUNTS (EPG) OF TWO GROUPS OF CALVES OFFERED UREA-MOLASSES MULTI-NUTRIENT BLOCK (UMMB) OR MEDICATED UMMB (MUMB) WITH *A. COMOSUS*

Treatment group	Pre-treatment mean EPG	Post-treatment (week after treatment)					
		1st week		2nd week		3rd week	
		Mean EPG	FECR	Mean EPG	FECR	Mean EPG	FECR
Group–A (*A. comosus* MUMB)	255	100 [a]	60%	95 [a]	63%	90 [a]	65%
Group–B (UMMB)	250	205	18%	265	–	210	16%

Within rows values with different superscripts differ (P <0.05)

TABLE XV. MEAN PRETREATMENT AND POST-TREATMENT WEEKLY FAECAL WORM EGG COUNTS (FEC, EPG) OF CALVES GIVEN MEDICATED UREA-MOLASSES MULTI-NUTRIENT BLOCK (MUMB) WITH *A. COMOSUS, M. CHARANTIA* OR FENBENDAZOLE OR MUMB WITHOUT MEDICATION (UMMB)

Weeks	Treatment							
	A. comosus		*M. charantia*		Fenbendazole		UMMB	
	epg	FECR*%	epg	FECR%	epg	FECR%	epg	FECR
0	270	–	270	–	290	–	250	–
1	70[b]	74.1	110	59.3	50 [b]	82.8	240	–
2	70 [b]	74.1	80 [b]	70.4	30 [b]	89.7	270	–
3	50 [a]	81.5	60 [b]	77.8	30 [b]	89	250	–
4	50 [a]	81.5	70 [b]	74.1	40 [b]	86.2	210	–

Within rows values with different superscripts differ (P <0.05)
*FECR = reduction in FEC

4. DISCUSSION

4.1. Effect of UMMB on animal production and reproduction

4.1.1. Production parameter

The intention of UMMB supplementation is to provide a constant source of degradable nitrogen throughout the day, to promote growth of ruminant microbes in ruminants fed with poor quality roughage [10]. In the present studies, UMMB use increased intake of available feeds by 4% and led to substantial increases in milk production and live-weight gain of dairy cattle in a cost effective way but there was no impact on body condition score. These results agree with previous work that showed UMMB supplementation resulted in increased milk production and live-weight gain of cattle [11, 12, 13].

The response of milk production to UMMB varied from >15% to around 5% increase in the current studies and this is probably due to seasonal variation in quantity and quality of the basal diet. There may also have been a greater awareness of the impact of improved nutrition in the latter studies since more farmers appeared to be using concentrate feeds during these studies than those conducted earlier. The studies with young heifers and bull calves showed a >15% increase in live-weight gain after supplementation with UMMB and again the response in individual trails was variable and probably relates to the available basal diet at each study site.

4.1.2. Reproduction parameter

Supplementation with UMMB resulted in substantial effects on reproductive parameters in the present studies. Calving to first service interval and calving to conception intervals were frequently reduced along with the number of services per conception. Heifers supplemented with UMMB were younger at first service and there also appeared to be less calving problems in cows supplemented with UMMB. All these factors contribute to more efficient dairy farming practices and should lead to improved incomes for farmers.

4.2. Development and usage of medicated block

Before attempting to develop a medicated UMMB formulation for use in Myanmar work was carried out to determine the efficacy of locally available plants considered to have anthelmintic properties [14, 15]. The primary reasoning behind this investigation was the high cost and sporadic availability of commercial anthelmintic compounds for ruminant livestock in Myanmar. Initial tests with bolus doses of *A. comosus*, *M. charantia* and *A. squamosa* indicated that all plants had anthelmintic activity provided more than one dose was given at weekly intervals. Farmers were reluctant to harvest *A. squamosa* leaves for this purpose, however, due to the valuable fruit produced by these trees and the possible negative impact of leaf collection on fruit production. Further comparative tests of *A. comosus* and *M. charantia* with albendazole indicated that weekly doses with either gave a similar level (>94%) of reduction in faecal worm egg counts to a single dose of the commercial preparation but at considerably lower cost. The success with bolus doses led to the incorporation of dried leaf material into UMMB formulations which were also tested for efficacy. Initial tests with *A. comosus*-UMMB resulted in a 65% reduction in faecal worm egg count but further tests comparing *A. comosus*-UMMB, *M. charantia*-UMMB and fenbendazole-UMMB resulted in >80%, >77% and >89% reductions respectively. The difference in efficacy of the *A. comosus*-UMMB in the two studies may relate to the dose rates provided with the earlier study providing a lower dose than the latter. These results indicate that there is tremendous potential for the use of UMMB containing herbal remedies against nematode parasites of cattle in

Myanmar and further work should be carried out to confirm dose rates and determine benefits of treatment after application on-farm. Consideration should also be given to studies to investigate the combination of *A. comosus* and *M. charantia* in one formulation to further improve efficacy.

The FECRs in the first and second week were the same in treatment A (74.1%) after which there was an increase. In this experiment the dosage of MUMB was higher and the duration of the trial longer (87.5 g/d for four days per week for three weeks) than in an earlier study (35 g/d for 14 d). *Anonas comosus* based MUMB was effective in the first week of treatment but *M. charantia* needed a longer period to become effective. Febendazole is highly effective in the first week of treatment.

5. CONCLUSIONS

The studies conducted in Myanmar show that UMMB supplementation improved milk production, feed intake and reproductive performance of cattle and increased the economic benefits for participating farmers. In addition, a beneficial effect of UMMB use in increasing weight gain was shown in calves over 12 months of age. The use of *A. comosa* and albendazole in UMMB (MUMB) was highly effective in controlling strongyle nematode infections in calves while *M. charantia* was moderately effective.

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SUSTAINABLE IMPROVEMENT OF LIVESTOCK PRODUCTION THROUGH STRATEGIC SUPPLEMENTATION WITH UREA-MOLASSES MULTI-NUTRIENT BLOCK (UMMB) AND OTHER FEED RESOURCES AVAILABLE IN PAKISTAN

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Abstract

Livestock are a vital source of meat and milk, and livestock production is an integral part of agriculture in Pakistan. The ruminant feeding system is based on low quality roughages that can be improved by creating conditions in the rumen for maximizing fibre digestion. A solidified urea-molasses multi-nutrient Block (UMMB), prepared with commonly available, cheap ingredients to provide critical nutrients for microbial fermentation, was formulated and tested. Another constraint to livestock production is the scarcity and fluctuation of quality and quantity of animal feed supply throughout the year. To overcome these problems, particularly in salt-affected wastelands, non-conventional and low-cost feed resources require evaluation. The present project attempts to introduce new management practices based on proven technologies for improvement of productivity and reproductive efficiency of livestock. Pilot farms were selected to evaluate the effects of UMMB feeding and various studies conducted on cattle and buffalo have shown its positive effects. Supplementation with UMMB resulted in improvements in intake of low quality roughages, digestibility, weight gain, milk production and resumption of post-partum oestrus. Supplementation of animals raised on low quality fodders with UMMB may be an alternative to other forms of supplementation especially when these become unavailable or too expensive. The cheapest source of nitrogen as well as of energy available has proved to be UMMB. The UMMB technology can also be utilized for the control of parasites in livestock through its potential as a carrier of anthelmintics, traditional herbal medicines and plants with anthelmintic properties. Effectiveness of medicated UMMB feed blocks to control gastrointestinal parasites in sheep and goat was tested. The medicated UMMB and conventional anthelmintics were both found to be highly effective but conventional therapies were thought to be most appropriate for application in most livestock production systems in Pakistan.

1. INTRODUCTION

Livestock are an integral part of the agriculture sector in Pakistan, because local livestock production is the primary supplier of meat and milk to the general population. Livestock also provides additional income to smallholder farmers and livestock owners. In general, productivity of most of animals is below their genetic potential due to inadequate nutrition, reproductive mismanagement, prevalence of diseases and lack of effective support services such as artificial insemination (AI). As the population of Pakistan is rapidly increasing (2.6% per annum) the production potential of the livestock sub-sector needs to be fully exploited to meet the future demand for meat and milk. One of the major barriers to the expansion of crop cultivation and livestock production is decreasing land availability due to increasing urbanization into agricultural areas. Another constraint to livestock production is the scarcity and seasonal fluctuation in the quality and quantity of animal feed supply throughout the year. During the rainy season, plants grow rapidly and their quality may be good in the early season but they mature rapidly with a resultant decline in quality. During the dry season, the predominant feed resource for ruminant livestock is often dry forages or stored crop residues (sugar cane tops, wheat straw, maize combs, rice polishings, wheat straw, cottonseed meal and sunflower meal). These low quality roughages are frequently low in protein, energy, minerals and vitamins. Sometimes the addition of foliage from tree species in ruminant diets can improve the utilization of low quality roughages, mainly through increasing the supply of dietary nitrogen to rumen microbes. Supplementation of deficient nutrients in the form of urea-molasses multi-nutrient block (UMMB) has also been shown to be very effective in many ruminant production systems [1, 2, 3]. With UMMB use ruminants can make better use of low quality forages, agricultural by-products and crop residues and other non-conventional feed resources.

In many developing nations, livestock production suffers from gastrointestinal parasitism affecting cattle, buffalo, goats and sheep. The associated losses are inflicted in the form of low productivity, reduced product quality and reproductive potential, and increased mortality. In Pakistan, the prevalence of the parasite infestations of ruminant livestock is very common. The UMMB technology can be exploited for the control of parasites in livestock through its potential for use as the carrier of anthelmintics, traditional herbal medicines and plants with anthelmintic properties by incorporating the appropriate doses of these materials in the block [4]. A wide variety of anthelmintics are used for the treatment of helminths in animals. However, the high cost of commercial preparations and the development of resistance in many strains of helminths to commonly used anthelmintics is currently a challenge to animal health care professionals in many countries. Therefore, as an alternative approach, studies on indigenous plants having anthelmintic potential were undertaken. Plants, as a traditional system of therapy, have been used from ancient times to cure diseases of humans and animals [5]. It was thought that herbal anthelmintics may have a role in controlling nematode infections in animals and lead to more efficient utilization of feed resources for increased productivity.

The present project envisages the development of a strategy to introduce new management practices based on established technologies for improvement of productivity and reproductive efficiency of livestock using nuclear and other related techniques. Pilot farms were selected to apply an integrated approach including UMMB technology for improved nutrition; progesterone radioimmunoassay (RIA) for improved reproductive management; deworming and vaccination for control of various livestock diseases. The details of studies undertaken on various aspects of UMMB and medicated UMMB (MUMB) at these farms are the subject of this report.

2. MATERIALS AND METHODS

2.1. Formulation and ingredients of UMMB

The local market was surveyed for the availability of ingredients that could be used for manufacturing UMMB. A variety of readily available and cheap ingredients were explored that could be incorporated in the UMMB formulation. The UMMB was manufactured by the cold method [3] and the composition of UMMB was modified in different formulas according to the availability of different ingredients at different locations. The ingredients and percentage composition of various UMMB formulas are shown in Table I.

TABLE I. COMPOSITION (%) OF UREA-MOLASSES MULTI-NUTRIENT BLOCK (UMMB)

Ingredients	UMMB 1	UMMB 2	UMMB 3	UMMB 4	UMMB 5	UMMB 6	UMMB 7	UMMB 8
Molasses	45	40	40	45	35	18	55	55
Urea	8	8	10	8	8	10	6	6
Lime Stone	8	8	10	8	–	–	2	5
Super Phosphate	–	–	3	2	–	–	–	–
Calcium Sulphate	–	–	–	2	–	–	–	–
Salt	5	5	5	1	–	1	–	–
Wheat Bran	25	39	22	26	–	–	6	15
Cottonseed Meal	9	–	10	8	20	10	–	–
Rice Polish	–	–	–	–	13	20	15	5
Maize Gluten	–	–	–	–	10	10	–	–
Mineral mixture	–	–	–	–	6	1	3	–
Sodium bentonite	–	–	–	–	6	–	–	–
Calcium Carbonate	–	–	–	–	2	–	–	–
Sunflower Meal	–	–	–	–	–	10	–	–
Maize Grain	–	–	–	–	–	10	–	–
Rape seed Meal	–	–	–	–	–	–	6	6
Cement	–	–	–	–	–	10	2	2
Press mud	–	–	–	–	–	–	5	6

A trial on feeding of UMMB was conducted at the Livestock Production Research Institute (LPRI), Bahadurnagar, Okara, for 60 days. Two closely related formulae viz., 7 and 8 were used in the preparation of UMMB, and the chemical composition of these formulae is given in Table II. Feeding trials were conducted on six male buffalo and six female calves (3–4 months old) divided in to two groups, A and B, each group receiving one of the formulations as supplementation. Eight kg of the fodder in season (berseem and grass) and 2 kg urea treated paddy straw was fed to each calf in addition to an *ad libitum* quantity of UMMB. These blocks were also tried on-farm on cows and buffalo calves maintained, by progressive breeders at four villages, using the same experimental design as used for the trial at LPRI.

2.2. Effect of UMMB supplementation on digestibility and fodder intake in Sahiwal cows and Nili-Ravi buffalo

This study was planned to investigate the intake of UMMB and the effect of its use on the utilization of available green fodder in 'Sahiwal' cows and 'Nili-Ravi' buffalo. Five dry non-pregnant buffalo and Sahiwal cows were selected for this experiment. The UMMB was offered daily and residues were recorded for a period of 76 days. In a second trial, this group of buffalo and cows was provided green fodder of Berseem along with UMMB. Five additional buffalo and Sahiwal cows were also included in this trial as a control group (without UMMB supplementation) and fed green fodder only. Digestibility data were collected for five days. For this purpose, measured quantities of UMMB and green fodder were offered individually and the refusals recorded. These observations were initially recorded with Berseem as the green fodder and then with chopped maize. Chemical composition of UMMB and different fodders were estimated by AOAC methods [6] and are given in Table III.

TABLE II. DRY MATTER (DM, g/kg) AND CHEMICAL COMPOSITION OF UREA-MOASSES MULTI-NUTRIENT BLOCK (UMMB) (g/kg DM)

Composition	UMMB 7	UMMB 8
Dry matter	796.2	801.8
Ether extract	38.1	38.5
Crude fibre	57.8	47.8
Crude protein	81	182
Ash	251.2	262.8
Nitrogen free extract	449	452.7

TABLE III. CHEMICAL COMPOSITION OF BERSEEM, MAIZE AND UREA-MOLASSES MULTI-NUTRIENT BLOCK (UMMB)

Composition	Berseem	Maize	UMMB
Dry matter (DM) g/kg	134	265	883
Crude Protein g/kg DM	119	77	356
Crude fibre g/kg DM	310	280	–
Ether Extract g/kg DM	120	88	–
Total minerals g/kg DM	18	20	–
Total Digestible Nitrogen %	–	–	78.6

2.3. Effect of UMMB feeding in lactating animals (buffalo and cows) at different pilot farms

Three studies were conducted on different pilot farms in this regard:

2.3.1. Effect of UMMB supplementation on milk production in buffalo at small dairy farms

Smallholder dairy farmers in peri-urban and rural areas were included in this study to observe the effect of UMMB feeding on milk production and resumption of post-partum oestrus in mixed breed buffalo. Basic information about the dairy herds and farms was collected. All the animals were fed by a cut-and-carry feeding system including chopped straw. Urea-molasses multi-nutrient blocks (formula 2) were given to the farmers for the feeding trials. Ninety-five buffalo were selected and divided into three groups:

(i) Early Lactation (Calved within 2 months)

(ii) Mid-Lactation (Calved between 2 and 5 months)

(iii) Late Lactation (Calved more than 5 months)

Data on daily milk yield was recorded to study the effect of UMMB supplementation on milk production.

2.3.2. Effect of UMMB supplementation on milk production and resumption of postpartum cyclicity in buffalo

Sixteen animals were selected for this study, 12 animals from Ayub Agricultural Research Institute (AARI), Faisalabad and four from a private farm situated on the Jhang road, Faisalabad. The animals were divided into two equal groups (on the basis of calving interval).

Lactation–I (Calved within one month)

Lactation–II (Calved between 3 and 4 months)

All animals were allowed free access to available green fodder, supplemented with concentrate (cottonseed meal, at the rate of 1:30 mixed with wheat straw). Four animals in each group received UMMB in addition to this diet and four animals were not given UMMB to serve as control. Milk yield was recorded weekly and a 5 mL milk sample from each animal was collected. The milk fat was removed by centrifugation and skim milk samples analysed for progesterone. Progesterone was estimated by the radioimmunoassay (RIA) method using DPC kits, supplied by IAEA [7]. The data was subjected to analysis by the Duncan Multiple Range (DMR) test by using a two factors factorial complete block design with four replications. Progesterone hormone profiles were estimated to determine the post-partum ovarian changes through progesterone hormone fluctuations at various reproductive phases as an indicator of reproductive efficiency.

2.3.3. Effect of UMMB supplementation in lactating cross-bred cows

A trial was conducted on lactating cross-bred cows at the Livestock Experiment Station (LES), Qadirabad to determine the benefits of UMMB supplementation in terms of milk production and impact on profitability. Twenty cross-bred cows at almost similar stages of lactation and milk production were selected and divided into two equal groups. Group A was kept as a control (on routine feeding) while Group B was supplemented with UMMB in addition to routine feeding. A concentrate ration (Table IV) was also provided to each animal based on milk production, i.e. one kg concentrate/3–L of milk produced. The intake of UMMB and milk production of each animal was recorded daily over a period of 52 days.

TABLE IV. RATION FORMULATION FOR LACTATING ANIMALS IN EXPERIMENT 2.3.3.

Ingredients	Percentage
Molasses	18
Rice polishing	25
Cotton seed meal	10
Mineral mixture	01
Maize grain	10
Maize gluten	25
Sunflower meal	10
Salt	01
Total	100

Crude protein: 180 g/kg DM
Total digestible nitrogen: 71.3%

2.4. Effect of UMMB supplementation on growth rate of Sahiwal calves

Thirty Sahiwal heifers of 12 to 18 months of age were selected from the herd maintained at Livestock Experiment Station (LES), Okara. The heifers were divided into two equal groups based on live weight (average 103 kg). Group A was offered green fodder available according to the season (sorghum, grass and wheat straw) *ad libitum*, 1 kg of concentrate ration (150–160 g/kg DM crude protein) per head and UMMB was freely available in the feeding troughs. Group B (Control group) was offered green fodder *ad libitum* and 1 kg of concentrate per animal daily. Data on live-weight change was recorded for 229 days.

2.5. Major gastrointestinal nematodes in young buffalo, sheep and goats

A survey was undertaken to observe the gastrointestinal nematodes in young buffalo, in six districts of Punjab, and in sheep and goats maintained at LPRI (Pilot Farm) and the area around Okara. Fresh faecal samples of 900 buffalo calves (20–24 months age), 386 sheep and 276 goats were collected in the morning. Samples were analysed for faecal worm egg counts (FEC) to estimate the level of infection in buffalo calves (Table V). The eggs of various nematodes were also identified microscopically on the basis of morphology and relative invasion of various species of parasites in sheep and goats (Table VI). The efficacy of various anthelmintics (Albendazole, Levamisole, Ivermectin, Systamax and Kameela) was also recorded.

TABLE V. INTENSITY OF PARASITIC INFESTATION IN YOUNG BUFFALO IN SIX DISTRICTS OF PUNJAB

S. No.	Faecal worm egg count	Total No. of samples	Infestation (%)
1	200–400	322	41.4
2	400–800	172	22.0
3	800–1200	115	14.8
4	> 1200	170	21.8

TABLE VI. PREVALENCE OF DIFFERENT PARASITES IN SHEEP AND GOATS IN DIFFERENT AREAS

Parasites	Sheep n = 386		Goat n = 276	
	Infected %	EPG	Infected %	EPG
Haemonchus contortus	83 (321)	3200–4800	85 (235)	1200–3400
Trichostrongylus spp	73 (282)	2600–4000	69 (192)	1200–3000
Nematodirus spathiger	44 (172)	200–1200	37 (103)	200–1600
Chabertia ovina	41 (161)	200–1400	35 (99)	200–1000
Trichuris globulosa	3 (92)	200–600	26 (73)	400–1000
Oesophagostomum spp.	13 (53)	200–400	14 (39)	200–800
Ostertagia circumcincta	5 (21)	200–400	9 (26)	200–600

*EPG = eggs per g of faeces

2.6. Effectiveness of medicated UMMB to control gastrointestinal parasitism in grazing sheep and goats.

The study was undertaken to observe the efficacy of medicated blocks on the control of parasitism in grazing sheep and goats. Medicated blocks were prepared at UMMB manufacturing mills, NIAB, using Levamisole HCl (Nilverm; ICI) according to the prescribed dose of 7.5 g/kg. Blocks were distributed to the NIAB Farm for sheep and BSRS–II, Pacca Anna, Faisalabad for goats to use for the control of parasites. Feeding trials on sheep and goats were conducted to compare the effectiveness of anthelmintic as an oral drench or through medicated feed blocks (offered as a free lick). Fifteen sheep and 15 goats were selected from the herds kept at NIAB Farm and BSRS–II, Pacca Anna respectively. Animals were then divided into three equal groups of five animals each (blocked according to live-weight and FEC). They were allowed free access to grazing on seasonal fodders or grasses plus free access to UMMB lick (200–250 g/d). The three experimental groups were as follows:

Treatment–1: No anthelmintic (control group).

Treatment–2: Oral drench of 10 mL Levamisole HCl (recommended dose).

Treatment–3: Medicated-UMMB containing 7.5 g/kg Levamisole HCl.

Fresh samples of faeces from individual animals were collected weekly for FEC and identification of parasite species.

3. RESULTS

3.1. Formulation and ingredients of UMMB

Various formulas were prepared, depending on the availability of the ingredients (season, cost), nutritional value, hardness and easy consumption by the animals. Formulae 4, 5, 6, 7, and 8 were found suitable at different locations and were used for various pilot project studies.

The results of the trials of formulas seven and eight proved that both the preparations were palatable and animals consumed them in equal amounts, both at Government farms and on-farm. No significant difference (P >0.05) was found between formulae seven and eight in term of weight gain of the experimental animals. Average weight gains of 530 g and 517 g per day were recorded for buffalo and cow calves respectively. An expenditure of Rupees (Rs.) 21 produced 1 kg live weight or 500 g of dressed meat (equivalent to Rs.35 at current market price) both at public and private farms.

3.2. Effect of UMMB supplementation on digestibility and fodder intake in Sahiwal cows and Nili-Ravi buffalo

As shown in Table III, berseem contained more crude protein (CP) (119 g/kg DM) and less dry matter (DM) (134 g/kg) when compared to maize (CP 77 g/kg DM, DM 265 g/kg) while UMMB contained 355 g/kg DM CP and the DM was 882 g/kg. Digestibility of berseem and maize fodders in buffalo and cows with and without UMMB supplementation are shown in Table VII and VIII. Buffalo ate more fodder than cows (655.5 kg vs 567.5 kg respectively), during the trial period.

TABLE VII. DIGESTIBILITY OF BERSEEM WITH AND WITHOUT SUPPLEMENTATION WITH UREA-MOLASSES MULTI-NUTRIENT BLOCK

Species	Dry matter (DM) consumed (kg)	DM refused	Digestibility %	Level of significance
Buffalo	9.55	2.33	75.6 Treated	0.015*
Buffalo	8.03	2.32	71.1 Control	
Cow	8.00	2.15	73.1 Treated	0.0099**
Cow	6.69	2.32	65.3 Control	

Daily DM intake and digestibility were higher when berseem was supplemented with UMMB in both buffalo and cows. Similar results to those for berseem were observed when maize was used as green fodder, the exception being in cattle where DM intake was not statistically higher when maize fodder, with and with out supplementation of UMMB was offered.

TABLE VIII. DIGESTIBILITY OF DRY MATTER (DM) OF GREEN FODDER (MAIZE) WITH AND WITHOUT SUPPLEMENTATION UREA-MOLASSES MULTI-NUTRIENT BLOCK

Species	Dry matter (DM) consumed	DM refused	Digestibility %	Level of significance
Buffalo	14.85	3.32	77.6 Treated	0.0003*
Buffalo	10.51	3.00	70.9 Control	
Cow	9.88	2.16	78.1 Treated	0.019**
Cow	9.29	2.67	71.3 Control	

3.2.1. *Effect of UMMB supplementation on milk production in buffalo at small dairy farms*

Adaptation to regular consumption of UMMB generally required 4–15 days. Wide variations in block intake were reported between individual experimental animals. On average, buffalo consumed 200–500 g/animal/d and the highest intake in pregnant buffalo was 1000 g/d. It was noted that UMMB increased feed and water intake and the lactation period was prolonged.

Figure 1 shows the average milk production in all groups (early lactation, mid-lactation, late lactation) over the trial. Milk production was shown to increase in treated buffalo two weeks after commencing UMMB feeding and remained higher throughout the trial in all groups. Feeding UMMB to the early lactation group (Fig. 1a) led to an increase of 10–16% in daily milk production while for the control group the daily milk yield remained static and then decreased after a few weeks. For the mid-lactation group animals (Fig. 1b), those fed on UMMB showed a 16.6% increase in milk production while in the control group milk production decreased up to 20% by the end of experiment. In the late lactation group (Fig. 1c), it was observed that milk yield had increased by 17.4% at the end of the trial, while in the control group it had dropped by 22.2%. Therefore, in this group the difference in milk production due to UMMB use was greatest at 39.6 %. Figure 1d shows the data for the three groups.

3.2.2. *Effect of UMMB supplementation on milk production and resumption of post-partum oestrus in buffalo*

In this study adaptation to UMMB consumption again required 4–15 days with wide variation in block intake between individual experimental animals. Overall, the buffalo consumed 400 g/animal/d. Figure 2 shows the average milk production in the first group (lactation–I). The average milk production increased two weeks after commencement of feeding of UMMB and remained higher throughout the trial. Statistical analysis (Table IX) showed that the UMMB fed animals produced more milk than the control group ($P < 0.05$).

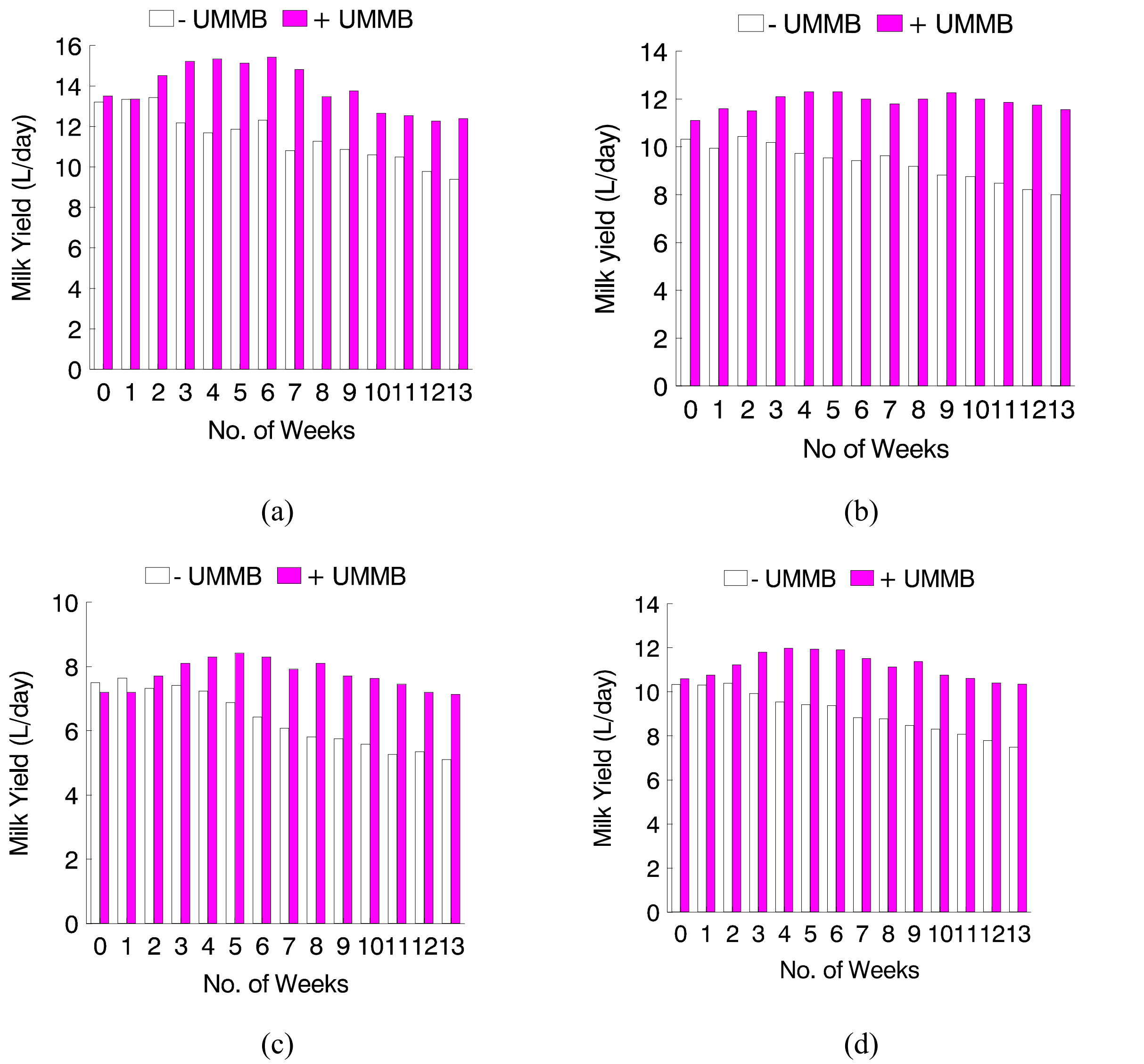


FIG. 1. Effect of urea-molasses multi-nutrient block (UMMB) on milk production in buffalo during various stages of lactation: (a) Early,(b) Mid, (c) Late and(d) Total lactation period.

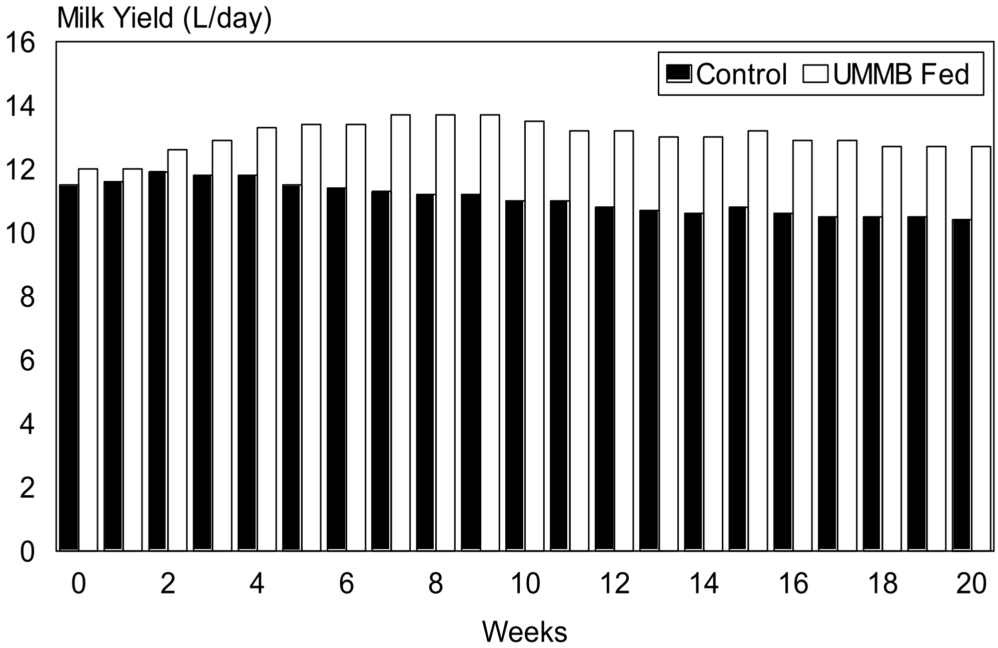


FIG. 2. Effect of urea-molasses multi-nutrient block (UMMB) on milk production (Lactation–1).

In the 2nd group (Lactation–II, Fig. 3), average milk production in UMMB fed animals increased gradually from the 3rd week and stayed higher than the control group throughout the experimental period. The UMMB fed animals showed a significant increase in milk production (P <0.05) when compared to control animals (Table IX).

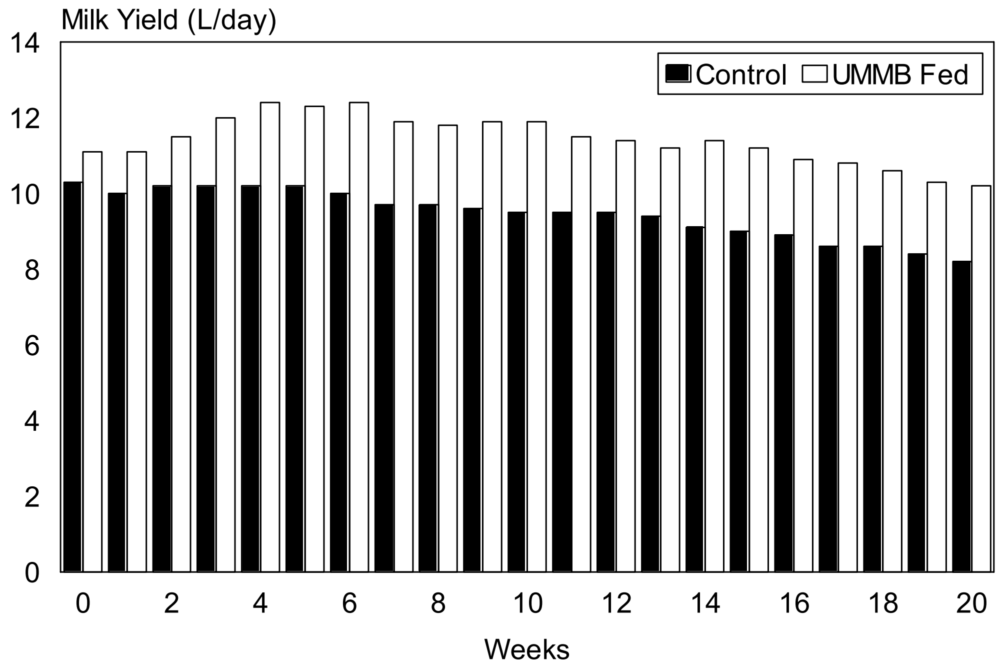


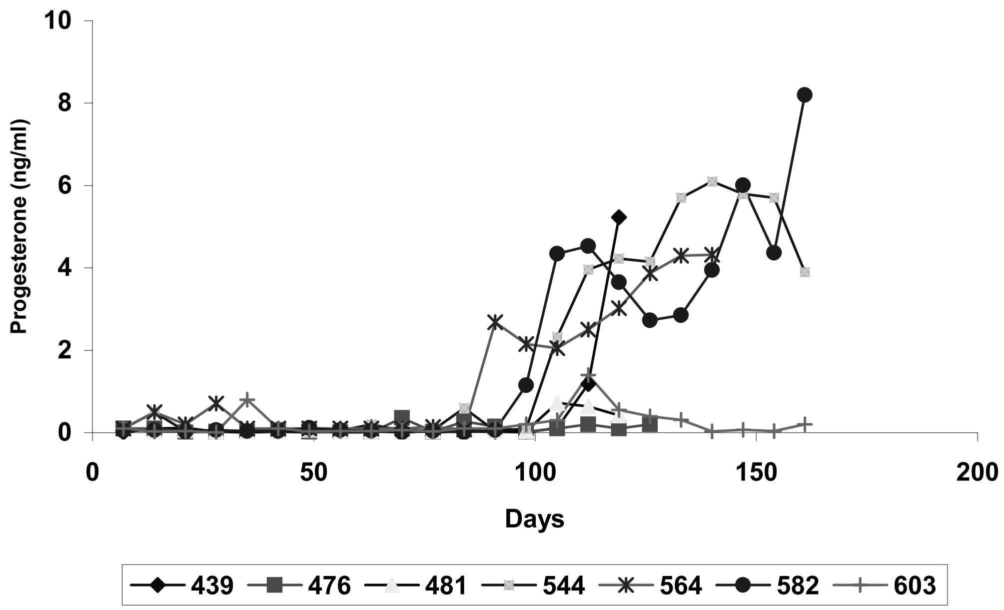
FIG. 3. Effect of urea-molasses multi-nutrient block (UMMB) feeding on milk production (Lactation–II).

TABLE IX. ANALYSIS OF VARIANCE

K value	Source	Degrees of freedom	Sum of squares	Mean Square	F value
A. (Lactation–I)					
1	Replications	3	49.591	16.530	3.3024*
2	Weeks (A)	20	19.083	0.954	0.1906 NS
4	*UMMB Feeding (B)	1	159.119	159.119	31.7884**
5	AXB	20	18.725	0.936	0.1870 NS
7	Error	123	615.683	5.006	
B. (Lactation–II)					
1	Replications	3	35.764	11.921	10.4515**
2	Weeks (A)	20	63.639	3.182	2.789**
4	*UMMB Feeding (B)	1	164.022	164.022	143.7999**
5	AXB	20	8.179	0.409	0.3585 NS
7	Error	123	140.279	1.141	

*UMMB = Urea-molasses multi-nutrient block

Figure 4 shows the milk progesterone levels of animals in lactation group I. The UMMB fed animals started ovarian activity at 88–105 days after parturition, showing higher (3–5 ng/mL) milk progesterone levels. These animals came into heat, were inseminated, conceived and maintained the higher milk progesterone level (confirmed pregnancy). The control group did not show any fluctuation in progesterone level (i.e. no oestrus) up to 130 days.



FiIG. 4, Milk progesterone levels in control (476, 481 and 603) and urea-molasses multi-nutrient block (UMMB) fed to buffalo (nos. 439, 544, 564 and 582) (Lactation–I).

In the Lactation–II group, UMMB fed animals demonstrated oestrus between 95 and 102 days post-partum, they were inseminated, conceived and maintained higher milk progesterone levels (Fig. 5). In the control group oestrus was observed later at 138–172 days. These animals also maintained higher progesterone levels after conception. One of the animals in the control group showed an increase in progesterone levels at day 140 post-partum, it then dropped to the basal level after completion of the cycle of 22 days. There was no significant difference in progesterone concentration, which fluctuated in the range of 2–9 ng/mL in both groups.

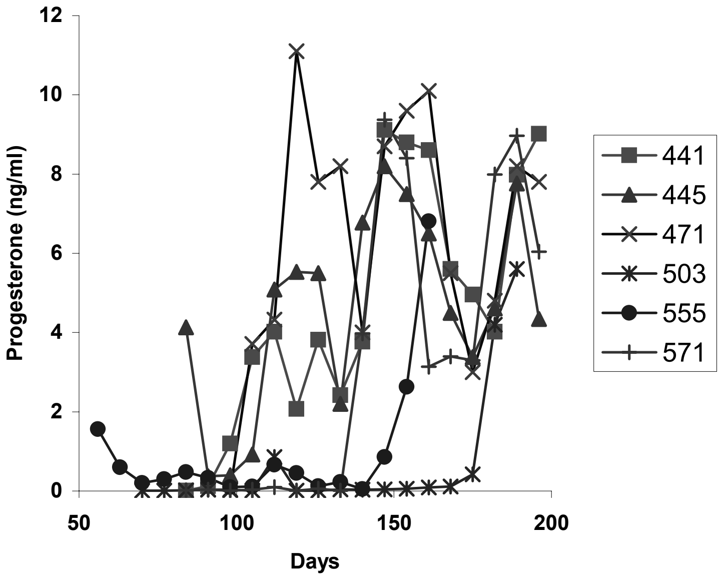


FIG. 5. Milk progesterone levels in control (503, 555 and 571) and urea-molasses multi-nutrient block (UMMB) fed to buffalo (nos. 441, 445 and 471) (Lactation–II)

3.2.3. Effect of UMMB supplementation in lactating cross-bred cows

As shown in Table X, the difference in milk production between groups A and B was 0.50 L/d/animal after consumption of 500 g UMMB/animal/d, resulting in a net benefit of Rs 8.0/animal/d and a cost : benefit ratio of 1 : 4.

3.3. Effect of UMMB supplementation on growth rate of Sahiwal calves

As shown in Table XI, the weight gain per animal was 117 and 113 kg and the average daily growth rate was 0.51 and 0.49 kg in groups A (control) and B (UMMB), respectively. The difference between two groups was found to be statistically significant ($P < 0.05$).

TABLE X. COMPARATIVE MILK PRODUCTION IN GROUP A AND B COWS, WITH AND WITHOUT SUPPLEMENTATION WITH UREA-MOLASSES MULTI-NUTRIENT BLOCK (UMMB)

Parameters	Group A	Group B
No. of animals	10.00	10.00
No. of days on trial	52.00	52.00
Initial milk production (L/animal/d)	18.50	18.50
Final milk production (L/animal/d)	15.30	15.80
Difference in milk production between groups A and B (L)		0.50
Block consumed (kg/animal/d)		0.50
Cost of one kg block (Rupees)		4.17
Price of increased milk 0.5 L milk/animal/d (Rupees)		8.00
Cost : benefit ratio		1 : 4

TABLE XI. EFFECT OF UREA-MOLASSES MULTI-NUTRIENT BLOCK (UMMB) SUPPLEMENT ATION ON GROWTH RATE OF SAHIWAL CALVES

Parameters	Group A	Group B
Number of animals	15	15
Initial weight (kg)	103	103
Final weight (kg)	220	216
Weight gain (kg)	117	113
Number of days	229	229
Average daily gain (kg)	0.51	0.49

3.4. Major gastrointestinal nematodes in young buffalo, sheep and goats

The results of this survey indicated that a majority of the animals were harbouring a burden of parasitic nematodes. Percentages of the various infestations found in the calves and young stock are given in Table V. Numbers of eggs of each species were recorded. The young buffalo were grouped on the basis of intensity of infection, expressed as a percentage. Among those infected 41.4% showed 200–400 eggs per gram (epg) faeces, while 22.0%, 14.8% and 21.8% showed the presence of 400–800, 800–1200 and above 1200 epg respectively.

In sheep and goats almost all samples (662) were found to be infested with one or more types of nematode eggs and the prevalence is shown in Table VI. Albendazole, Levamisole, Ivermectin, Systamax and Kameela are commonly used against gastrointestinal parasites and Ivermectin is used for ectoparasites.

3.5. Effectiveness of medicated UMMB blocks to control gastrointestinal parasitism in grazing sheep and goats.

Tables XII and XIII show that medicated-UMMB supplementation has decreased the FEC by 75% and 97% after seven days and 90% and 97% after 21 days in sheep and goats respectively. Similar effects were recorded for Levamisole treatment in both host species. There were no significant differences between the medicated block and Levamisole treatments both in sheep and goats. Medicated blocks were equally effective as drenching with Levamisole. In addition, the results suggest that the use of UMMB also helped the sheep and goats to control parasites to some extent, since FEC decreased by up to 16% after UMMB use.

TABLE XII. EFFICACY OF UREA-MOLASSES MULTI-NUTRIENT BLOCK (UMMB) AND MEDICATED UMMB (MUMB) TO CONTROL PARASITES IN SHEEP AT NIAB FARM FAISALABAD (NUMBER OF ANIMALS = 5 IN EACH GROUP)

Groups	EPG before treatment	EPG after 7 d of treatment	EPG after 14 d of treatment	EPG after 21 d of treatment
MUMB	1002 ± 99	250 ± 50	100 ± 70	105 ± 33
Levamisol Treatment	923 ± 150	394 ± 70	50 ± 30	70 ± 25
UMMB Supplementation	1155 ± 124	969 ± 104	1050 ± 115	1061 ± 80

* EPG = eggs per g faeces

TABLE XIII. EFFICACY OF UREA-MOLASSES MULTI-NUTRIENT BLOCK (UMMB) AND MEDICATED UMMB (MUMB) BLOCK TO CONTROL PARASITES IN GOATS AT BSRS–II PACCA ANNA, FAISALABAD (NUMBER OF ANIMALS = 5 IN EACH GROUP)

Groups	Before Treatment	EPG after 7 d of treatment	EPG after 14 d of treatment	EPG after 21 d of treatment
MUMB	970 ± 104	33 ± 20	30 ± 15	25 ± 20
Levamisol Treatment	907 ± 107	25 ± 14	20 ± 13	0.00
UMMB Supplementation	666 ± 80	650 ± 60	600 ± 90	560 ± 140

*EPG = eggs per g faeces

4. DISCUSSION

4.1. Formulation and ingredients of UMMB

Cereal straws and other forages derived from crop residues have been used as basal feed for ruminants for many years in South-East Asia and other developing counties. These feeds are of low metabolizable energy and digestible protein content [8]. Such feed resources are poor in fermentable nitrogen, energy and minerals and thus cannot fully support the maintenance needs of ruminants. Many of the available conventional rations are based on agro-industrial by-products like cottonseed cake or maize gluten. Due to the high price of these feed ingredients, the cost of balanced rations is very high and livestock production becomes uneconomical. Of the various methods available to producers, supplementation of deficient nutrients in the form of UMMB has been shown to be effective for the utilization of cereal straws and other low quality forages in cattle and buffalo [9, 10].

4.2. Effect of UMMB supplementation on digestibility and fodder intake in Sahiwal cows and Nili-Ravi buffalo

Fodder intake and digestibility of dry matter was higher in UMMB supplemented groups when fed with Berseem or maize as green fodder (Table II). The UMMB contains rumen degradable and undegradable (bypass) protein, degradable carbohydrates, non-protein nitrogen and some minerals [11] and can assist in meeting the nutrient requirement of rumen microbes and ruminant livestock. Several workers have reported that UMMB supplementation can lead to increase in feed intake [1, 12]. An increase in intake and digestibility of straws and fodders when supplemented with urea and molasses as a feed supplement has also been reported [9].

4.3. Effect of UMMB supplementation on milk production in lactating buffalo and Sahiwal cows at different pilot farms.

Results of the present studies indicated that feeding of UMMB has beneficial effects by enhancing milk production. The basal diet for dairy buffalo and cattle in Pakistan is based on unimproved pastures and crop residues, which are low in protein and have low digestibility. Supplementation with UMMB improves the utilization of these roughages by satisfying the requirement of the rumen micro-organisms, by creating better fermentation of fibrous material and increasing production of microbial protein and volatile fatty acids [12]. Some workers have showed urea-molasses mixtures improved the digestibility of neutral detergent fiber (NDF) and hemicelluloses in Lipo grass [13]. It is also reported that UMMB had a stimulating effect on the rumen ecosystem, particularly in supplying extra ammonia, energy and also minerals [2]. Urea is a product which, after hydrolyzing into ammonia in the rumen, becomes the nitrogen source for microbes. Molasses is a source of readily fermentable energy and also an excellent source of trace elements. Ammonia is probably not the only deficient nutrient supplied in the form of urea. Calcium in lime, phosphorus in dicalcium phosphate and sulphur in gypsum, all promote rumen microbial growth. The particular deficiencies corrected almost certainly vary with diet and with the location from where the cut-and-carry forage is obtained [14]. The nitrogen content of the diet of cut and carry systems when supplemented with UMMB is closed to the value suggested by Leng and Kunju [15].

An increase in milk production after feeding of UMMB has also been reported in dairy cattle [12, 16], buffalo [1, 17] and cows [18].

The present study also indicates that UMMB has reduced the time to onset of oestrus after parturition in dairy buffalo and cattle. Similar results of UMMB feeding on reproduction of cattle (reduced calving to conception interval 135 ± 15 to 115 ± 9 days and 199 ± 72 to 162 ± 73 d) were reported in Vietnam and Bangladesh [19, 20], respectively. On the basis of these results it was concluded that UMMB could be used for the milking animals for the improvement of milk yield in animals.

4.4. Effect of UMMB supplementation on growth rate of Sahiwal calves

Supplementation with UMMB led to a positive response on the growth rate of calves since daily weight gain of the UMMB supplemented group was significantly higher than the control group. Similar results have been reported for cross-bred and local breeds of cattle in Indonesia [10]. Various studies on supplementation of UMMB with straw base diet of dairy cows have shown that UMMB use increased live-weight gain as well as body condition score of calves and cows [21]. Improved nutrition through UMMB supplementation has also been shown to improve the rate of growth and general health of female growing sheep of smallholders in Malaysia [22].

4.5. Major gastrointestinal nematodes in young buffalo, sheep and goats

Parasitic infestation exerts adverse affects on the health and productivity of animals. These effects are frequently more pronounced in sheep and goats compared to those seen in other species of livestock. The prevalence of haemonchosis was highest in the sheep and goats in areas where rice was grown. In the present study, the prevalence of *Haemonchus contortus* was recorded to be the highest; (i.e. 83.2% and 85.1%) in sheep and goats respectively, followed by *Trichostrongylus* spp. (sheep 73.1% and goats 69.6%) and *Nematodirus spathiger* (sheep 44.6% and goats 37.3%). The prevalence rate of *Haemonchus contortus* in these findings could be due to its high fecundity and survival and, therefore, availability in the pastures utilized by these animals. This parasite is an important parasite of sheep and goats and causes an insidious drain on production causing impaired health and reduced productivity and increased mortality of young animals. Albendazole at 7.5 mg/kg given orally and Ivermectin at 1 mL/50 kg by subcutaneous injection were found to be highly effective against nematode infections in both sheep and goats.

4.6. Effectiveness of medicated UMMB blocks to control gastrointestinal parasitism in grazing sheep and goats

As far as the efficacy comparison of medicated UMMB with conventional anthelmintics was concerned, both were found to be highly effective. It has also been reported that a single oral administration of albendazole produced 100% egg reduction [23]. It has also been observed that the administration of the benzimidazole anthelmintics over a number of days is frequently a more effective method of removing nematode parasites than a single dose, due to the maintenance of lethal concentrations of drug over a longer period of time [24, 25]. Parasitic infestation in Pakistan is seasonal and highest in the rainy season of 2–3 months (July–September). The effect of strategic anthelmintic dosing is only limited to that specific period immediately after treatment whereas, albendazole fed in a medicated-block for the period of greatest larval exposure can have a similar effect to that shown for slow release capsules where the therapeutic effect lasts for up to three months [26]. The levamisole blocks prepared in the present study were for demonstration of the principles of medicated blocks only and although effective this chemical is not recommended for field applications due to potential problems with toxicity if block consumption is excessive. In addition, the long-term impact of incorporation of levamisole into UMMB mixtures on anthelmintic efficacy and toxicity has not been evaluated.

Most progressive farmers have realized the adverse effect of parasites on animal production and have been trained to use chemical medicines to control the parasites. Some farmers also have the knowledge to apply locally available herbal medicines for worm control, particularly in our Northern areas. A large number of plants of medicinal value are available and the smallholder farmers of that region use these for the treatment of their animals. The herbal medicines are readily available and cost little. At present, it is thought that medicated blocks offer no advantages over conventional anthelmintic treatment and traditional remedies in Pakistan. As a member of the World Trade Orbanization (WTO), The Pakistani Government policy makers are very much concerned about the drug residues in animal products for international markets due to the fact that chemical medicines are often used for parasite control under our current system. For this reason, it is anticipated that future research efforts will focus on improving herbal medicated block technology for smallholder farmer use.

4.7. Medicinal plants with anthelmintic activity used for parasite control in Pakistan

Based on the investigations conducted by the Faculty of Veterinary Sciences, University of Agriculture Faisalabad, a review of the findings is given below:

A study on fascioliasis in buffalo and cattle and its chemotherapy with different indigenous drugs was conducted. *Nigella sativa, Fumaria parviflora, Caesalpinia crista, Saussurea lappa* and oxfendazole (Eterna International; 1 mL/5 kg) were used to control fascioliasis in buffalo and cattle. Among herbal drugs, *Fumaria parviflora* at a dose rate of 60 mg/kg body weight was equally effective as that of triclabendazole. This drug was much cheaper than triclabendazole and other allopathic drugs [27]. *In vitro* anthelmintic activity of *Allium sativum, Zingiver officinale, Curcubita mexicana* and *Ficous religiosa* was studied [28]. Methanol extracts of these plants were screened out and results showed that *Zingiver officinale*, killed all the test worms within two hours post-exposure. *Allium sativum* and *Curcubita mexicana* extracts were equally effective at two and four hours exposure (100% effective), but by 6 hours post-exposure *Curcubita mexicana* extract was only 83% effective. *Ficous religiosa* was 100% effective by four hours post-exposure and was as good as *Allium* *sativum*, and *Zingiver officinale*. It was concluded that extracts of all the studied plants have significant anthelmintic activity *in vitro*. Therefore, *in vivo* trials should be conducted to confirm their potential for use to control parasitism in animals [28]. Similarly, anthelmintic activity of *Chenopodium album, Melia azedarach, Saussurea lappa* in goats and sheep were evaluated by various researchers. *Chenopodium album* at 100 mg/kg reduced percent FEC to the same level as oxfendazole (Eterna International; 1 mL/5kg) on days 10 to 15 post-treatment. It has been suggested that oral administration of 30 mg/kg *Melia azedarach* was equally effective in the treatment of mixed gastrointestinal nematode infection in goats. Treatment with 8g/kg body weight of *Saussurea lappa* powder resulted in a significant reduction from the pre-treatment value of 232 ± 48 to post-treatment counts of 85 ± 0.4, 40 ± 11 and 3 ± 0.7 on 3^{rd}, 10^{th} and 15^{th} day respectively [29].

5. CONCLUSIONS

(i) UMMB proved to be the cheapest and the most economical source of protein as well as of energy when compared to other supplementary feeding strategies.

(ii) Fodder intake and digestibility of dry matter was significantly increased by UMMB use.

(iii) Supplementation with UMMB resulted in improvements in intake of low quality roughages, digestibility, live-weight gain and milk production.

(iv) Supplementation with UMMB enhanced the resumption of post-partum oestrus of buffalo and cattle.

(v) Supplementing animals raised on low quality fodders with UMMB may be an attractive alternative to other forms of supplementation especially when these become unavailable or too expensive.

(vi) Farmers are fully convinced and quite receptive to this technology for its positive effects on milk yield, reproductive efficiency and health of animals.

(vii) Supplementation with UMMB may be an innovative feeding strategy for livestock where concentrate feeding is not commonly practiced, such as in goat and sheep farming.

(viii) Preparation, transport and storage of UMMB is relatively easy.

6. FOR FUTURE WORK

Urea-molasses multi-nutrient block (UMMB) technology has great potential to be further promoted and extended throughout Pakistan.

Local government, extension workers and NGOs may be involved in the dissemination of UMMB and related technologies to farmers on a more extensive scale.

The farmers from the pilot farms should be intensively trained through demonstrations for preparation of UMMB and medicated UMMB with herbal and chemical anthelminthics for controlling GI nematode parasites. The benefits of feeding medicated UMB should be discussed in detail to motivate the farmers for adopting the technology and benefits might be shown through demonstration of the supplementation strategy.

Medicated blocks might be advertized, under the supervision of technical persons or veterinarians who could differentiate between infestations of nematodes, trematodes and cestodes.

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UREA-MOLASSES MULTI-NUTRIENT BLOCK (UMMB) SUPPLEMENTATION OF DAIRY COWS RAISED BY SMALLHOLDER FARMERS IN SARIAYA, QUEZON, PHILIPPINES

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Abstract

An 'on-farm' study was conducted to determine the effects of urea-molasses-multi-nutrient block (UMMB) supplementation in Holstein-Friesian-Sahiwal dairy cows raised by smallholder farmers in the southern part of Luzon, Philippines. There were a total of 105 cows in the project. The basal diet of these animals was cut-and-carry forages (20–30 kg/head/d), obtained from cultivated and natural grasses, given with mixtures of trees and shrub leaves (1–2 kg/head/d). During the day, the cows were allowed to graze. In the summer months (March–April), rice straw and other agricultural by-products, e.g. corn stover, were provided. To assist with long-term sustainability of the project, a UMMB Production Centre was established through a micro-financing scheme.

The calving interval of the UMMB supplemented cow group was 418 days, while that of the unsupplemented group was 504 days ($P < 0.05$). The monthly milk yield of 343 kg of the treated animals was higher ($P < 0.05$) than that of the untreated group (273 kg). The body weight of the supplemented group was 430 kg, and of the unsupplemented group was 400 kg. The supplemented cows had a better body condition score of 3.2, compared to 2.8 on a scale of 1 (very thin) to 5 (overfat), for the unsupplemented cows.

1. INTRODUCTION

The Philippine dairy farming sector produces less than 5% of the country's milk requirement, necessitating the continued importation of milk and milk products. The sinking value of the Philippine pesos against the U.S. dollar ($1.00 = P 56.00) and the increase in prices for all major dairy products is causing a drain on the country's foreign exchange reserves.

The project was undertaken to improve dairy cattle production and reproductive efficiency through the use of a cost-effective nutritional supplement for dairy cattle raised by smallholder farmers. Dairy development in the smallholder sector is the major aim of the government for the purposes of improving rural income, achieving food security and self-reliance in milk and milk products. For this study, a formulation of urea-molasses multi-nutrient block (UMMB) was given to dairy cattle raised within the smallholder system for field assessment of treatment effects.

2. MATERIALS AND METHODS

2.1. Selection of project site

At the start of the project in 1999, the Philippine Nuclear Research Institute and the National Dairy Authority conducted a series of seminars on the topics "The Use of UMMB as a Strategic Feed Supplement" and "Nutrition-Reproduction Interactions in Dairy Cattle". The target groups were seven farmer cooperatives in southern Luzon and three in northern Luzon, the major island of the Philippines.

Among these cooperatives, PALCON multi-purpose dairy cooperative in Sariaya, Quezon, 120 km south of Manila, was selected as the site for the establishment of a UMMB Production Centre. The majority of the farmers of PALCON were interested in the technlogy, and a total of 105 dairy cows were available for the study.

2.2. Establishment of the UMMB production centre

In order to ensure the sustainability of the on-farm project, a UMMB production centre was established, with P 30 000 (US$ 600) available as starting capital. This was used by the cooperative as a revolving fund. A locally produced mixer, which had previously been used for block manufacture, proved to be too expensive to operate for economic UMMB production, as it was electrically operated. With assistance from the IAEA, a good quality, diesel-fueled UMMB mixer with a capacity of 100 kg was obtained and is now being used by the cooperative for the commercial production of UMMB.

2.3. Animals

A batch of imported Holstein-Friesian-Sahiwal pregnant heifers was bought by the Philippine government in the 3rd quarter of 2000. Thirty-two of these animals were distributed as a loan to 14 farmers, members of the PALCON multi-purpose dairy cooperative, bringing the total number of dairy cows in the area to 105. Their average live weight was 405 kg. Some of the pregnant heifers calved in December of 2000 and the majority during the first quarter of 2001.

During the third and fourth quarters of 2000, we took note of the farmers' supplementation programme. There were these who: a) regularly gave UMMB to their animals; b) gave UMMB only to lactating animals; and c) gave UMMB when their income was satisfactory; and d) those that never gave UMMB. Based on this, trial animals were divided into two groups, based on parity, a supplemented group and an unsupplemented (control) group. Apart from the provision of UMMB to the supplemented group, management of both groups was similar. In the morning and in the afternoon, cut-and-carry forages obtained from cultivated and natural grasses were given with mixtures of trees and shrub leaves. During the day, the cows were allowed to graze. Breeding was by artificial insemination throughout the year using imported semen. A 62.5% Holstein-Friesian and 37.5% Sahiwal blood line is the objective, to be maintained by the National Dairy Authority. The study lasted until the third quarter of 2004.

Due to funding constraints in implementing the field study, the observations were limited to cows managed by the PALCON cooperative. However, farmers in other cooperatives also supplemented their cows with UMMB.

2.4. Feeding management

Cut-and-carry forages (20–30 kg/head/d) obtained from cultivated and natural grasses were given with a mixture of those tree and shrub leaves (1–2 kg/head/d) abundant in the area. In addition, 3–4 kg/head/d of a dairy concentrate were given during lactation. During the day, the cows were allowed to graze. During the summer months (March–April), rice straw and other agricultural by-products, e.g. corn stover, were provided. The cows were continuously given UMMB, 500 g/head/d, during the duration of the study. A 500 g block was cut into two parts. One part was given in the morning and another half was given in the afternoon. The UMMB was composed of 40% molasses, 40% rice bran, 8.0% urea, 10% cement, 1.8%, salt and 0.2% mineral premix. The percentage of the molasses and rice bran varied depending on the consistency of the molasses.

2.5. Reproductive data

At each farm, data on dates of breeding and calving were recorded by either the farmer or the local field technician of the National Dairy Authority. Monthly body weights of cows were estimated using a weigh band. Monthly body condition scores on a scale of 1, very thin, to 5, overfat [1] were also taken. The calving intervals were computed over two successive calvings.

2.6. Milk production

Cows were milked twice a day, in the morning and again in the afternoon. Daily milk yields were recorded. The quality of the milk (fat, solid, density and protein contents) was assessed daily by the cooperative responsible for the processing and marketing of milk. Microbial analysis was also carried out on a regular basis.

2.7. Monitoring of animals for infertility and repeat breeding problems

Those cows not conceiving at one of the first two services were subjected to ovarian examination and rectal palpation. Progesterone profiles, obtained from milk samples of the cows, were analysed twice weekly, for three consecutive weeks. Cows with abnormal progesterone profiles were supplemented with UMMB, containing 2% of a vitamin/mineral mix, at 500 g/head/d in addition to their regular ration.

2.8. Monitoring of animals for nematode parasites

The level of nematode parasite eggs in the faeces of animals at the project site was regularly monitored by the sugar flotation technique to indicate worm burdens. The level of sensitivity of this technique was not determined, however, this is currently the standard method used in the Philippines to estimate the numbers of nematode eggs in faeces.

3. RESULTS

3.1. Live weight and body condition of animals

As shown in Table I, lactating cows supplemented with UMMB were heavier than the unsupplemented group (430 kg vs 400 kg). Body condition scores were also increased by supplementation (3.2 for the supplemented group, 2.8 for the unsupplemented). After calving, live weight and body condition score fell in both groups, but recovery was earlier in the supplemented group.

3.2. Reproductive performance

The supplemented group had a shorter calving interval than the unsupplemented group, the difference being 82.6 days (P <0.05). Seven cows were identified as having problems with reconception and treated accordingly. The cost of each insemination is shown in Table II.

3.3. Milk production

Monthly milk yields were higher (P <0.05) in the UMMB supplemented, than in the unsupplemented group (Table I). The difference in yield between the two groups was 69.9 L (P <0.01). The data presented is from third parity cows of a similar age. Supplemented cows also had longer lactations (up to 10 months), compared to 7–8 months for the unsupplemented group.

TABLE I. MONTHLY LIVE WEIGHTS, BODY CONDITION SCORE (SCALE 1–5, 1 = VERY THIN, 5 = OVERFAT) AND MILK YIELD, AND CALVING INTERVAL OF COWS, EITHER RECEIVING UREA-MOLASSES MULTI-NUTRIENT BLOCK (UMMB) OR UNSUPPLEMENTED

	With UMMB	Without UMMB
Live weight (kg)	430 ± 38 (n = 12)	400 ± 19 (n = 12)
Body condition score	3.2 ± 0.4 (n = 12)	2.8 ± 0.2 (n = 12)
monthly milk yield (kg)	343 ± 71 (n = 8)	273 ± 52 (n = 8), P <0.01
Calving interval (d)	418 ± 43 (n = 15)	504 ± 109 (n = 15), P <0.05

3.4. Cost benefit analysis

Cost : Benefit:	1 : 1.9
Monthly expenditure (in P)/cow receiving UMMB:	
Feed Concentrate	1200
UMMB	150
Labour* (including Cut-and-carry)	1500
Electricity/water	100
Total	2950

Sales of milk: 342.98 L at P 17.00/L = P 5830.66

* Labour was estimated from the farmer's input of time and effort.

3.4.1. Income of farmer derived from UMMB supplementation

- Higher milk yield: The monthly increase in milk yield, due to UMMB supplementation (cost P 150) was 70 L (Table I), worth a total of P 1190. The net gain was P 1040.

- Longer lactation period: An additional month of lactation in the UMMB supplemented cows gave the farmer a greater net income of P 2880.

- Shortened calving interval: The calving interval for the UMMB supplemented group was 418 days compared to 504 days for the unsupplemented cows. This means that UMMB supplementation had substantially reduced the amount of maintenance feed the cows required while dry.

The calf: a female calf is more expensive than a male calf and is very seldom sold, unless the owner has very urgent financial needs. A heifer is accepted by the government as payment for the loan of the cow. Male calves are usually sold by the owner and during the study period were worth P 7000.

3.4.2. Income of the Cooperative from UMMB production

TABLE II. PRODUCTION COST/KG OF THE UREA-MOLASSES MULTI-NUTRIENT BLOCK (UMMB)

Ingredients	%	Price/kg of ingredients (P)	Cost of ingredients/kg of UMMB (P)
Molasses	40	7.00	2.80
Rice bran	40	8.00	3.20
Urea	8.0	12.00	0.96
Cement	10	2.50	0.25
Salt	1.8	2.90	0.05
Mineral premix	0.2	250.00	0.50
			7.76

Note: the percentage of molasses and rice bran vary depending on the consistency of the molasses
Other expenses per kg UMMB:
Cost of labour P 1.00
Cost of diesel fuel P 0.14
Total cost of UMMB per kg P 8.90
Selling price at the cooperative was P 10.00/kg, giving a profit of P 1.10 per kg UMMB

3.5. Number of farmers utilizing UMMB

Because of the information dissemination programme and the training and seminars conducted by the National Dairy Authority and the Philippine Nuclear Research Institute, to increase farmers' awareness of UMMB as a dairy supplement, the number of farmers adapting the technology increased as shown in Table III.

TABLE III. NUMBER OF FARMERS ADOPTING UMMB TECHNOLOGY

Name of Cooperative	Number of farmers
Southern Luzon:	
PALCON Dairy Mutipurpose Cooperative	25
SALBA dairy Cooperative	20
CARNATION Dairy Cooeprative	15
BUKAL Dairy Cooperative	10
GLAD Dairy Cooperative	10
ALBAY Dairy cooperative	10
Northern Luzon:	
Sta. Maria, Bulacan Dairy Cooperative	20
Talabera Dairy Cooperative Dairy Cooperative	10
Zambales Dairy Cooperative	5

TABLE IV. ECONOMIC BENEFIT OF IMPROVED FERTILITY DUE TO SUPPLEMENTATION WITH UREA-MOLASSES MULTI-NUTRIENT BLOCK *

Gain Loss Components	Quantity	Price (P)
Semen Straw	1 Semen Straw	300
Straw Sheet	1 peace per insemination	10
Artificial insemination (AI) gloves	1 peace per insemination	7
Incentive for AI technician	per service	500

* This information was obtained from the reproduction component of the project

3.6. Parasite monitoring

Faecal egg counts (eggs per g, epg), to monitor nematode infections, were low. Even during the peak months of the rainy season (July–August), when high levels of infection were expected, on-farm faecal examination showed that of the 50 animals examined, two cows had moderate levels of strongyle nematode infection (100 and 150 epg respectively) and four cows had a low level of coccidian cysts while the rest were negative. Moderate level nematode infections were also evident in young calves, with four 3-month-old calves having 250 epg, one 5-month-old calf 150 epg and another 5-month-old calf had eggs of strongyles which were too numerous to count.

4. DISCUSSION

Feeding trials, [2, 3] established that access to UMMB results in increased productivity. Urea-molasses multi-nutrient blocks increase feed intake and improve digestibility of roughage-based diets [4]. The heavier body weights and better body condition scores of the UMMB-supplemented cows indicate efficient digestibility of the feeds taken by these cows.

Higher milk yield were also observed in the UMMB supplemented group. It has been shown that the major limiting factors to obtaining high milk yield are low intake, nitrogen content and quality of tropical green fodder [5].

The importance of body reserves for mobilization after parturition is well known. The body condition scores of the supplemented cows suggested that they were not nutritionally stressed in the important first two to three weeks of lactation, thus ensuring the onset of ovarian activity and expression of oestrus [3, 6]. This explained why the supplemented group had shorter calving intervals compared to the unsupplemented group.

The improvements noticed in seven cows, who previously had a prolonged post-partum anoestrus period, or failed to conceive, after supplementation with UMMB, containing 2% vitamin mineral premix, demonstrated the positive effect of this intervention on the fertility of dairy cows. The effect, though, may be due to UMMB even without the addition of vitamin-mineral premix.

The results of the faecal examinations among the adult cattle at the project site indicated a low prevalence of nematode parasite infection in most animals, but moderate levels of infection in a small number of cows and young calves. Up to the present time there has been no attempt to determine the requirement for anthelmintic intervention in these cows except for those suffering from clinical signs of parasitism. However, since some cows and calves have been shown to be moderately infected with nematodes, it can be assumed that exposure to nematode larvae is occurring, and the adult cows maybe resisting establishment of infection leading to the high proportion of negative egg counts. Alternatively, individual farmer husbandry practices may be precluding exposure of the majority of cows to infective larvae. These possibilities can only be confirmed by further study which should include continued monitoring of faecal egg counts along with some measurement of productivity response after anthelmintic intervention. Similar studies in Europe, North America and other parts of Asia have yielded considerable milk yield increases after treatment even though faecal egg counts were very low [7, 8].

5. CONCLUSIONS

To maximize productivity, the nutritional gap in many dairy cows in the smallholder system needs addressing by supplying extra energy, protein and minerals, thus improving the digestibility and intake of the poor forages and residues, which are often the major constituents of the diet. In the Philippines, UMMB has been shown to improve utilization of low quality roughages and agricultural residues and enhance productivity of dairy cattle. In addition, this 'on-farm' study has shown that the use of UMMB is a cost-effective means of improving farmer income.

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DEVELOPMENT, EVALUATION AND POPULARIZATION OF MEDICATED AND NON-MEDICATED UREA-MOLASSES MULTI-NUTRIENT BLOCKS FOR RUMINANT LIVESTOCK PRODUCTION UNDER SMALLHOLDER CONDITIONS OF SRI LANKA

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Abstract

A series of laboratory and field experiments led to development of four suitable urea-molasses multi-nutrient block (UMMB) formulas to suit different agro-ecological zones of Sri Lanka, for improving livestock productivity. The formulas developed were based on the production potential of the target animals and the quality of available roughage feeds. Feeding of UMMB to dairy cattle and buffalo resulted in both 'catalytic' and 'supplementary' effects. These effects were demonstrated by improved feed intake and digestibility and increased live weight gain of cattle and buffalo calves. The body condition of adult cows was satisfactorily maintained with UMMB use. Supplementation with UMMB improved milk yield and butterfat content, and extended the persistency of the lactation curve compared to traditional concentrate feedings. Reproductive performance was also improved by reducing the number of days from parturition to first service. Benefit : cost ratio for UMMB use was variable between the management systems, basal feed on offer and the agro-ecological zones but the benefits were, overall, satisfactory. Medicated blocks for goats substantially reduced the parasitic burden as indicated by reduced faecal worm egg counts. Supplementation with molybdenum also significantly decreased the parasite burden of goats. For cattle, due to logistical reasons the medicated block was considered unsuitable under local conditions in Sri Lanka.

1. INTRODUCTION

The dairy industry in Sri Lanka has rapidly declined over the past few decades and the present self-sufficiency of milk and other dairy products of the country is about 15% [1]. The industry may decline further if proper emphasis is not paid to problems encountered by dairy producers. One of the major problems of the dairy industry in Sri Lanka is low productivity of livestock due to poor feeding management. Under smallholder conditions of dairy farming in Sri Lanka, lack of knowledge and underfeeding are critical factors in determining productivity. Most of the roughage feeds available in Sri Lanka are low quality, naturally growing forages. During the major dry seasons, which fall between the two monsoon periods (May–September) there is little green forage for animal feed. Frequently the quantities available are not sufficient to satisfy the bulk dietary requirement and many farmers have to depend on alternate sources of roughage such as rice straw, which is inherently low in quality.

Supplementation of livestock with concentrate feeds is not a common practice among smallholder farmers in Sri Lanka due to low availability, high cost and the low farm-gate price of liquid milk. It has also been established that concentrates alone are not sufficient to fill the nutritional gap, both for production and efficient rumen function, caused by the low quality feeds. Therefore, there is a vital need for a supplement to yield both 'supplementary' and 'catalytic' nutritional effects. Urea-molasses multi-nutrient blocks (UMMB) has been shown to meet this need and in many tropical countries, years of experience have proven the suitability of UMMB as a feed supplement when low quality roughages are fed. This supplement has many advantages such as its low cost, its reliability as a vehicle for non-protein nitrogen sources, as a source of fermentable energy and its potential for use as carrier of anthelmintic drugs (in medicated blocks). Initially, however, Sri Lankan farmers were not very familiar with this supplement and were sceptical about some of its ingredients as animal feeds. Therefore, training of both field officers and farmers in the principles of ruminant livestock production was critical. Knowing this crucial task, the Food and Agriculture Organization (FAO) and the International Atomic Energy Agency (IAEA) developed and disseminated information regarding affordable and sustainable supplementation packages to improve the livestock productivity in smallholder farms.

2. MATERIALS AND METHODS

2.1. Development of UMMB and distribution among the State and smallholder farmers

The objectives of this programme were to develop blocks with different formulas to satisfy the nutritional requirements of dairy cattle in different agro-ecological zones based on the available roughage feed and the production potential of the animals.

2.1.1. Development of the UMMB

The composition of the blocks was decided after one year's laboratory analysis and on-farm assessment using both *in vitro* and *in vivo* techniques. In developing different formulations for the blocks the proportion of ingredients, especially the binding material (cement), urea, absorbent (rice polishings) and the by-pass protein (fish meal) were given due consideration based on the production potential of the animals in the target agro-ecological zones. Finally, the selected formulas (one formula per agro-ecological zone) were field tested with key dairy farmers prior to more widespread recommendation for use in each zone. During the field testing, the productive, reproductive and other animal parameters were evaluated.

2.1.2. Feeds and feeding

A field study was conducted in the Mid-country region to evaluate the production and reproductive performance of cattle in selected smallholder dairy farms. Guinea grass was used as the basal roughage and UMMB was used as the supplementary feed. Cows producing more than 6 L of milk per day were further supplemented with commercial concentrates at the rate of 500 g/L of additional milk production.

Forty smallholder dairy farmers were selected from both of the Wet zone and Mid-country, to givea total of 80 farmers, in order to compare the two agro-ecological zones. Roughage was given as the basal diet and UMMB was used as the supplement to cows with a daily milk yield of up to 6 L/d. For any cows giving more than 6 L/d, an additional 500 g of commercial concentrate was recommended. In both field studies milk yield and quality and reproductive parameters were recorded and evaluated. The benefit : cost was calculated according the current milk price.

2.2. Training of field officers and farmers

Island-wide training programmes were conducted for field veterinarians, livestock officers, farm managers and farmers. In addition, many other personnel who were interested were also trained. Training was done in different agro-ecological zones with the collaboration of the Department of Animal Production and Health Extension and Training Unit and the Mahaweli Livestock Development Authority. Both formal and informal training sessions were held and many training sessions consisted of demonstrations and field visits. Model farms have also been set up for demonstration purposes.

2.3. Use of medicated block to control helminth parasites

Medicated blocks containing fenbendazole and molybdenum were used in field trials. The majority of dairy farmers deworm their cows regularly on the advice of and under the supervision of field veterinary officers. Therefore, the worm burdens in dairy cows are not severe and it was thought that medicated block use may not be beneficial in these cows. On the other hand, free grazing goats are rarely dewormed, if at all, and it was thought that they could show a response to medicated blocks. Therefore, free ranging goats were used as the test animal for the medicated UMMB (MUMB) trial.

2.3.1. Medicated UMMB with fenbendazole

Medicated blocks were made using UMMB (intermediate zone formula) with the inclusion of 0.5 g fenbendazole/kg of block. The goats were allowed to lick the medicated block during the first week of the month and for the rest of the period access was given to the non-medicated UMMB. Another group (n = 12), were not supplemented with any form of UMMB. After 30 days, the first egg count was taken from the control (without UMMB), UMMB and MUMB group goats. This was continued for eight months. Faecal samples were taken from the rectum and the egg counts were done using the floatation technique. The worm egg count was expressed as eggs per gram of faeces (epg)

2.3.2. UMMB supplemented with molybdenum

Molybdenum was included in the UMMB at the rate of 0 or 10 mg/kg block. Two groups (n = 15) of goats were allowed to lick both UMMB and MUMB separately, and the third group as the control was not supplemented with either type of block. Faecal samples were taken from the rectum and the eggs were counted using the floatation technique. The egg count was expressed as epg.

3. RESULTS

3.1. Development and use of UMMB

Different formulas of UMMB were prepared to satisfy the nutritional needs of the cows in different agro-ecological zones.

3.1.1. UMMB formulas

Four UMMB formulas were developed after extensive laboratory and field experimentation. Subsequently, the selected formulas were field tested with dairy farmers in many locations prior to widespread recommendation for use. During the past eight years, these formulas have been accepted by the farmers and state organizations responsible for national livestock development. The formulas recommended and accepted are given in Table I.

TABLE I. UREA-MOLASSES MULTI-NUTRIENT BLOCK FORMULAS RECOMMENDED FOR SUPPLEMENTARY FEEDING BASED ON THE AGRO-ECOLOGICAL REGION

Ingredient (g/kg block)	Agro-ecological Zone			
	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	20	20
Cement	100	100	100	100
Total	1000	1000	1000	1000

The UMMB production in Sri Lanka is determined by the price of the ingredients and the availability. The change in molasses price and the cost per tonne of UMMB are given in Table II.

TABLE II. PRICE OF MOLASSES AND COST OF PRODUCTION OF UREA-MOLASSES MULTI-NUTRIENT BLOCK (UMMB)

Year	Price of Molasses (SLR*/tonne)		Cost of UMMB (SLR/kg)			
			Without fish meal		With fish meal	
1999	1500	(= $ 14.7)	7.25	($0.07)	9.50	($0.09)
2000	1800	(= $ 17.6)	9.45	($0.09)	12.00	($0.12)
2001	2300	(= $ 22.5)	12.50	($0.12)	15.50	($0.15)
2002	9000	(= $ 88.2)	16.75	($0.16)	20.75	($0.20)
2003	15000	(= $147)	22.30	($0.22)	27.30	($0.28)
2004	–		24.30	($0.24)		–

* SLR = Sri Lankan Rupees
Values in parantheses are in US dollar ($)
Exchange rate was taken as of current value (1$ = 102 SLR)
Present farm-gate price of a litre of liquid milk is SLR 15 (= $ 0.15)

The quantity of UMMB produced by various manufactures depends on the availability and the price of molasses. As shown in Table II, the cost of production of UMMB has escalated due to a drastic increase in the price of molasses in the local market.

3.1.2. Manufacture of UMMB

Production of UMMB, following the recommendations made by the research group, was undertaken by organizations directly involved in the dairy industry. Of the four organizations, only one (MILCO) is a private organization, but is operated with the sponsorship of the government. There is a lapse in production of UMMB at present with the change of management of the major private sugar milling companies. The total production of UMMB by different manufacturers from 1999 to 2004 is given in Table III.

TABLE III. MANUFACTURE OF UREA-MOLASSES MULTI-NUTRIENT BLOCK (kg) FROM 1999 TO 2004 BY DIFFERENT ORGANIZATIONS

Year	MLDA	DAP&H	NLDB	Milco	Total
1999	2085	8600	4545	–	15230
2000	900	8500	29935	–	39335
2001	6675	10200	27590	–	44465
2002	1800	12000	39460	6000	59260
2003	–	–	2000	8500	10500
2004*	–	–	–	12000	12000

MLDA– Mahaweli Livestock Development Authority
DAP&H– Department of Animal Production & Health
NLDB– National Livestock Development Board
MILCO– Milco (Pvt) Limited
*Projected amount

3.2. Training programmes for officers and farmers

Training is a crucial component in introducing any new technology. Training on UMMB use was carried out from the inception of field introduction of the technology and has continued through the national extension services. The training has been conducted with the collaboration of the training division of the Department of Animal Production and Health (DP&H) and Mahaweli Livestock Development Authority (MLDA). The Department of Animal Science of the University of Peradeniya provided expert and technical knowledge. During the training, the field veterinary officers, livestock officers, dairy farmers and any other interested parties on livestock production were trained using formal and informal presentations, discussions, demonstrations and field visits. The details of the training activities are given in Table IV.

TABLE IV. TRAINING CONDUCTED WITH DIFFERENT GROUPS OF PEOPLE (MAN DAYS)

Year	VS*	LO**	Farmers	Others	Total
1999	24	30	124	52	230
2000	16	27	90	48	181
2001	4	20	28	36	88
2002	10	28	56	22	116
2003	30	37	78	18	163
2004	22	18	123	12	175

*VS– Field Veterinary Surgeons
**LO– Field Livestock Officers

3.3. Animal performance at field level

Two independent studies in two agro-ecological zones (Mid country and Wet zone) revealed the benefits gained by the smallholder dairy farmers as a result of UMMB supplementation, in terms of productivity, milk quality and reproductive performance.

As shown in Table V, feed intake was significantly increased by UMMB supplementation. As a result, both the milk yield and butterfat content of the milk increased, thereby increasing the farm-gate price per unit of milk. Concentrate feed use was drastically lowered after UMMB use, in some cases down to zero. In addition, the number of days from calving to next service was reduced by 25% in UMMB supplemented cows.

3.4. Benefit : cost ratio

In both field studies substantial economic benefits were derived (Table VI). In the Mid-country study, the net overall economic gain in terms of milk yield was equivalent to a net increase of 2 L milk/d.

In the comparison study, the benefit: cost ratio with supplementation of UMMB was much higher in the mid-country (7.67) than in the Wet zone (5.50). However, with concentrate supplementation, the Mid-country exhibited a higher benefit : cost ratio than Wet zone (1.89) (Table VI).

TABLE V. THE EFFECT OF UREA-MOLASSES MULTI-NUTRIENT BLOCK (UMMB) ON THE PERFORMANCE OF DAIRY CATTLE IN THE SMALLHOLDER SYSTEM IN THE CENTRAL PROVINCE OF SRI LANKA

Item	Response	Magnitude	Farmers responded (%)
Feed Intake, dry matter (DM kg/d)	Increased	2.67 ± 0.4 (20–30%)	99
Milk yield (kg/d)	Increased	1.50 ± 0.5 (21%)	89
ButterFat (g/kg milk)	Increased	0.08 ± 0.003 (23%)	82
Farm-gate price (SLR/L)	Increased	2.00 ± 0.52 (13 %)	82
Concentrate Feeding			
Cows <5 kg milk/d	Decreased	100%	
Cows 5–8 kg milk/d	Decreased	40%	
Calving to next service (d)	Decreased	From 120 ± 40 to 90 ± 23	
Net overall income gain /cow/d)	Increased	SLR 20.00 to 28.50	86

TABLE VI. COST COMPARISON OF UREA-MOLASSES MULTI-NUTRIENT BLOCK (UMMB) SUPPLEMENTATION IN TWO AGRO-ECOLOGICAL ZONES

Item	Mid-country	Wet zone	Difference
Milk yield (L/d)	8	6	2
Concentrate fed (kg/cow)	3	6	3
Total feeding cost :			
with concentrates	36.00	24.00	12.00
with UMMB	12.00	12.00	0.00
Total income/cow/d (Rs)	104.00	78.00	26.00
Total profit/cow/d (Rs):			
with concentrates	68.00	54.00	14.00
with UMMB	92.00	66.00	26.00
% change in profit with UMMB	35%	22%	13%
Benefit : Cost ratio			
With concentrate feed	1.89	2.25	0.36
With UMMB	7.67	5.50	2.17

3.5. Effect of medicated block on faecal worm egg counts

3.5.1. UMMB with fenbendazole on worms

Supplementation with added medicated block lowered the faecal worm egg count by 90% in goats up to 120 days. Thereafter, the egg count exhibited a static nature indicating no additional response to the medication. Non-medicated UMMB also had an effect in the first 60 days by reducing the faecal egg counts by 50%. The faecal egg count of the control animals (without any type of UMMB) did not change substantially throughout the experiment (Table VII).

TABLE VII. EFFECT OF UREA-MOLASSES MULTI-NUTRIENT BLOCK (UMMB) AND MEDICATED UMMB (0.5 g FENBENDAZOLE/kg BLOCK) ON FAECAL WORM EGG COUNT (EPG) OF GOATS

Duration after Treatment	Control (without UMMB)	UMMB only	UMMB + Fenbendazole
Day 0	5540 ± 530	5420 ± 480	5880 ± 556
Day 30	5860 ± 447	3216 ± 317	2401 ± 246
Day 60	5366 ± 346	2644 ± 366	1075 ± 143
Day 120	4870 ± 539	2660 ± 414	620 ± 81
Day 180	5012 ± 416	2714 ± 442	530 ± 68
Day 240	4917 ± 510	2624 ± 397	545 ± 54

3.5.2. UMMB with added molybdenum on worms

Supplementation with UMMB tended to reduce the faecal worm egg count but this was not significant (*P* >0.05). Addition of molybdenum into the block decreased the faecal worm egg counts at both the 5 and 10 mg/kg levels. The low parasitic burden due to molybdenum was reflected by changes in the packed cell volume (PCV) and hemoglobin (Hb) which increased during the experiment (Table VIII).

TABLE VIII. EFFECT OF MOLYBDENUM ADDED TO UREA-MOLASSES MULTI-NUTRIENT BLOCK (UMMB) ON FAECAL WORM EGG COUNT (EPG) AND HEMATOLOGICAL PARAMETERS OF GOATS

Parameter	Control (No UMMB)	Level of molybdenum in UMMB (mg/kg block)		
		0	5	10
Faecal worm egg count (epg)				
Dry season	$4544^{a} \pm 545$	$3558^{a} \pm 741$	$249^{b} \pm 39$	$164^{b} \pm 20$
Rainy season	$4946^{a} \pm 541$	$3955^{a} \pm 934$	$260^{b} \pm 17$	$191^{b} \pm 40$
Packed Cell Volume (PVC %)				
Dry season	$22.0^{c} \pm 3.2$	$26.6^{b} \pm 3.3$	$37.2^{a} \pm 2.1$	$38.0^{a} \pm 1.8$
Rainy season	$19.7^{c} \pm 1.5$	$24.3^{b} \pm 1.7$	$33.5^{a} \pm 2.8$	$35.8^{a} \pm 1.5$
Hemoglobin (Hb g/dL^{-1})				
Dry season	$6.8^{c} \pm 1.1$	$8.6^{b} \pm 0.5$	$12.8^{a} \pm 0.8$	$12.9^{a} \pm 0.9$
Rainy season	$6.6^{c} \pm 0.6$	$8.0^{b} \pm 0.5$	$11.6^{a} \pm 1.4$	$11.9^{a} \pm 0.8$

Values in rows with different superscripts, differ significantly (*P* <0.05)

4. DISCUSSION

Productivity of dairy cattle in Sri Lanka raised under smallholder conditions is frequently low due to unsatisfactory feeding. Quantitatively, the availability of roughage (both green and dry) is not a limiting factor. The major limitation appears to be the lack of farmer education of methods of utilization of available feed resources and the necessity for strategic feeding during times of greatest need. The know-how of improving the use of the abundant low quality roughage through ‘Catalytic’ or ‘Supplementary’ supplementation is also lacking.

The introduction of UMMB with a training package can substantially improve the livestock productivity and enhance the economic gain of the rural smallholder dairy farmers. The UMMB formulas described earlier were developed to suit the nutritional requirements of the dairy cattle in different agro-ecological zones of Sri Lanka. In developing these formulas the available roughage and the production potential of the cows in the respective agro-ecological zones were given due consideration. During the development of UMMB all efforts were made to minimize the urea content of the block and to exclude coconut oilcake, the most common feed ingredient in cattle feed. The reason for exclusion of the coconut oilcake was that this ingredient is in high demand for other commercial rations and its price fluctuates considerably during the year. Its inclusion could, therefore, lead to seasonal fluctuation in the price of the UMMB which may discourage and confuse the dairy farmers and result in low adoption of the block in their feeding systems.

The total annual production of blocks was increasing each year until 2002. Thereafter, the production of UMMB declined due to the unavailability of molasses and escalation of the price of molasses. This was due to a change in management of the three major private sugar-milling companies and their increased use of molasses for alcohol production. At the present price of molasses, feeding of UMMB may not economical and attempts to bring down its cost are being made through state intervention.

Even though the feeding of UMMB in the future may not be as economically attractive as previously, training in the use UMMB along with other feeding strategies has continued. Training is considered to be a vital part in introducing and sustaining the new technology at field level. Understanding this phenomenon, field officers, of all levels, and dairy farmers were trained with the collaboration of AP & H and MLDA. This resulted in a tremendous service to the industry by creating a close interaction between the officers and farmers and convincing both parties about the new interventions. This was proven to be very successful technique under local conditions. [2].

Supplementation with UMMB resulted in many beneficial effects. This included improved feed intake, improved milk yield and quality and improvements in measured reproductive parameters. The Mid-country field study with 100 smallholder dairy farmers, revealed that supplementation with UMMB increased the daily feed intake by 20–30%. This is no doubt due to the improvement of rumen environment, by elevating the rumen ammonia level, and provision of soluble carbohydrate to facilitate an efficient rumen microbial activity [3]. In the same study, milk production and butterfat content increased by 21 and 23% respectively. Due to improvement in milk quality the farm-gate price paid for milk was also improved by 13%. Similar results were observed in many other field experiments conducted in other location with dairy buffalo supplemented with UMMB [4].

Animals supplemented with UMMB also showed improved reproductive performance and body condition compared to animals with no supplementation [5] with calving to first service being reduced from 120 days to 90 days. Another study also revealed that the birthweight of buffalo calves from cows supplemented with UMMB was higher (8.4 %) than from cows receiving traditional concentrates [3]. Similarly, buffalo cows supplemented with UMMB exhibited a better body weight gain than the animals without UMMB. This study also revealed that in utilizing UMMB, dairy cattle are more responsive than dairy buffalo [6]. Cross-bred dairy cattle when supplemented with 500 g UMMB/d showed a higher body condition score than similar cows on similar feed with 2 kg commercial concentrates [7].

Cows supplementated with UMMB showed a further response from the addition of fishmeal in the diet only if their milk production was more than 6 L/d. In addition to the increased milk yield and quality, greater persistence of the lactation curve was also observed with UMMB supplementation [5].

The field study conducted in Mid-country revealed considerable financial benefits for the smallholder dairy farmers. The net overall extra income per cow per day ranged from 20.00 to 28.50 SLR. Considering the level of production and the farm-gate price of milk, this amount is substantial. Another study revealed that the cost of production of one kg of milk under free grazing conditions, when supplemented with UMMB and commercial concentrates was 1.38 and 2.93, SLR, respectively [8]. The difference in profit when comparing mid-country and Wet zone animals supplemented with UMMB and traditional concentrates was 35 and 22%, respectively. The benefit : cost ratio of UMMB supplementation in the Mid-country and Wet zone were 7.67 and 5.50 respectively. The benefit : cost ratio was lower in the Wet zone due to lower milk production in this area. In Sahiwal cows, the daily milk production increased by 12% due to supplementation with UMMB [7]. The profits/cow/d of dairy cattle receiving UMMB supplementation under an intensive low roughage system and a semi-intensive system with a high roughage diet were 13.00 and 39.00 SLR respectively [9], suggesting that there are greater benefits of UMMB supplementation under extensive systems with their higher roughage diets.

To improve animal productivity we should not only consider the influx of nutrients but attempt to reduce the losses of nutrients, which are equally important. Under tropical conditions the major source of nutrient loss can be the effects of infection with internal parasites. Periodic introduction of medicated blocks to young goats significantly reduced the parasitic egg count by 89% from day 0 to day 120. From day 120 to day 240, the egg count was only 11% of the day 0 egg count and remained static until day 240. Introduction of fenbendazole-based medicated block has been shown to be very effective, but care with its use must be taken to avoid the development of tolerance by the parasites. Continual use is not recommended and strategic use should be promoted to coincide with seasonal parasite abundance. It was also shown that good nutritional status due to UMMB supplementation helps control the parasitic burden, but to a lower extent, by improving the animal vigour.

Some studies have suggested that molybdenum (Mo) supplementation can reduce the impact of internal parasites. The mode of action suggested being by enhancing the inflammatory reaction in the intestinal mucosa leading to worm rejection and impaired establishment [10]. Supplementation of young goats with Mo via UMMB significantly reduced the egg count. When Mo was supplemented with UMMB at 5 and 10 mg the reduction in egg count was 93% and 95% respectively. Between 5% and 10% of Mo supplementation the difference in egg count was only 34%. The results were similar for both dry and wet seasons. The effect of UMMB supplementation with added Mo is reflected in other blood parameters such as packed cell volume (PCV) and Hb which were improved by UMMB and further improved by 33% when Mo was included.

5. CONCLUSIONS

Supplementation of ruminants with UMMB benefited the rural smallholder dairy sector and improved productivity. The UMMB technology has been well accepted and adopted by smallholder dairy holder farmers and by the state livestock sector in Sri Lanka. This technology has caused a revolution in the dairy industry in the country by enhancing the productivity and reproductive performance and thereby economic benefits. This is clearly demonstrated by the number of stakeholders who became involved in the manufacture of UMMB. One of the reasons that this technology became popular and widely adopted was the effective field based training and awareness programmes that were carried out along with the intervention. Unfortunately periodic shortages of molasses in the open market may affect the longer term sustainability of UMMB, unless an alternative energy source is identified. There is no doubt that UMMB is the solution to salvage the Sri Lankan dairy industry in areas where the feed supply and quality of feeds are subjected to seasonal fluctuation.

Medicated blocks for dairy cattle are not likely to be adopted in Sri Lanka due to current management practices. Dairy cattle are routinely dewormed on the recommendation of the field veterinary surgeon and farmers believe that giving a 'one-shot' chemical treatment is more convenient than feeding the block. Use of MUMB containing fenbendazole or molybdenum in small ruminants has been shown to be effective in limited studies. Some local veterinarians are also sceptical about the development of resistance by the parasites by long term infusion of small doses of chemical anthelmintics but numerous published studies indicate that this rarely occurs if MUMB are used according to recommended practices. Further work is warranted in this field before wider adoption can proceed in Sri Lanka.

Finally it can be concluded from these long term studies and experiences that UMMB technology can make tremendous progress possible in the dairy industry in Sri Lanka, provided the availability and the cost of molasses are within an affordable range.

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FEED SUPPLEMENTATION OF DAIRY CATTLE IN THE NORTH-EASTERN REGION OF THAILAND

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Abstract

Experiments were carried out to study the effects of urea-molasses multi-nutrient blocks (UMMB) on milk production and reproductive performance in dairy cattle. The rate of decline in the milk yield of cows before supplementation with UMMB was –0.0126 kg/d. This changed to an increasing trend after supplementation, to +0.0142 kg/d in Experiment I, and a similar trend was observed in Experiment II. Supplementation with UMMB resulted in a significant decline in services per conception (P <0.01), from 2.54 to 1.88, and reduced the mean calving to conception interval (days open) from 127.2 ± 11.3 days to 92.4 ± 6.6 days. The UMMB supplement also reduced the interval from calving to first service and calving interval from 77.5 days and 405.4 days before UMMB supplementation to 65.9 days and 365.1 days after UMMB supplementation.

On-farm trials were carried out to study the effects of medicated UMMB (MUMB). Forty-six dairy cross-bred heifers were divided into three treatment groups. The MUMB containing fenbendazole at 0.5 g/kg of UMMB was given to one group, UMMB to another group and the third group was not supplemented. Faecal egg counts per gram, packed cell volume and body condition score were evaluated before supplementation and every 30 days after supplementation commenced. Average daily gain was also recorded at 60 days before and after supplementation. The MUMB supplementation led to zero faecal egg counts by 30 days after its introduction, and faecal egg counts of the UMMB supplemented group were lower than without supplementation. The PCVs of the MUMB group animals were higher than in the UMMB group animals and those without supplementation after 60 days. Average daily gain (kg) after 60 days in the MUMB group (0.73 ± 0.17) was significantly higher (P <0.05) than for the UMMB (0.51 ± 0.19) and control groups (0.42 ± 0.16)

1. INTRODUCTION

Dairy production in Thailand has been increasing rapidly during the past 10–12 years. According to available statistics the number of dairy farms has increased from around 6 600 in 1987 to over 24 000 in 1998. Similarly, during this period the number of dairy cattle increased from around 75 000 to about 290 000, and milk production increased from 90 000 to 385 000 tonnes/year (Table I). This increase is mainly due to the concerted efforts of four organizations, namely: (a) the Dairy Farming Promotion Organization (DPO); (b) the Co-operative Promotion Department; (c) the Department of Livestock Development; and d) the Bank of Agriculture and Co-operatives. Government policies, including the initiation of Dairy Extension Projects, the Milk Consumption Campaign and the School Milk Programme, have also played an important role in dairy development and the increasing demand for dairy products. However, despite the sharp increase in milk production during the last decade, the availability of milk has not been adequate to meet the national demand and, Thailand has been importing about $ 415 million in milk powder and other milk products annually.

TABLE I. THE NUMBERS OF DAIRY FARMERS, DAIRY CATTLE AND MILK PRODUCTION BETWEEN 1987 AND1998

Year	Number of Dairy farms	Number of Dairy cattle	Raw milk production (tonnes)	Demand (tonnes)	Milk imports (million $)*
1987	6.617	75.791	89.713	126.250	70.3
1990	11.539	116.457	129.248	199.593	104.5
1994	17.190	181.026	205.407	417.986	155.0
1998	24.485	287.732	387.918	796.161	290.1

* 1 US$ = 40 Baht.
Source: [1]

The typical basal diet of dairy cattle in the North-East of Thailand consists of unimproved pastures and crop residues. These forages are generally of low quality because of their lack of protein and low digestibility. It is also apparent that the quality and quantity of rations fed to dairy cattle varies according to the season, with an abundance of forage during the rainy season and frequently a scarcity during the dry season. Usually concentrates are offered during both rainy and dry seasons, the amounts varying depending on the availability and price. Thus, there is a vast fluctuation in the nutrient supply to dairy cattle and this is a major cause of low production and reproductive performance, characterized by low milk yields and long inter-calving intervals.

Supplementation with urea-molasses multi-nutrient blocks (UMMB) can improve the utilization of these roughages by satisfying the requirements of the rumen microorganisms and creating a better environment for the fermentation of fibrous material, thereby increasing the production of microbial protein and volatile fatty acids [2]. Urea, after hydrolysis to ammonia in the rumen, can be used as a nitrogen source by the microbes. 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 in many countries. The inclusion of benzimidazole anthelmintic fenbendazole (FZB) into medicated urea-molasses blocks (MUMB) at a sufficient concentration to give an effective dose from the expected normal daily consumption of blocks has proved to successfully control nematode parasites of cattle. Continuos low level doses of FBZ have also been shown to be very effective for this purpose [3, 4]. The low cost of alternative ethnoveterinary treatments to control gastrointestinal parasites may also contribute to wider adoption of this technology.

2. MATERIALS AND METHODS

2.1. Effect of UMMB supplementation on milk production

2.1.1. Experiment I

Twenty-three cross-bred dairy cows, belonging to four farmers of the Sithat Milk Collection Center, were used in this study. The selected cows were in 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. The daily milk yield was recorded for each cow for a period of 15 days. Thereafter, the cows were offered free access to UMMB. The daily milk yield was once again recorded for a further 15 days.

2.1.2. Experiment II

Thirty-one dairy cows, about 60 days after calving and belonging to 10 farmers of Kudjub Milk Collection Center, were used in this study. Five farmers with 16 cows were not provided with the supplement while 15 cows, belonging to a group of five farmers, were offered free access to UMMB. All animals received a basal roughage diet and concentrate, considered adequate by their respective owners. Daily milk yield of each cow was recorded for 30 days.

2.2. Effect of UMMB supplementation on reproductive performance

Seventy cows of equal parity, from nine demonstration farms in the Nasee Village of Namphong Milk Collection Center, were used to monitor the reproductive performance of cows without supplementation during the period September 1995 to September 1997. From October 1997 until September 1999 these cows received UMMB as a supplement to their regular diet.

Records were kept of all reproductive parameters, namely, time to first oestrus after calving, calving to first service interval, calving to conception interval, number of artificial inseminations (AI) services, until confirmation of pregnancy by rectal palpation, and inter-calving interval.

2.3. Effect of MUMB on farm

The study was carried out at Kranuan over 120 days during the dry season of December 2001 to April 2002. Forty-six dairy cross-bred heifers from nine farms and aged between 6 and 18 months, were divided into three treatment groups; T1, T2 and T3. Group T1, consisting of 14 heifers (nine showing zero faecal egg counts at the start of the experiment) was offered MUMB containing fenbendazole at 0.5 g/kg for 15 days, after which the MUMB was replaced with UMMB for 45 days before repeating the programme. Group T2, consisting of 17 heifers (11 showed zero faecal egg counts at the start of the experiment), was offered UMMB continuously for 120 days. Group T3, consisting of 15 heifers (11 showed zero faecal egg counts at the start of the experiment), was not supplemented with UMMB during the trial. Faecal worm egg counts (eggs/g, epg), packed cell volume (PCV) and body condition score were evaluated before commencing the trial and every 30 days thereafter. Average daily live-weight gain was recorded for the first 60 days of the trial. The composition of UMMB consisted of molasses 40%, rice bran 40%, urea 5%, cement 12% and a mineral mixture 3%.

2.4. Cost : benefit analysis

The UMMB and MUMB were introduced to dairy farmers in six milk collection centers of the North-Eastern DPO. This involved training programme for UMMB production, the setting up of demonstration farms, farm and field visits and the production of a newsletter, posters and reports on UMMB use for publication in the DPO bulletins. A dairy journal was also produced to encourage the dairy farmers in the area to utilize UMMB and MUMB as an essential supplement in the daily diet of their cattle.

Cost : benefit analysis of UMMB and MUMB supplementation was carried out using data collected from milk production studies.

3. RESULTS AND DISCUSSION

The urea-molasses blocks were made by farmers at the Farmer Cooperatives or Milk Collection Centers. The blocks contained 40% molasses, 6% urea, 40% rice bran, 10% cement, 1% triple phosphate, 1% sulphur and 2% mineral mixture. The average block consumption was 0.68 (±0.07) and 0.52 (±0.32) kg/head/d for the first and second experiments, respectively.

3.1. Effect of UMMB supplementation on milk production

Supplementation with UMMB altered the rate of decline in milk production normally observed during the declining phase of lactation. The rate of change in daily milk production of cows before supplementation with UMMB was –0.0126 kg/d but this changed to an increasing trend after supplementation, to +0.0142 kg/d (Experiment I, Table II and Fig. 1). In Experiment II, however, both treatments recorded a decline, the supplementation treatment showing a reduced rate of decline in milk production (Table III) compared to the unsupplemented control.

These feeding trials clearly demonstrated the positive effect of UMMB supplementation on milk production.

TABLE II. THE EFFECT OF UREA-MOLASSES MULTI-NUTRIENT BLOCK (UMMB) SUPPLEMENTATION ON MILK PRODUCTION IN EXPERIMENT I

	Without UMMB	With UMMB
Duration of experiment (d)	15	15
Number of farmers	4	4
Number of cows	23	23
Average milk production (kg per cow/d) (estimated by regression analysis)		
beginning of experimental period	9.92	9.74
end of experimental period	9.74	9.95
Mean rate of change (slope) in milk production (kg/d)	–0.0126	+0.0142

TABLE III. THE EFFECT OF UREA-MOLASSES MULTI-NUTRIENT BLOCK (UMMB) SUPPLEMENTATION ON MILK PRODUCTION IN EXPERIMENT II

	Without UMMB	With UMMB
Duration of experiment (d)	30	30
Number of farmers	5	5
Number of cows	15	16
Average milk production (kg per cow/d) (estimated by regression analysis)		
beginning of experimental period	10.63	10.64
end of experimental period	10.39	10.61
Mean rate of change (slope) in milk production (kg/d)	–0.0077	–0.0011

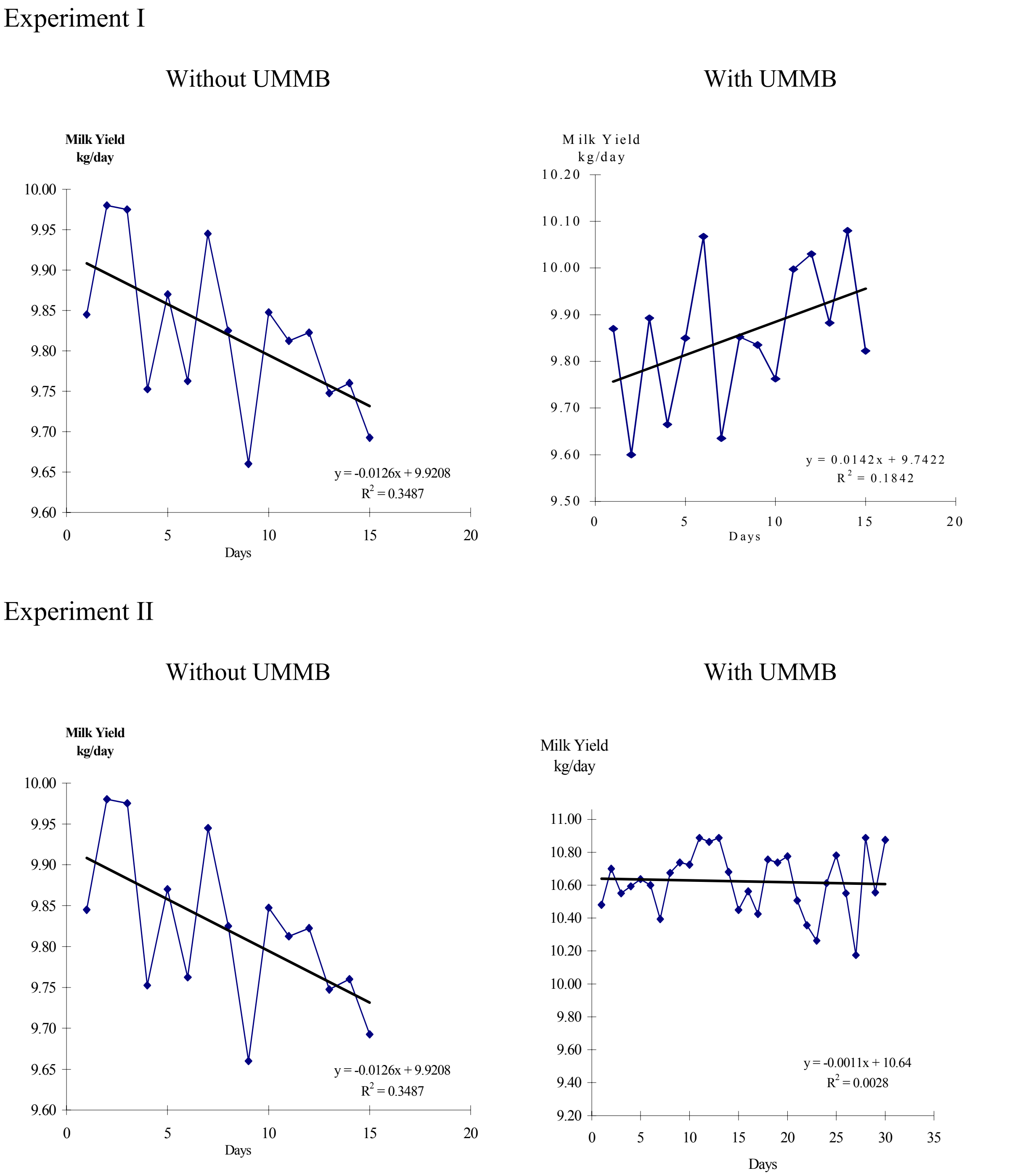

FIG. 1. Regression line of milk yield from cows before and after supplementation with urea-molasses multi-nutrient block (UMMB).

3.2. Reproductive performance of UMMB supplemented cows

Table IV shows that the first service conception rate was low and services per conception were high when cows were being maintained without UMMB. Following UMMB supplementation, the first service conception rate improved and there was a significant decline in services per conception (*P* <0.01) from 2.54 to 1.88. This decline in services per conception reduced the mean calving to conception interval (days open) by 34.8 days. The

UMMB supplement also reduced the calving to first service interval by 11.6 days and the inter-calving interval by 40.3 days.

TABLE IV. THE EFFECT OF UREA-MOLASSES MULTI-NUTRIENT BLOCK (UMMB) SUPPLEMENTATION ON SOME FERTILITY INDICES OF CROSS-BRED DAIRY CATTLE IN THE NORTH-EASTERN REGION OF THAILAND

Parameter	Without UMMB	With UMMB
Number of cows selected for study	70	62
Period of study	Sept.1995–Sept. 1997	Oct. 1997–Sept. 1999
Number of artificial inseminations (AI) carried out	173	117
Number of cows conceiving by 1st AI (%)	29 (45.3)	34 (56.7)
Total number of cows conceived during the experiment	68	62
* Number of services/conception	2.54 ± 0.25	1.88 ± 0.19
* Calving to 1st service interval (days)	77.5 ± 5.2 (n=64)	65.9 ± 3.5 (n = 60)
* Calving to conception (d)	127.2 ± 11.3 (n=64)	92.4 ± 6.6 (n = 60)
* Inter-calving interval (d)	405.4 ± 11.3 (n=64)	365.1 ± 5.3 (n = 60)

Mean values with SE within rows are significantly different (*P* <0.01)

3.3. Effect of MUMB on-farm trial

Free access to MUMB and UMMB supplements resulted in daily intakes of 1.1 ± 0.2 and 1.2 ± 0.3 kg, respectively.

3.3.1. Faecal egg counts and packed cell volume

As shown in Tables V and VI, there was no re-infection with nematodes after MUMB supplementation in Group T1 heifers and the faecal egg counts were zero on all occasions (measurement at 30, 60, 90 and 120 d). For Group T2 heifers, UMMB supplementation resulted in lower faecal egg counts when compared to the heifers that received no supplement (Group T3). For Group T1, PCV increased from 27.38 ± 5.38 to 31.54 ± 2.89 at 60 days after the introduction of MUMB, and was higher than in both Group T2 and Group T3 heifers (*P* <0.05); Groups T2 and T3 did not differ (*P* >0.05). There were no significant effects of treatment on PCV at 30, 90 and 120 days (*P* >0.05).

TABLE V. EVALUATION OF REINFECTION OF NEMATODES IN DAIRY HEIFERS SUPPLEMENTATED WITH UREA-MOLASSES MULTI-NUTRIENT BLOCK (UMMB) OR MEDICATED UMMB (MUMB)

Groups	Number of observations.	Faecal egg counts per gram (EPG)				
		Day 0	Day 30	Day 60	Day 90	Day 120
MUMB	9	0	0	0	0	0
UMMB	11	0	9.1 ± 30.1	22.7 ± 75.3	0	0
Control	11	0	68.2 ± 129.0	81.8 ± 255.2	0	63.6 ± 167.5

TABLE VI. EVALUATION OF FAECAL EGG COUNTS PER GRAM (EPG) OF DAIRY HEIFERS SUPPLEMENTATED WITH UREA-MOLASSES MULTI-NUTRIENT BLOCK (UMMB) OR MEDICATED UMMB (MUMB)

Groups	Number of observations.	Faecal egg counts per gram (EPG)				
		Day 0	Day 30	Day 60	Day 90	Day 120
MUMB	14	32.1 ± 49.0	0.0[a] ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
UMMB	17	52.9 ± 92.2	5.9[ab] ± 24.3	20.6 ± 63.9	11.8 ± 48.5	0.0 ± 0.0
Control	15	30.0 ± 65.9	50.0[b] ± 113.4	60.0 ± 218.9	0.0 ± 0.0	46.7 ± 144.5

3.3.2. Daily weight gain and body condition score (BCS)

The daily weight gain of animals in the Group T1 MUMB supplemented heifers at day 60 was higher than in both Group T2 UMMB supplemented heifers and Group T3 heifers without supplementation (P <0.05). There was no difference between Group T2 and Group T3 heifers (P >0.05). The BCS differed at the start of the trial due to grouping for other parameters (faecal egg count, PCV) and improved in all groups (Table VII).

TABLE VII. PACKED CELL VOLUME (PCV), LIVE-WEIGHT GAIN AND BODY CONDITION SCORE (BCS) OF DAIRY HEIFERS, SUPPLEMENTED WITH UREA-MOLASSES MULTI-NUTRIENT BLOCK (UMMB), MEDICATED UMMB (MUMB), OR UNSUPPLEMENTED (CONTROL) FOR 120 D

Days	Supplement	0	30	60	90	120
PCV	MUMB	27.4 ± 5.38	29.6 ± 3.9	31.5^a ±2.9	28.4 ± 2.8	29.6 ± 3.4
	UMMB	27.0 ± 3.0	28.5 ± 3.4	26.5^b ±7.5	26.2 ± 4.2	27.4 ± 3.0
	Control	28.7 ± 3.7	29.3 ± 3.5	27.1^b ±2.9	28.2 ± 2.8	28.4 ± 2.5
Weight gain (kg)	MUMB			0.7^a ±0.2		
	UMMB			0.5^b ±0.2		
	Control			0.4^b ±0.2		
BCS*	MUMB	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	2.3^b ± 0.5	2.5^b ± 0.37	2.7^b ± 0.3	2.8^b ± 0.2	2.8^b ± 0.2
	Control	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

$^{a, b, c}$ Value within the same column bearing different superscripts differ significantly (P <0.05)

*BCS 1 = very thin, 5 = overfat

3.4. Cost : benefit analysis

3.4.1. Cost : benefit analysis of UMMB

Data on actual intake of roughages, concentrate and UMMB by cows and the extent to which concentrates have been replaced by UMMB were not available in all cases and, therefore, it was not possible to accurately work out the cost : benefit analysis of UMMB supplementation. However, there is no doubt that UMMB supplementation reduced the rate of decline in milk yield, which would result in an increase in milk production during the declining phase of lactation, thus increasing total lactation yield.

Based on available information it has previously been estimated that the economic benefit of UMMB supplementation per cow/d would be in the region of Baht 4.5 (Pant, unpublished). This calculation assumes that UMMB could replace about 25% of the concentrate supplement, suggesting that the economic benefits could be even higher than Baht 4.5 per cow/d when the increase in milk yield was also taken into account.

Taking into consideration milk production data and the quantity of UMMB that has been produced in the six milk collection centers in1999 (Tables VIII), it is clear that the DPO has benefited from the UMMB technology. Production of UMMB increased from 19 tonnes in 1997 to 82 tonnes in 1999. Total milk production during the same period 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 (from 2535 to 2936), the above results suggest that part of the increase in milk production was due to improved feeding, through UMMB supplementation, and the consequent improvement in reproductive performance.

Assuming that the cost of production of 1 kg of UMMB is Baht 4, the total cost incurred in the production of UMMB during the year 1999 would be Baht 328 000 (1 US$ = 40 Baht) (Table VIII). The value of increased milk production at the rate of Baht 12 per kg of milk would be Baht 4172 million. Even if one assumes that only 10% 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. The economic benefits derived from Experiment 3 are presented in Table IX.

TABLE VIII. QUANTITIES OF UREA-MOLASSES MULTI-NUTRIENT BLOCK (UMMB) (kg) AND TOTAL MILK PRODUCED IN THE SIX MILK COLLECTION CENTERS AND INCOME DERIVED BY THE FARMERS IN 1999

Name of Milk Collecting Center	UMMB production (kg)	Numbers of cow	Total milk production (Tons/year)	Income from milk production (Baht)
Namphong	35000	777	2371	25261164
Kranaun	7900	414	1657	17609567
Srithat	20500	702	2444	26141845
Kudjub	10840	453	1228	13142398
Jareonsin	7360	341	968	10333992
Tungfon	600	249	997	10646635
Total	82200	2936	9665	76993756

TABLE IX. INCREASE IN ANNUAL MILK PRODUCTION, AND CHANGE IN INCOMES OF NINE SMALLHOLDER FARMERS SUPPLEMENTING THEIR COWS WITH UREA-MOLASSES MULTI-NUTRIENT BLOCK (UMMB) DURING THE FOUR YEAR EXPERIMENTAL PERIOD (DATA FROM EXPERIMENT III)

Farm Number	Milk production (L/year)		Increase in Production (L)	Value of extra milk (US$)*
	– UMMB 1996–97	+ UMMB 1998–99		
11	16016	24412	8396	2519
59	22549	33061	10512	3154
61	16278	24207	729	2379
62	21628	66694	45066	13520
63	17851	30201	12350	3705
65	22497	30370	7873	2362
67	24186	39577	15391	4617
68	21495	45420	23925	7178
69	23562	54848	31286	9386

*1 US$ = 40 Baht

3.4.2. Cost : benefit ratio analysis

The MUMB supplementation per head/d was 1.2 kg which cost 7.2 Baht/head/d. It improved body weight gain of heifers from 0.4 kg/d without MUMB to 0.7 kg/d with MUMB. This calculation assumes that 1 kg of daily weight gain was worth 30 Baht, giving a cost : benefit ratio 1 : 1.3 from feeding MUMB.

4. CONCLUSIONS

The cost effectiveness of UMMB supplementation in Thailand's North-Eastern region is evidenced from the data collected during this study. An increase in milk production was observed due to UMMB supplementation resulting in additional income for the smallholder dairy farmers. It is predictable that improved reproductive performance would lead to an increased number of calves and increased efficiency of the dairy operation, thus improving the social status of the farmers.

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DEVELOPMENT OF UREA-MOLASSES MULTI-NUTRIENT BLOCK (UMMB) AND MEDICATED UMMB (MUMB) FOR RUMINANTS IN VIETNAM

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Abstract

This report covers research and development of UMMB and MUMB for cattle in Vietnam. Based on locally available ingredients, two UMMB formulations were identified. The main and most important nutrient components of UMMB were urea and molasses and other components were those that were cheap and locally available. The medicated UMMB (MUMB) studied were prepared to contain febendazole (0.5 g/kg block) and dried pineapple leaves (150 g/kg block). Results of experiments showed that pH and NH_3 of rumen fluid of dairy cows were higher and more stable with UMMB supplementation. This leads to an improvement of milk production and reproductive performances of dairy cows. Use of both types of MUMB showed that the level of parasite infection decreased significantly, and the weight gains of young dairy and beef cattle heifers improved substantially.

1. INTRODUCTION

In order to meet the demand for milk and meat, the development of livestock production is a priority of the National Food Program in Vietnam. Ruminant production is almost entirely in the hands of smallholder dairy farmers in this country. Although it is reported that 1.0 million ha of natural pasture exists [1], in reality Vietnam has very few large areas of natural pasture. With the increase of the human population and the establishment of new economic zones, natural pasture has been reduced to small areas and the remainder is now used for crop production and building construction. This has resulted in a shortage of grass for livestock feeding and farmers have been forced to use agro-industrial by-products such as rice straw, sugar cane tops and cassava root waste as cattle feed [1]. Nutritionally, these feedstuffs are unbalanced, especially in terms of their energy and protein content. Use of these feedstuffs frequently results in poor body condition, short lactation periods, low reproductive performances, early culling and eventually reduced economic returns for cattle farmers. To improve nutrition for ruminants in such conditions, the use of urea-molasses multi-nutrient blocks (UMMB) is a convenient and inexpensive method of providing a range of nutrients, required by both the rumen microbes and the animal, which may be deficient in the diet. The main justification for using the blocks is convenience for packaging, storage, transport and ease of feeding.

In addition to the problem of under-nutrition discussed above, gastrointestinal nematode parasitism of ruminant livestock can cause significant loss in production through increased mortality and reduced production of meat, milk and work potential. To address this, some research has been carried out to develop means of controlling nematode parasites through the use of UMMB containing anthelmintic (medicated blocks, MUMB) in production systems where the regular use of UMMB supplements has proven to be beneficial [2].

2. MATERIALS AND METHODS

2.1. Study on formulas and nutritive composition of UMMB

Different formulations for on-farm and factory production of UMMB were prepared based on the nutrient value of the ingredients. Ten samples of each formulation were then analysed to determine dry matter, crude protein, crude fiber and fat. Based on the chemical composition of ingredients the metabolizable energy of UMMB was also calculated.

2.2. Effect of UMMB on some indices of the rumen environment of cattle

Four fistulated cows (F1 Holstein Friesian x Sindhi) at the Ruminant Center of the Institute of Agricultural Sciences (IAS), were used to assess the effect of UMMB on pH and NH_3N of rumen fluid. The experimental design is shown in Table I.

TABLE I. DESIGN OF EXPERIMENT TO MEASURE THE EFFECT OF UREA-MOLASSES MULTI-NUTRIENT BLOCK (UMMB) ON THE RUMEN ENVIRONMENT IN COWS

Period	With UMMB	Without UMMB
Period 1 (15 d)	Cow 1 + Cow 2	Cow 3 + Cow 4
Period 2 (15 d)	Cow 3 + Cow 4	Cow 1 + Cow 2

One kg of UMMB was offered in two equal feeds to individual cows at 6:00 and 18:00 h each day. Samples of rumen fluid were collected daily from each cow at seven times, on each of the last 3 days of the experiment, at 07:00, 09:00, 12:00, 15:00, 18:00, 24:00 and 06:00 h.

2.3. Effect of UMMB on milk production, reproductive performance and economic efficiency in dairy cattle production

Forty dairy cows (F1 and F2 Holtein Friesian x Sindhi) at the Ruminant Center of IAS were selected and divided into two equal groups: a control group (without UMMB) and an experimental group (with UMMB). Milk yields were recorded daily. Milk samples were collected monthly for fat content analysis. The intervals from calving to the first artificial insemination (AI) and to conception were recorded for each cow during the study.

2.4. Survey on infection of parasites in cattle in Vietnam

Faecal samples (20 g) from 157 beef cattle and 73 dairy cattle of different ages were collected and analysed at the University of Ho Chi Minh City in order to assess the level of gastrointestinal parasite infection in cattle (Table II).

TABLE II. LOCATION AND NUMBER OF ANIMALS INVOLVED IN THE SURVEY

Areas	Number of animals		
	Dairy	Beef	Total
Binh Phuoc province		105	105
Dong nai province	58	52	110
Ruminant center (IAS)	15		15
Total	73	157	230

2.5. Supplementation with MUMB containing ferbenzol (FBZ-UMMB)

Twenty-four dairy heifers naturally infected with gastrointestinal parasites at a farm in Long Thanh district, Dong Nai province were divided into three equal groups. The animals in Group 1 were offered 1 kg of UMMB containing 0.5 g FBZ/kg (FBZ-UMMB) on one occasion every tenth day and offered UMMB without anthelmintic for the remainder of the time; animals in Group 2 were offered 1 kg of UMMB without anthelmintic throughout; and animals in Group 3 were an untreated control (Table III).

TABLE III. DESIGN OF EXPERIMENT ON USING OF FBZ-UMMB

Treatment group	Treatment	Number of animals	Body weight (kg/head)
I	FBZ-UMMB	8	178.9 ± 4.8
II	UMMB	8	177.7 ± 5.2
III	Control	8	176.9 ± 3.7
Total/Average		24	177.8 ± 4.4

The experiment was carried out over three months. The animals were kept all day in a cattle shed and offered 25 kg of improved grasses, grown on land which had received unprocessed manure, 2 kg rice straw and 1 kg of concentrate. Faecal samples were collected before the trial and six times during the trial for quantification of gastrointestinal nematode egg counts. Body weight of the animals was also determined by a weigh tape at the time of faecal sample collection.

2.6. Effect of adding Pineapple leaves to UMMB

From a population of 220 cattle, 20 animals with average faecal worm egg counts of around 380 eggs/g faeces, were divided into two equal groups. The animals in Group 1 were given 1 kg of UMMB containing 150 g dried ground pineapple leaves (PL-UMMB)/kg every 15 days, while the animals in Group 2 were untreated controls (Table IV). The basic diet of the animals, duration of the trial, times of faecal sample collection and body weight monitoring were as in the experiment described in Section 2.5 above.

TABLE IV. DESIGN OF EXPERIMENT ON USING PL-UMMB

Treatment group	Treatment	Number of animals	Body weight (kg/head)
I	PL-UMMB	10	177.5 ± 6.1
II	Control	10	162.4 ± 5.7
Total/Average		20	170.0 ± 5.9

3. RESULTS

3.1. Ingredients and nutritive composition of UMMB

3.1.1. Ingredients of UMMB

Based on the availability, nutritive value, price, handling and the effect on quality of block, two formulas of UMMB were developed: one to be used in sugar factories (UMMB–1) and the other for use by smallholder farmers (UMMB–2). The ingredients of these different UMMB are shown in Table V. Both formulas had the same percentage of urea (8%), cement (5%), lime (5%), salt (1%) and premix (1%) but differed since smallholder farmers did not use bagasse while the factory used 15% of this sugar by-product for UMMB production.

TABLE V. FORMULAS OF UREA-MOLASSES MULTI-NUTRIENT BLOCKS (UMMB)

Ingredients (%)	UMMB–1 (Sugar factory)	UMMB–2 (Smallholder farms)
Molasses	40	37
Urea	8	8
Rice bran	25	43
Bagasse	15	–
Lime	5	5
Cement	5	5
Salt	1	1
Mineral premix	1	1

3.1.2. *Nutritive composition of UMMB*

The nutritive values of the UMMBs are shown in Table VI and only minor differences between the formulations are indicated, except for crude fibre which was almost 50% lower in UMMB–2 than UMMB–1.

TABLE VI. CHEMICAL COMPOSITION OF UREA-MOLASSES MULTI-NUTRIENT BLOCK (UMMB) MADE IN A SUGAR FACTORY OR ON-FARM

Indices	UMMB 1 (Sugar factory)	UMMB 2 (Smallholder farms)
Dry matter (DM, g/kg)	893	908
Crude protein (g/kg DM)	145	160
Crude fiber (g/kg DM)	301	158
Ether extract (g/kg DM)	52	73
Metabolizable energy (Kcal/kg)	2350	2480

3.2. Effect of UMMB on pH and NH_3–N of rumen fluid in dairy cows

Results of the study on the effect of UMMB on pH and NH_3–N of rumen fluid in dairy cows are shown in Figure 1. The average pH of dairy cows fed with and without UMMB was 6.86 and 6.75, respectively. However, there was a significant difference between NH_3–N (mg–N/L) contents of dairy cows fed with and without UMMB (175.78 and 152.70, respectively).

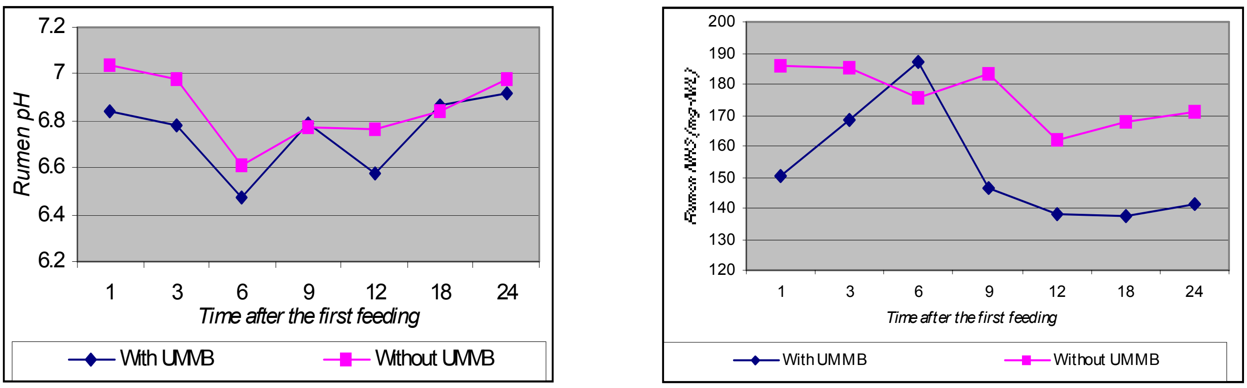

FIG. 1. pH and NH_3–N in cows supplemented with urea-molasses multi-nutrient (UMMB) or not supplemented.

3.3. Effect of UMMB on milk production and reproductive performance

Milk yield, milk fat content and reproductive performance of dairy cows are shown in Table VII. Daily milk yield and milk fat content were greater in UMMB supplemented cows, and the supplementation significantly improved reproductive performance.

TABLE VII. MILK YIELD, MILK FAT CONTENT AND REPRODUCTIVE PERFORMANCE OF DAIRY COWS EITHER SUPPLEMENTED WITH UREA-MOLASSES MULTI-NUTRIENT BLOCK (UMMB) OR UNSUPPLEMENTED

Indices	–UMMB	+UMMB	*P* value
Number of cows	20	20	
Milk yield (kg/cow/d)	12.6 ± 2.2	13.97 ± 1,25	$P < 0.05$
Milk fat content (%)	3.21 ± 0.12	3.32 ± 0.22	$P < 0.05$
Interval from calving to 1st oestrus (d)	135 ± 39	110 ± 26	$P < 0.05$
Conception rate 1st AI (%)	60	70	$P > 0.05$
Interval from calving to conception (d)	152 ± 51	121 ± 49	$P < 0.05$
Calving interval (months)	14.4 ± 1.7	13.4 ± 1.6	$P < 0.05$

3.4. Survey on infection levels with parasites

Tables VIII and IX shows that most of the cattle kept in grazing systems, were infected by gastrointestinal parasites Overall the percentage of animals infected was between 70 and 100%. Table IX shows that although the dairy heifers were kept all the time in cattle sheds, the percentage of animals infected remained high (20–100%).

TABLE VIII. PERCENTAGE AND GENUS OF PARASITE INFECTION IN BEEF CATTLE

Animals in different ages	Total infected (%)	Genus of parasites				
		1	2	3	4	5
A. In Dong Nai province						
Calves< 12 months (n = 19)	68.4	10.52	36.8	21.1	–	42.4
Heifers (n = 24)	62.5	0	20.8	16.6	25.00	33.3
Adult cows (n = 62)	67.7	0	22.5	16.1	33.9	22.5
B. In Binh Phuoc province						
Calves < 12 months (n = 15)	93.3	0	40.0	6.7	46.7	53.3
Heifers (n = 5)	100.0	0	60.0	0	60.0	40.0
Adult cows (n = 35)	71.9	0	15.6	9.4	43.8	21.9
Average of A and B						
Calves < 12 months (n = 34)	80.9	5.3	38.4	13.9	23.3	47.9
Heifers (n = 29)	81.3	0	40.4	8.3	42.5	36.7
Adult cows (n = 97)	69.8	0	19.1	12.7	38.8	22.2

Notes: 1: Neoascaris; 2: Haemonchus; 3: Oesphagostomum; 4: Paramphistomum; 5: Eimeria

3.5. Effects of FBZ-UMMB on deworming and weight gain in dairy heifers

Table XI shows that FBZ-UMMB supplementation decreased the percentage of animals infected with parasites by 75% compared to the control group. In addition, the use of UMMB also assisted in controlling parasites with the percentage of animals infected decreasing by 37.5% compared to the control group. Due to decreased parasite infection, the weight gain of the heifers was improved by about 7 kg/head/month in the FBZ-UMMB group and 3 kg/head/month in the UMMB group compared to the control group (Table XI).

TABLE IX. PERCENTAGE AND GENUS OF PARASITE INFECTION IN DAIRY CATTLE

Animals in different ages	Total infected (%)	Genus of parasites				
		1	2	3	4	5
A. In Dong Nai province						
Calves < 12 months (n = 09)	100.00	0	55.6	22.2	22.2	22.2
Heifers (n =16)	81.3	0	12.5	6.25	50.0	31.3
Adult cows (n = 30)	87.88	0	27.3	12.1	36.4	33.3
B. At Ruminant Center (IAS)						
Heifers (n = 05)	80.0	0	20.0	20.0	20.0	60.0
Adult cows (n = 10)	20.0	0	0	0	20.0	20.0
Average of A and B						
Calves < 12 months (n = 09)	100.0	0	55.6	22.2	22.2	22.2
Heifers (n = 21)	80.6	0	16.3	13.1	35.0	45.6
Adult cows (n = 40)	53.9	0	13.6	6.1	28.2	26.7

Notes: 1: Toxocara; 2: Haemonchus; 3: Oesphagostomum; 4: Paramphistomum; 5: Eimeria

TABLE X. EFFECT OF SUPPLEMENTING WITH UREA-MOLASSES MULTI-NUTRIENT BLOCK (UMMB) OR UMMB WITH FERBENZON (FBZ-UMMB) ON INFECTION OF PARASITES IN DAIRY HEIFERS

Time of faecal sample collection	Infected animals (%)		
	Control	FBZ-UMMB	UMMB
Before trial	100.0	100.0	100.0
During trial			
1st time (after 15 d)	100.0	25.0	75.0
2nd time (after 30 d)	100.0	37.5	62.5
3rd time (after 45 d)	100.0	25.0	75.0
4th time (after 60 d)	100.0	12.5	50.0
5th time (after 75 d)	100.0	25.0	50.0
6th time (after 90 d)	100.0	25.0	62.5
Average	100.0[a]	25.0[b]	62.5[c]

Values with different superscripts differ at $P > 0.05$

TABLE XI. EFFECT OF SUPPLEMENTING WITH UREA-MOLASSES MULTI-NUTRIENT BLOCK (UMMB) OR UMMB WITH FERBENZON (FBZ-UMMB) ON WEIGHT GAIN IN DAIRY HEIFERS

Time of weighing	Weight of animals (kg)		
	Control	FBZ-UMMB	UMMB
Before trial	178.9 ± 4.8	176.9 ± 3.7	177.7 ± 5.2
During trial			
1st time (after 15 d)	181.4 ± 5.2	183.5 ± 4.6	184.5 ± 5.4
2nd time (after 30 d)	187.2 ± 4.7	191.2 ± 5.3	189.4 ± 4.3
3rd time (after 45 d)	188.8 ± 4.9	197.6 ± 3.9	196.3 ± 6.1
4th time (after 60 d)	192.6 ± 5.6	206.5 ± 3.8	201.3 ± 5.7
5th time (after 75 d)	199.1 ± 3.5	217.8 ± 4.2	207.4 ± 4.1
6th time (after 90 d)	204.4 ± 3.2	223.0 ± 5.1	211.3 ± 4.5
Weight gain: kg/month	8.5 ± 3.08[a]	15.38 ± 3.39[b]	11.21 ± 3.14[c]
g/d	283	513	374

Values with different superscripts differ at $P > 0.05$

TABLE XII. EFFECT OF UREA-MOLASSES MULTI-NUTRIENT BLOCK CONTAINING PINEAPPLE LEAF (PL-UMMB) ON GROWTH IN DAIRY HEIFERS

Time of weight measure	Worm eggs/gram faeces (X ± SD)	
	Control	PL-UMMB
Before trial	381 ± 42.4	392 ± 35.4
During trial		
1st time (after 15 d)	390 ± 46.7	106 ± 42.1
2nd time (after 30 d)	389 ± 54.3	124 ± 36.5
3rd time (after 45 d)	387 ± 64.3	165 ± 41.2
4th time (after 60 d)	401 ± 41.2	99 ± 24.1
5th time (after 75 d)	366 ± 39.8	106 ± 18.6
6th time (after 90 d)	395 ± 38.7	150 ± 23.4
Average	388 ± 43.9[a]	125 ± 26.7[b]

Values with different superscripts differ at $P > 0.05$

3.6. Effect of PL-UMMB on deworming and weight gain in beef heifers

The use of PL-UMMB can control nematodes in cattle with the average faecal worm egg count decreasing by more than 60% (Table XII). The daily weight gain of beef heifers was also improved in treatment PL-UMMB by more than 600% (Table XIII).

TABLE XIII. EFFECT OF UREA-MOLASSES MULTI-NUTRIENT BLOCK CONTAINING PINEAPPLE LEAF (PL-UMMB) ON GROWTH IN BEEF HEIFERS

Time of faecal sample collection	Weight of animals	
	Control	PL-UMMB
Before trial	162.4 ± 72.3	177.5 ± 74.2
During trial		
1st time (after 15 d)	163.2 ± 71.4	184.9 ± 74.9
2nd time (after 30 d)	164.7 ± 72.1	191.6 ± 75.5
3rd time (after 45 d)	166.2 ± 71.1	193.6 ± 75.5
4th time (after 60 d)	164.8 ± 71.7	205.5 ± 79.3
5th time (after 75 d)	167.0 ± 72.9	215.0 ± 84.9
6th time (after 90 d)	169.4 ± 73.1	219.9 ± 84.2
Weight gain: kg/month	2.33 ± 1.9 (b)	14.13 ± 6.2 (a)
g/d	78	471

Values with different superscripts differ at $P > 0.05$

4. DISCUSSION

Two important components in UMMB, urea and molasses are inexpensive sources of NH_3–N and energy for rumen microbes and assist in the optimization of rumen function when animals are fed low quality roughages. Other locally available and comparatively cheap feed resources were the other components of block formulations developed for Vietnam. For example, the formulation for the sugar factories utilized the by-product bagasse with its inclusion in the block formulations restricted to 15% because it has very low digestibility. The formulations developed for Vietnam contained around 150 g/kg DM crude protein. Some other authors have produced UMMB containing higher crude protein: 410 g/kg DM crude protein-UMMB with urea and cottonseed and 535 g/kg DM crude protein-UMMB with urea and fishmeal [3]; UMMB for milking cows and heifers, which contained 400 g/kg DM CP (16% Urea); and 311 g/kg DM CP (12% urea) respectively [4].

Microbes use NH_3 and energy more effectively if these are provided gradually to help maintain a stable pH in the rumen. It is reported that dairy cattle supplemented with UMMB have a rumen pH fluctuating from 6.7 to 6.9. In addition, due to continued release of NH_3–N from urea, rumen NH_3 is higher and more stable [5]. Supplementing dairy cattle with UMMB increased rumen NH_3 to 259–300 mg–N/L [6], while the recommended level is 277 mg–N/L [5]. In the present studies the average pH values of dairy cows fed with and without UMMB were 6.86 and 6.75, respectively; and rumen NH_3–N (mg–N/L) contents were 175.78 and 152.70, respectively.

The most important finding from the present study was that supplementation of the diet with UMMB significantly improved the productivity of dairy cows. The improvement in milk yield and milk fat content when the ration was supplemented with UMMB can be explained by the fact that the metabolizable energy: crude protein (ME : CP) ratio was balanced in the rations and the subsequent maintenance of NH_3 level and pH in the rumen lead to an improved ruminant environment for microorganisms. Most animals, especially dairy cattle are energy deficient after parturition due to high energy demands of milk production. Energy from any source in such animals is important for uterine involution, onset of ovarian activity and expression of oestrus [7]. Energy deficiency has been reported to lead to acyclicity, silent heat, delayed ovulation and follicular cysts [8]. The improvement in reproductive performance of cows in the present study is, therefore, due to energy provided through UMMB.

Concerning infection with gastrointestinal nematode parasites, it is thought that the grazing system, especially the use of improved grasses fertilized with raw manure are the main contributors to a high incidence of infection in both dairy and beef cattle in Vietnam. It is reported that in Northern areas the percentages of infection with gastrointestinal parasites in buffalo and cattle were 93.20% and 93.60% respectively [9]. Level of infection of gastrointestinal parasites also depends on nutritient supply to the animals. In the tropics, nutritional deficiency is common, which leads to increased levels of infection with gastrointestinal parasites. It is frequently necessary to have suitable methods available for controlling gastrointestinal parasites in ruminants. Results of studies on effects of FBZ-UMMB and PL-UMMB for controlling gastrointestinal parasites showed that these are effective and suitable methods for dairy and beef production systems in Vietnam. This supports the results that FBZ-UMMB can assist in preventing infection with gastrointestinal parasites and can also kill resident mature parasites [10]. When the ruminants are supplied medicated UMMB to control gastrointestinal parasites, the weight gain can increase by more than 18%, as in the present study with beef heifers [2]. Besides FBZ-UMMB, results with PL-UMMB also showed similar effects in controlling parasites and boosting productivity. These results support previous observations [11, 12]. This is an important finding since Vietnam currently has a pineapple development programme in most provinces to increase farmer income. The use of pineapple by-products as herbal medicine for control gastrointestinal parasites in ruminants may become an important strategy for livestock development in this region.

5. CONCLUSIONS

From this study it could be concluded that UMMB and MUMB supplementation can improve productivity of cattle:

- The milk yield was increased by 1.37 kg/cow/d.
- The calving interval was decreased by 30 days.

- Percentage of beef and dairy cattle infected with gastrointestinal parasites was high: in beef cattle infection prevalence ranged from 62 to 100% and in dairy cattle from 20 to 100%. The most common genera of gastrointestinal parasites was *Haemonchus and Oesphagostomum*.

- Use of FBZ-UMMB decreased parasite infections by 75% and increased weight gain by around 8 kg/head/month compared to the control group.

- Pineapple leaves can be used as a herbal medicine in UMMB for controlling gastrointestinal parasites of young cattle since they decreased average worm egg counts by around 70%.

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PART II.
EFFICIENT UTILIZATION OF ALTERNATE FEED RESOURCES

IMPROVING ANIMAL PRODUCTIVITY AND REPRODUCTIVE EFFICIENCY: STRATEGIC SUPPLEMENTATION OF FEEDS WITH LEGUME FORAGES AND NON-CONVENTIONAL PLANT RESOURCES

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Abstract

Identification and evaluation of potential plant resources and their dissemination among rural farmers have been attempted. The work was done in three phases. In the first phase, laboratory evaluation of proximate components, *in vitro* digestibility and energy contents was carried out. Fifteen plant species were evaluated in this phase. Some of the plant species (*Sesbania*, *Dhaincha*, *Lathyrus, Crotalaria* and *Leucaena*) were promising, containing relatively large amounts of protein (18–34%) and having high digestibility values (53–60%). Some species contained reasonably good levels of metabolizd energy (6.5–8.5 MJ/kg). In the second phase, four promising species (*Sesbania*, *Lathyrus*, *Crotalaria* and *Leucaena*) were offered as supplements to lactating and growing cattle, in four *in vivo* feeding trials carried out on-station. Supplementation with *Sesbania* gave significantly (P <0.01) higher milk yields, resulting from increased feed intake and digestibility of organic matter (OM) and crude fibre (CF). *Lathyrus* also gave similar results in terms of milk yield and digestibility but had little effect on feed intake. *Leucaena* supplementation also significantly (P <0.05) increased milk yield but not feed intake or digestibility. *Crotalaria* gave a significant (P <0.05) increase in live-weight gain of growing calves. In the third phase, *Sesbania*, *Lthyrus* and *Leucaena* forages were grown by rural smallholders for feeding to their cattle. The forages were fed to lactating cows as supplements to straw-based diets. All the forage supplements resulted in increased milk yield compared to the control diets, however, *Sesbania* gave the best result in terms of output. The practice of cultivating legume forages and feeding to cattle receiving straw diets created enormous interest among the farmers as the increase in milk yield was cost effective.

1. INTRODUCTION

Feed shortage is the major reason for low livestock productivity in Bangladesh. The farmers can neither spare land for feed production nor can they afford to buy expensive concentrates to feed their animals. Efficient utilization of land for forage production and utilization of non-conventional and lesser-utilized plant resources by ruminants is a priority. These topics have been researched for several decades [1, 2, 3], with some success in developing ruminant feeding systems. Recently, technology has been developed for integrated rice/fodder production to mitigate shortages of forage for livestock [4]. Two legume forages, *Sesbania rostrata* and *Lathyrus sativus,* have been grown in rice fields over two seasons, thereby increasing forage output significantly and through feeding these forages milk yield of cows was increased by 25%. The cultivation of forages also increased the rice yield by 12% through increased soil nutrient status [3, 4]. There is a need to extend this technology to farmers.

There are many trees, herbs and shrubs in Bangladesh, that are lesser known and not well utilized, which may have potential to be used as animal feed. Inclusion of these non-conventional feeds could bridge the gap between the forage supply and demand. Tree leaves are a cheap source of feed, harvesting and storing being the major inputs, and thus could contribute to sustaining smallholder livestock production in rural areas. The research shows that the leaves of some tree species have potential in increasing growth and feed digestibility in animals [2, 5]. However, many of the trees and plants having leaves with potential for use as livestock feed are yet to be evaluated. Research on the adoption of rice/forage intercropping, using some of the less known species, is also investigated.

PART–A

LABORATORY EVALUATION OF LESSER-UTILIZED FORAGES AS LIVESTOCK FEED

1. MATERIALS AND METHODS

1.1. Collection and preparation of samples of potential forages

Leaves of unconventional fodder trees and shrubs, such as *Bambusa, Sesbania, Atrocarpus, Streblus, Mangifera, Leucaena, Erythrina, Azadirachta* and Ananas species, and other plants, such as *Lathyrus, Arachis, Crotalaria, Enhydra and Eichhornia* species were harvested in sufficient quantities for laboratory studies early in the day so that they could be sun-dried on the day of collection. Each species sample consisted of leaves from several plants. The harvested material was mixed thoroughly. The samples were initially sun-dried, followed by oven-drying and grinding through a 20 mm mesh sieve. The samples were then stored in polybags to await chemical analyses and in vitro studies.

1.2. Determination of nutrient contents

Dry matter (DM) was determined, as were crude protein (CP), fat, and crude fibre (CF) by proximate analysis [6]. *In vitro* OM digestibility (iOMD) and metabolizable energy (ME) content were estimated by the *in vitro* gas technique [7]. The rumen fluid was collected under anaerobic conditions from ruminally cannulated bullocks and added to the previously prepared medium mixture (containing micro-mineral solution, macro-mineral solution, buffer, resazurin and distilled water) in the ratio of 1 : 2 (rumen liquor and medium mixture). This mixture of rumen liquor and medium mixture was added to the ground feeds (200 mg DM) contained in the incubation syringe. The incubation was carried out at 39^{o}C for 24 h. All the forage species were incubated in two batches. Each species was incubated in triplicate samples with three blanks in each batch. Total volume of gas produced during 24 h was recorded and by using the following formulae iOMD and ME were calculated:

$$iOMD = 16.49 + 0.9042GP + 0.0492CP + 0.0387A$$

$$ME = 2.20 + 0.1357GP + 0.0057CP + 0.0002859L$$

where: GP = Gas production (mL/200 DM) and CP, L and A are Crude protein, fat and ash contents of feed under test, as g/kg DM

2. RESULTS

Results for the laboratory analysis are shown in Table I. *Sesbania*, *Lathyrus*, *Leucaena*, *Erythrina* and *Streblus* leaves contain relatively large amounts of CP (18–34%) and digestible organic matter (OM) (53–60%), suggesting they are potential protein supplements for ruminants. Pineapple leaves, *Enhydra*, *Sesbania*, *Streblus* and Mango leaves contain moderate levels of energy (6.5–8.5 MJ/kg ME) which could be added to a low energy diet. Dry matter contents of some of the feeds, such as water hyacinth and *Enhydra* are very low, however, these resources can be fed to livestock after wilting in the sun, or by mixing with straw or stover. They could be particularly important in periods of feed scarcity.

TABLE I. DRY MATTER (DM), CRUDE PROTEIN (CP), CRUDE FIBRE (CF), *IN VITRO* ORGANIC MATTER DIGESTIBILITY (iOMD) AND METABOLIZABLE ENERGY (ME) VALUES OF SOME POTENTIAL FEEDS

Plant species	DM g/kg	CP g/kg DM	CF g/kg DM	iOMD (g/kg DM)	ME MJ/ kg DM
Bamboo leaves (*Bambusa tulda*)	460.2	90.5	276.1	35.9	5.00
Dhaincha leaves (*Sesbenia aculeate*)	218.7	250.3	186.7	55.3	7.31
Sesbania leaves (*Sesbania rostrata*)	208.3	348.5	173.0	60.1	7.90
Khesari (*Lathyrus sativus*)	212.2	245.4	216.6	57.6	7.01
Groundnut straw (*Arachis hypogaea*)	860.5	127.0	268.4	483.2	8.02
Shon pat (*Crotalaria juncea*)	190.3	227.1	218.4	563.2	6.91
Jackfruit leaves (*Artocarpus heterophylus*)	328.1	123.0	224.5	54.8	6.10
Shaora leaves (*Streblus asper*)	346.2	186.6	162.7	55.2	6.80
Mango leaves (*Mangifera indica*)	452.2	93.2	241.0	46.2	6.51
Halencha (*Enhydra Fluctuans*)	105.6	120.6	201.5	54.1	7.78
Iple Iple leaves (*Leucaena leucocaphala*)	285.3	240.5	184.3	53.0	5.77
Mander leaves (*Erythrina spp*)	228.6	223.4	203.5	53.1	5.28
Neem leaves (*Azadirachta indicus*)	248.1	154.2	218.3	42.8	6.06
Pineapple leaves (*Ananas comosus*)	175.6	98.4	254.3	59.4	8.53
Water hyacinth (*Eichhornia crassipes*)	91.8	93.1	199.5	38.1	5.33

3. DISCUSSION

There are many different species of trees and shrubs available in the rural areas, many of which are eaten by ruminants. However, not all of them are available in sufficient quantities for feeding animals, nor are they all nutritious. Therefore, identification and screening is required. The most important aspect of fodders from trees and shrubs is that, unlike dry season grasses, they are usually protein-rich [8]. It is this characteristic which gives value to the lesser-utilized and non-conventional plant resources and justifies evaluating them as animal feeds. *In vitro* OMD indicated that some of the materials evaluated were comparable to grasses in energy content. However, before being promoted all potential non-conventional feeds should be evaluated to ensure that there are no anti-nutritional factors present in them [2] and that they are acceptable to livestock. This study indicated that some of the forages, including *Sesbania*, *Leucaena*, *Dhaincha*, pineapple leaves, *Streblus* and *Erythrina* leaves contained useful amounts of crude protein and digestible energy. These species can be used as supplements to straw-based diets for ruminants, especially those in extensive production systems such as practiced by rural smallholders. The evaluation techniques used in this study have enabled screening of the most promising lesser-utilized plant resources available to local farmers, and should be seen as a template for plant screening in the future.

PART–B

IN VIVO EVALUATION OF SELECTED FORAGES FOR NUTRITIONAL QUALITY

1. MATERIALS AND METHODS

1.1. Experiment 1

1.1.1. Animals, diets and location of experiment

Nine indigenous lactating cows (live weight, LW 152.6 ± 12.6 kg) were divided into three groups (A, B and C), each having three animals. They were grouped based on their milk yield and parity. Three diets, all containing rice straw (*ad libitum*), wheat bran (1.0 kg) and a small amount of mustard oil cake (0.25 kg) were supplemented with 0, 1.0 and 1.5 kg/d of fresh green *Sesbania* fodder (see Table I). The diet without supplementation contained low quality (~70 g/kg CP) green grass (1.5 kg). Each diet was fed to one of the groups. This experiment and three others (Experiment 2–4) were carried out in the field laboratory of the Department of Animal Nutrition, Bangladesh Agricultural University at Mymensingh.

1.1.2. Duration and parameters measured

The trial was continued for 45 days. Data on feed intake, digestibility and daily milk yield of animals was recorded. A digestion trial was conducted at the end of the experimental period with faeces being collected over seven days. The animals were housed in a well-ventilated open-sided barn with individual mangers and water troughs for feeding and watering. Feeds were supplied twice daily at 7:30 a.m. and 4:30 p.m. Water was supplied at all times. Representative samples of faeces were taken from the bulk and sun-dried, ground and stored in polybags to await analysis.

1.1.3. Chemical analysis

The samples of feeds and faeces were analysed for DM, CP, CF, ether extract (EE) and ash following the procedures for proximate analysis. Milk was analysed for protein and fat. Milk samples (0.25 kg) from each cow were collected for analysis at the start and end of the experiment.

1.1.4. Statistical analysis

The data was subjected to analysis of variance for a completely randomized block design.

1.2. Experiment 2

1.2.1. Animals, diets and location of study

Eight indigenous lactating cows (LW 165.3 ± 12.1 kg) were divided into two groups of four, according to milk yield and parity. Each group received one of the following diets: a diet containing rice straw, wheat bran and mustard oil cake (the same amounts as in Experiment 1) and with 1.5 kg low quality green grass (~ 70 g/kg CP) or the same diet supplemented with 1.0 kg/d of Lathyrus hay (see Table I).

1.2.2. Duration and parameters of study

The trial was continued for 60 days. Housing, feeding and management of the animals, both for the feeding and digestibility trial, were as described for Experiment 1.

1.2.3. Chemical analysis

Feeds, faeces and milk were sampled and analysed using the procedures described for Experiment 1.

1.2.4. Statistical analysis

The data of this experiment was analysed using the paired t-test procedure.

1.3. Experiment 3

1.3.1. Animals, and diet

Eight indigenous lactating cows, of similar live weight (LW 175.4 ± 13.9 kg), were selected based on their milk yield and parity, and were divided into two groups of four. A diet containing rice straw (*ad libitum*), wheat bran (0.70 kg) and mustard oil cake (0.40 kg) was offered with 1.5 kg/h/d of fresh grass to 1st group called control (Table I) and a supplement of 2.0 kg/d of fresh *Leucaena* leaves to the second group.

1.3.2. Feeding and recording of data

The feeding trial lasted for 60 days. Housing, feeding and management of the animals were the same as in Experiment 1. Data on feed intake, digestibility and daily milk yield of animals was recorded. A digestibility trial was conducted at the end of the trial period (see Experiment 1 for details of procedure).

1.3.3. Chemical analysis

Analysis of feeds, faeces and milk followed the procedures described for Experiment 1.

1.3.4. Statistical analysis

The data for all the parameters were analysed using the paired t-test procedure.

1.4. Experiment 4

1.4.1. Selection of animals, groups, and diets

Ten indigenous growing male calves, of about 2.5 years of age and having similar live weight (LW 95.5 ± 9.0 kg), were divided into two groups, each of five animals. Each animal received a daily diet comprising rice straw (*ad libitum*), rice polish (0.50 kg) and mustard oil cake (0.25 kg); in the first group they each received 2.0 kg/h of low quality fresh grass and in the second group they each received a supplement of 2.0 kg/d of fresh *Crotalaria* leaves (Table I).

1.4.2. Feeding and recording of data

The feeding trial lasted for 60 days. The animals were fed twice a day at 7:30 a.m. and 4:30 p.m. Leaves were mixed with the rice straw before feeding. Animals were weighed at the beginning of the trial and thereafter every week. They were housed in individual pens with separate feeders. Water was available at all times. Feed intake was recorded. A digestibility trial was conducted at the end of the trial period (see Experiment 1 for the procedure).

1.4.3. Chemical and statistical analysis

Feeds and faeces were analysed for proximate components, as described for Experiment 1. The data was statistically analysed using the paired t-test procedure.

2. RESULTS

2.1. Experiment 1

Supplementation of a straw-based ration with *Sesbania rostrata* increased feed intake, digestibility and milk yield in dairy cows (Table II), especially at the higher level of supplementation.

TABLE II. FEED INTAKE, DIGESTIBILITY, YIELD AND COMPOSITION OF MILK OF COWS FED DIETS SUPPLEMENTED WITH *SESBANIA ROSTRATA* (SESBANIA)

Parameters	Diets*			SE	Level of significance
	A	B	C		
Dry matter intake (kg/d)	5.00[a]	5.05[a]	5.17[b]	0.05	*
Digestibility (g/kg)					
Organic matter	649.0[a]	657.0[a]	671.0[b]	3.0	*
Crude protein	680.0	704.0	711.0	19.2	NS
Crude fibre	612.0[a]	637.0[b]	651.0[b]	3.3	*
Milk yield (kg/d)	3.12.0[a]	3.38.0[a] (8.3%)	4.15[b] (33.0%)	0.3	**
Composition of milk (g/kg)					
Milk protein	581.0	619.0	630.0	11.3	NS
Milk Fat	540.0	620.0	628.0	15.3	NS

*Diets A, B and C contain 0, 1.0 and 1.5 kg/d fresh *Sesbania* leaves respectively
The percentage values in parentheses are the increase in milk yield compared to the control group
Within rows, different superscripts denote significant differences ($P < 0.05$)

Animals receiving 1.5 kg/d gave significantly ($P < 0.01$) higher milk than both the unsupplemented cows and those receiving 1.0 kg/d of supplement. Although supplementation increased slightly the crude fibre digestibility the differences were not significant ($P > 0.05$). The small changes in milk composition due to supplementation were also not significant ($P > 0.05$).

2.2. Experiment 2

Supplementation of a straw-based diet with *Lathyrus* hay at 1.0 kg/d did not alter feed intake of dairy cows, but improved ($P < 0.05$) digestibility of organic matter and crude fibre (Table III). Supplementation also increased ($P < 0.01$) milk yield. Milk composition was not increased ($P > 0.05$) by the supplement.

2.3. Experiment 3

Supplementation of a straw-based diet with *Leucaena leucocephala* (Iple Iple) did not increase feed intake ($P < 0.05$) in dairy cows (Table V). However, milk yield was increased ($P < 0.05$) by the supplement. Supplementation had no effect ($P > 0.05$) on the digestibility of OM and CP, but that of CF was increased ($P < 0.05$). As in the cases of the earlier *in vivo* studies presented above, the composition of milk was not affected by the supplementation ($P > 0.05$).

TABLE III. FEED INTAKE, DIGESTIBILITY, MILK YIELD AND COMPOSITION OF COWS FED DIETS SUPPLEMENTED WITH *LATHYRUS SATIVUS* HAY (KHESARI HAY)

Parameters	Diets*		SE	Level of significance	Percent increase in milk yield
	A	B			
Dry mater intake (kg/d)	5.06	4.97	0.17	NS	
Digestibility (g/kg)					
Organic matter	638.0	685.0	2.50	*	
Crude protein	655.0	661.0	6.20	NS	
Crude fibre	621.0	643.0	0.40	*	
Milk yield (kg/d)	2.10	2.52	0.03	**	20.5%
Composition of milk (g/kg)					
Milk protein	48.0	50.3	3.1	NS	
Milk Fat	38.0	45.5	5.1	NS	

*Diets A and B contained 0 and 1.0 kg *Lathyrus* hay/d, respectively; NS, not significant

TABLE IV. FEED INTAKE, DIGESTIBILITY, MILK YIELD AND COMPOSITION OF COWS FED DIETS SUPPLEMENTED WITH *LEUCAENA LEUCOCEPHALA* (IPLE IPLE)

Parameters	Diets*		SE	Level of significance	Percent increase in milk yield
	A	B			
Dry mater intake (kg/d)	5.27	5.26	0.42	NS	
Digestibility (g/kg):					
Organic matter	638.0	645.0	8.50	NS	
Crude protein	625.0	631.0	10.20	NS	
Crude fibre	610.0	632.0	7.40	*	
Milk yield (kg/d)	2.22	2.88	0.25	*	29.7
Composition of milk (g/kg)					
Milk protein	53.40	57.10	5.20	NS	
Milk Fat	53.40	58.00	6.80	NS	

*Diets A and B contained 0 and 2.0 kg *Leucaena* fresh leaves/d, respectively; NS, not significant

2.4. Experiment 4

Supplementation of a straw-based ration, offered to growing calves, with *Crotalaria* at 2.0 kg/d did not change feed intake, increased (P <0.05) organic matter digestibility and live weight gain (Table V). Although supplementation of the forage slightly increased crude protein and crude fibre digestibility, differences were not significant (P >0.05).

TABLE V. FEED INTAKE, DIGESTIBILITY AND GROWTH OF CALVES FED DIETS SUPPLEMENTED WITH *CROTALARIA JUNCEA* (SHON PAT)

Parameters	Diets*		SE	Level of significance
	A	B		
Dry mater intake (kg/d)	2.97	3.06	0.37	NS
Digestibility (g/kg)				
Organic matter	608.0	635.0	8.50	*
Crude protein	655.0	671.0	13.20	NS
Crude fibre	608.0	619.0	9.40	NS
Initial live weight (kg)	94.8	96.3	–	
Final live weight (kg)	112.5	117.4	–	–
Live weight gain (kg/d)	0.296	0.362	0.08	*

*Diets A and B contained 0 or 2.0 kg/d, fresh *Crotalaria* leaves/d, respectively; NS, not significant

3. DISCUSSION

The four forages selected for *in vivo* studies are all lesser-utilized and non-conventional forages generally available in Bangladesh. Other lesser-known species are not available in sufficient quantities to help rural farmers feed their livestock in periods of scarcity. These four species are not, at present, being used by farmers for feeding livestock although the results of this study suggest they could be.

The results of the first experiment indicated that increasing levels of a supplement of *Sesbania* forage increased feed intake, possibly for two reasons: firstly, the palatability of the diet was increased; and secondly, its high CP content improved the rumen environment and hence the digestibility of the diet (33% at the higher level of supplementation, Table II). It is likely that the *Sesbania* increased the supply of soluble nitrogen to the rumen microbes, thereby increasing microbial activity. The contribution of Sesbania forage to increased milk yield (Table II) may through its high protein content and high digestibility.

Significant improvement in the digestibility of OM and CF, as observed in Experiment 2, with *Lathyrus* supplementation might be due to its high protein content (241.1 g/kg, Table I) benefiting the growth of the rumen microbes, and thus improving digestion in the rumen. The improvement in digestibility of nutrients has probably lead to the increase in milk yield.

Although *Leucaena* supplementation of a straw diet did not improve feed intake, it increased milk yield by up to 30%. As with the other supplements, improving the CP content of the diet improved microbial biomass and activity, thereby increasing CF digestibility. Digestibility of other fractions (OM and CP) was not affected, possibly because *Leucaena* is rich in bypass protein. Although CF digestibility increased slightly, this and the relatively small improvement in CP digestibility were not sufficient to materially effect OM digestibility (Table III).

In the last experiment growing calves were fed diets supplemented with *Crotalaria*. Unlike *Sesbania, Crotalaria* supplementation did not increase dry matter intake possibly because of its lower protein content (227 g/kg vs 348 g/kg for *Crotalaria* and *Sesbania*, respectively). It is recognized that rumen degradable protein increases microbial biomass yield and hence digestibility and feed intake [9]. It is reasonable to assumed that the variation in the CP content of the basal feeds in all the trials reported here were similar and, therefore, differences between protein content of the diets supplemented with *Sesbania* and *Crotalaria* are due to differences in the protein content of the supplements. However, supplementation with *Crotalaria* increased weight gain of the calves, probably because its protein content maintained a favourable rumen environment for optimum OM digestibility.

Of the forages considered, although *Sesbania* gave the largest responses, all four forages were considered worth promoting on-farm.

PART–C

EXTENSION OF PROMISING FORAGE SPECIES FOR LIVESTOCK FEEDING TO FARMERS

1. METHODOLOGY: INTEGRATION OF FODDER LEGUMES INTO A RICE-BASED CROPPING SYSTEM FOR INCREASED FORAGE SUPPLY TO RUMINANTS

1.1. Study 1: Cultivation and feeding of *Sesbania* to dairy cows

1.1.1. Selection and training of farmers

Twenty four pilot farmers in Delduar Upazila of Tangail District and ten farmers in Muktagacha Upazila of Mymensingh District, all having land and at least two breeding cows, were selected for training in integrated rice/fodder production in order to increase the supply of green forage for ruminants. The farmers were selected by the local livestock extension officers, and then provided training. Technical advice was given at all stages, supported by leaflets and folders written in the local language. This group of farmers took part in the three studies reported in Part–C.

1.1.2. Distribution of seeds to farmers and cultivation of forage

The farmers were provided training on cultivation of *Sesbania* forage, including soil preparation, sowing procedure, management of the growing crop, harvesting and feeding to animals. *Sesbania* seeds were distributed and sown in a small area at each homestead. When the seedlings were 2 m high, cuttings (each of about 50 cm length) were made and planted either between the rows of standing Boro rice (wet season rice) crop or in fallow land after the Boro was harvested. Yield of *Sesbania* was highest when the crop was planted in fallow land, and this practice is now recommended.

1.1.3. Monitoring forage growth, harvesting and feeding to dairy cows

Growth of the crop was monitored at regular intervals. About six weeks after planting, the crop had developed branches and was considered ready for harvesting. The forage yield was 20 t/ha of fresh material. The fine-stemmed portions of the plant were cut off, chopped and mixed with straw, and fed to the milking cows at the rate of 3.0 kg *Sesbania*/cow/d.

1.1.4. Recording of data

Daily milk yield of the cows was recorded by the farmers in a pre-designed book, supplied by the project. Data for reproductive parameters such as post-partum heat, calving interval and lactation length were also recorded by the farmers.

1.2. Study 2: Cultivation and feeding of *Lathyrus* to dairy cows

1.2.1. Distribution of seeds to farmers and cultivation of forage

Seeds of *Lathyrus* were distributed among the selected farmers (see 1.1). The seeds were sown in their standing Aman rice (dry season rice) 15 days before the rice harvest. After harvesting of the rice, the forage grew quickly and was ready for harvesting about two months later, thus clearing the ground just before the next season rice (Boro, wet season) was ready for transplanting.

1.2.2. Making hay from Lathyrus forage and use of the box-baler for better storage

Almost all the *Lathyrus* was harvested within a few days and a small portion was fed fresh, but most was sun-dried to make hay (the procedures for making and storing were demonstrated in the field). It was then box-baled and stored for feeding when required. Each farmer in Delduar Upazila was given two baling boxes, and in Muktagacha Upazila they each received one. The *Lathyrus* hay was fed to lactating cows at 1.0 kg/cow/d, after mixing with rice straw.

1.2.3. Monitoring of feeding and recording of milk yield

Researchers visited the farmers periodically. Milk yield was recorded as described above. The reproductive parameters of reproductive performance were also collected as in Study 1.

1.3. Study 3: Extension of the cultivation and use of Leucaena as feed for lactating cows

1.3.1. Distribution of seeds to farmers and cultivation of forage

The *Leucaena* seeds were sown by the farmers in their homestead areas and around ponds (bunds). The forage took two months to reach the harvesting stage, at which point the edible portions were cut.

1.3.2. Monitoring of feeding and recording of milk yield

The cows were fed 2.0 kg/cow/d of the forage. Researchers visited the farms and milk yield recording and reproduction data was collected as previously described.

2. RESULTS

Data in Table VI shows that supplementation of straw-based diet with all types of legume forages gave rise to increased milk yield compared to that of control. However, when the forages were compared it was seen that *Sesbania* gave the highest increase in daily milk yield (25.4%) over control.

Supplementation of the straw-based diet with legume forages reduced the time from calving to onset of oestrus, and there was also a reduction in the calving interval (Table VII). Legume forage supplementation was also associated with an increase in length of lactation. Feeding legume forages with straw diets to cows resulted in longer lactations (35 d) compared to the unsupplemented control diet.

TABLE VI. MILK YIELD FROM COWS RECEIVING A STRAW-BASED DIET SUPPLEMENTED WITH LEGUME FORAGES

Feeds	Milk yield (L/d)		Increase in milk yield (%)
	Initial	Final	
Control	2.74 ± 0.70	2.61 ± 0.58	–4.74
Control + *Lathyrus*	2.82 ± 0.53	3.40 ± 0.46	20.57
Control + *Sesbania*	2.64 ± 0.60	3.31 ± 0.68	25.38
Control + *Leucaena*	2.62 ± 0.48	3.21 ± 0.61	22.52

TABLE VII. REPRODUCTIVE PERFORMANCE OF COWS RECEIVING STRAW-BASED DIETS WITH OR WITHOUT ACCESS TO LEGUME FORAGES

Parameter	Without supplementation	With supplementation
Post-partum heat period (days)	130 ± 10	100 ± 10
Calving interval (days)	440 ± 15	400 ± 15
Lactation length (days)	225 ± 15	270 ± 15

The values are the average for the three legume supplements used in Studies 1–3

3. ECONOMIC ANALYSIS

The cost : benefit analysis (Table VIII) showed that the inclusion of a supplement of legume forage in the straw-based diet made it more cost effective than the unsupplemented diet. Among the forages included, *Sesbania* showed the greatest response, *Leucaena* was intermediate and the lowest was from *Lathyrus*.

The cost : benefit ratios of all the supplemented diets (Table VIII) were calculated based on a negligible cost for the legumes. The only direct cost was for seed.

TABLE VIII. COST AND NET PROFIT OF SUPPLEMENTING LEGUME FORAGES TO STRAW DIET FED TO DAIRY COWS

Parameters	Control + *Lathyrus*	Control + *Sesbania*	Control + *Leucaena*
Yield of control cow (L/cow/d)	2.82	2.64	2.62
Yield of supplemented cow (L/d/cow)	3.40	3.31	3.21
Additional milk yield (L/cow/d)	0.58	0.67	0.59
Value of additional milk (Tk./cow/d)	10.44	12.06	10.62
Cost of additional milk yield (Tk./d/cow)	2.00	3.00	2.00
Net profit from supplementation (Tk/d/cow)	8.44	9.06	8.62
Cost:benefit ratio	1:8.44	1:9.06	1:8.98

Price of milk/L is Tk. 18.00
Cost of forage was estimated as Tk. 1.00/kg for *Sesbania* and *Leucaena* and Tk. 2.00/kg for Lathyrus hay.
$1.00 = Tk 59.00

4. DISCUSSION

Throughout the study, milk yield and health of the cows has been monitored. Farmer reaction and comment was recorded at field days held in each study area.

Growing of *Sesbania* for feeding to livestock, especially the newly introduced variety, *S. rostrata*, was popular among the farmers, where it was judged an improvement on the local variety, in that it contains 8% more protein and gave a 10% improvement in yield. It can be propagated through stem cuttings (not possible with the local variety), and, most importantly, its cultivation improves rice yield by 13% [3] due to increased soil fertility. The local variety also tends to be unpalatable because of its bitter taste and smell, and is, therefore grown for green manuring, fencing and fuel. Farmers were unaware that *Sesbania* was a potential animal feed. Some neighbouring farmers, from outside the project, attended the demonstrations and have adopted the technology. Some pilot farmers grew more cuttings than they needed and, in total, distributed them to a further 24 farmers. Initially seed supply was a problem but some farmers are now harvesting seed.

Lathyrus used to be grown as an insurance for human consumption during famine; however, this has stopped in recent years. It is now seen as a potentially valuable livestock fodder, which can benefit (soil fertility increased, rice yield up 8%), rather than decrease, rice yield [4]. A major advantage with this crop is that it can be made into hay, a new technique for the farmers, baled (box baler) and stored for use when fresh forages are in short supply. The farmers in the Tangail (Delduar) particularly appreciated the feed security afforded by storing forage as hay. A total of 70 farmers are now growing *Lathyrus* to feed with straw-based diets.

Cultivation, around homesteads and bunds, and feeding of *Leucaena* is also creating interest in all three pilot areas. Farmers are reporting increased yields of milk when the leaves are added to straw–based diet.

The three forages enabled rural farmers to supply high quality forage to their animals for most of the year, thereby increasing the milk yield of their cows. The contribution of the forages to improved reproductive performance is also noteworthy.

5. CONCLUSIONS

The legume forages, *Sesbania*, *Lathyrus* and *Leucaena* were selected for testing on-farm after laboratory analysis and an *in vitro* study. When given as supplements to straw-based diets to lactating and growing cattle, increases in output were recorded. Among the forages, responses were greatest with *Sesbania.* The economic analysis confirmed *Sesbania* as the best of the legumes. The transfer of the technology of forage production and feeding has been well received by the rural farmers, and is expected to be sustainable, especially with smallholder dairy farmers.

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EVALUATION OF TREE FORAGES AS NON-CONVENTIONAL FEEDS IN GANSU PROVINCE OF CHINA

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Abstract

The digestibility of some trees and shrubs leaves was determined by *in sacco* and on-farm feeding methods in Gansu Province, China. The results indicated that *Elaeagnus angustifolia*, *Belianthus tuberosus*, *Robinia pseudoacacia*, *Populus* spp., and *Salix matsudana* were potential feed resources. In the shrub group, *Hippophae tibetica* contained the highest crude protein. In sheep, daily live-weight gains of ewes and lambs feeding on *Elaeagnus angustifolia* were 23.7% and 17.1% higher than the control, respectively.

1. INTRODUCTION

In Gansu Province of China, agriculture is the major activity. The population of cattle and sheep in the Province Gansu has reached 3.74 and 12 859 millions, respectively [1]. The staple cereals in Gansu are wheat and maize, resulting in the availability of large amounts of cereal by-products and residues. The staple fodder of cattle and sheep is almost totally comprised of wheat straw and maize stover. The cattle and sheep graze on natural grassland in the pastoral areas and receive a roughage-based diet in the agronomy areas (including maize silage, maize stover and wheat straw). In the last decade, the government has been encouraging farmers to raise cattle in order to improve their livelihoods, through fully utilizing the crop residues. However, cattle productivity has been restricted by the supply of good quality feed, especially those rich in protein. To increase economic benefits from their livestock, farmers must supplement the basal roughage diet with protein-rich ingredients for meat and milk production. Feeding grain-containing concentrates to livestock generates competition with man for limited grain resources. However, large amounts of tree leaf are available and government is encouraging farmers to exploit unused feed resources for animal production. Farmers are eager to get new information regarding non-conventional feeds.

Tree leaves were historically used as feeds in Gansu, however, there was no scientific information regarding their nutritive value resulting in farmers haphazardly feeding whatever leaves were available. In this study, leaves from several tree species were evaluated, both in the laboratory and on-farm, in order to provide farmers with the necessary information.

2. MATERIALS AND METHODS

2.1. Materials

2.1.1. Laboratory evaluation

Three Tianzhu White yaks (six-years old, 153 kg; four-years old, 121 kg; six-years old, 150 kg) were selected and simple rumen cannulas were inserted for determining the disappearance rate of digesta, using the nylon bag method, and gas production technique [2, 3].

The leaves tested came from the following sources:

Tree leaves: *Elaeagnus angustifolia* (Russian olive), *Robinia pseudoacacia* (locust tree), *Platycladus orientalis* (arborvitae), *Tamarix chinensis* (Chinese tamarisk), *Populus* spp. (poplar), *Salix matsudana* (hankow willow). These are the dominant trees in northern China and most of them are used as protection plants against sandstorms.

Shrubs: *Potentilla fruticosa, Caragana jubata, Hippophae tibetica* (Tibetan sallow thorn). These are the most common shrubs on the alpine grasslands of Gansu.

Grasses: *Elymus nutans*, one of the dominant species of Alpine grassland and has been selected as a major species for grassland restoration in recent years because of its adaptability to cold weather. *Belianthus tuberosus* (succulent), its root is used as a vegetable but the leaf is not used.

2.1.2. On-farm evaluation

Twenty adult ewes (around three-years old) and 20 lambs (around one-year old) were selected on farm and randomly divided into two groups. One group was given a typical farm diet (control) and the other group the same diet supplemented with *E. angustifolia* leaves. The mature tree leaves were harvested in late October (cold season) and crushed into powder for evaluation in the laboratory and on-farm.

2.2. Methods

Plant samples were collected in July, dried at 60°C and ground through a 1.0 mm screen for dry matter (DM), crude protein (CP), ether extract (EE), ash and acid detergent fibre (ADF) determination [4]. Calcium and Phosphorus were measured by the EDTA-sodium method and colorimetric method respectively [4]. The disappearance rate of dry matter was determined *in sacco;* by the nylon bag method, with samples ground through a 2.5 mm screen [2], and *in vitro* gas production [3] was measured using samples ground through a 1.0 mm screen.

All the animals in the control group received a daily ration: for ewes 1.5 kg DM/head, consisting of 1 kg maize straw, 0.3 kg concentrate (50% wheat bran, 20% rape seed cake and 30% maize flour), 0.2 kg wheat straw (wheat straw was chopped and mixed with the concentrate and a small amount of water) for ewes; for lambs 1.1 kg DM/d/head consisting of 0.6 kg maize straw, 0.2 kg of the concentrate, 0.3 kg wheat straw. For the supplemented group, 50% of the straw and concentrate were replaced by *E. angustifolia* leaves. This species was chosen because it is plentiful in the trial area. Ewes and lambs were fed separately, in groups according to treatment, and water was available at all times. All animals received routine veterinary care.

The feeding trials were conducted at Yongchang in Gansu Province from 15 December 2003 to 15 March 2004 (90 d).

3. RESULTS

The results of the laboratory studies will be presented first, followed by those from the feeding trial.

3.1. Laboratory trials

The chemical composition of the leaves sampled is shown in Table I. The results indicated that CP content and ash varied greatly between species. Based on the CP content, *E. angustifolia, B. tuberosus, R.. pseudoacacia, Populus* spp., (poplar), and *S. matsudana* were judged to be potential feed resources. In the shrub group, *H. tibetica* contained the highest CP.

TABLE I. THE CONTENT (g/kg DM) OF CRUDE PROTEIN (CP), ASH, ACID DETERGENT FIBRE (ADF), ETHER EXTRACT (EE), CA AND P IN SELECTED LEAF SAMPLES

	Plant	CP	Ash	ADF	EE	Ca	P
Trees	*Elaeagnus angustifolia*	144	55	233	32	33	2.1
	Robinia pseudoacacia	213	96	213	36	38	2.6
	Platycladus orientalis	75	101	265	58	31	2.3
	Tamarix chinensis	90	205	267	31	28	7.2
	Populus spp.	112	112	256	45	42	1.6
	Salix matsudana	146	129	228	23	44	2.3
Shrubs	*Potentilla fruticosa*	89	69	355	19	20	.4
	Caragana jubata	51	46	535	17	85	1.4
	Hippophae tibetica	162	50	287	48	14	1.9
Grasses	*Elymus nutans*	85	50	303	44	13	1.4
	Belianthus tuberosus	196	204	208	33	40	4.0

The *in sacco* disappearance of nutrients from the leaves is shown in Table II. The *E. angustifolia, Belianthus tuberosus, Robinia pseudoacacia, Populus* spp. (poplar), and *S. matsudana* are potential feed resources based on the disappearance of DM and CP.

TABLE II. PERCENT DISAPPEARANCE OF DRY MATTER (DM), CRUDE PROTEIN (CP), ORGANIC MATTER (OM), AND ACID DETERGENT FIBRE (ADF), AFTER 48 h IN SACCO INCUBATION IN RUMEN

	Plant	DM	CP	OM	ADF
Trees	*Elaeagnus angustifolia*	74.5	84.7	74.0	41.5
	Robinia pseudoacacia	64.6	66.6	64.8	9.3
	Platycladus orientalis	46.9	44.3	46.2	27.3
	Tamarix chinensis	54.5	48.3	46.5	20.3
	Populus spp.	81.2	91.2	81.2	62.0
	Salix matsudana	76.9	83.1	75.7	51.0
Shrubs	*Potentilla fruticosa*	46.8	44.0	46.5	7.2
	Caragana jubata	45.4	45.4	44.1	29.3
	Hippophae tibetica	55.0	55.9	54.5	14.1
Grasses	*Elymus nutans*	58.5	–	–	–
	Belianthus tuberosus	92.2	97.2	90.4	84.1

3.2. On-farm study

The results are shown in Table III. Ewes and lambs receiving tree leaves gained more weight than those on the control diet.

TABLE III. LIVE-WEIGHT GAIN OVER 90 DAYS IN SHEEP, EITHER UNSUPPLEMENTED (CONTROL) OR RECEIVING A SUPPLEMENT (TEST) OF *ELAEAGNUS ANGUSTIFOLIA* LEAVES

Group	Treatment	Number of animal	Initial weight (kg)		Final weight (kg)		Weight gain (kg)	
			Mean	SD	Mean	SD	Mean	SD
Ewe	Control	10	43.91	4.24	50.74	4.31	6.83	0.61
	Test	10	43.37	4.08	51.82	3.96	8.45	0.92
Lamb	Control	10	31.50	3.35	38.89	3.03	7.39	0.56
	Test	10	31.59	3.57	40.24	3.34	8.65	0.50

4. DISCUSSION

From the results of this study, *E. angustifolia, R. pseudoacacia,* and *Populus* spp. are potential feed resources, as judged by their CP content and high disappearance of CP and DM. The CP content of *E. angustifolia* is 69.4% higher than that of *E. nutans*, the most important grass species of natural grassland in the alpine area of Gansu. Its CP content is also higher than that of *Kobrecia capillifolia* (134.5 g/kg DM), a dominant species in alpine grassland, and it is close to wheat bran (157 g/kg DM) and rice bran (151 g/kg DM) [5].

The gas production method compares favorably with the *in sacco* nylon bag procedure for determination of nutritive value (results not shown). Since the gas method is easier and uses small amount of sample, it could be a useful tool for screening and ranking large numbers of samples.

The results of the on-farm feeding trial also suggested that this tree leaf is a promising feed resource. After 90 days of the experiment, the daily live-weight gains of ewes and lambs receiving *E. angustifolia* leaves were 23.7% and 17.1% higher than those in the control animals, respectively. The results indicate that the concentrate can be partially replaced by this tree leaf.

Elaeagnus angustifolia is planted widely in Gansu, principally for protecting arable land and along the roads. This study has shown that it has the potential for use as a feed for ruminants. However, farmers will require advice on harvesting and storing the leaves, and how and how much to incorporate into livestock diets. Other tree leaves should also be studied, employing the same criteria as used in this study. Through systematic studies on evaluation of nutritional quality of alternative feeds, the shortages of feeds in Gansu region could be gradually reduced.

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NUTRITIONAL VALUE OF TREE LEAVES FOR LIESTOCK FROM A SEMI-HILLY ARID REGION OF INDIA

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Abstract

Samples of 13 species of forest tree leaves growing in the semi-hilly arid zone of Punjab State in India were collected at 30 day intervals over 12 months, in order to assess their nutritional value for livestock. The ground samples were pooled for four seasons: dry hot, hot humid, fall, and winter. The data were arranged in a 13 x 4 factorial design for analysis. For tannin fractionation, leaves of 12 species containing more than 3.5% total phenols were selected and data were analysed within a 12 x 12 factorial design. The chemical composition, irrespective of the season, revealed that *Leucaena* had the highest crude protein (CP, 220 g/kg dry matter). Globulin was the major protein fraction in most of the leaves. The lowest concentration of neutral detergent fibre (NDF) was in *Morus, Acacia* and *Grewea* spp. Fibre and lignin content increased during the fall and winter. The leaves of *Grewea*, *Morus, Leucaena, Carrisa* and *Acacia* were rich in Ca, P and most of the trace elements. The total phenolics ranged between 38 (*Toona*) and 169 g/kg DM (*Anogeisus*). The leaves of *Anogeisus* had the highest concentration of hydrolysable tannins (16.9%) whereas those of *Carrisa* had highest condensed tannins (4.6%). The condensed tannins (>3%) were negatively correlated to the digestibility of dry matter (DM), NDF and CP. The digestion kinetic parameters for DM, NDF and CP revealed that leaves of *Morus alba, Zizyphus* and *Ehretia* were most degradable. The minimum rumen fill values also revealed that leaves of *Grewea, Azadirachta, Morus, Ehretia* and *Leucaena* had higher potential for voluntary DM intake, especially compared to leaves of *Ougeinia, Zizyphus xylopyrus, Dodonea* and *Carrisa.* During winter, most of the leaves had a low potentially degradable fraction, with a low rate of degradation. Screening leaves by the *in vitro* gas production technique suggested that leaves of *Melia azedarach, Azadirachta indica*, *Morus alba* and *Leucaena leucocephala* were potential feeds for ruminants. Nutritional value of *Toona ciliata*, *Morus alba, Melia azedarach* and *Leucaena leucocephala* was assessed *in vivo* in bucks. The excretion of purine derivatives, in the urine and, therefore, microbial protein synthesis, was greatest in bucks receiving *Melia azedarach.* The leaves of *Melia azedarach*, *Morus alba* and *Leucaena leucocephala* supplemented with a mineral mixture and common salt could be fed as a complete feed for small ruminants. It was concluded that the leaves of *Morus*, *Ehretia*, *Grewea, Melia azedarach* and *Leucaena* had great potential as livestock feed, while feeding of *Ougeinia, Zizyphus* and *Dodonea* leaves should be avoided.

1. INTRODUCTION

Livestock is an important sub-sector of Indian agriculture. Its contribution to the gross domestic product (GDP) increased from 14% in 1980–81 to 23% in 1998, while the share of agriculture to the GDP declined from 35% to 25%. India is now the world's largest producer of milk (84.6 MT/year), but to sustain this status, an extra 26 MT, 280 MT and 44 MT of concentrates, forages/grasses and dry roughages, respectively, are still required. Increased pressure on land due to increasing population and industralization is leading to decreased forage production. This necessitates evaluation of non-conventional feed resources or lesser-known seed bearing plants capable of growing on waste and poorly irrigated land.

In Punjab State, about 81% of farmers in the semi-hilly arid zone belong to the marginal, small and semi-middle classes, who have less than 4 ha of land. The livestock production depends largely on grasses and tree leaves, available in the forest, which contain tannins. In low to moderate concentrations tannins prevent bloat and increase the flow of non-ammonia nitrogen and essential amino acids from the rumen [1, 2], but high concentrations reduce feed intake and digestibility of protein and carbohydrates [3, 4] which may have deleterious effect on livestock production [5]. The refusal of animals to eat certain tree leaves in a particular season may be due to high concentrations of antimetabolite(s). The purpose of this study was to exploit the real potential of forest tree leaves as livestock feed.

2. MATERIALS AND METHODS

2.1. Collection of leaves

For *in sacco* evaluation, forest tree leaves (13 cultivars: *Acacia nilotica; Toona ciliata; Morus alba; Carrisa spinarum; Ehretia leavis; Dalbergea sisso; Ougenia oojeiuealis; Leucaena leucocephala; Zizyphus mauritiana; Azadirachta indica; Zizyphus xylopyrus; Dodonea viscosa;* and *Grewea optiva*), available in a semi-hilly arid region of Punjab State, were collected at 30 day intervals, for 12 months, and dried in a forced air oven at 60°C for 48 h. The samples were ground in a Willey mill, pooled according to season: dry hot (April to June), hot humid (July to September), fall (October to December), and winter (January to March), and stored in the dark until required.

For assessing the seasonal variation in tanninniniferous tree leaves, containing more than 3.5% total tannins, 12 cultivars: *A. nilotica; T. ciliate; Bauhinia variegata; Phoenix acaulis; Kango; Anogeisus latilfolia; C. spinarum; O. oojeiuealis; L. leucocephala; Z. mauritiana; Z. xylopyrus;* and *Dodonea viscosa*), were collected as described above.

2.2. *In sacco* Studies

Three male rumen fistulated buffalo (live weight 387 ± 25.2 kg) were used for the *in sacco* incubations. Animals were maintained on a daily ration of 1.5 kg concentrate (% composition, maize 15, wheat 15, mustard cake 20, groundnut cake 10, rice bran 10, de-oiled rice polish 27, mineral mixture 2 and salt 1 part each), 5 kg wheat straw and 2 kg green fodder [6]. The adaptation period was 20 days.

In sacco degradability was assessed by the parachute nylon bag (8 x 15 cm; 50 ± 10 μm pore size) technique [7]. Each bag contained 3 g of sample, and for each incubation period (0, 3, 6, 9, 12, 24, 36, 48, 60 and 72 h) there were three bags per sample. After removal from the rumen, the bags were washed under running tap water until the water was clear. The bags were then squeezed gently and dried at 55°C for 48 h. The disappearance of DM was then calculated. The residue was analysed for N and neutral detergent fibre (NDF) and the apparent rumen digestibility calculated.

The parameters characterizing extent and rate of ruminal degradation ('a' rapidly soluble fraction; 'b' insoluble but degradable fraction; and 'c' degradation rate of the potentially degradable fraction 'b') were calculated [8]. The effective degradability was estimated [9] at an outflow rate of 5% per hour. The rumen fill (the capacity of the animal to consume feed) values were calculated [10]. The data were analysed according to a 13 x 4 factorial and completely randomized design [11].

2.3. *In vitro* Studies

The nutritional value of nine tree leaves (*Melia azedarach; Ficus glomerata* var. *sublanceolata, T. ciliate, M. alba, F. glomerata, Albizzia lebbock, F. religoosa, L. Leucocephala,* and *Azadirachta indica*) was assessed by the *in vitro* gas production technique [12, 13]. About 375 mg of the finely ground tree leaves were incubated at 39°C for 24 h, in triplicate, in 100 mL calibrated glass syringes. Blank samples of standard hay and concentrate were run in triplicate with each set. The contents of the syringes were mixed at hourly intervals for the first 6–8 h and gas production was recorded. After the incubation period, the contents of the syringes were transferred to spoutless beakers and boiled with neutral detergent solution, to dissolve the microbial biomass, for assessing *in vitro* true organic matter (OM) digestibility. The metabolizable energy (ME) was estimated [12]. The data were analysed as a completely randomized design [11].

2.4. *In vivo* studies

Each of the four species of fresh tree leaves (*M. azedarach, T. ciliate, Morus alba;* and *L. leucocephala)* supplemented with a mineral mixture and common salt were fed *ad libitum* to three bucks (56.7 ± 1.12 kg) as a complete feed. Bucks were fed once per day at 09:00 h. Fresh water was offered twice-a-day. The adaptation period was 30 days followed by seven-day metabolism trial. During the trial, the animals were kept in individual metabolic cages and records of feed intake, orts, faeces and urine excretion were maintained. Urine was collected into plastic cans, over 300 mL of 20% sulphuric acid to maintain the pH below 3. A portion of the urine was diluted with distilled water (1 : 5, urine : water), and stored in a deep freezer at –20^{o}C until till analysed for purine derivatives (PD) and creatinine. The animals were weighed, on three consecutive days, at the start and end of the experimental period. The data were analysed as a completely randomized design [11].

2.5. Analytical methods

2.5.1. Chemical composition

The chemical composition of tree leaves was estimated for proximate components [14], cellulose [15], other cell wall constituents [16] and oxalates [17]. The defatted samples were fractionated into four protein fractions based on solubility in different solvents [18]. The protein content of these fractions was estimated by Lowry's method [19]. The trace elements were estimated by Atomic Absorption Spectrophotometer and calcium by AOAC [14] and phosphorus was determined by a colorimetric method [20].

2.5.2. Extraction of tannins

Tannins were extracted, from fat free samples, using 70% aqueous acetone. The contents were centrifuged and the supernatant was taken for determination of tannins. Total phenols were estimated using Folin-Ciocalteu reagent [21] and tannins were calculated by difference between total phenols before and after polyvinylpolypyrillidone treatment. Condensed tannins were estimated by using Butanol-HCl [22], protein precipitable phenolics by the BSA precipitation method [23].

2.5.3. Purine derivatives

The urine samples were analysed for total-N [14], purine derivatives, allantoin [24] and uric acid [25] and creatinine by the method of Folin and Wu described by Hawk et al [26]. Purines absorbed were calculated from the daily urinary PD excreted [27].

TABLE I. CHEMICAL COMPOSITION* (g/kg DRY MATTER) OF TREE LEAVES IRRESPECTIVE OF SEASON

Local name	Botanical name	OM	CP	EE	NDF	ADF	Cellulose	Hemi-cellulose	ADL
Kikar	*Acacia nilotica*	942^{gh}	122^{b}	19^{a}	508^{a}	297^{a}	167^{a}	210^{g}	109^{b}
Tun	*Toona ciliata*	896^{ab}	128^{b}	37^{c}	589^{de}	419^{cd}	229^{bc}	169^{ef}	132^{cd}
Tut	*Morus alba*	889^{a}	151^{def}	47^{d}	500^{a}	392^{bcd}	233^{bc}	108^{abc}	118^{bc}
Garuna	*Carrisa spinarum*	928^{f}	89^{a}	38^{cd}	577^{cde}	499^{e}	236^{bc}	79^{a}	173^{ef}
Chamroar	*Ehretia leavis*	902^{bc}	136^{bcd}	37^{c}	559^{bcde}	413^{cd}	246^{cd}	147^{cde}	99^{ab}
Tahli	*Dalbergea sisso*	919^{de}	144^{cde}	19^{a}	545^{abcd}	399^{bcd}	234^{bc}	146^{cde}	104^{ab}
Chanjhan	*Ougeinia oojeineusis*	920^{def}	120^{b}	21^{a}	706^{g}	553^{e}	279^{d}	152^{def}	218^{h}
Subabul	*Leucaena leucocephala*	908^{bcd}	221^{g}	37^{c}	564^{bcde}	372^{bc}	196^{ab}	192^{fg}	104^{ab}
Beri	*Zizyphus mauritiana*	932^{fg}	165^{f}	19^{a}	598^{ef}	438^{d}	205^{abc}	160^{def}	179^{fg}
Nim	*Azadirachta indica*	909^{cd}	150^{def}	17^{a}	537^{abc}	412^{cd}	195^{ab}	125^{bcd}	153^{de}
Malha	*Zizyphus xylopyrus*	946^{h}	134^{bc}	21^{a}	702^{g}	538^{e}	279^{d}	164^{def}	205^{h}
Mahender	*Dodonea viscosa*	949^{h}	102^{a}	31^{bc}	643^{f}	539^{e}	239^{cd}	103^{ab}	197^{gh}
Biul	*Grewea optiva*	909^{cd}	159^{ef}	25^{ab}	525^{ab}	344^{ab}	238^{cd}	181^{efg}	86^{a}
Pooled SE		4.4	5.6	3.2	16.7	19.4	14.7	14.1	7.8

*OM–Organic matter; CP–Crude protein; EE– Ether extract; NDF–Neutral detergent fibre; ADF–Acid detergent fibre; ADL–Acid detergent lignin; Values with different superscripts within column differ significantly (P <0.05)

3. RESULTS AND DISCUSSION

3.1. Chemical composition

The proximate constituents of different tree leaves, irrespective of season (Table I) indicated that leaves of *Dodonea* had the highest (P <0.05) and *M. alba* had the lowest (P <0.05) OM content. The OM contents of *Z. xylopyrus* and *Acacia* were comparable to that of *Dodonea*. The CP content in tree leaves varied between 89 and 220 g/kg DM. The leaves of *Leucaena* had the highest (P <0.05) CP followed by *Zizyphus*, which was comparable with that of *Grewea, Morus* and *Azadirachta*. The ether extract was highest (P <0.05) in leaves of *M. alba,* comparable with that of *Carrisa,* followed by *Toona, Leucaena* and *Ehretia.* The lowest concentration was observed in leaves of *Azadirachta* and *Zizyphus*.

The cell wall analysis, based on detergent extraction, is a good indicator for predicting nutritional value of fibrous feeds, because, voluntary DM intake and DM digestibility are dependent on cell wall constituents, especially NDF and lignin. The leaves of *Ougeinea, Z. xylopyrus* and *Dodonea* were highly fibrous and lignified (highest NDF, ADF and ADL contents). The lowest NDF and ADF contents were observed in the leaves of *M. alba*. *Acacia* and *Grewea* had NDF and ADF contents equivalent to that of *M. alba*. The leaves of *Grewea* had the lowest lignin content followed by that of *Ehretia* and *Acacia* leaves. The variation in the proximate and cell wall constituents observed in the present study and elsewhere [28, 29], could be due to differences in time of collection of tree leaves (Table II).

TABLE II. SEASONAL VARIATION IN THE CHEMICAL COMPOSITION* (g/kg DRY MATTER) OF TREE LEAVES

Constituent	Seasons				Pooled SE
	Dry hot	Hot humid	Fall	Winter	
OM	916	918	922	921	2.4
CP	141^{ab}	142^{ab}	144^{b}	134^{a}	3.1
EE	31^{b}	32^{b}	28^{b}	22^{a}	1.8
NDF	565^{a}	573^{a}	577^{a}	609^{b}	9.3
ADF	421	440	426	441	10.8
Cellulose	232	235	215	235	8.2
Hemi cellulose	144^{a}	133^{a}	150^{ab}	169^{b}	7.8
ADL	136^{a}	153^{b}	146^{ab}	143^{ab}	4.3

*OM–Organic matter; CP–Crude protein; EE–Ether extract; NDF–Neutral detergent fibre; ADF–Acid detergent fibre; ADL–Acid detergent lignin; values with different superscripts within column differ significantly (P <0.05)

Different seasons showed significant effects on the chemical composition of tree leaves (Table II). The leaves, in general, became more fibrous and lignified during winter and fall, because of shorter days and cooler temperatures, which signal leaf senescence (when the concentration of the enzyme that promotes the breakdown of cells increases). The veins that carry fluids into and out of the leaf gradually close off as a layer of cells (abscission layer) form at the base of each leaf petiole where it is attached to the twig. These clogged veins trap sugars in the leaf and promote production of anthocyanins, the secondary metabolites. However, a significant effect (P <0.05) was observed in case of EE content, possibly due to the presence of more pigments like chlorophyll and carotenoids during the summer season. Organic matter content was not affected by season (P >0.05).

The water-soluble sugars in tree leaves ranged from 2.7 to 7.1%. The highest amount of water-soluble sugars was observed in the leaves of *Dalbergea* followed by that in *M. alba* (6.0%) and the lowest in *Z. mauritiana* (2.7%).

TABLE III. RELATIVE PROPORTION OF DIFFERENT PROTEIN FRACTIONS IN TREE LEAVES

Botanical name	Albumin	Globulin	Prolamin	Glutelin
Acacia nilotica	13.4	18.5	51.1	17.0
Toona ciliata	7.3	42.1	39.9	10.7
Morus alba	16.2	41.7	21.7	20.4
Carrisa spinarum	12.6	30.9	30.1	26.4
Ehretia leavis	28.7	46.2	13.3	11.8
Dalbergea sisso	10.9	46.6	25.5	16.8
Ougeinia oojeineusis	10.1	40.8	26.9	22.2
Leucaena leucocephala	8.1	65.1	15.5	11.4
Zizyphus mauritiana	6.5	41.2	30.3	22.0
Azadirachta indica	14.2	50.8	21.2	13.8
Zizyphus xylopyrus	8.8	36.1	33.3	21.8
Dodonea viscosa	10.1	25.5	47.4	17.0
Grewea optiva	15.7	48.9	14.3	21.1

The highest amount of true protein was observed in *A. nilotica,* followed by that in *Carrisa* species. In almost all the tree leaves, the major protein fraction was salt soluble, i.e. globulin (Table III), except for *A. nilotica* and *D. viscosa*, where an alcohol soluble fraction, prolamin predominated. The water-soluble fraction, albumin ranged between 6.5 and 29.0%. The glutelin fraction ranged between 10 and 26% of total proteins.

3.2. Antimetabolites

Water-soluble oxalates ranged from 0.4 to 1.2%. The highest level was observed in the leaves of *Azadirachta* and lowest in *Morus*. High concentrations of oxalates reduce the availability of calcium by forming precipitates of calcium oxalates. The level of soluble oxalates in tree leaves was below the toxic level of 4% [30].

The total phenolics and net tannin content, irrespective of season (Table IV) were highest in *A. latifolia* (17.4 and 15.9%) followed by those in *A. nilotica* (16.2 and 14.6%). The total phenolics content of *Z. xylopyrus*, *Ougeinia*, *Bauhinia,* and *Toona* ranged between 3.8 and 4.8%. *Bauhinia variegata, P. acaulis, C. spinarum* and *D. viscose* had moderate levels (3–5%) of net tannins. A Low level of net tannin content (2–3%) was observed in *T. ciliala, Kango, O. oojeivealis, Leucaena, Z. mauritiana* and *Z. xylopyrus.* Tannins could exhibit both negative and positive effects on nutritive value depending upon their net tannin content in the forages [31]. The high levels of tannins in *A. nilotica* reduced growth rates of animals due to lower feed intake and protein digestibility [5]. The positive effects of moderate tannin content on nutritive value include protein protection from microbial enzymes, by formation of tannin protein complexes within the rumen, which then bypass the rumen. These complexes are unstable at the acid pH of the abomasum and the protein thus becomes available for digestion [32]. A level of 5.5% of total tannins exerted no deleterious effects on crude protein utilization of animals [33].

TABLE IV. TANNIN (g/kg DM) PROFILE OF TREE LEAVES, IRRESPECTIVE OF SEASON

Leaves of	Total phenols[1]	Simple phenols[1]	Tannins[1]	Condensed tannins[2]
Acacia nilotica	162^{d}	16^{cd}	146^{e}	11^{bc}
Toona ciliala	38^{a}	15^{cd}	23^{ab}	9^{ab}
Bauhinia variegata	48^{bc}	11^{ab}	37^{bcd}	34^{e}
Phoenix acaulis	58^{bc}	9^{a}	48^{d}	43^{f}
Kango	48^{bc}	24^{g}	24^{ab}	16^{c}
Anogeisus latifolia	174^{d}	15^{cd}	159^{e}	4^{a}
Carrisa spinarum	66^{c}	21^{fg}	45^{d}	46^{f}
Ougeinia oojeineusis	42^{ab}	13^{bc}	29^{abc}	26^{d}
Leucaena leucocephala	49^{bc}	28^{h}	21^{a}	8^{ab}
Zizyphus mauritiana	49^{bc}	20^{ef}	29^{abc}	26^{d}
Zizyphus xylopyrus	39^{ab}	14^{bc}	26^{ab}	24^{d}
Dodonea viscosa	58^{bc}	18^{de}	41^{cd}	33^{e}
Pooled SE	4.7	1.0	5.1	2.3

Values with different superscripts within a column differ significantly (P <0.05)
1, as tannic acid equivalent; 2, as leucocyanidin equivalent

The leaves of *C. spinarum and P. acaulis* had higher (P <0.05) levels of condensed tannins compared to *B. variegata* and other leaves, and their condensed tannin (CT) content constituted almost 76–79% of the total tannin content. The level was observed to be lowest in *A. latilfolia* (0.4%) followed by that in *Leucaena, Toona, Acacia* and *Kango* species. The presence of higher levels of condensed tannins, in the diet, is toxic to the animal as they affect the mucosa of the digestive tract, which could decrease absorption of methionine and lysine. Decreased methionine availability could increase the toxicity of other plant compounds such as cyanogenic glycosides, because methionine is involved in the detoxification of cyanide [31]. The CT had a negative effect on the digestibility of DM, NDF and CP, as indicated by the negative correlations (–0.71, –0.79 and –0.64, respectively).

The total phenols and net tannin content of tree leaves also showed seasonal variations (Table V). Moderate but comparable concentration of total phenols and tannin was observed in leaves harvested between February and August. The highest concentrations were observed in May, September and December, whereas the lowest was observed in November. During summer, the level of net tannin content decreased in *B. variegata, P. acaulis, Leucaena, Z. mauritiana* and *Z. xylopyrus* but increased in *A. latifolia* and *C. spinarum* species. Elsewhere seasonal changes in tannin content have been reported [34]. In some species tannin content increased in summer and in others in winter. *Toona ciliata* and *P. acaulis* showed an increase in net tannin content during the winter. Again, such increases have been reported for other plant resources [35].

The concentration of CT, irrespective of species, was significantly affected by the season (TableV). The highest (P <0.05) concentration of CT was observed in the dry hot (May) period and in winter, but was exceptionally low in the hot humid period (June–August). The CT of *P. acaulis* increased from December and peaked in April/May. Leaves of *C. pinarum* showed increasing levels of CT from September to April. *Ougenia, Z. xylopyrus* and *Leucaena* species had lower CT levels but seasonal variations followed the same trend, also observed elsewhere [36, 37]. Increasing the concentration of tannins during winter is an adaptive process of frost resistant mesophyll cells, to avoid damage from low temperatures [35], and to help the newly emerging leaves against attacks by herbivorous insects.

TABLE V. MONTHLY VARIATION IN THE TANNIN (g/kg DM) PROFILE OF TREE LEAVES (POOLED DATA FROM 13 SPECIES, SEE TEXT FOR DETAILS)

Month	Total phenols[1]	Simple phenols[1]	Net tannins[1]	Condensed tannins[2]
October	77^{ef}	18^{de}	59^{cdef}	32^{de}
November	46^{a}	11^{a}	35^{a}	20^{c}
December	83^{f}	16^{bcd}	67^{f}	31^{de}
January	57^{ab}	14^{b}	43^{ab}	19^{bc}
February	67^{bcde}	19^{ef}	54^{bcdef}	30^{d}
March	72^{cdef}	19^{ef}	53^{bcde}	29^{d}
April	75^{def}	21^{f}	40^{ab}	32^{de}
May	82^{f}	18^{de}	64^{def}	37^{e}
June	64^{bcd}	15^{bc}	49^{abc}	7^{a}
July	68^{bcde}	17^{cde}	51^{bcd}	10^{a}
August	60^{bc}	15^{bc}	45^{abc}	13^{ab}
September	84^{f}	19^{def}	65^{ef}	18^{bc}
Pooled SE	4.6	1.0	5.1	2.3

Values with different superscripts within a column differ significantly (P <0.05)
[1], as tannic acid equivalent; [2], as leucocyanidin equivalent

Protein precipitable phenolics (PPP) were observed to be low (7–10%) in *E. leavis* and *L. leucocephala* leaves and high (more than 50%) in *A. latilfolia, C. spinarum, B. variegata* and *P. acaulis* leaves. The level of PPP corresponded well with the content of net tannins present.

Seasonal variation in the levels of PPP showed a trend similar to that of condensed tannins. Leaves of *Phoenix, Carrisa, Leucaena, Z. xylopyrus* and *Ougenia* species all showed increases in PPP concentration from winter into spring. During summer, the contents decreased to undetectable values in the leaves of *Leucaena, Ougenia* and *Z. xylopyrus.* Leaves of other species, e.g. *Toona, Bauhinia, Ehretia* and *Z. mauritiana,* also showed lower or negligible amounts of PPP in the summer. The PPP content of *Anogeisus* and *Kango* species was almost constant throughout the year. On average, the levels of PPP adversely affected the digestibility of nutrients, as indicated by their negative correlations with DMD (–0.50), NDFD (–0.62) and CPD (–0.54). Other workers have reported that both the percentage of protein precipitable phenolics and the protein precipitating capacity of the tannin fractions increase with the increase in the degree of polymerization of tannins [38].

The mineral profile of tree leaves revealed that *Grewea* leaves had the highest concentration of calcium followed by leaves of *T. ciliata* and *M. alba. Dodonea viscosa* had the lowest Ca (1.05%) content, which was comparable to that of *Zs xylopyrus* (Table VI). The level is above that recommended in the diet (0.19–0.82%) [6], and could benefit high yielding animals during the early stages of lactation. Calcium is closely associated with phosphorus metabolism. Tree leaves of *M. alba* had the highest concentration of phosphorus followed by that in *Z. xylopyrus, G. optiva* and *Leucaena.* The minimum requirement of P in the diet of ruminants varies from 0.12 to 0.24%. Leaving aside the leaves of *Grewea* and *Leucaena,* the others, if fed as a complete feed, may not meet the P requirements of ruminants.

The tree leaves were observed to be rich in magnesium, which ranged from 22 ppm in *A. nilotica, Z. xylopyrus* and *D. viscosa* to 72 ppm in *E. leavis*. The trace element composition revealed that leaves of *Grewea* had the highest concentration of Zn and Co, while leaves of *C. spinarum* had the highest Fe and Mn. The leaves of *Z. mauritiana* and *A. nilotica* were richest in Cu. The leaves of *M. alba* appeared to be good source of Fe and Ca.

TABLE VI. MINERAL PROFILE (PPM) OF TREE LEAVES

Botanical name	Ca^*	P^*	Mg	Zn	Fe	Mn	Cu	Co
Acacia nilotica	19^{c}	0.9^{bc}	22.0^{a}	0.18^{b}	0.057^{a}	0.14^{c}	0.089^{gh}	0.05^{ab}
Toona ciliata	32^{hi}	0.6^{ab}	50.9^{e}	0.24^{d}	0.057^{a}	0.10^{a}	0.072^{ab}	0.09^{ab}
Morus alba	30^{ghi}	1.8^{d}	39.0^{cd}	0.18^{b}	0.061^{ab}	0.15^{e}	0.073^{ab}	0.09^{ab}
Carrisa spinarum	19^{c}	0.7^{ab}	40.9^{d}	0.18^{b}	0.065^{b}	0.27^{i}	0.076^{cd}	0.08^{ab}
Ehretia leavis	23^{d}	0.6^{ab}	71.6^{h}	0.18^{b}	0.060^{ab}	0.15^{e}	0.087^{g}	0.11^{ab}
Dalbergea sisso	27^{efg}	0.5^{a}	48.6^{e}	0.16^{a}	0.059^{a}	0.20^{g}	0.072^{b}	0.08^{ab}
Ougeinia oojeineusis	27^{ef}	0.6^{ab}	31.3^{b}	0.16^{a}	0.058^{a}	0.11^{b}	0.078^{e}	0.04^{ab}
Leucaena leucocephala	26^{e}	1.1^{c}	37.2^{c}	0.16^{a}	0.057^{a}	0.15^{d}	0.074^{ab}	0.03^{a}
Zizyphus mauritiana	22^{cd}	0.7^{ab}	29.3^{b}	0.18^{b}	0.057^{a}	0.15^{e}	0.090^{h}	0.03^{a}
Azadirachta indica	29^{fgh}	0.6^{ab}	67.3^{g}	0.18^{b}	0.059^{a}	0.16^{e}	0.068^{a}	0.04^{ab}
Zizyphus xylopyrus	14^{b}	1.2^{c}	21.7^{a}	0.18^{b}	0.057^{a}	0.17^{f}	0.084^{f}	0.12^{b}
Dodonea viscosa	11^{a}	0.9^{bc}	22.3^{a}	0.20^{c}	0.057^{a}	0.17^{f}	0.074^{bc}	0.08^{ab}
Grewea optiva	33^{i}	1.1^{c}	61.4^{f}	0.44^{e}	0.059^{a}	0.24^{h}	0.078^{de}	0.56^{c}
Pooled SE	1	0.1	1.2	0.01	0.002	0.001	0.004	0.03

*g/kg DM —Values with different superscripts within a column differ significantly (P <0.05).

TABLE VII. DEGRADATION PATTERN OF DRY MATTER (DM, %) OF TREE LEAVES IRRESPECTIVE OF SEASON

Botanical name	48 h degra–dability	Rapidly soluble fraction (a)	Potentially degradable fraction (b)	Degradation rate/h (c)	UDF*	Effective degrada–bility (Ed)	Rumen fill (kg)	Predicted DM intake (kg/d)
Acacia nilotica	68.7^{def}	30.7^{cd}	43.0^{cde}	0.056^{abc}	26.3	59.9^{bc}	20.2^{bc}	6.9^{cd}
Toona ciliata	69.9^{def}	34.2^{cd}	37.4^{bcd}	0.065^{abc}	28.4	61.2^{bc}	19.5^{bc}	7.2^{cde}
Morus alba	73.5^{f}	28.9^{bc}	50.2^{e}	0.057^{abc}	20.9	63.6^{c}	18.4^{abc}	7.4^{def}
Carrisa spinarum	64.6^{d}	27.9^{bc}	39.6^{bcd}	0.061^{abc}	32.6	55.8^{b}	21.1^{c}	6.7^{cd}
Ehretia leavis	71.7^{ef}	27.1^{bc}	48.7^{e}	0.058^{abc}	24.2	61.0^{bc}	19.1^{abc}	7.2^{cde}
Dalbergea sisso	65.9^{de}	32.2^{cd}	35.5^{bc}	0.066^{bc}	32.3	57.7^{bc}	20.8^{c}	6.6^{cd}
Ougeinia oojeineusis	47.7^{a}	26.2^{bc}	24.7^{a}	0.043^{a}	49.1	42.1^{a}	27.6^{d}	4.7^{a}
Leucaena leucocephala	71.7^{ef}	38.7^{de}	35.6^{bc}	0.059^{abc}	25.8	63.5^{c}	19.5^{bc}	7.1^{cd}
Zizyphus mauritiana	63.4^{cd}	21.7^{ab}	49.1^{e}	0.051^{abc}	29.1	54.6^{b}	21.4^{c}	6.3^{bc}
Azadirachta indica	73.4^{f}	28.4^{bc}	45.9^{de}	0.090^{d}	25.7	64.2^{c}	17.3^{ab}	8.4^{f}
Zizyphus xylopyrus	53.4^{ab}	17.3^{a}	40.0^{bcd}	0.046^{abc}	42.7	43.2^{a}	25.7^{d}	5.4^{ab}
Dodonea viscosa	57.2^{bc}	26.6^{bc}	32.4^{ab}	0.044^{ab}	41.0	47.3^{a}	25.5^{d}	5.4^{ab}
Grewea optiva	80.8^{g}	44.1^{e}	38.1^{bcd}	0.070^{cd}	17.8	71.9^{d}	16.2^{a}	8.2^{ef}
Pooled SE	2.4	2.9	2.9	0.008		2.3	1.1	0.4

*UDF–Undegradable fraction; Values with different superscripts within a column differ significantly (P <0.05)

3.3. Digestion kinetic parameters

3.3.1. Dry matter

The digestion kinetics of dry matter irrespective of season (Table VII) revealed that the soluble fraction (a) ranged from 17.3 to 44.1%. The leaves of *Grewea* had the highest (44%) level of the rapidly soluble fraction followed by *Leucaena* (38.7%). The insoluble, but potentially degradable, dry matter ranged from 24.7 to 50.2%, and that of *Morus, Z. mauritiana* and *Ehretia* was close to 50%. The rate constant, at which potentially degradable dry matter is degraded, ranged between 4.3 and 9.0% per h. The potentially degradable fractions of *Morus, Z. mauritiana* and *Ehretia,* were degraded at almost the same rate, i.e. 5.1 to 5.8% per h, resulting in almost same value for 48 h degradability in *Morus* and *Ehretia*, but the difference in *Z. mauritiana* was due to a smaller soluble fraction (22%) compared to 27–29% in *Ehretia* and *Morus*. The leaves of *Grewea* had the highest (P <0.05) 48 h degradability. The minimum rumen fill values indicated that leaves of *Grewea,* *Azadirachta, Morus, Ehretia* and *Leucaena* could all be eaten in sufficient quantities to support maintenance. The opposite was indicated for leaves of *Ougeinia, Z. xylopyrus* and *Dodonea.*

The digestion kinetic parameters for DM varied little with change of season (Table VIII), except that the rapidly soluble fraction of the leaves was higher, and the potentially degradable fraction lower, during winter and fall. The leaves being highly lignified during winter resulted in potentially high rumen fill values and low voluntary DM intake.

TABLE VIII. EFFECT OF SEASON ON THE DEGRADATION OF DRY MATTER (DM)

Parameters	Seasons				Pooled SE
	Dry hot	Hot humid	Fall	Winter	
48 h degra-dability, %	65.2	67.9	67.1	64.9	1.4
Rapidly soluble fraction, %	24.9[a]	27.7[a]	33.1[b]	32.4[b]	1.6
Potentially degradable fraction, %	43.6[b]	43.1[b]	37.3[a]	36.1[a]	1.6
Degradation rate/h	0.061	0.063	0.056	0.056	0.004
Effective degradability, %	55.3	58.2	58.9	57.2	1.3
Rumen Fill, kg	21.2	20.2	20.9	21.5	0.6
Predicted DM intake, kg/d	6.8[ab]	7.0[b]	6.7[ab]	6.4[a]	0.6

Values with different superscripts within a row differ significantly ($P < 0.05$)

3.3.2. Neutral detergent fibre

The digestion kinetic parameters for NDF indicated that leaves of *Z. mauritiana* and *Morus* (Table IX) were potentially the most degradable of the tree leaves selected. Rate of degradation of the insoluble, but potentially degradable fraction of *Morus* was higher than that of *Zizyphus* leaves. The high fibre and/or lignin content in *Ougeinia, Z. xylopyrus* and *Dodonea* leaves resulted in a low potentially degradable fraction, degraded at a slow rate. The effective degradability values were lower ($P < 0.05$) in these leaves than in *Grewea, Ehretia, Toona, Morus* and *Leucaena* leaves. The higher undegradable fractions in *Dodonea, Ougeinia, Z. xylopyrus* and *Carrisa* leaves were responsible for higher ($P < 0.05$) rumen fill values, restricting the potential for voluntary NDF intake in these leaves. The lowest rumen fill values were observed in the leaves of *Grewea,* followed by *Azadirachta, Ehretia, Morus, Toona* and *Leucaena*. The predicted NDF intake followed the opposite trend to that of rumen fill.

Availability of the potentially degradable fraction was low in winter, the reverse of the soluble fraction, which was low during July to September (Table X). However, effective NDF degradability was not affected by the season.

TABLE IX. DEGRADATION PATTERN OF NEUTRAL DETERGENT FIBRE (NDF, %) OF TREE LEAVES, IRRESPECTIVE OF SEASON

Botanical name	Degra-dability at 48 h (%)	Rapidly soluble fraction (a)	Potentially degradable fraction (b)	Degra-dation rate/h (c)	UDF*	Effective degrada-bility (Ed)	Rumen fill (kg)
Acacia nilotica	50.7^{bc}	8.8^{bc}	49.5^{c}	0.051^{abc}	41.7	41.2^{defg}	24.9^{bc}
Toona ciliata	58.4^{cd}	13.3^{cd}	47.4^{bc}	0.071^{c}	39.3	48.1^{g}	22.4^{ab}
Morus alba	57.1^{cd}	–0.02^{ab}	64.3^{d}	0.061^{abc}	35.7	45.1^{efg}	22.3^{ab}
Carrisa spinarum	47.1^{ab}	7.9^{bc}	42.2^{abc}	0.065^{abc}	49.9	37.8^{bcde}	25.8^{cd}
Ehretia leavis	60.1^{de}	11.9^{bcd}	51.9^{cd}	0.059^{abc}	36.1	48.4^{g}	22.3^{ab}
Dalbergea sisso	50.0^{bc}	4.2^{abc}	49.3^{c}	0.065^{abc}	46.5	39.3^{edef}	25.4^{bc}
Ougeinia oojeineusis	38.6^{a}	13.4^{cd}	29.6^{a}	0.044^{ab}	57.0	32.5^{abc}	29.4^{e}
Leucaena leucocephala	58.5^{cd}	11.7^{bcd}	51.4^{cd}	0.058^{abc}	36.4	47.3^{fg}	22.7^{abc}
Zizyphus mauritiana	50.6^{bc}	–6.6^{a}	64.8^{d}	0.051^{abc}	41.8	36.8^{abcd}	24.8^{bc}
Azadirachta indica	57.8^{cd}	7.3^{bc}	51.6^{cd}	0.070^{c}	41.1	45.0^{defg}	22.0^{ab}
Zizyphus xylopyrus	41.5^{ab}	4.1^{abc}	41.4^{abc}	0.045^{ab}	54.5	30.4^{ab}	28.9^{de}
Dodonea viscosa	40.6^{a}	7.2^{bc}	34.9^{ab}	0.041^{a}	57.8	29.2^{a}	29.6^{e}
Grewea optiva	68.4^{e}	23.7^{d}	46.4^{bc}	0.068^{bc}	29.9	57.3^{h}	19.9^{a}
Pooled SE	3.2	4.5	4.9	0.009		2.9	1.2

*UDF–Undegradable fraction; Values with different superscripts within a column differ significantly (P <0.05)

TABLE X. SEASONAL VARIATION IN DEGRADATION OF NEUTRAL DETERGENT FIBRE

Parameters	Seasons				Pooled SE
	Dry hot	Hot humid	Fall	Winter	
48 h degra-dability, %	49.6	54.2	52.8	52.5	1.8
Rapidly soluble fraction, %	6.1^{ab}	3.3^{a}	10.7^{b}	12.8^{b}	2.5
Potentially degradable fraction, %	47.6^{ab}	54.9^{b}	45.8^{a}	43.9^{a}	2.7
Degradation rate/h	0.052^{a}	0.067^{b}	0.055^{ab}	0.055^{ab}	0.005
Effective degradability, %	38.2	42.7	42.2	42.6	1.6
Rumen fill, kg	25.4^{b}	23.5^{a}	24.8^{ab}	24.8^{ab}	0.7

Values with different superscripts within a row differ significantly (P <0.05)

3.3.3. Crude protein

The digestion kinetics for the crude protein of tree leaves, irrespective of season (Table XI), showed a lag phase (negative rapidly soluble fraction) in the leaves of *Acacia*, which could be due to high tannin content that may have delayed microbial colonization. The leaves of *Acacia* had the largest potentially degradable fraction amongst the leaves evaluated. The potentially degradable fraction in the leaves of *Morus, Carrisa* and *Azadirachta* was more than 60%. The rapidly soluble fraction was greatest (P <0.05) in leaves of *Dodonea* (66%) and *Grewea* (91%). *Grewea* leaves had the highest effective protein degradability.

Seasons had no consistent effect on digestion kinetics of crude protein (Table XII). The rapidly soluble fraction and effective degradability of CP at 48h were significantly higher during the winter season. The trend was reversed for the potentially degradable fraction.

3.4. Screening using the *in vitro* technique

Nine tree leaves were selected for preliminary screening. The OM content of the leaves ranged between 800 and 930 g/kg DM (Table XIII). The OM of leaves of *A. indica*, *A. lebbock* and *T. ciliate* were similar and higher (*P* <0.05) than the other leaves. Leaves of *F. glomerata* had the lowest OM. The CP content varied between 108 and 199 g/kg DM. The leaves of *L.leucocephala, M. azedarach* and *M. alba* contained more than 90 g/kg DM CP, which was significantly (*P* <0.05) higher than that of other leaves.

TABLE XI. DEGRADATION PATTERN OF CRUDE PROTEIN (CP, %) OF TREE LEAVES, IRRESPECTIVE OF SEASON

Botanical name	48 h degradability (%)	Rapidly soluble fraction (a)	Potentially degradable fraction (b)	Degradation rate /h (c)	UDF*	Effective degradability (Ed)
Acacia nilotica	73.8^{bcd}	–1.3^{a}	79.4^{f}	0.080^{c}	21.9	57.9^{b}
Toona ciliata	82.8^{efg}	28.6^{bc}	56.1^{cde}	0.074^{c}	15.3	70.6^{defg}
Morus alba	89.8^{g}	31.5^{bc}	60.9^{de}	0.073^{c}	7.6	77.0^{g}
Carrisa spinarum	75.4^{cde}	19.0^{b}	60.5^{de}	0.064^{c}	20.4	62.1^{bc}
Ehretia leavis	81.5^{defg}	33.2^{bc}	52.1^{cde}	0.53^{c}	14.7	68.6^{cdef}
Dalbergea sisso	78.5^{cdef}	29.9^{bc}	49.9^{cd}	0.083^{e}	20.2	68.2^{cdef}
Ougeinia oojeineusis	45.9^{a}	22.7^{b}	26.9^{b}	0.038^{c}	50.4	39.6^{a}
Leucaena leucocephala	84.4^{fg}	42.0^{c}	45.6^{c}	0.066^{c}	12.4	74.6^{efg}
Zizyphus mauritiana	75.6^{cde}	25.5^{b}	55.4^{cde}	0.55^{c}	19.1	63.5^{bcd}
Azadirachta indica	87.7^{g}	22.3^{b}	65.7^{ef}	0.104^{c}	11.9	75.4^{fg}
Zizyphus xylopyrus	70.9^{bc}	31.8^{bc}	42.8^{c}	0.043^{c}	25.4	58.3^{b}
Dodonea viscosa	65.3^{b}	65.7^{d}	1.3^{a}	–0.86^{b}	32.9	67.1^{cde}
Grewea optiva	89.9^{g}	90.7^{e}	0.1^{a}	–2.01^{a}	9.2	90.8^{h}
Pooled SE	3.0	5.1	5.1	0.1		2.8

*UDF–Undegradable fraction; values with different superscripts within a column differ significantly (*P* <0.05)

TABLE XII. EFFECT OF SEASON ON THE DEGRADATION OF CRUDE PROTEIN (CP)

Parameters	SEASONS				Pooled SE
	Dry hot	Hot humid	Fall	Winter	
48 h degradability, %	76.2	74.5	79.0	78.4	1.7
Rapidly soluble fraction, %	28.1^{a}	32.4^{ab}	35.8^{ab}	39.5^{b}	2.9
Potentially degradable fraction, %	51.3^{b}	45.7^{ab}	45.2^{ab}	41.3^{a}	2.8
Degradation rate/h	–0.083^{b}	–0.271^{a}	–0.146^{ab}	–0.154^{ab}	–0.064
Effective degradability, %	65.9^{ab}	64.3^{a}	69.7^{b}	68.9^{b}	1.5

Values with different superscripts within a row differ significantly (P <0.05)

TABLE XIII. CHEMICAL COMPOSITION* (g/kg DM) OF TREE LEAVES

Botanical name	Local name	OM	CP	NDF	ADF	Hemi-Cellulose	Cellulose
Melia azedarach	Dhrake	903^{e}	193^{f}	350^{a}	225^{b}	125^{b}	135^{b}
Ficus glomerata Var. *sublanceolata*	Pilkan	860^{d}	108^{a}	530^{bc}	370^{f}	160^{c}	180^{cd}
Toona ciliata	Tun	925^{f}	130^{c}	530^{bc}	345^{e}	185^{d}	170^{c}
Morus alba	Tut	813^{b}	196^{fg}	350^{a}	265^{c}	85^{a}	80^{a}
Ficus glomerata	Gular	800^{a}	118^{b}	600^{c}	455^{g}	145^{bc}	200de
Albizzia lebbock	Sreen	923^{f}	183^{e}	580^{bc}	340^{e}	240^{e}	210^{e}
Ficus religoosa	Pipal	845^{c}	125^{c}	480^{abc}	380^{f}	100^{a}	190^{cde}
Leucaena leucocephala	Subabul	893^{e}	199^{g}	440^{ab}	185^{a}	255^{e}	145^{b}
Azadirachta indica	Nim	933^{f}	159^{d}	510^{bc}	305^{d}	205^{d}	200de
Pooled SE		3.5	1.9	44.1	7.1	7.1	7.8

*OM–Organic matter; CP–Crude protein; EE–Ether extract; NDF–Neutral detergent fibre; ADF–Acid detergent fibre; ADL–Acid detergent lignin; values with different superscripts within columns differ significantly (P <0.05)

Since DM intake and digestibility depend on cell wall constituents, especially NDF, detergent extraction can indicate the feed value of fibre-rich feeds. In the leaves tested, NDF and ADF content varied between 350–600 g/kg DM and 185–455 g/kg DM, respectively. The leaves of *F. glomerata* were highly fibrous and lignified, indicating they would not be readily eaten.

The leaves of *M. azedarach* and *M. alba* had low NDF concentrations, and these and leaves of *L. leucocephala* were low in ADF (185–265 g/kg DM), indicating their potential as livestock feeds. The hemicellulose content of the leaves varied between 85 and 255 g/kg DM, being highest in *L. leucocephala* and lowest in *M. alba.* Leaves of *F. glomerata*, *A. indica* and *A. lebbock* contained most (P <0.05) cellulose. Leaves of *M. alba* had least (P <0.05) cellulose (80 g/kg DM). The variation in the proximate and cell wall constituents between this study and values reported in the literature could be due to differences in time and stage of collection of tree leaves.

The net gas production of tree leaf (Table XIV) varied from 71.3 to 172.4 mL/g DM/24 h, being highest (*P* <0.05) in leaves of *M. azedarach* and lowest in the leaves of *F. glomerata* var. *sublanceolata* and *F. glomerata*, possibly due to the presence of anti-nutritional factors. The true OM digestibility (TOMD) was observed to be highest (*P* <0.05) for leaves of *M. azedarach*, but lowest (*P* <0.05) for *F. glomerata* and *F. glomerata* var. *sublanceolata*. The TOMD for other leaves varied between 626 and 681 g/kg DM. Amongst the leaves selected for preliminary studies, digestibility of NDF was highest (*P* <0.05) for the leaves of *A. lebbock* followed by *A. indica* and *Toona ciliata* leaves, suggesting the potential of these leaves for further exploitation.

TABLE XIV. *IN VITRO* GAS PRODUCTION (mL/g DM/24 h) AND DIGESTIBILE (g/kg DM) NUTRIENTS

Botanical name	NGP	NDFD	OMD
Melia azedarach	172.4^{h}	137.8^{ab}	716.6^{d}
Ficus glomerata	71.3^{a}	105.8^{a}	462.9^{a}
Var. *sublanceolata*			
Toona ciliata	117.8^{c}	211.2^{cde}	633.5^{c}
Morus alba	144.1^{f}	163.1^{abc}	652.4^{c}
Ficus glomerata	93.9^{b}	184.8^{bcd}	411.0^{a}
Albizzia lebbock	122.9^{d}	259.5^{e}	627.6^{bc}
Ficus religoosa	130.8^{e}	173.8^{bcd}	564.2^{b}
Leucaena leucocephala	132.4^{e}	146.9^{ab}	626.2^{bc}
Azadirachta indica	164.0^{g}	132.4^{de}	680.8^{cd}
Pooled SE	1.64	19.97	19.85

NGP– Net gas produced; NDFD– Neutral detergent fibre digestibility; OMD–Organic matter digestibility; values with different superscripts within a column differ significantly (*P* <0.05)

3.5. *In vivo* evaluation

Based on the availability and preliminary studies, leaves of *M. alba, M. azedarach, L. leucocephala* and *T. ciliata* were selected for *in vivo* evaluation in bucks. The voluntary dry matter intake (as kg/d or as % live weight) was highest (*P* <0.05) when leaves of *M. alba* were fed (Table XV). Leaves of *Toona ciliata* were the least acceptable. The voluntary DM intake, up to 3.21% of live weight (LW) was comparable to that of conventional green fodder for leaves of *M. alba, L. leucocephala* and *M. azedarach.* The leaves of *M. alba, Leucaena,* and *M. azedarach* had the highest (*P* <0.05) DMD. The cellulose digestibility of leaves of *M. alba* and *Leucaena* was higher (*P* <0.05) than the leaves of *Toona* and *M. azedarach*. The leaves of *Toona* showed the lowest digestibility for all nutrients.

TABLE XV. DRY MATTER INTAKE (DMI) AND DIGESTIBILITY IN BUCKS RECEIVING TREE LEAVES AS A COMPLETE DIET

Parameter	*Toona ciliata*	*Morus alba*	*Leucaena leucocephala*	*Melia azedarach*	Pooled SE
DMI, kg/d	0.7^{a}	1.8^{c}	1.6^{bc}	1.5^{b}	0.1
DMI, % live weight	1.3^{a}	3.2^{c}	2.9^{bc}	2.6^{b}	0.1
Digestibility, g/kg DM					
Dry matter	481.0^{a}	573.0^{bc}	536.3^{bc}	612.3^{c}	23.3
Organic matter	496.3^{a}	549.3^{ab}	523.3^{a}	609.7^{b}	21.6
Crude protein	105.2^{a}	155.8^{b}	265.9^{c}	244.6^{c}	10.1
Cellulose	25.6^{a}	32.7^{a}	68.4^{b}	70.7^{b}	4.2

Values with different superscripts within a row differ significantly (P <0.05)

3.5.1. Microbial nitrogen supply

The urinary excretion of purine derivatives, an indicator of microbial biomass produced in the rumen, showed that the excretion of allantoin and uric acid was highest (P <0.05) in bucks fed leaves of *Leucaena* and *M. azedarach* (Table XVI). The total urinary excretion of purine derivatives was highest (P <0.05) in animals fed *M. azedarach* leaves. Allantoin constituted the major portion (69–91%) of purines excreted in urine. The values are similar to those reported earlier for goats [39].

The urinary creatinine excretion varied between 0.34 and 2.9 mmol/kg $W^{0.75}$/d. The excretion of urinary creatinine was highest in animals fed *T. ciliata* or *M. azadirach.* Pregnant and lactating ewes were found to excrete 0.49 mmol/kg $W^{0.75}$ and 0.42 mmol/kg $W^{0.75}$, respectively [40]. The purine N index (PNI), an indicator of efficiency of microbial protein synthesis, was highest (P <0.05) in animals fed *M. azedarach* leaves and lowest in animals fed *M. alba* leaves. Microbial protein synthesis was highest (P <0.05) in animals fed *M. azedarach* leaves and lowest in those fed *T. ciliata* leaves.

TABLE XVI. EXCRETION OF PURINE DERIVATIVES (PD), MMOL/KG $W^{0.75}$/D AND MICROBIAL NITROGEN SUPPLY (MNS)

Constituent	*Toona Ciliate*	*Morus alba*	*Leucaena leucocephala*	*Melia azedarach*	Pooled SE
Allantoin	0.3^{a}	0.4^{a}	0.7^{b}	5.0^{c}	0.13
Uric acid	0.3^{a}	0.3^{a}	1.2^{b}	1.0^{b}	0.12
Total PD	0.6^{a}	0.7^{a}	1.9^{b}	6.0^{c}	0.3
Creatinine	1.1^{b}	0.4^{a}	0.3^{a}	2.9^{c}	0.07
PD absorbed mmol/d	11.8^{a}	14.2^{a}	46.5^{b}	158.6^{c}	6.9
Purine nitrogen index	0.06^{ab}	0.04^{a}	0.11^{b}	0.35^{c}	0.02
MNS, g/d	8.6^{a}	10.3^{a}	33.8^{b}	115.3^{a}	5.08

Values with different superscripts within a row differ significantly (P <0.05)

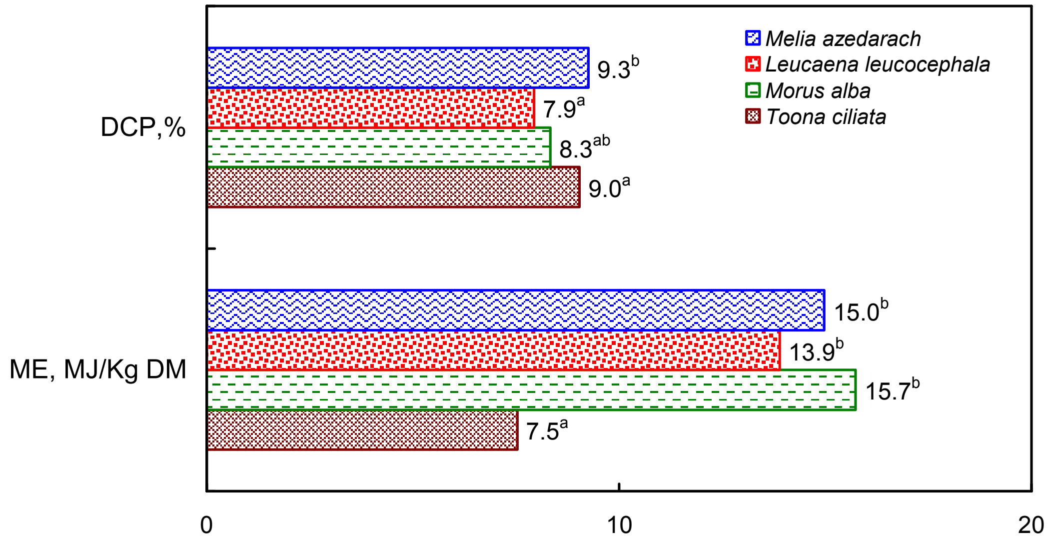
3.5.2. Efficiency of nitrogen utilization

The highest (P <0.05) N intake (57 g/d) was from feeding *M. alba* leaves and the lowest from *T. ciliata* leaves (Table XVII), which also resulted in the lowest DMI (P <0.05). Faecal N excretion was highest (P <0.05) from *Leucaena* leaves*.* Large amounts of urinary N excretion resulted in low retention of nitrogen. The apparent biological value (BV) was positive for all but the *T. ciliata* leaves. However, the apparent biological value (BV) of these leaves was lower than that of a conventional green fodder, *A. sativa*, (36.4). The higher N content and significantly higher digestibility of crude protein resulted in high DCP from *M. azedarach* and *M. alba* leaves, which were comparable with *Leucaena*, but significantly (P <0.05) higher than that of *T. ciliata* leaves (Fig. 1).

TABLE XVII. NITROGEN (N) UTILIZATION IN BUCKS, g/d

Constituent	*Toona Ciliate*	*Morus alba*	*Leucaena leucocephala*	*Melia azedarach*	Pooled SE
Intake	16.0^{a}	57.0^{c}	52.3^{c}	45.9^{b}	1.8
Faecal N	4.9^{a}	11.6^{C}	15.8^{d}	9.0^{b}	0.6
Urine N	14.9^{a}	24.1^{b}	25.8^{bc}	27.1^{c}	0.8
N Retained	–3.9^{a}	21.4^{c}	10.8^{b}	9.8^{b}	1.6
Apparent biological value (BV), %	–35.3	17.1	25.2	18.6	4.4

Values with different superscripts within a row differ significantly (P <0.05)



Values with different superscripts within a parameter differ significantly (P <0.05)

FIG. 1. Nutritive value of tree leaves.

4. CONCLUSIONS

Based on the chemical composition, presence of anti-nutritional factors and availability of nutrients, the leaves of *M. azedarach, M. ehretia, Grewea* and *Leucaena* showed their potential as livestock feed, equivalent to, or better than, conventional green fodders such as *A. sativa;* whereas, leaves of *Ougeinia, Z. xylopyrus* and *Dodonea* have little nutritional value for feeding to ruminants.

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NUTRITIONAL VALUE OF ENSILED FRUIT AND VEGETABLE WASTES

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Abstract

Chaffed cauliflower leaves (CL), fruit waste (FJW), after juice extraction, or a mixture of CL and FJW in a 1 : 1 ratio were each ensiled, either alone or after mixing with either wheat straw, rice straw or berseem straw in 70 : 30 mixtures. The chemical composition of cauliflower leaves, fruit juice waste and the 1 : 1 combination of the two revealed that these wastes had a high crude protein (CP) content, and low neutral detergent fibre (NDF) and acid detergent fibre (ADF) contents, indicating their potential as alternative feedstuffs for dairy cattle. The ensiling of the fruit and vegetable wastes resulted in a significant depression in the net gas production and digestibility of nutrients. The per cent decrease in net gas production, NDF and organic matter (OM) digestibility varied from 26.3 to 50.8%, 26.3–47.7% and 19.4–22.5%, respectively. The NDF, ADF, and cellulose contents were increased, when CL, FJW and CL–FJW were ensiled with straw (either of the straws), by 84, 77 and 71%; 51, 35 and 54% and 69, 48 and 37%, respectively in ensiled CL, FJW and CL–FJW. Maximum ($P < 0.05$) net gas production and OM digestibility was observed in the ensiled FJW, irrespective of the source of added straw. The digestibility of NDF was observed to be highest in ensiled CL–FJW, irrespective of the straw combination. Amongst the straws, the ensiled wheat straw, irrespective of the combination of fruit and vegetable waste, resulted in maximum net gas production and digestibility of nutrients.

1. INTRODUCTION

The margin of profit in traditional crops like wheat and rice has gone down considerably and has forced farmers to diversify to other promising enterprises. Vegetable farming is one of such highly profitable ventures in India. India is the second largest producer of vegetables in the world (about 90 million MT of vegetables are produced/annum), but hardly 2% of vegetables are processed and about 33% are wasted during harvesting, marketing and processing. Domestic use, or export, of fresh and processed fruits and vegetables, leave huge amount of wastes, which currently are being ploughed back into the land, as soil conditioners, or are left on the road side, posing an environmental threat. However, these ‘wastes’ may be a potential source of feed for livestock. *In vivo* evaluation in bucks revealed that vegetable wastes (cauliflower leaves, cabbage leaves and pea pods) and cannery wastes (sarson saag waste), proved to be excellent non-conventional feedstuffs for ruminants, equivalent to conventional green fodders such as *Avena sativa* [1, 2]. Because of their high moisture content, fruit and vegetable wastes (FVWs) have a short shelf life and need to be utilized immediately or conserved to avoid deterioration in their nutritive value. In this study the nutritional value of fruit and vegetable wastes ensiled with poor quality roughages was assessed, using *in vitro* techniques.

2. MATERIALS AND METHODS

2.1. Ensiling

After removal of the curd from cauliflower plants, procured from local farmers, the leaves and stems were chaffed. The fruit residue, remaining after extraction of the juice, was procured from the local market. The wheat straw, rice straw and berseem straw (*Trifolium alexandrium*), procured from University farms, were chaffed. The chaffed cauliflower leaves (CL), fruit juice waste (FJW) or a 1 : 1 mixture of both, CL–FJW, were each ensiled, either alone or after mixing with either wheat straw, rice straw or berseem straw in 70 : 30 ratio in batches of 3 kg each. Each mixture was packed in a thermocol box, which had a lining of double-layered polypropylene (PP) bags. The material was thoroughly pressed and the neck of the PP bags was sealed with nylon thread. The lids of the thermocol boxes were sealed with taflon tape. The 36 boxes so prepared were kept at room temperature for 42 days, after which the boxes were opened. Dry matter (DM) content was determined [3] and a digital pH meter was used to measure pH. The remaining sample was dried in a forced air oven maintained at 80°C, for 48 h. The finely ground (1.0 mm) samples were analysed for proximate components [3], cellulose [4] and other cell wall constituents [5].

2.2. *In vitro* studies

The effect of ensiling on the nutrient utilization from the different substrates was assessed by the *in vitro* gas production technique [6, 7]. About 375 mg of the substrate (fresh or ensiled) was incubated at 39°C for 24 h, in triplicate, in 100 mL calibrated glass syringes. Blanks and samples of a standard hay and standard concentrate were also run in triplicate with each set. The contents of the syringes were mixed at hourly intervals for the first 6–8 h and gas production was recorded. After the 24 h incubation was completed, gas production was recorded and the content of each syringe was transferred to a spout-less beaker, boiled with neutral detergent solution (to dissolve microbial biomass) to assess organic matter digestibility (OMD). The metabolizable energy (ME) was estimated [7].

2.3. Statistical analysis

The data were analysed statistically in a completely randomized design (CRD) and 3 x 4 factorial design [8].

3. RESULTS AND DISCUSSION

The chemical composition of cauliflower leaves, fruit juice waste and a combination of the two, revealed that these wastes had a high crude protein (CP) content, and low neutral detergent fibre (NDF) and acid detergent fibre (ADF) contents (Table I), indicating their potential as feedstuffs for dairy cattle. Earlier studies also revealed that cauliflower leaves supplemented with minerals and common salt were highly palatable (as indicated by voluntary feed intake) and could be regarded as feed for ruminants [9]. Contents of NDF and ADF, in FJW and CL–FJW, increased (P <0.05) after ensiling. The increases were not significant in CL (P >0.05). The improvement in cell wall content (CWC) was most pronounced in FJW. The CP content was reduced (P <0.05) in ensiled cauliflower leaves.

TABLE I. EFFECT OF ENSILING ON THE CHEMICAL COMPOSITION* (g/kg DM) OF FRUIT AND VEGETABLE WASTES

Comp.	Cauliflower leaves (CL)			Fruit juice waste (FJW)			CL–FJW		
	Fresh	Ensiled	Pooled SE	Fresh	Ensiled	Pooled SE	Fresh	Ensiled	Pooled SE
OM	825^{b}	776^{a}	4.4	955	935	1.8	885	872	5.6
CP	236^{b}	204^{a}	2.0	81	87	5.2	159	168	2.1
NDF	280	315	7.9	310^{a}	420^{b}	7.1	298^{a}	370^{b}	7.2
ADF	235	250	12.7	230^{a}	348^{b}	4.0	244^{a}	310^{b}	7.5
HC	55	65	5.0	80	72	4.0	55	60	1.1
Cellulose	160	175	5.0	160^{a}	210^{b}	7.1	185	220	7.9

*DM–Dry matter; OM–Organic matter; CP–Crude protein; NDF–Neutral detergent fibre; ADF–Acid detergent fibre; HC–Hemicellulose; Values with different superscripts within a row differ significantly (*P* <0.05)

The ensiling of fruit and vegetable wastes resulted in a depression in net gas production (an indicator of nutritive value) and digestibility of nutrients (Table II). Ensiling resulted in 26.3–50.8%, 26.3–47.7% and 19.4–22.5%, decrease in net gas production, neutral detergent fibre digestibility (NDFD) and organic matter digestibility (OMD), respectively. The FVW (irrespective of CL, FJW or CL–FJW) ensiled alone also had a very obnoxious smell.

TABLE II. EFFECT OF ENSILING ON *IN VITRO* GAS PRODUCTION (mL/g DM/24 h) AND DIGESTIBILITY (g/kg DM) OF NEUTRAL DETERGENT FIBRE (NDFD) AND ORGANIC MATTER (OMD)

Parameters	Cauliflower leaves (CL)			Fruit juice waste (FJW)			CL–FJW		
	Fresh	Ensiled	Pooled SE	Fresh	Ensiled	Pooled SE	Fresh	Ensiled	Pooled SE
Net gas produced	164.9^{b}	115.2^{a}	2.39	298.9^{b}	147.0^{a}	1.12	231.7^{b}	170.7^{a}	3.62
NDFD	174.6^{b}	128.6^{a}	3.16	203.5^{b}	146.9^{a}	4.10	273.1^{b}	142.9^{a}	7.56
OMD	756.6^{b}	609.5^{a}	2.30	875.3^{b}	678.5^{a}	2.30	805.0^{b}	645.3^{a}	5.00

Values with different superscripts within a row differ significantly (*P* <0.05)

The leguminous berseem straw had the highest CP, ADF and acid detergent lignin (ADL) contents, whereas wheat straw had the highest OM, NDF, hemicellulose and cellulose contents (Table III). The rice straw had the lowest OM and lignin contents. The values were comparable to those reported elsewhere [9].

TABLE III. CHEMICAL COMPOSITION* (g/kg DM) OF STRAWS

Component	Wheat straw	Rice straw	Berseem straw
OM	923	868	910
CP	27	32	87
NDF	840	780	720
ADF	520	505	570
H–cellulose	320	275	150
Cellulose	435	390	395
ADL	60	45	125

*OM– Organic matter; CP–Crude protein; NDF–Neutral detergent fibre; ADF–Acid detergent fibre; HC-Hemicellulose; ADL–Acid detergent lignin

The ensiled CL, irrespective of the straw supplement, was low (P <0.05) in DM content compared to the ensiled FJW (Table IV). The ensiled CL, irrespective of the source of straw supplement, also had the lowest (P <0.05) OM, NDF, ADF and cellulose contents compared to other ensiled products. The improvement, in the cell wall contents in FJW ensiled with all straws, over FVW (all; CL, FJW or CL–FJW) ensiled alone, was noteworthy. The NDF, ADF, and cellulose content were improved by 84, 77 and 71%; 51, 35 and 54%; and 69, 48 and 37%, respectively, in ensiled CL, FJW and CL–FJW, when supplemented with straw. Maximum (P <0.05) net gas production and OMD was observed in the ensiled FJW, irrespective of the source of straw supplement (Table V). Digestibility of NDF was highest in ensiled CL–FJW, irrespective of the straw combination.

TABLE IV.CHEMICAL COMPOSITION* (g/kg DM) OF VEGETABLE (CL), FRUIT (FJW), AND A MIXTURE OF BOTH (CL–FJW) WHEN ENSILDED WITH STRAW IRRESPECTIVE OF THE SOURCE OF THE STRAW

Component	CL	FJW	CL–FJW	Pooled SE
DM	250^{a}	286^{c}	270^{b}	5.3
OM	856^{a}	917^{c}	887^{b}	9.2
CP	118^{b}	81^{a}	105^{b}	4.8
NDF	580^{a}	636^{b}	625^{b}	8.5
ADF	444^{a}	473^{b}	459^{ab}	9.0
HC	136	163	166	11.0
Cellulose	299^{a}	324^{b}	301^{a}	6.0

*DM–Dry matter; OM–Organic matter; CP–Crude protein; NDF–Neutral detergent fibre; ADF–Acid detergent fibre; HC–Hemicellulose; CL–Cauliflower leaves; FJE–Fruit juice waste; values with different superscripts within a row differ significantly (*P* <0.05)

TABLE V. *IN VITRO* GAS PRODUCTION (NGP, mL/g DM/24 h) AND DIGESTIBILITY (g/kg DM) OF NEUTRAL DETERGENT FIBRE (NDFD) AND ORGANIC MATTER (OMD) OF VEGETABLE (CL) AND FRUIT (FJW) WASTES, AND A MIXTURE OF BOTH (CL–FJW), WHEN ENSILED WITH STRAW, IRRESPECTIVE OF THE SOURCE OF THE STRAW

Parameters	CL	FJW	CL–FJW	Pooled SE
Net gas produced	98.3^{a}	115.7^{b}	115.7^{b}	2.71
NDFD	165.1	168.6	197.2	11.1
OMD	469.1	477.4	474.0	9.4

CL–Cauliflower leaves; FJE–Fruit juice waste; Values with different superscripts within a row differ significantly (*P* <0.05)

TABLE VI. CHEMICAL COMPOSITION (g/kg DM) OF ENSILED STRAW, IRRESPECTIVE OF THE SOURCE OF FRUIT AND VEGETABLE WASTES (FVW)

Component	FVW	WS–FVW	RS–FVW	BS–FVW	Pooled SE
DM	86^{a}	359^{c}	277^{b}	353^{c}	6.1
OM	863^{a}	921^{c}	868^{ab}	896^{bc}	10.6
CP	168^{c}	63^{a}	71^{a}	103^{b}	5.5
NDF	372^{a}	752^{c}	664^{b}	668^{b}	9.8
ADF	303^{a}	498^{b}	488^{b}	547^{c}	10.4
HC	69^{a}	253^{d}	177^{c}	121^{b}	12.7
Cellulose	202^{a}	367^{c}	327^{b}	337^{b}	7.0

DM–Dry matter; OM–Organic matter; CP–Crude protein; NDF–Neutral detergent fiber; ADF–Acid detergent fiber; HC–Hemicellulose; WS–Wheat straw; RS–Rice straw; BS–Berseem straw; FVW–Fruit and vegetable waste; Values with different superscripts within a row differ significantly (*P* <0.05)

The DM content (89 g/kg DM) of fruit and vegetable waste ensiled alone was too low ($P < 0.05$) for successful conservation in practice. When ensiled with straw, the DM of FJW in combination with straws of berseem and wheat was the most suitable for ensiling (Table VI).

The pH was highest in the berseem straw combinations, followed by those of wheat straw, and was least where fruit and vegetable wastes were ensiled alone (Fig. 1).

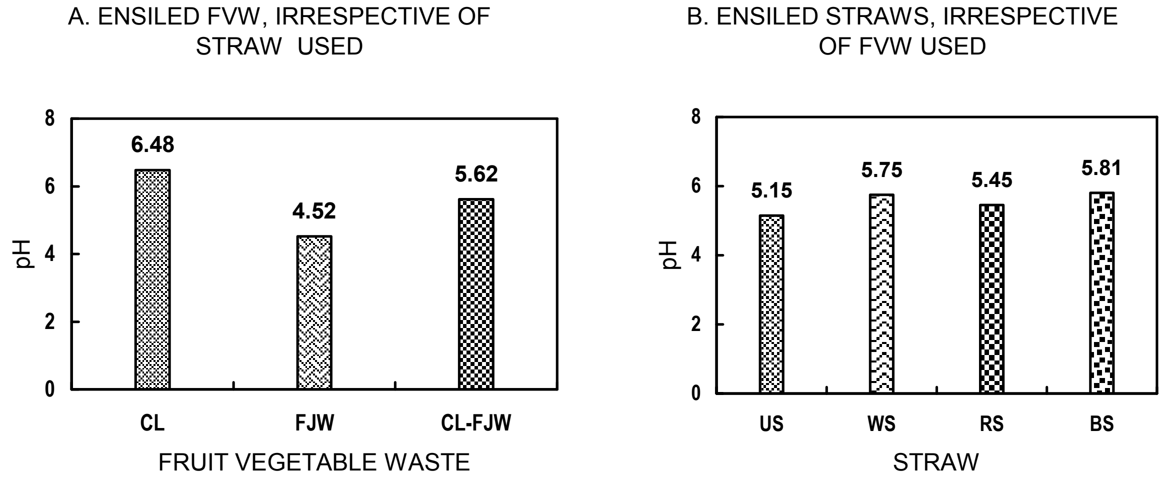

FIG. 1. pH of ensiled product.

The ensiled wheat straw combinations, irrespective of the fruit and vegetable wastes, had the highest ($P < 0.05$) OM, NDF, hemicellulose and cellulose contents as compared to the other straws ensiled. However, the highest CP and lowest hemicellulose, when FVW was ensiled in combination, was with barseen straw ($P < 5$).

TABLE VII. *IN VITRO* GAS PRODUCTION (mL/g DM/24 h) AND DIGESTIBILITY (g/kg DM) OF NUTRIENTS OF ENSILED STRAWS, IRRESPECTIVE OF THE COMBINATION OF FRUIT AND VEGETABLE WASTES IN THE SILAGE

Parameter	FVW	WS–FVW	RS–FVW	BS–FVW	Pooled SE
NGP	144.3^{c}	102.4^{b}	99.6^{ab}	93.3^{a}	3.13
NDFD	139.5^{a}	207.2^{b}	183.9^{b}	177.2^{ab}	12.78
OMD	644.4^{b}	409.3^{a}	409.2^{a}	431.1^{a}	10.81

NGP–Net gas produced; NDFD–Neutral detergent fiber digestibility; OMD–Organic matter digestibility; WS–Wheat straw; RS–Rice straw; BS–Berseem straw; FVW–Fruit and vegetable waste; Values with different superscripts within a row differ significantly ($P < 0.05$).

The lowest NDF content was observed when the fruit and vegetable wastes were ensiled alone ($P < 0.05$). The low NDF in fruit and vegetable wastes ensiled alone was the reason for the high ($P < 0.05$) *in vitro* net gas production and NDF digestibility in FVW (Table VII).

Amongst the straws, the ensiled wheat straw, irrespective of fruit and vegetable wastes in the silage, resulted in maximum net gas production (an indicator of nutritional value) and

NDF digestibility. The latter was significantly higher than with rice and berseem straw combinations. The OMD was highest (P <0.05) in ensiled wheat straw combinations.

4. CONCLUSIONS

The results showed that ensiling of fruit and vegetable wastes with wheat straw, in the ratio of 70 : 30, for a period of 42 days, is long enough to improve the nutritive value of otherwise waste material. The ensiled mixture supplemented with minerals and common salt could be used as a complete feed for ruminants.

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LABORATORY AND FIELD EVALUATION OF POTENTIAL FEED RESOURCES IN MALAYSIA

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Abstract

Two of the factors limiting livestock production in Malaysia are deficiency and imbalance of nutrients, particularly protein, energy and minerals. This is aggravated by large variations in quantity and quality of the conventional feeds. Some agricultural by-products, especially from oil palm and rice industries are abundantly available. However, most of these resources are limiting in protein and may not be suitable to be major ingredients in ruminant diets, although there are exceptions such as palm kernel cake. Some of the by-products need processing and supplementation for enrichment. In the smallholder sector there are shortages of bulk feeds and protein-rich feeds, especially for dairy cows. Smallholders are unable to feed according to requirements, their livestock having to make do with what is available locally. Leaves from five species were selected for laboratory evaluation, to determine which of them could have potential for planting on smallholdings. They included Kenaf (*Hibiscus cannabinus*); *gliricidia* (*Glyricidia sepium*), *leucaena (Leucaena leucocephala), asystasia* (*Asystasia intrusa*) and mulberry (*Morus alba*). Two of the five, Kenaf and *gliricidia* are recognized as easy to grow and protein-rich. On-farm activities, included the use of complete feeds based on oil palm fronds (OPF) and guinea hay, both recently introduced as feeds for dairy cattle. Problems related to the acceptance by smallholders of newly introduced plant species and recommendations for future work are discussed.

1. INTRODUCTION

A shortage of protein and energy-rich feeds is a major limitation to the development of ruminant production in Malaysia. The feeds available include agricultural by-products and abundant crop residues from the oil palm and rice industries. Apart from improved grasses and legumes, most supplements for dairy cattle are imported feeds such as corn, soybean meal (SBM) and fish meal. Palm kernel cake (PKC) and oil palm fronds (OPF) are widely available and have successfully been utilized as sources of energy and fibre respectively, for various ruminant species. However, within the smallholder sector, total dry matter intake (DMI) is limited, due to a shortage of fodder. There are several lesser-known seed bearing and fodder producing plants of interest for ruminant feeding in Malaysia. These include Kenaf (*Hibiscus cannabinus*), *Leucaena leucocephala, Gliricidia sepium,* mulberry *(Morus alba) and Asystasia intrusa.* Oil palm *(Elaeis guinensis)* by-products, particularly the OPF, though in a different category of forage, offer tremendous potential as a new feed for ruminants. The objective of the work is to exploit potential use of low-cost unconventional materials.

2. MATERIALS AND METHODS

2.1. Evaluation of new feed resources

Samples of Kenaf, G*liricidia, Asystasia,* mulberry and a complete feed based on OPF were collected, dried and ground for proximate analyses. Kenaf and *Gliricidia* samples were collected at eight weeks of age while mulberry and OPF-based feeds were sampled at varying stages of maturity after planting (see below) and three days after processing respectively. *In vivo* studies and tannin analyses were carried out on Kenaf and *Asytasia.*

2.1.1. Kenaf (Hibiscus cannabinus)

An experiment was carried out to determine *in sacco* dry matter (DM) disappearance of Kenaf (Khon Kaen variety) at 4, 6 and 8 weeks after planting and to compare it with alfalfa hay and SBM. The samples were dried at 60°C for 48 h and then ground through a 2 mm screen for the determination of *in sacco* disappearance of DM. For the determination of crude protein (CP), neutral detergent fibre (NDF), acid detergent fibre (ADF) and organic matter (OM), the samples were ground through a 1 mm screen. The *in sacco* DM disappearance of Kenaf at 4, 6 and 8 weeks after planting, alfalfa hay and SBM were evaluated in the rumen of dairy steers. Three cross-bred dairy steers, with an average body weight of 228 $\pm$ 0.2 kg and fitted with rumen cannulas, were fed a basal diet, equivalent to 1.5% DM of body weight, in equal feeds at 8:30 h and 16:30 h daily. After 14 days adaptation, nylon bags, with an average pore size of 45 µm, containing about 5 g of each sample was introduced into the rumen of each animal in a reversed order for 72, 48, 24, 16, 12, 8 and 4 h. The bags when removed were immediately washed in a washing machine, rinsed and dried at 60°C to a constant weight. Dry matter disappearance characteristics were estimated using the NEWAY Program [1]. Gas production of processed Kenaf was estimated by the *in vitro* gas method.

2.1.2. Gliricidia sepium

Samples of *Gliricidia sepium* were collected from a goat farm in Sarawak, East Malaysia, after eight weeks of growth. Duplicate samples, each weighing 500 g, were dried and ground for proximate and tannin analyses.

2.1.3. Mulberry (Morus alba)

Samples of mulberry planted at the Universiti Putra Malaysia (UPM) were collected at four stages of maturity (from the third to the ninth weeks after planting), ground and analysed for proximate analysis.

2.1.4. Asytasia intrusa

Duplicate samples of A*systasia intrusa* (about 375 mg $\pm$ 5 mg) were used to measure *in vitro* gas production [2, 3]. Fat free samples were analysed for tannins [4, 5].

2.1.5. Complete feeds based on OPF (pelleted or cubed)

Complete feeds were formulated by using locally available feedstuffs and agricultural by-products. The ingredients included PKC, rice bran, palm oil mill effluent (POME), cassava wastes and OPF. The latter was added at a 30% inclusion level. These feeds were processed as both pellets and cubes. Both forms of the feed were re-dried, ground and analysed for proximate components.

2.2. Introduction of new feed resources to farmers

2.2.1. Preliminary survey and on-farms trials

A survey was initially carried out on selected smallholder farmers, throughout Peninsular Malaysia, in the first quarter of 2001. Apart from explaining the overall objectives of the project and the introduction of selected plant species (initially Kenaf, *Leucaena* and *Gliricidia*) and a complete feed based on OPF, the survey aimed at identifying their interest and experience of growing and utilizing these species as livestock feed. Out of 30 smallholders interviewed, 10 were initially selected to take part in on-farms trials in 2002. However, due to the interest in the initial results expressed by large-scale private farmers the programme was broadened to include them.

2.2.2. Complete feeds based on cubed diets containing OPF, for smallholder dairy cattle

A trial was carried out, at Banting, Selangor, on two smallholder farms. At each farm there were six dairy cows, of which three animals of the same age and weight were individually fed a cubed complete feed, based on OPF. The remaining three animals, also of a similar age and weight, were offered a conventional feed (mainly comprised of PKC and rice-bran). The cubes were individually packed in 7 kg bags and delivered at intervals to the farms. All feed inputs were recorded. The animals were milked once per day. Milk yields were weighed and recorded on one day each week. Statistical analysis was carried out by ANOVA.

2.2.3. Indigenous grasses and guinea hay in rations of dairy cattle

Two farmers, each contributing 10 milking cows selected from their main dairy herd of 18 and 17 respectively, were identified at Banting, Selangor. The 10 cows, at each site, were all in early-to-mid lactation with a mean live weight of 300 kg. They were assigned at random to one of two groups (5 cows/group/farm). All animals, fed individually in tie-stalls, were offered 6.8 kg of a standard concentrate mixture plus 3 kg of either guinea hay (group 1) or cut local grasses (group 2), on a dry matter basis. The concentrate mixture consisted of 44% commercial cattle pellet, 29% brewer's grain, 21% POME and 6% molasses. The CP (g/kg DM) was 120, 185 and 215, and the metabolizable energy (ME, MJ/kg) content 8.8, 11.5 and 12.0, for guinea grass, local grass and a concentrate mixture respectively. Guinea hay was produced at the MARDI Station, Serdang. Milking was done by a portable mini-milking machine. Milk yield was recorded for a 150-day period, starting 21 days after adaptation to the diets. Feeds were sampled regularly to monitor changes in composition. Statistical analysis was carried out by ANOVA.

2.2.4. Feeding of complete, cubed or pelleted diets containing OPF to beef cattle

A trial was carried out, to evaluate a complete feed, either cubed or pelleted, on the growth rate of beef cattle, at the Johore Tenggara Oil Palm Plantation Commercial farm (JTOP), Kota Tinggi, Johore. This farm is one of the Johore state farms and is often used as a model farm for smallholders in the southern region of Peninsular Malaysia. Seventy-five head of Kedah–Kelantan (KK) cross-bred cattle were divided into three groups of 25 animals each. The treatments were: (1) a pelleted diet containing 15% OPF; (2) the same diet, but cubed; and (3) a diet containing 80% PKC plus 20% cut guinea grass. The pelleted and cubed diets contained: OPF 15%; PKC 40%; wheat pollards 32%; soy bean meal 8%; calcium carbonate 1%; salt 2%; a vitamin and mineral mix 1%; and urea1%. The experiment lasted for 133 days. Statistical analysis was carried out by ANOVA. There were differences in particle size between pelleted and cubed feeds. Pellets were based on ground ingredients (including the OPF) whereas in the latter the OPF was not ground.

2.2.5. Feeding a complete feed, based on OPF and cubed, to beef cattle of two initial live weights

A separate trial was conducted at a second farm, owned by the JTOP plantation in Kota Tinggi, Johore. In this trial 50 male KK cross-bred cattle, about 12 months old, were used. The animals were divided into two groups based on body-size (either large or small) and they were fed a cubed complete feed based on OPF for 16 weeks. Daily feed intake and changes in live weight were monitored. Statistical analysis was carried out by ANOVA.

2.2.6. Growth of goats receiving a complete diet containing OPF

A trial was carried out at a government-linked farm (owned by the Rubber Industry for the Smallholders Development Authority, RISDA) to study the benefit of feeding complete pelleted diets, containing OPF (30%), on the growth performance of Boer x Cashmere goats in feedlots. The diets included PKC, rice-bran, molasses, calcium carbonate and mineral premix. The farm operates a goat breeding programme, whereby kids are distributed to RISDA smallholders, who grow them using the diets advised by the farm, after which the farm will repurchase them. Twenty male and 20 female Boer goats, about 6–7 months of age, were randomly divided into four groups of 10, each group comprising five males and five females. The animals were fed the following: Group 1 (control) received a conventional diet containing 80% grass, 10% corn and 10% soya-hull; Group 2 received 50% grass and 50% of a complete diet; Group 3 received 50% PKC and 50% of the pelleted OPF diet; Group 4 received 100% of the pelleted OPF diet. The live-weight change of the animals was monitored over 112 days. Statistical analysis was carried out by ANOVA.

TABLE I. DRY MATTER (DM, g/kg) AND CHEMICAL COMPOSITION (g/kg DM, OF THE WHOLE PLANT AND LEAF AND STEM FRACTIONS OF KENAF (KHON KAEN 60) AT 4, 5, 6, 7 AND 8 WEEKS AFTER PLANTING (EXPERIMENT 2.1.1.)

Parameters (g/100g) DM)	W4*	W5	W6	W7	W8	SEM
Whole plant						
DM	97.5^{c}	109^{c}	150	139^{a}	123^{b}	4.3
CP**	304^{a}	283^{b}	250^{c}	209^{d}	195^{d}	14.3
NDF**	327^{d}	383^{cd}	401^{bc}	463^{ab}	522^{a}	23.3
ADF**	232^{d}	257	305^{c}	334^{b}	386^{a}	18.4
OM**	883^{d}	893^{c}	918^{b}	924^{a}	926^{ab}	5.8
Leaf						
DM	142^{c}	120^{d}	75^{a}	162^{ab}	156^{b}	4.3
CP	366^{a}	348^{b}	39^{d}	299^{e}	317^{c}	8.4
NDF	298^{b}	306^{b}	352^{a}	368^{a}	391^{a}	12.7
ADF	157^{c}	177^{b}	187^{ab}	188^{ab}	193^{a}	4.6
OM	891^{d}	898^{c}	917^{b}	921^{a}	924^{a}	4.4
Stem						
DM	980^{b}	107^{ab}	165^{a}	173^{a}	166^{a}	7.5
CP	154^{a}	116^{b}	95.1^{b}	867^{b}	86.6^{b}	9.0
NDF	51^{d}	635^{c}	650^{c}	677^{b}	723^{a}	15.8
ADF	451^{e}	490^{d}	505^{c}	531^{b}	572^{a}	13.6
OM	862^{d}	876^{c}	917^{b}	936^{a}	935^{a}	10.2

Means in the same row with different superscripts are significantly different (P <0.05),
SEM: Standard error of means,
*W = week
**CP = crude protein; NDF = neutral detergent fibre; ADF = acid detergent fibre; and OM = organic matter

3. RESULTS

3.1. Evaluation of new feed resources

3.1.1. Kenaf (Hibiscus cannabinus)

The chemical composition of Kenaf at different stages of growth is shown in Table I and *in sacco* DM disappearance in Table II

TABLE II. *IN SACCO* DRY MATTER DISAPPERANCE OF KENAF HARVESTED 4, 6 AND 8 WEEKS AFTER PLANTING (g/100 g DM), ALFALFA HAY AND SOYABEAN MEAL (EXPERIMENT 2.1.1.)

Items	Kenaf			Alfalfa hay	Soyabean meal	SEM
	4 weeks	6 weeks	8 weeks			
a	44.3	44.3	39.6	32.9	32.7	2.43
b	44.9^{abc}	37.8^{bc}	29.7^{c}	51.8^{ab}	60.8^{a}	3.99
a+b	89.1^{b}	82.1^{d}	69.3^{e}	84.8^{c}	93.4^{a}	2.73
c	0.14	0.13	0.11	0.15	0.06	0.01
ED[2]	77.6^{a}	71.4^{b}	59.8^{d}	72.2^{b}	66.5^{c}	2.02

Notes: a = intercepts, b = insoluble but potentially degradable component at a time t, c = rate of degradation of fraction contant of b, a+b = total degradability. ED = effective degradability at an outflow rate (fraction/h) of 0.05/h. (Based on the equation of $p = a + b(1–e^{-ct})$ where p = The actual degradation at time t)
Means in the same row with different superscripts are significantly different (P <0.05)
Source: [6]

3.1.2. Gliricidia sepium

The composition of *Gliricidia sepium* is shown in Table III.

TABLE III. CHEMICAL COMPOSITION OF *GLIRICIDIA SEPIUM* (EXPERIMENT 2.1.2.) [ALL CONSTITUENTS ARE g/kg DRY MATTER EXCEPT MICROMINERALS WHICH ARE IN PPM]

Nutrient	
Crude protein	190
Crude fibre	170
Acid detergent fibre (ADF)	390
Netral detergent fibre (NDF)	230
Ether extract (EE)	30
Ash	66
Nitrogen free extract	–
Ca	7
P	2
Mg	4
K	18
Mn (ppm)	16
Zn (ppm)	11
Cu (ppm)	trace
B (ppm)	21

Gross energy, determined by a Bomb calorimeter: 4501 Cal/g
Dry matter of gliricidia: 30%

3.1.3. Mulberry (Morus alba)

The chemical composition of the whole plant and leaves of mulberry at four stages of maturity are shown in Table IV.

TABLE IV. DRY MATTER (DM, G/KG) AND CHEMICAL COMPOSITION (G/KG DM) OF THE WHOLE PLANT LEAVES OF MULBERRY (MORUS ALBA) BETWEEN WEEKS 3 AND 9 (EXPERIMENT 2.1.3.)

Nutrient	Plants				SEM	Leaves				SEM
/Week	*W3	W5	W7	W9		W3	W5	W7	W9	
DM	252^{c}	309^{b}	303^{b}	344^{a}	4^{2}	249^{c}	318^{ab}	304^{b}	324^{a}	4.3
CP	320^{a}	249^{b}	215^{c}	176^{d}	1.8	358^{a}	306^{b}	285^{c}	278^{c}	1.4
Ash	99^{a}	101^{a}	85^{b}	67^{c}	4.9	96^{bc}	109^{a}	99^{b}	92^{b}	3.6
NDF	332^{c}	397^{b}	411^{b}	524^{a}	7.1	283^{b}	309^{a}	283^{b}	305^{ab}	4.0
ADF	224^{d}	277^{c}	13^{b}	379^{a}	6.8	179	183	179	185	1.7
ADL	52^{b}	67^{b}	68^{b}	112^{a}	3.4	48^{ab}	34^{b}	55^{a}	42^{ab}	2.5
Cel	172^{c}	208^{b}	192^{bc}	282^{a}	5.8	131^{b}	149^{b}	141^{b}	169^{a}	3.4

Means with the different superscripts within rows for each plant fraction differ significantly (P <0.05).
*W = week.
DM = dry matter, CP = crude protein, NDF = neutral detergent fibre, ADF = acid detergent fibre, ADL = acid detergent lignin, Cel = Cellulose.

3.1.4. Asytasia intrusa

The 24-h gas production from *Asystasia intrusa* was 34 mL in presence of PEG and 18.8 mL in absence of PEG. Tannin activity, as measured by the reduction in the fermentation was 44.6%.

3.1.5. 3Complete feed based on OPF (pelleted or cubed)

The chemical composition of the complete feeds containing OPF, and either pelleted or cubed, for feeding beef cattle (feedlots), dairy cattle, goats and sheep is shown in Table V.

TABLE V. DRY MATTER (DM, g/kg) AND CHEMICAL COMPOSITION g/kg DM) OF COMPLETE FEEDS CONTAINING OIL PALM FRONDS (OPF, SEE TEXT FOR DETAILS) EITHER PELLETED OR CUBED (EXPERIMENT 2.1.5.)

Nutrient	Beef Feedlot (Pellets)	Beef Feedlot (Cubes)	Goat / sheep (Pellets)	Dairy Cattle (Cubes)	100 % OPF (pellet / cube)
DM	892	901	896	894	900
CP	156	140	149	168	47
EE	36	21	32	31	21
CF	268	231	207	189	450
Ash	64	66	74	64	32
Ca	2.0	1.3	8.1	6.8	0.6
P	3.6	3.7	5.9	5.2	0.5
ME (MJ/kg)+	8.3	9.1	9.1	8.4	5.6

DM = dry matter, CP = crude protein, EE = ether extract, CF = crude fibre, ME = metabolizable energy
+ Based on estimation: ME (kcal/kg) for ruminants = digestible energy (DE) (kcal) x 0.82, where DE (kcal/kg) = total digestible nutrients (TDN)%/100 x 4409 and TDN = digestible protein + digestible N–free extract + digestible fibre + 2.25 (digestible ether extract); 1 MJ = 0.25 Mcal

3.2. Introduction of new feed resources to farmers

3.2.1. Preliminary Survey and On-Farm Trials

Table VI shows the initial response from selected smallholders to the recommended plant species (Kenaf and *Leucaena*) or a complete feed based on OPF.

TABLE VI. SMALLHOLDERS RESPONSES TO THE INTRODUCTION OF NEW PLANTS OR A COMPLETE FEED BASED ON OIL PALM FRONDS (OPF) (BASED ON PRELIMINARY SURVEY) (ACTIVITY 2.2.1.)

Know-how	*Leucaena leucocephala*[+]			Kenaf *(Hibiscus cannabinus)*[@]			Complete feed based on OPF[++]		
States	K*	J*	S*	K	J	S	K	J	S
Knowing the species	Yes	Yes	Yes	No	No	No	Yes	Yes	Yes
Perceived benefits of supplementation	Yes	Yes	No	No	No	No	Yes	Yes	Yes
Experience in planting/utilization	No	No	No	No	No	No	No	No	Yes
Interest in participating in the trial	Yes	Yes	Yes	No	No	No	Yes	Yes	Yes

*K; Kelantan, J: Johore and S: Selangor representing the northern, southern and Central Region of Peninsular Malaysia respectively.

+: Widely known by smallholders throughout Peninsular Malaysia

@: New plant species

++ Known through mass-media promotion, exposition and seminars held throughout Peninsular-Malaysia. Fresh OPF or OPF-silage is used by smallholders to feed livestock

3.2.2. *Complete feed, based on cubed diets containing OPF as the diet for smallholder dairy cattle*

The sequence in which dairy cows received the complete feeds, contatining OPF and cubed diets, is given in Table VII. Milk yields were similar for both the diet containing OPF and the conventional diet.

TABLE VII. SEQUENCE OF DIETS ASSIGNMENT TO COWS ON TWO SMALLHOLDINGS (EXPERIMENT 2.2.2.)

Farm A

Period	Cow J23	Cow Z42	Cow Z43	Cow Z41	Cow Z40	Cow 9909
1	Diet A[1]	Diet C[2]	Diet A	Diet C	Diet A	Diet C
2	Diet C	Diet A	Diet C	Diet A	Diet C	Diet A
3	Diet A	Diet C	Diet A	Diet C	Diet A	Diet C

Farm B

Period	Cow S12	Cow S5	Cow S13	Cow 9843	Cow S2	Cow S7
1	Diet A	Diet C	Diet A	Diet C	Diet A	Diet C
2	Diet C	Diet A	Diet C	Diet A	Diet C	Diet A
3	Diet A	Diet C	Diet A	Diet C	Diet A	Diet C

[1] Diet A: Complete feed based on oil palm frond

[2]Diet C: Conventional diet (Palm kernel cake, rice bran and others).

3.2.3. *Indigenous grasses and guinea hay in rations of dairy cattle*

Table VIII shows milk yields of dairy cows fed guinea grass or local grass on two farms.

TABLE VIII. MILK YIELD OF SAHIWAL-FRIESIAN COWS FED DIETS CONTAINING GUINEA HAY OR LOCAL GRASSES (EXPERIMENT 2.2.3)

Month of lactation	Milk yield (kg/d)			
	Farmer A		Farmer B	
	Guinea hay	Local grass	Guinea hay	Local grass
1	11.1 ± 2.22	11.4 ± 1.54	8.4 ± 2.38	8.9 ± 4.68
2	10.7 ± 1.77	11.1 ± 0.98	8.2 ± 2.25	8.7 ± 4.67
3	10.0 ± 1.46	10.2 ± 1.07	7.7 ± 1.40	8.3 ± 4.31
4	8.7 ± 1.32	9.2 ± 1.32	5.9 ± 1.33	7.2 ± 3.59
5	6.7 ± 0.86	7.8 ± 1.16	6.2 ± 1.26	7.5 ± 2.89
Overall	9.4 ± 1.53	9.9 ± 1.21	7.2 ± 1.72	8.1 ± 4.03

3.2.4. *Feeding of complete, cubed or pelleted diets containing OPF to beef cattle*

The performance of cattle offered a complete diet, either cubed or pelleted and containing OPF, is given in Table IX.

TABLE IX. GROWTH OF CATTLE RECEIVING A COMPLETE DIET, CUBED OR PELLETED AND CONTAINING OIL PALM FRONDS (OPF), COMPARED TO CATTLE RECEIVING A CONVENTIONAL DIET (CONTROL) FOR 133 DAYS (EXPERIMENT 2.2.4.)

Parameter	Treatment 1 (pellets)	Treatment 2 (cubes)	Treatment 3 (control)
Number of animals	25	25	24
Initial Body weight (BW, kg)	195	196	192
Final BW (kg)	311[a]	320[a]	224[b]
Total increase in BW (kg)	1164	124[a]	32[b]
Daily LW gain (kg)	0.9[a]	0.9[a]	0.2[b]
Feed intake/d (kg)	8.3[a]	8.2[a]	5.3[b]
Feed conversion ratio	9.5[a]	8.8[a]	21.9[b]

Means within rows with different superscripts are different (P <0.05)

3.2.5. *Feeding a complete cubed feed, based on OPF, to beef cattle of two initial live weights (Experiment 2.2.5.)*

The initial live weights for the large and small body size groups were 252 kg and 231 kg respectively, and the final live weights were 343 kg and 313 kg respectively. At the beginning of the trial, daily feed intake of the large and small groups were 11 kg and 10 kg respectively, and over the 14 week trial period, the respective values were 11 kg and 9.0 kg. There were no significant differences in the live-weight gains between the treatments.

3.2.6. *Growth of goats receiving a complete diet containing OPF (Experiment 2.2.6.)*

Table X shows growth in goats, receiving either a complete diet containing OPF or a conventional diet. Regardless of the sex, the gains from the OPF diet were higher than those goats fed conventional diets.

TABLE X. THE PERFORMANCE OF GROWING BOER X CASHMERE GOATS FED A COMPLETE DIET, CONTAINING OIL PALM FRONDS (OPF) OR A CONVENTIONAL DIET FOR 122 DAYS (EXPERIMENT NO 2.2.6.)

Group/diet	Sex	Initial LW (kg)	LW gain (g/d)	Total LW gain (kg)	Cost to achieve total LW gain (RM)+	Cost of feed per kg LW (RM)+
Grass:Corn:	Male	18.8	87.0	10.6	35.7	3.7
Soya hull,	Female	17.3	85.1	10.4	26.4	2.5
80 : 10 : 10	Mean	18.1	86.6	10.6	31.5	3.0
Grass:OPF	Male	20.0	135	16.5	52.0	3.2
complete and	Female	18.4	83.1	10.1	42.0	4.2
pelleted, 50 : 50	Mean	19.2	113	13.8	47.5	3.4
Grass: palm	Male	18.4	35.7	4.4	25.8	5.9
kernel cake,	Female	17.0	18.8	2.3	20.5	8.9
50 : 50	Mean	17.8	28.6	3.5	23.4	6.7
OPF pelleted,	Male	19.8	209.8	25.6	94.5	3.7
100%	Female	19.3	147.3	18.0	66.6	3.7
	Mean	19.6	167.4	20.4	76.0	3.7

1US$ = RM3.8

4. DISCUSSION

4.1. Evaluation of new feed resources

Multi-purpose fodder trees like Kenaf, *gliricidia* and mulberry are considered non-conventional and feed resources for ruminants, as they have yet to be widely accepted in Malaysia. These fodders have a high protein content, which can contribute to microbial growth leading to increased rumen fermentation and increased supply of amino acids to the host animal. Processed OPF, either cubed or pelleted can also be considered a new feed as further promotion is needed to enhance its uptake, especially for dairy cattle. Fresh OPF is used by smallholders, especially those living within 5 km of oil palm plantations. *Asystasia* is a well-known plantation species, but its utilization is limited due to lack of appreciation of its feeding value. It is best utilized by grazing.

Information on nutritional value from laboratory investigations was available on Kenaf, but there has been little information on the performance of animals fed Kenaf.

4.1.1. Kenaf (Hibiscus cannabinus) (Experiment 2.1.1.)

Crude protein content of Kenaf whole plant, leaf and stem reduced rapidly from the fourth to the sixth week (Table I) but the rate of decline was slower thereafter. The NDF, ADF and OM contents of whole plant, leaf and stem increased with stage of harvesting. Leaf contained more CP than stem, which contained a higher proportion of NDF and ADF. This data supports the suggestion that Kenaf could be harvested between 6 and 8 weeks after planting, when CP content is approximately 200 g/kg DM [6]. The effective degradability (ED) of Kenaf was reduced as age of harvesting increased (Table II). The decline was lower in the water insoluble fraction, although higher in the potentially degradable fraction at six weeks than found in the previous study [7]. Comparing DM disappearance of Kenaf to alfalfa hay and SBM, it was shown that the insoluble fractions of alfalfa hay and SBM were similar to Kenaf at four weeks of age but higher at six weeks of age ($P < 0.05$). Effective degradability of Kenaf and alfalfa hay at six weeks was similar and higher than that of SBM ($P < 0.05$). The lowest effective degradability was found in Kenaf at eight weeks. The greatest potential degradability was observed for SBM ($P < 0.05$). Potential degradation of alfalfa hay was similar to that of Kenaf between four and six weeks of age. The data indicated that DM disappearance of Kenaf reduced sharply from the sixth to the eighth week after planting. Kenaf between four and six weeks after planting could be substituted for alfalfa hay and SBM in ruminant diets [6, 8].

In a separate study carried out in our laboratory recently (unpublished), gas production of processed and stored Kenaf indicated that there is no tannin activity when Kenaf is processed and stored over a 12 month period. However, type of tannins in fresh Kenaf should be identified and evaluated for all the varieties likely to be used as feed.

4.1.2. Gliricidia sepium (Experiment 2.1.2.)

The feeding value of *Gliricidia sepium* may differ between varieties. Based on our analyses, CP and CF content in *Gliricidia* are high (Table III). *Gliricidia* is a browse tree legume commonly found in Malaysia and often used to form live fencing, or it is planted in plots in smallholdings. However, its use as a feed for ruminants has been limited. Earlier studies showed that the tannin concentration in *Gliricidia* is lower than in other tree and shrub legumes, including *Leucaena*. Further studies are required to determine optimum inclusion levels of *Gliricidia* and the long term effects of feeding on growth and reproductive performance in ruminants. The essential amino acid and mineral profiles of *Gliricidia sepium* have been reported [9, 10] *Gliricidia* is an important forage crop in cut-and-carry systems for large and small ruminants, though in some areas its use is limited by apparent palatability problems [11]. It can be used as a high protein supplement to low quality basal feeds such as rice straw, OPF and other crop residues for increased live weight gain and milk production [9, 12, 13]. For low quality diets, *Gliricidia* is most effectively used when fed at about 30% of the DM of the diet [11, 12].

4.1.3. Mulberry (Experiment 2.1.3.)

Mulberry (*Morus alba*) has been cultivated in Malaysia for sericulture, but no studies have evaluated it as a fodder crop. The chemical composition of the whole plant and the leaf fraction were analysed at different times of harvesting (Table IV). Both CP and ash in the whole plant and leaf fractions declined with increasing maturity, and cell walls (NDF, ADF and ADL) increased [14]. Its nutritional value is comparable to oilseed cakes, making it a suitable supplement, particularly of protein, to poor quality high fibre diets [15].

4.1.4. Asytasia intrusa (Experiment 2.1.4.)

Results from the *in vitro* gas analysis revealed that inclusion of PEG increased the gas by 44.6 % suggesting the presence of tannins in *A. intrusa* after 24 h incubation.

Asytasia intrusa grows extensively under shade. The CP content of its aerial parts is considered high and comparable to other high protein forages like Kenaf or gliricidia. The consumption of *A. intrusa* is often associated with diarrhoea and soft faeces in grazing ruminants. The occurrence of soft faeces in animals is usually associated with a high content of water and protein in this plant. However, an experiment conducted earlier, revealed that there were no signs of diarrhoea or soft faeces when PKC was fed, at about 30% of total DMI, to growing sheep grazed on *A. intrusa*. Moreover, their carcass quality was superior to those fed high PKC diets [16]. The differences in these results could be attributed to soil type and varieties of Asytasia.

4.1.5. Complete feeds based on OPF (pelleted or cubed) (Experiment 2.1.5.)

The optimum inclusion level of OPF in a complete diet for ruminant animals is about 30%. Pellets are suitable for small ruminants, whereas cubes are preferred by large ruminants. The use of pellets, particularly in beef and dairy cattle, is associated with a faster rate of passage in the gastrointestinal tract (GIT), leading to reduced digestibility of nutrients [17, 18] even though increased intake was commonly reported. The longer particle size (>15 mm) in cubes, compared to pellets (<1 mm), allows more time for efficient microbial digestion in the rumen [18]. Complete feeds, based on 30% OPF in the form of cubes, can support daily milk production of 21.8 L/d. Intakes of 14 kg/d have been recorded. Growth rates of 0.8–0.9 kg/d can be obtained in beef cattle, when intake is around 7 kg/d [19, 18, 20].

Before the introduction of complete feeds containing OPF, farmers depended on conventional diets, particularly PKC, soybean wastes and POME. The diets were often imbalanced, thus limiting milk production. This was aggravated by farmers often being reluctant to follow advice when it entailed purchasing expensive protein feeds. Use of complete feeds has overcome some of these constraints.

4.2. Introduction of new feed resources to farmers, and adoption of the recommendations

4.2.1. Preliminary survey and on-farm trials (Eperiment 2.2.1.)

The survey carried out with smallholders indicated awareness of *Leucaena leucocephala* and OPF, but not Kenaf. The former species was promoted for smallholder use, as a high protein source, in Malaysia during 1970–1980. However, its popularity was reduced, probably due to attacks by *psyllid* and poor management of the trees. Complete feeds, containing OPF, were widely known due to intensive promotions by MARDI in 2001. None of the smallholders interviewed knew how to plant and manage the crops for animal feed. Kenaf was totally new to all of them and *Leucaena* was the plant of choice by the smallholders interviewed (Table VI). Consequently in the field trials emphasis was placed on the growing and feeding of Kenaf, the promotion of which is government policy.

4.2.2. Complete feeds, based on cubed diets containing OPF, for smallholder dairy cattle (Experiment 2.2.2.)

Based on experiments at two farms, a complete feed containing OPF resulted in similar milk yields as the current practice of 'wet feeding', using available agro-industrial by-products (like wet brewers grains, POME, wet soybean waste and fresh grass in combination, depending on availability). In interviews with five neighbouring farmers, there was some reluctance to change to the complete diet because of cost, but one farmer felt that the complete diet would be easier to manage, especially during critical periods.

4.2.3. Indigenous grasses and guinea hay in rations for dairy cattle (Experiment 2.2.3.)

Indigenous grass is often used as part of the diet for dairy cows throughout Malaysia. Grass is usually 25–35% of the diet, the balance being concentrates, which normally consists of dairy cattle pellets, PKC, brewer's grain, POME and molasses. In the trial, guinea hay was compared to indigenous grass, when fed to dairy cows receiving similar amounts of concentrates. Freshly cut grasses contained more CP (185 g/kg DM) than the MARDI-made guinea hay (120 g/kg DM). This could be due to the generous levels of N fertilizer applied to the grass during the growing stage. This resulted in more milk being produced by the grass fed group than from the cows receiving guinea hay throughout the 150-day lactation (Table VIII). However, guinea hay, once made, saves the labour involved with a cut-and carry-system and is easy to establish in Malaysia and, therefore, is a potentially useful feed resource for dairy cattle.

4.2.4. *Feeding of complete, cubed or pelleted diets containing OPF to beef cattle (Experiment 2.2.4.)*

The conventional diet for beef cattle, at the JTOP farm, was based on PKC (80%) and cut grass (20%), providing a diet which was short of CP, especially when the forages were mature resulting in low growth rates. The diets that contained OPF, resulted in improved growth rates in the cattle, especially when they were fed as cubes (Table IX). It is likely that the longer particles in the cubes accounted for this [17]. Complete OPF based diets are suitable for use in feedlots and the potential improvement is between 40 and 50%.

4.2.5. *Feeding a complete cubed feed based on OPF, to beef cattle of two initial live weights (Experiment 2.2.5.)*

The results indicated that at the same age of beef cattle, larger animals grew faster than the smaller animals over the 16 weeks experimental period.

4.2.6. *Growth of goats receiving a complete diet containing OPF (Eperiment 2.2.6.)*

The growth performance of cross-bred Boer x Cashmere goats fed a complete feed containing OPF was superior to goats fed a 1 : 1 mix of the complete feed and grass, or a 1 : 1 mixture of the complete feed and PKC (Table X). The nutritive value of the complete feed was higher than that of either the grass or PKC. The PKC used in this trial contained more than 40 g/kg of oil, which may have resulted in some rancidity and, therefore, depression in DMI. The PKC also contained excess Cu (25 ppm), which may have limited growth. Under the conditions of the trial, a formulation of 50% grass and 50% complete feed containing OPF was practical for an intermediate rate of growth (112.5 g/d), with a feed to weight gain cost of RM 3.8 compared to RM 4.1 with a 100% complete diet.

5. CONCLUSIONS

There are some problems with regard to the introduction of new feed resources for smallholder owned livestock in Malaysia. Some smallholders are reluctant to introduce new forage species because:

- Land is either limited or not available
- Heavy investment in fertilizer and labour is required (especially for Kenaf and mulberry)
- Lack of knowledge of growing new species of forage compared to indigenous grasses and, to some extent, *Leucaena leucocephala.*
- Lack of knowledge of potential benefits from feeding new species of forage to livestock, for example *Leucaena leucocephala.*

Kenaf shows sufficient promise as a feed to be encouraged, in suitable growing areas, because of its satisfactory CP content and rapid leaf growth. *Leucaena leucocephala* was promoted during the 1970s but the impact was short-lived. *Gliricidia sepium* and Mulberry are also easy to grow, particularly if fertilizer is available. Special emphasis should be given to *Gliricidia sepium,* because of its high productivity and leaf quality as well as its ability to grow on a wide range of soils, including acid soils. *Asystasia intrusa* is a legume commonly found in plantations, but on smallholder farms could be an excellent protein source for grazing animals.

6. FUTURE WORK

Data on the nutritive values of Kenaf, *Gliricidia* and mulberry are currently available in Malaysia [21, 22, 23]. However, more research needs to be conducted on long-term effects of feeding as well as on the identification of anti-nutritive factors. Feeding trials and i*n vivo* gas production studies have been used to evaluate Kenaf and *Asystasia intrusa* but more studies are needed on *gliricidia* and mulberry. Smallholder farmers also need to be aware of the value of complete diets, especially those containing OPF for cattle and goats, and the value of guinea hay. Harvesting and drying of Kenaf, *Gliricidia* and mulberry are still the critical factors that need to be solved.

Long-term feeding of Kenaf and *Gliricidia* to various ruminant species should be conducted both at the institutions and on-farms in order to convince smallholders of the benefits of feeding these feed resources. Other new species high in protein pertinent to local environment should be sourced, characterized and utilized for livestock feeding. Modern techniques for the *in vivo* and *in vitro* evaluations of newly introduced species will be used intensively to generate the information.

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EVALUATION OF PASTURE FORAGES AS LIVESTOCK FEED

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Abstract

Some of the lesser-known fodder plants, of the steppe and forest-steppe zones of Mongolia, namely *Artemisia frigida, Carex duriuscula, Cleistogenes squarrosa, Elytrigia repens, Festuca lenensis, Puccinella tenitifrora, Stipa krylovii* or their mixtures at different stages of growth, i.e. flowering, seeding, and dormant, were evaluated for their nutritional value in a 3 x 3 factorial design study. The *Cleistogenes* and a mixture of *Carex-Cleistogenes* had the highest (P <0.05) organic matter (OM) and crude protein (CP) contents and the lowest (P <0.05) cell wall constituents(CWC), compared to other pastures from the steppe zone. The net gas production, OM digestibility and metabolizable energy (ME) in different pastures, irrespective of the stage of maturity were similar. In the forest-steppe zone, irrespective of the stage of maturity, *Stipa krylovii* had the highest (P <0.05) OM and lowest (P <0.05) acid detergent lignin (ADL) contents and *Festuca lenensis* had the lowest (P <0.05) CWC compared to other grasses. In both the steppe and forest-steppe zones, irrespective of the plant species, CP content declined (P <0.05) and CWC increased (P <0.05) linearly with the maturity of the pastures. The rate as well as extent of net gas production, OM digestibility and ME also declined (P <0.05) with the maturity of pastures in both the zones. These parameters were negatively correlated with ADL, acid detergent fibre and neutral detergent fibre contents of the pastures. The organic matter digestibility and ME content of the plants of the steppe zone were higher than that of the plants from the forest-steppe zone.

1. INTRODUCTION

Livestock rearing has been traditionally important in the economy of Mongolia. Most livestock relies on pasture forage for their feed requirements throughout the year. With the continuous increase in population, the demand for livestock products has been growing consistently. In 2000, the urban population accounted for 60% of the total population, compared to 21.6% in 1960. To meet the growing demands of urbanites, it is imperative to increase livestock production in the country. At present the total livestock population is 24.4 million. Livestock numbers have increased almost threefold in the last eight years due mainly to privatization and favorable environmental conditions. The livestock sector contributes around 32% of the GNP and 30% of exports. The population of the local Mongolian cattle in the Republic is 2 million, with Yaks and Hainaks accounting for over 20% of these. One of the main attributes of local animals is their ability to survive on the low quality pastures, where the feed supply is also irregular dependent on the weather conditions. Drought occurs in summer and it snows in winter, both affecting plant growth and availability. As a consequence there is scarcity of forage during these periods and supplementary feeds are required. The present study was undertaken to evaluate the nutritional value of some of the lesser-known fodder plants of steppe and forest-steppe zones of Mongolia, at different stages of maturity, for livestock feeding.

2. MATERIALS AND METHODS

2.1. Sample collection

Samples of seven plant species, *Artemisia frigida, Carex duriuscula, Cleistogenes squarrosa, Elytrigia repens, Festuca lenensis, Puccinella tenitifrora, Stipa krylovii* or their mixtures, were collected from the steppe and forest-steppe zones of Mongolia. Whole plants at three stages of growth, flowering, seeding and dormant, were collected. The plants were harvested 2–3 cm above ground level from 1 m square quadrants. The same procedure was repeated five times for each pasture.

2.2. Proximate analyses and *in vitro* evaluation

Samples were dried to constant weight in a forced air oven and ground in a Wiley mill to pass through a 1 mm screen and then analysed for proximate [1] and cell wall constituents [2]. Hemicellulose was calculated as the difference between neutral detergent fibre (NDF) and acid detergent fibre (ADF) and cellulose as the difference between ADF and acid detergent lignin (ADL). The nutritional value was assessed by an *in vitro* gas production technique [3, 4]. For assessing the rate and extent of gas production, the gas volume was recorded at 3, 6, 9, 12, 18, 24, 36, 48, 60, 72, 84 and 96 h from the start of the incubation. The potential extent (b) and rate (c) of gas production were determined using a single pool exponential model [5]. Metabolizable energy (ME) and organic matter digestibility (OMD) were estimated from the resulting gas value [3].

The data were analysed by using simple ANOVA for a 3 x 3 factorial design study [6].

3. RESULTS AND DISCUSSION

3.1. Nutritional value of pasture grasses of the steppe zone

The chemical composition of different pasture grasses of the steppe zone, irrespective of the stage of maturity, revealed that CP content was similar (Table I), as also reported earlier for various types of pasture [7, 8]. The mixture of *Carex-Cleistogenes* (Cd–Cs) had a higher ($P < 0.05$) OM content, but lower ($P < 0.05$) cell wall constituents (CWC), except for ADL, compared to the other grasses. The CWC of the two grasses, *Carex* and *Artemisia*, were similar. In the three pastures of the steppe zone, ADL content was similar.

Although the cell wall content of *Carex-Cleistogenes* mixed pasture was low, the in vitro gas production was similar for the three samples. The OMD and estimated ME content were also similar.

3.2. Stage of maturity and nutritional value of pasture grasses of the steppe zone

Irrespective of plant species in the steppe zone, the OM and CP contents declined ($P < 0.05$) as the pasture matured (Table II). This confirms earlier work on Mongolian pastures [9].

TABLE I. COMPOSITION AND AVAILABILITY OF NUTRIENTS, OF PASTURE GRASSES (STEPPE ZONE), INDEPENDENT OF STAGE OF MATURITY

Parameter	*Cd	*Af	*Cd–Cs	Pooled SE
Chemical composition (g/kg dry matter [DM])				
Organic matter	858^{a}	887^{b}	898^{b}	9.0
Crude protein	146	141	146	6.0
Neutral detergent fibre	673^{b}	656^{b}	617^{a}	12.0
Acid detergent fibre	527^{b}	517^{b}	495^{a}	3.0
Hemicellulose	146	139	122	12.0
Cellulose	320^{b}	319^{b}	286^{a}	6.0
Acid detergent lignin	206	198	208	5.0
Total ash	142^{b}	113^{a}	102^{a}	9.09
Net gas produced, mL/96 h by 200 mg DM	44.6	44.4	42.1	1.3
Rate of gas production	0.047	0.054	0.058	0.004
Organic matter digestibility	0.57	0.59	0.57	1.6
Metabolizable energy (MJ/kg DM)	7.1	7.8	7.7	0.2

Values with different superscripts within a row differ significantly, *P* <0.05

*Af– *Artemisia frigida;* Cd– *Carex duriuscula;* Cs–*Ceistogenes squarrosa*

TABLE II. COMPOSITION AND AVAILABILITY OF NUTRIENTS, IRRESPECTIVE OF PASTURE SPECIES, AT DIFFERENT STAGES OF MATURITY (STEPPE ZONE)

Parameter	Flowering	Seeding	Dormant	Pooled SE
Chemical composition (g/kg dry matter [DM])				
Organic matter	899^{b}	887^{b}	856^{a}	9.0
Crude protein	178^{b}	164^{b}	92^{a}	6.0
Neutral detergent fibre	560^{a}	613^{b}	774^{c}	12.0
Acid detergent fibre	452^{a}	489^{b}	599^{c}	3.0
Hemicellulose	108^{a}	124^{a}	175^{b}	12.0
Cellulose	282^{a}	277^{a}	366^{b}	6.0
Acid detergent lignin	169^{a}	211^{b}	233^{c}	5.0
Ash	101^{a}	113^{a}	144^{b}	9.0
Net gas produced, mL/96 h	49.8^{b}	41.4^{a}	39.9^{a}	1.3
Rate of gas production	0.064^{b}	0.055^{b}	0.039^{a}	0.004
Organic matter digestibility	0.65^{c}	0.60^{b}	0.49^{a}	0.016
Metabolizable energy (MJ/kg DM)	8.8^{c}	7.8^{b}	6.0^{a}	0.2

Values with different superscripts within a row differ significantly, *P* <0.05

All the CWC contents increased (*P* <0.05) linearly with the maturity of pasture grasses, similar to trends reported earlier [10]. The increased lignification of pastures with maturity resulted in low (*P* <0.05) gas production at a slower rate. The OMD was also depressed (*P* <0.05) by increasing maturity of plants from the steppe zone, resulting in low (*P* <0.05) ME availability, as also reported earlier [11]. In an earlier study, the values for ME (MJ/kg DM) were 9.08 in the summer and 6.82 in the winter in the steppe, respectively, the corresponding values for the Gobi Region being 10.17 and 8.23 respectively [12].

In addition to the three pasture grasses of the Steppe zone, pasture-grass mixtures of *Artemisia-Cleistogenes, Elytrigia-Stipa* and *Cleistogenes*-forb, when evaluated during the flowering stage only, showed that *Cleistogenes*-forb had the highest (*P* <0.05) OM and CP content and the lowest (*P* <0.05) CWC, except for cellulose which was lowest in *Artemisia-Cleistogenes* pasture (Table III). The rates of gas production in *Cleistogenes*-forb and

Artemisia-Cleistogenes were comparable, but considerably higher, than that produced by the *Elytrigia-Stipa* mixture, though the net gas production was highest (P <0.05) in *Elytrigia-Stipa* mixtures. The higher (P <0.05) OMD of this pasture resulted in greater (P <0.05) availability of ME in this pasture mixture.

TABLE III. COMPOSITION AND AVAILABILITY OF NUTRIENTS OF PASTURE GRASSES (STEPPE ZONE), DURING FLOWERING STAGE

Parameter	*Af –Cs	*Er–Sk	*Cs–forb	Pooled SE
Chemical composition (g/kg dry matter [DM])				
Organic matter	843^{a}	928^{b}	923^{b}	1.8
Crude protein	164^{a}	184^{b}	192^{c}	1.7
Neutral detergent fibre	554^{b}	581^{c}	500^{a}	1.1
Acid detergent fibre	462^{a}	495^{b}	454^{a}	2.2
Hemicellulose	92^{b}	86^{b}	46^{a}	1.4
Cellulose	256^{a}	322^{c}	288^{b}	1.8
Acid detergent lignin	240^{c}	173^{b}	165^{a}	1.4
Ash	157^{b}	82^{a}	77^{a}	1.3
Net gas produced, mL/96h	43.2^{a}	53.2^{c}	44.5^{b}	0.19
Rate of gas production	0.064	0.056	0.062	0.003
Organic matter digestibility	0.63^{b}	0.64^{c}	$0,61^{a}$	0.002
ME, MJ/kg DM	7.9^{a}	8.8^{b}	8.3^{ab}	0.16

Values with different superscripts within a row differ significantly, P <0.05.
*Af– *Artemisia frigida;* Cs–*Ceistogenes squarrosa;* Er– *Elytrigia repens;* Sk– *Stipa krylovi*

3.3. Nutritional value of pasture grasses of the forest-steppe zone

The chemical composition of different grass species, or mixtures of them, in the forest-steppe zone, irrespective of stage of maturity, revealed that the *Stipa krylovii* pasture contained most (P <0.05) OM, NDF, hemi-cellulose and cellulose contents (Table IV) compared to other pastures, but the lowest (P <0.05) total ash and lignin contents. Amongst the three forages, *Festuca lenensis* had the lowest (P <0.05) CWC, except for ADL. The rate of *in vitro* gas production was lowest (P <0.05) in *Stipa krylovii,* but net gas production was higher (P <0.05) than that in the other two forages. The OMD and ME availability from all the pastures were similar.

3.4. Stage of maturity and nutritional value of pasture grasses from the forest-steppe zone

The effect of stage of maturity of pasture, irrespective of the plant species in the forest-steppe zone, on the chemical composition exhibited a similar trend to that observed in the steppe zone. The CP content declined (P <0.05) and the CWC increased (P <0.05) linearly with the maturity of the pasture (Table V).

The increased lignification with maturity, resulted in a lower (P <0.05) rate of gas production and net volume of gas produced. The OMD and ME availability were also depressed (P <0.05) with increasing maturity of the forages.

TABLE IV. COMPOSITION AND AVAILABILITY OF NUTRIENTS OF PASTURE GRASSES (FOREST-STEPPE ZONE), IRRESPECTIVE OF STAGE OF MATURITY

Parameter	*Pt	*Fl	*Sk	Pooled SE
Chemical composition (g/kg dry matter [DM])				
Organic matter	941[b]	918[a]	952[c]	3.0
Crude proein	108	90	94	8.0
Neutral detergent fibre	681[b]	616[ba]	728[c]	12.0
Acid detergent fibre	587[b]	527[a]	579[b]	8.0
Hemicellulose	94[a]	89[a]	149[b]	5.0
Cellulose	358[b]	321[a]	386[b]	9.0
Acid detergent lignin	228[b]	204[a]	193[a]	7.0
Ash	59[b]	82[c]	48[a]	3.0
Net gas produced, mL/96 h by 200 mg DM	39.5[a]	41.2[a]	46.9[b]	0.6
Rate of gas production	0.047[b]	0.047[b]	0.037[a]	0.002
Organic matter digestibility	49.3	49.7	51.3	1.2
Metabolizabe energy (MJ/kg DM)	6.8	6.9	7.3	0.2

Values with different superscripts within a row, differ significantly, P <0.05.
*Pt– *Puccinella tenitifrora;* Fl– *Festuca lenensis;* Sk– *Stipa krylovi*

TABLE V. AFFECT OF STAGE OF MATURITY, ON THE COMPOSITION AND NUTRIENT AVAILABILITY OF PASTURE GRASSES (FOREST-STEPPE ZONE)

Parameter	Flowering	Seeding	Dormant	Pooled SE
Chemical composition (g/kg dry matter [DM])				
Organic matter	938	933	940	3.0
Crude protein	132[c]	100[b]	60[a]	8.0
Neutral detergent fibre	608[a]	655[b]	762[c]	12.0
Acid detergent fibre	507[a]	557[b]	628[c]	8.0
Hemi-cellulose	101[a]	98[a]	134[b]	5.0
Cellulose	321[a]	341[a]	404[b]	9.0
Acid detergent lignin	186[a]	214[b]	224[b]	7.0
Ash	62	67	60	3.0
Net gas produced, mL/96 h	48.2[c]	40.9[b]	38.5[a]	0.6
Rate of gas production	0.051[b]	0.046[b]	0.035[a]	0.022
Organic matter digestibility	0.57[c]	0.51[b]	0.41[a]	0.012
Metabolizable energy (MJ/kg DM)	8.0[b]	7.4[b]	5.6[a]	0.2

Values with different superscripts within a row, differ significantly, P <0.05

In addition to the species discussed above, *Carex duriuscula* was evaluated during the flowering stage when grown either in mountain (Mm–Cd), riparian meadowland (Rm–Cd), or mixed with *Elytrigia repens* (Er–CD). The Mm–Cd had the highest (P <0.05) CP, NDF and hemi-cellulose contents. Lowest (P <0.05) CP, NDF and hemi-cellulose contents were observed in Er–Cd pastures (Table VI).

TABLE VI. CHEMICAL COMPOSITION OF PASTURES (FOREST-STEPPE ZONE), DURING THE FLOWERING STAGE (g/kg DRY MATTER)

Parameter	*Mm–Cd	*Rm–Cd	*Er–Cd	Pooled SE
Organic matter	912^{a}	934^{b}	907^{a}	1.7
Crude protein	204^{b}	162^{a}	163^{a}	1.1
Neutral detergent fibre	584^{c}	496^{b}	469^{a}	1.9
Acid detergent fibre	288^{a}	332^{c}	316^{b}	1.8
Hemicellulose	296^{c}	164^{b}	153^{a}	2.2
Cellulose	71	58	–	–
Acid detergent lignin	217	274	–	–
Ash	88^{b}	66^{a}	93^{b}	1.7

Values with different superscripts within a row, differ significantly, $P < 0.05$

*Mm–Mountain meadow's; Rm–Riparian meadow's; Er–*Elytrigia repens;* CD–*Carex duriuscula*

3.5. Interrelationship between CP, NDF, ADF, ADL and net gas production

The net gas production, OMD and ME availability were negatively correlated with ADL (–0.94, –0.71 and –0.83, respectively), ADF (–0.63, –0.93 and –0.90, respectively) and NDF (–0.52, –0.78 and –0.86, respectively) content of different pasture, irrespective of zone of origin (steppe or forest-steppe). The CP content of browses was positively correlated with potential gas production (r = 0.58) as also reported earlier [13, 14]. The negative effect of NDF on digestibility has also been reported earlier [15], although the extent of the negative effect of NDF, on gas production and digestibility was much higher in grass hay compared to alfalfa [15]. This demonstrates that the effect of NDF on fermentation becomes less important as the level of NDF declines.

4. CONCLUSIONS

From the proximate and *in vitro* analysis undertaken in this study, it can be concluded that all the species evaluated have some feeding value. Crude protein levels were considerably higher than those of crop residues, although crude protein in all species fell as the season advanced. This was associated with an increase in cell wall contents. While predictable, this change in nutritive value as the season advances does have implications where hay, made relatively late in the season, is a major forage source in the winter.

5. RECOMMENDATIONS

Field studies are now required on growing, managing, conserving and feeding the available forages, within the livestock systems of the two regions. There are also a number of practical management issues which need addressing by farmers, researchers and extension agents. These include:

- Regulating the number of animals and practicing controlled grazing well within the carrying capacity of these grazing areas

- Soil and water conservation for sustainable agriculture development needs promoting

- Low output degraded pastures should be regenerated through reseeding and the use of fertilizer

- Improved species of leguminous forages and grasses should be introduced: cultivated pastures fodder-lands with several combinations and rotations of selected grasses and legumes should be established as demonstration plots

- Existing pasture should be surveyed, their fertilizer requirements determined and promising grass species identified

- The system of grazing should be reviewed and adjusted to match the environment and the demands of the livestock system

- Obnoxious weeds should be controlled and the planting of fodder trees encouraged.

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THE ADVANTAGES OF USING NEW FEED RESOURCES FOR RUMINANT PRODUCTION IN MYANMAR

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Abstract

Locally available new feed resources were identified and evaluated in the laboratory. Protein content (g/kg DM) of the feeds was between 79 and 312. These feeds were evaluated in on-farm and field trials using nine indigenous female calves (Pya-Zein), aged between 12 and 15 months. The three diets given as a percentage of body weight (BW) were GHRSC (groundnut hay 2%, concentrate 1% and rice straw *ad libitum*), LBRSC (Lebbek 0.5%, concentrate 1% and rice straw *ad libitum*) and RSC (concentrate 1.5% and rice straw *ad libitum*). The highest daily live-weight gain (11.4 ± 0.49% of body weight, BW) and lowest live-weight gain (3.8 ± 0.41% of BW) were observed in the GHRSC and LBRSC groups respectively.

In the second trial, eight Friesian cross-bred cows were divided into two groups by age, parity, body condition score, stage of lactation and milk yield. Group I was fed *ad libitum* with sugar cane tops (SCT) and group II received *ad libitum* rice straw (RS). Concentrates were allocated according to milk yield. Dry matter intakes of groups I and II were similar. A slight decline in milk yield was observed in group II.

In the third trial, 12 dairy cows (Friesian cross-breds) were divided into two groups and offered either a diet expressed as a % of BW containing 2% of pea hay, 1% of concentrate and rice straw *ad libitum* (PRSC) or 1% concentrate and rice straw *ad libitum* (RSC). Daily milk yields for PRSC and RSC were 9.9 ± 4.63 and 9.5 ± 1.88 L/head/d respectively. The cost : benefit ratio of PRSC and RSC were 1 **:** 2.85 and 1 **:** 1.98 respectively.

Eighteen calves of 5 to 10 months were randomly divided into three groups of six and received one of the three diets. Dry matter intake (as a percentage of BW) of treatment A (*Leucaena* 0.5% + concentrate 0.5% and rice straw *ad libitum*), B (*Leucaena* 0.25% + concentrate 0.75% and rice straw *ad libitum*) and C (Concentrate 1% + rice straw *ad libitum*) were 2.0, 2 and 1.9 kg/d/calf respectively. Metabolic feed intakes for treatments A, B and C were 1.97, 1.96 and 1.95 kg/head/d respectively. Body weight changes were higher in treatment A and B than treatment C; 32 ± 3.35, 21.84 ± 5.86 and 18.5 ± 5.2 kg, (P >0.05) respectively. Daily live-weight gains for treatments A, B and C were 0.53, 0.36 and 0.31 kg/d respectively and the feed conversion ratios (FCR, kg DM/kg gain) were 4.6, 6.8 and 7.9 respectively. Cost : benefit ratios for three treatments were 1 **:** 12.1, 1 **:** 6.0 and 1 **:** 3.8.

1. INTRODUCTION

Dairy production is a major activity of smallholders both in rural and peri-urban parts of Myanmar. The peri-urban dairying is based on cross-breds of Zebu and exotic breeds of dairy cattle. The major forage for the animals during the dry seasons is rice straw and dry grasses supplemented with locally available fodder. However, ruminants are not able to maintain their normal live-weight when fed only rice straw [1, 2, 3]. There are number of plants and trees that should be evaluated as alternative feed resource in order to increase ruminant production.

In the central regions of Myanmar, when fodder is in short supply ruminants are fed on bamboo leaves, banana leaves, toddy shells, plum leaves, lebbek leaves and pods and groundnut hay. Best known to farmers and easily available are groundnut hay, sugar cane tops and *Leucaena,* which are established in central Myanmar. Groundnut hay is high in protein and energy, and is comparable to para grass [4]. Lebbek trees can be found along roadsides occasionally throughout Myanmar and ruminants feed on their leaves and pods. Sugar cane tops available throughout the sugar cane growing area, especially in central Myanmar are used as green fodder during the harvesting season [5, 6]. In 1997–98, five million tons of sugar cane were produced from 0.25 million acres [7]. Many varieties of peas are cultivated in central Myanmar. By-products and plant residues from many of these varieties are available for feeding livestock. Species of *Leucaena* are some of the most productive fodder for feeding ruminant in central areas of the country. *Leucaena* is a high protein forage and rich in digestible nutrients and is also a good source of many macro and micro-elements needed for ruminants [8, 9, 10, 11, 12]. Unfortunately, the leaves also contain mimosine, which causes toxicity in many animals if fed in excessive amounts. A maximum of 15% *Leucaena* leaf meal in ruminant rations is generally recommended to avoid this problem [13]. Where *Leucaena* is fed to unadapted stock at the rate of more than 30% of the total diet, the degraded products of mimosine may act as potent goitrogens and result in hyperthyroidism and death [14].

The objective of the present study was to study the possibility of using non-conventional feed resources, to reduce the cost of livestock production and enhance livestock productivity during periods of feed shortages.

2. MATERIALS AND METHODS

2.1. Laboratory evaluation of new feed resources

Starting in 1999, locally available plant species have been collected to identify as potential feed resources for ruminants. Those collected were subjected to chemical analysis [15].

2.2. Evaluation of some selected feed resources in on-farm and field trials

2.2.1. Experiment 1

The experiment was conducted at Yangon from February to May 2002. Female calves of the local Pya-Zein breed were used to evaluate three dietary treatments A, B, and C. Nine female calves aged between 12 and 15 months were randomly divided into three groups and allocated to diets in a 3 x 3 Latin square design trial. The diets contained mixtures of rice straw, peanut hay, kokko pod (Lebbek) and concentrate. Each experimental period consisted of a 10 days preliminary period and 20 days experimental period. The control group C was given concentrates at the rate of 1.5% body weight and rice straw *ad libitum* (RSC). Group A was given Lebbek at 0.5% of body weight, concentrate at 1% body weight and rice straw *ad libitum* (LBRSC). Group B was give groundnut hay at 2% of body weight, concentrate at 1% of body weight and rice straw *ad libitum* (GHRSC). Samples were analysed according to AOAC procedure [15]. All the data were statically analysed [16].

2.2.2. Experiment 2

The experiment was conducted at the Yangon, from March to April 2002. Ten cross-bred Friesian cows were divided into two homogenous groups in respect of age parity, body condition score, stage of lactation and milk yield. Group I was fed *ad libitum* sugar cane tops (SCT) and group II was fed *ad libitum* rice straw (RS). Concentrates supplementation for all cows was adjusted weekly and was based on the previous seven days average daily milk yield. Concentrate was fed according to the milk yield. Cows were milked twice a day. All the feedstuffs were chemically analysed [15]. Milk yields were recorded daily for three months. All data were statically analysed [16].

2.2.3. Experiment 3

The experiment was carried out in Sinkyone village, Tadau township, near Mandalay during March to May, 2003. Twelve Friesian cross-bred milking cows (second to forth parity; body weight ranging from 308 to 366 kg) were divided into two groups, A and B. Pea hay, concentrate (sesame cake 60% + pea bran 40%) and rice straw *ad libitum* were used in this experiment. Treatment A cows (PRSC) received pea hay at 2% of BW with concentrate at 1% of BW and rice straw *ad libitum* and group B cows (RSC) received concentrate at 2% of BW with rice straw *ad libitum*. The period of study was 90 days and feed intake, milk production and body weight changes were recorded. All feeds were chemically analysis [15] and data were statistically analysed [16].

2.2.4. Experiment 4

The trial was conducted on calves at Myabayin dairy farm, Kyaukse, near Mandalay, during July to September 2003. Eighteen calves (5 to 10 months old) were randomly divided into three treatment groups (A, B and C) giving six calves in each treatment. *Leucaena* foliage was air dried for 2–3 days and fed at the rate of 0.5% of body weight to group A calves with a concentrate (wheat bran and pea bran in a 3 : 1 mix) at the rate of 0.5% of BW. Group B calves received *Leucaena* at 0.25% of BW and concentrate at 0.75% of BW. Group C calves received the concentrate at 1% of BW. All animals received chopped rice straw *ad libitum* and animals were fed twice-a-day. The amount of foliage supplementation was adjusted weekly according to the live-weight of the animals. Animals were weighed at the start of the experiment and then weekly by estimation using a weigh band (Dalton Supplies Ltd. England). Daily feed intake was recorded. Duration of the experiment was 60 days. All feed samples were chemically analysed [15]. The design of experiment was a complete randomized block (CRD).

3. RESULTS

3.1. Laboratory evaluation of new feed resources

Crop residues are deficient in protein and hence protein becomes the most important characteristic of potential supplementary feeds for enhancing productivity. In the feeds evaluated crude protein ranged from 79.0 to 312.5 g/kg DM (Table I).

3.2. Evaluation of some selected feed resources in on-farm and field trial

3.2.1. Experiment 1

The DM contents of GHRSC, LBRSC and RSC were 887, 938 and 916 g/kg, respectively. The crude protein contents of the experimental diets were 93, 88 91 g/kg DM in diets GHRSC, LBRSC and RSC, respectively (Table II). Daily feed intakes per 100 kg body weight of animals are shown in Table III. The intakes of dry matter and crude protein of the group receiving Lebbek were lower compared to the others. Live-weight gain and feed efficiency are shown in Table IV.

TABLE I. DRY MATTER (DM, g/kg) AND CHEMICAL CONSTITUENTS (CRUDE PROTEIN [CP], CRUDE FIBRE [CF], ASH AND ETHER EXTRACT [EE], g/kg DM) OF LOCALLY AVAILABLE NON-CONVENTIONAL FEEDSTUFFS

Source	DM	CP	CF	Ash	EE
Bamboo leaves	453	127	231	118	41
Banana leaves	179	118	231	72	56
Banyan leaves	323	97	226	144	29
Brewery by product	203	250	200	64	80
Coconut cake	887	205	261	66	4
Cotton seed cake	893	230	56	66	55
Gliricidia	248	265	170	47	43
Groundnut hay	829	105	382	32	19
Jackfruit	366	140	221	115	–
Lebbek pod	817	151	118	46	46
Leucaena leucocephala	968	312	615	44	65
Neem	358	134	147	103	62
Pineapple fresh leaves	206	91	236	49	16
Pea-nut hay	803	149	315	63	27
Plum leaves	371	79	207	70	26
Pumpkin leaves	76	145	132	139	26
Sugar cane leaves and tops	57	373	319	61	22
Tamarind seed	906	144	80	35	60
Toddy soft shell	197	116	277	111	16
Water hyacinth	78	128	246	119	33

TABLE II. DRY MATTER (DM g/kg) AND CHEMICAL COMPOSITION (g/kg DM) OF FEEDSTUFF AND DIET (SEE TEXT FOR DETAILS)

Description	DM	CrudeProtein	Crude Fibre
Exp. 1:			
Rice straw	916	35	377
Groundnut hay	829	105	382
Lebbek pod	817	151	118
Concentrate*	918	224	130
GHRSC	887	93	331
LBRSC	938	881	296
RSC	911	91	305
Exp. 2:			
Sugar cane top	57	37	319
Rice straw	960	38	377
Concentrate	918	244	130
Exp. 3:			
Sesame cake	896	372	1.8
Pea hay	803	146	315
Exp. 4:			
Rice straw	912	50	320
Pea bran	901	182	159
Wheat bran	891	149	81
Leucaena leucocephala	968	312	62

*Concentrate = 40% groundnut cake, 35% rice bran and 25% broken rice

TABLE III. DAILY INTAKES OF DRY MATTER (DM), CRUDE PROTEIN (CP) AND CRUDE FIBRE (CF) (SEE TEXT FOR DETAILS)

Description	DM	CP	CF
GHRSC	4.2	0.4	1.4
LBRSC	3.2	0.3	0.9
RSC	4.1	0.4	1.3

TABLE IV. BODY WEIGHT CHANGES, DAILY LIVE-WEIGHT GAIN, MEAN VALUE OF DAILY DMI AND FEED EFFICIENCY

Exp. 1			
Description	GHRSC	LBRSC	RSC
Initial body weight (kg)	87.4 ± 18.62	88.7 ± 20.83	84.4 ± 11.86
Final body weight (kg)	98.5 ± 20.73	92.2 ± 21.73	94.5 ± 13.42
Body weight changes (kg)	11.1 ± 2.17	3.67 ± 0.98	10.1 ± 1.62
Days of measurement (d)	30	30	30
LW gain/d (kg)	0.4 ± 0.11	0.1 ± 0.03	0.3 ± 0.05
LW gain % body weight	11.4 ± 0.49	3.8 ± 0.41	10.7 ± 0.38
Feed conversion (DMI/LWG)	10.6	26.7	12.0
Exp. 2			
Description	Group I SCT+Conc.	Group II RS+Conc.	
Initial body weight (kg)	263	265	
Final body weight (kg)	259	262	
Body weight changes (kg)	–4	–3	
Days of measurement (d)	30	30	
LW changes/d (kg)	44.4	33.3	
LW changes % body weight	0.02	0.01	
Exp. 3			
Description	A (PRSC)	B (RSC)	
Body weight before experiment (kg)	363.5	359.8	
Body weight after experiment (kg)	349.2	341.8	
Dry matter intake (kg/head/d)	141 ± 2.35	13.7 ± 1.65	
Milk production (L/head/d)	9.9 ± 4.63	9.5 ± 1.88	
Exp. 4			
Description	A	B	C
Initial body weight (kg)	82	86.66	94
Final body weight (kg)	114	108.5	112.5
Body weight changes (kg)	32 ± 3.35	21.8 ± 5.86	18.5 ± 5.2
Days of measurement (d)	60	60	60
LWG /d (kg)	0.53	0.36	0.31
LWG (% body weight)	32.9	22.3	17.9
Dry matter intake (DMI) (kg/kg $^{0.75}$ W/d)	1.97	1.96	1.95
DMI % BW	2.0	2	1.9
Feed conversion (DMI : LWG)	4.6	6.8	7.9

3.2.2. *Experiment 2*

Chemical composition of the feed is shown in Table II and daily intakes are shown in Table V. The higher dry matter intake (DMI) of sugar cane tops compared to rice straw indicates its palatability. However, the average dry matter intake (kg per 100 kg BW) was similar for all groups. Daily live-weight changes were shown in Table IV. All animals lost weight. Milk yield was higher in cows receiving sugar cane tops compared to those cows receiving rice straw (Table IV).

3.2.3. Experiment 3

Dry matter intakes of animals in Treatment A (PRSC) and B (RSC) were 14.1 ± 2.35 and 13.7 ± 1.65 kg/head/d. Milk yield and live-weight change were presented in Table IV. Intakes and yield were similar for both treatment groups and both groups lost weight during the trial period.

3.2.4. Experiment 4

Results for this trial are given in Table IV. Intakes were similar for all treatments but animals in group A gained more weight than those in groups B and C. However, differences were not significant (*P >0.05*). The feed conversion ratio (FCR) was highest for treatment A and this diet was also the cheapest (Table IV and VI).

TABLE V. AVERAGE DRY MATTER INTAKE (DMI) DIFFERENT TREATMENT GROUPS

Treatment Group	DMI (kg)			Total DMI per head	Total DMI per 100 kg
	Sugar cane tops (SCT)	Rice straw (RS)	Concentrate (kg)	BW(kg)	
I	6.7	–	8.0	14.7	5.7
II	–	6.5	7.8	14.3	5.5

BW = body weight (average BW 260 kg)

TABLE VI. COST : BENEFIT RATIO FOR EACH TREATMENT IN EXPERIMENTS 3 [A, B] AND 4 [A, B, C]

Description	A	B	
Production cost (1 kyat/L/milk)	52.5	758	
Milk price (kyats/L)	150	150	
Cost and benefit ratio	1 : 2.9	1 : 2.0	
Description	**A**	**B**	**C**
Average feed cost (Kyats/calve/d)	39.6	54.5	72.0
LW gain (kg/calve/d)	0.5	0.4	0.3
Cost : benefit ratio	1 : 12.1	1 : 5.9	1 : 3.8

4. DISCUSSION

Myanmar has a wide diversity of trees and shrubs, which are rich in protein and minerals and can be used as a source of feed for ruminants especially in the dry season, when the available natural pasture and crop residues are of low nutritive value. The presence of anti-nutrients, in particular tannins in fodder trees and shrubs can limit animal performance. A number of technologies are available that can increase the use of foliage from trees and shrubs. Smallholder farmers need this knowledge so that they can exploit non-conventional and underutilized feed resources to increase ruminant productivity.

4.1. Experiment 1

The dry matter and crude protein content of groundnut hay used in this study, 829 g/kg and 105 g/kg DM respectively, were higher than reported elsewhere [17]. Dry matter intake of LBRSC was lower (*P* >0.05) than the other diets, possible because it contained less CP

(Fig. 1). However Lebbek pod may contain tannins, which protects dietary protein degradation. It may also restrict the availability of nitrogen for the rumen micro-organisms, thus resulting in low digestibility of fibre and intake [18]. Live-weight gain and feed conversion ratios are shown in Figures 2 and 3, respectively. Differences in live-weight gain were not significant ($P > 0.05$). Young legumes are more rapidly degraded by rumen micro-organism than more matured plants. In this study, the groundnut hay was old, having been harvested in the previous season. Therefore, protein in the groundnut hay used here may have degraded at a slower rate than anticipated. Although Lebbek contained more CP than rice straw and groundnut hay, the lowest dry matter intake and live-weight gain, and the highest feed conversion ratio (FCR) were associated with this forage.

4.2. Experiment 2

Sugar cane tops supported a higher milk yield than rice straw. Because of their higher yields, the cows on sugar cane tops also received more concentrates than those on rice straw. Milk production based on diets containing molasses or sugar cane has generally been associated with cows loosing weight and falling milk yields [5, 6], possibly because milk production has a high demand for glucose for lactose synthesis and by-pass protein for milk protein synthesis. In this experiment, the group I ration (sugar cane tops) provided more sucrose and by-pass protein than the group II (rice straw) ration. The diet containing sugar cane tops was also more palatable than the rice straw diet. In the first week of the trial some cows receiving sugar cane tops suffered from diarrhea resulting in low intakes, probably because the adaptation period to this diet was not long enough. Cows lost weight. Sugar cane tops could provide glucose for lactose synthesis needed by higher yielding cows making them a better alternative to cereal straw for milk production.

4.3. Experiment 3

Feed intakes for both treatments were similar and within the range predicted for lactating cows [19]. Moreover, dry matter intake of the cows was influenced considerably by the composition of the diet, method of feeding, timing and frequency of feeding [20]. Pea hay can replace part of the protein feeds during the dry season thus reducing feed costs without reducing milk yield. The cost : benefit ratio for group A and B were 1 : 2.9 and 1 : 2.0, respectively.

4.4. Experiment 4

The protein content of *Leucaena* leaves (312 g/kg DM) was higher in this study compared to the levels found in earlier reports; 140–300 g/kg DM [9], 283 g/kg DM [21] and 212 g/kg DM [22]. *Leucaena leucocephala* meal (LLM) is used as a protein supplement for high yielding cows with up to 60% passing through the rumen undegraded [9, 23]. Total DMI was similar in all three treatments but DMI expressed as a percentage of BW was lower for treatment C (Fig. 4). The FCR were lowest for the unsupplemented treatment C. Body weight change was higher in treatment A and B than in treatment C. These findings agree with those of previous reports in that *Leucaena* foliage promoted an increase in DM digestibility and DMI of fibrous crop residues thereby increasing growth rates [8, 24–27].

Leucaena content in the diet in this experiment ranged between 0.5% (A) and 0.3% (B) of body weight, well below the 0.8–1.2% of body weight regarded as necessary for optimal growth in young cattle on low quality diets [28]. Leucaena has been used as a source of by-pass protein [29]. The amount of the leucaena supplement will depend on the quality of the basal feed [30]. In this experiment, live-weight gain was between 0.4 and 0.53 kg/d for the group receiving *Leucaena* (Figs. 5 and 6). Elsewhere young steers grazing a *Leucaena*/*Nandi-Setaria* pasture, gained up to 1 kg/d during the main summer season, and when fed chopped sugar cane supplemented with *Leucaena* the gain was 0.6 kg/d [10, 31]. Feeding *Leucaena* increased the dry matter digestibility of fibrous crop residues in beef cattle [32].

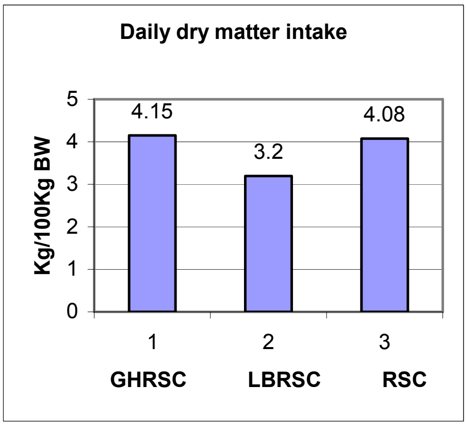

FIG. 1. Daily dry matter intake of dietary treatment.

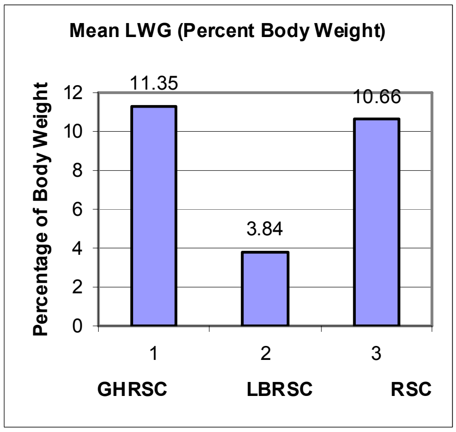

FIG. 2. Mean live weight gain of dietary treatment.

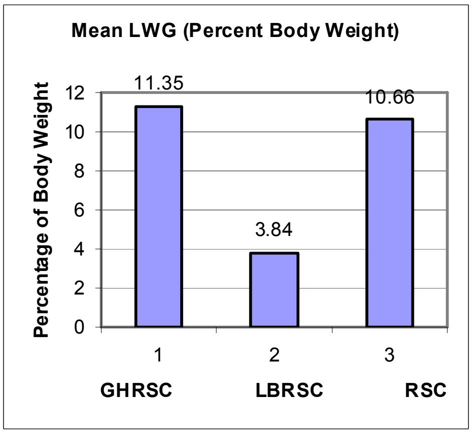

FIG. 3. Mean feed conversion ratio (FCR) of dietary treatment.

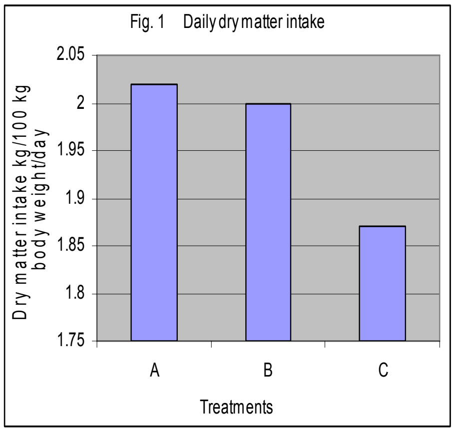

FIG. 4. Daily dry matter intake.

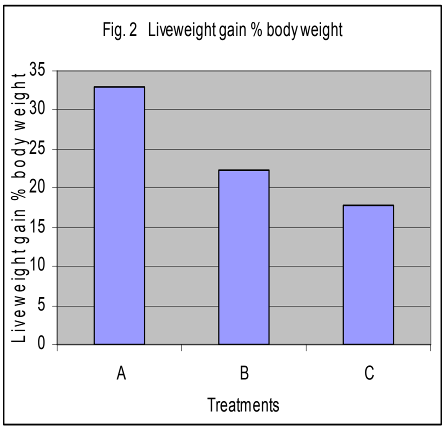

FIG. 5. Live weight gain (% body weight).

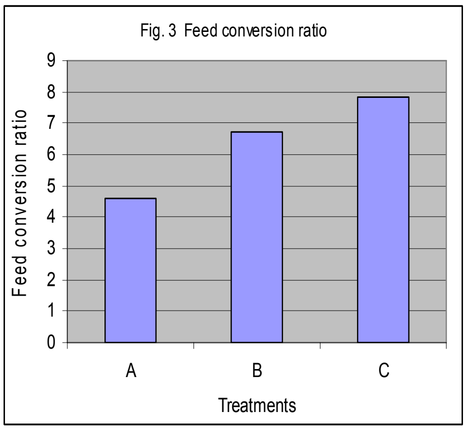

FIG. 5. Feed conversion ration.

5. CONCLUSIONS

It ahs been shown that feeds such as groundnut hay, pea hay and *leucaena* can be used as cheap protein sources in dairy calf rations based on rice straw in the dry season. Live-weight gain and feed conversion were particularly good when groundnut hay was included in the diet. Further investigations are necessary to find out the long term effects of feeding sugar cane tops on milk yield of cross-bred Friesian cows.

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UNCONVENTIONAL FEED RESOURCES FOR LIVESTOCK PRODUCTION IN PAKISTAN

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Abstract

Salinity is one of the major agricultural problems facing Pakistan. A biological approach has been developed whereby salt tolerant plants that are more suited to the environment have been grown. The green biomass thus produced could be used as a fodder for animal production. Since the plants that grow on such lands have not traditionally been used as forages it was necessary to evaluate their nutritional value. Studies were undertaken to identify and evaluate the nutritional quality of some conventional and non-conventional feed resources by using the *in vitro* gas production method. Chemical composition of the feeds was also determined. Estimated metabolizable energy (ME) values were found to be low in feeds with a high fibre and low protein content. These included some grasses and crop residues. Low ME values were found in wheat straw (5.10 MJ/kg dry matter [DM]) and *Acacia* leaves (7.09 MJ/kg DM). Concentrate feeds such as cottonseed meal, sunflower meal, cottonseed cake, rice polishings and rapeseed meal have higher ME values (12.44–9.27 MJ/kg DM). The difference in ME of the feeds evaluated reflected differences in concentrations of fermentable carbohydrates and available N. Among the non-conventional feeds evaluated, *Acacia ampliceps*, *A. nilotica*, *Sesbania aculeate*, *Leptochloa fusca* and *Prosopis juliflora* were judged to be potential fodders. The *in vitro* gas production method showed its potential for rapid screening and ranking of ruminant feeds.

1. INTRODUCTION

Salinity is one of the major agricultural problems facing Pakistan, with about 6.0 million ha of land being affected. The Nuclear Institute for Agriculture and Biology (NIAB) has developed a biological approach to the problem, by identifying plants adapted to a saline environment, thus increasing the amount of forage available for animal production. Because the species identified are not regarded as conventional forages, and little is known about them, an evaluation study has been necessary. *In vivo* feeding and digestibility studies are expensive and require sophisticated resources; therefore, laboratory analysis and an *in vitro* gas production technique were employed [1, 2, 3]. The feeds evaluated included tree leaves, grasses, crop residues and concentrates.

2. MATERIALS AND METHODS

Samples of various feeds, including wild grasses, cultivated fodders, by-products, crop residues and browse plants, used for feeding ruminants were selected for nutritional evaluation. All the roughages were cut into small pieces to facilitate easy handling and uniform sampling for analysis. Samples were dried, ground through a 1 mm sieve and stored at room temperature to await analysis.

2.1. Chemical analysis

The dry matter (DM) content of the feeds was determined. The feeds were then analysed for crude protein (CP), neutral detergent fibre (NDF), acid detergent fibre (ADF), ether extract (EE) and ash, using standard methods [4]. Nitrogen free extract (NFE) was determined by difference.

2.2. *In vitro* gas studies

Rumen fluid, including the particulate fraction, was collected from two cattle (Sahiwal breed) fed a conventional diet including forage sorghum. The rumen fluid was collected into a pre-warmed thermos flask filled with CO_2, transferred to the laboratory, homogenized in a laboratory blender, and filtered through cheese-cloth. All laboratory procedures involving the rumen fluid were carried out under continuous flushing of the fluid with CO_2.

A dry sample of feed, weighing 200 mg and ground to pass through 1 mm sieve, was placed in a small polypropylene spoon, which was fixed to a glass rod with a rubber adapter, to place the sample at the closed end of the syringe. Each sample was replicated in triplicate. Every batch of samples incubated included three blanks, three replicates of a standard reference concentrate and three replicates of standard reference forage. The syringes were placed in an incubator, at 39^{o}C, to await addition of the medium. The medium was prepared and placed in a water bath, at 39^{o}C, and CO_2 bubbled slowly through for 15 to 20 min. A total of 30 mL medium, consisting of 10 mL rumen fluid and 20 mL of a bicarbonate-mineral-distilled water solution was injected into each syringe through the silicon tube. After removal of gas bubbles the tubes were closed with clamps. The gas produced was recorded after 24 h of incubation. After termination of the incubation, contents of the syringes were emptied quantitatively in a refluxing beaker, washed with two 20-mL portions of neutral detergent solution (NDS) and digested for one hour. Then the contents were filtered and washed with hot water and transferred into crucibles. The crucibles were dried overnight and weighed after cooling in a desiccator. The crucibles containing the residue were transferred to a muffle furnace to ash the sample. After determining the weight of ash, the organic matter content was calculated.

Using the chemical composition and net gas production (corrected for the blanks and the appropriate reference standard) after 24 h incubation, digestibility of organic matter (DOM %) and metabolizable energy (ME, MJ/kg DM) were calculated using the following mathematical equations [2, 5].

(1) For Compound feed (Cereals and by-products)

$$DOM\ \% = 9 + 0.9991GP + 0.0595CP + 0.0181Ash$$
$$ME = 1.06 + 0.1570GP + 0.0084CP + 0.0022EE – 0.0081Ash$$

(2) For Roughages (forages and straws) and by-products

$$DOM\ \% = 16.49 + 0.9042GP + 0.0492CP + 0.0387Ash$$
$$ME = 2.20 +0.1357GP + 0.0057CP + 0.0002859EE$$

Gas production (GP) (mL/200 mg DM) after 24 h incubation; CP, EE and Ash as g/kg DM.

3. RESULTS

Chemical composition and ME for the feeds evaluated are given in Tables I–IV. Dry matter content of grasses, tree leaves and green fodders varied from 140.8 g/kg in maize to 604.3 g/kg in *Acacia,* and in compound or concentrate feeds it varied from 823 g/kg in molasses to 929 g/kg in maize gluten. Crude protein content ranged from 40.2 g/kg (sorghum) to 205.6 g/kg (*Sesbania*).

TABLE I. DRY MATTER (DM, g/kg) AND CHEMICAL COMPOSITION (g/kg DM) OF GRASSES

Description of Samples	DM	OM	NDF – ADF	CP	EE	ME (MJ/kg, DM)
Wild grass	476.0	94.8	283.5	98	14	7.29
Leptochloa fusca	312.7	107.4	249.7	80	17	6.75
Brecharia grass	340.3	91.2	284.3	65	15.3	6.4
Cynodon grass	561.5	136.5	268.1	92	22.2	6.4
Mot grass	319.4	140.2	285.4	57	18	6.0
Trienthema	156.7	235.6	205.0	146	25.6	8.8

OM = organic matter; NDF = neutral detergent fibre; ADF = acid detergent fibre; CP = crude protein; EE = ether extract; ME = metabolzable energy

TABLE II. DRY MATTER (DM, g/kg) AND CHEMICAL COMPOSITION (g/kg DM) OF TREES

Description of Samples	DM	OM	NDF – ADF	CP	EE	ME (MJ/kg, DM)
Iple iple	384.1	84.2	157.0	199	42.8	8.7
Kochia indica	195.0	228.8	194.8	116	14.8	6.4
Lana	335.6	385.1	137.9	170	11.2	4.7
Azadirachta indica leaves	332.8	78.5	147.8	122	26.4	6.8
Acacia ampliceps	220.3	207.2	196.4	103	32.5	7.3
Eucalyptus	353.0	60.0	176.4	99	36.0	5.8
A. nilotica	604.3	73.8	158.2	146	30.0	7.1
Eugenia Leaves	404.7	79.0	157.3	75	21.0	4.9
Zizyphus leaves	563.1	85.1	151.8	125	13.9	6.2

OM = organic matter; NDF = neutral detergent fibre; ADF = acid detergent fibre; CP = crude protein; EE = ether extract; ME = metabolzable energy

Crude protein in concentrate feedstuffs ranged from 383 g/kg (sunflower meal) to 124 g/kg (rice polishing) (Table V). The lowest CP values were found in molasses (30 g/kg) and wheat straw (26 g/kg). Organic matter (OM), CF, EE and NFE contents for roughages were 60 g/kg–385.1 g/kg, 137.9 g/kg–351.8 g/kg, 10.5 g/kg–48 g/kg and 295.2 g/kg–667.4 g/kg, respectively; in concentrate feedstuffs the corresponding values were 56.9 g/kg–283.9 g/kg, 13 g/kg–413.1 g/kg, 10.4 g/kg–159.0g/kg and 238.0 g/kg–863.3g/kg, respectively.

TABLE III. DRY MATTER (g/kg) AND CHEMICAL COMPOSITION (g/kg DM) OF FODDERS

Description of Samples	DM	OM	NDF–ADF	CP	EE	ME (MJ/kg, DM)
Sugar cane tops	378.7	95.3	258.6	67	13.4	5.9
Sorghum	287.6	68.4	283.4	46	16	9.9
Sesbania aculeata	172.1	108.4	169.8	205	48	8.0
Maize 1	140.8	128.5	246.6	140	25.9	8.0
Maize 2	254.8	95.6	282	85	21	9.3
Cotton	274.7	189.7	177.8	138	27.8	7.4
Echino chloa	292.6	134	257.5	156	28.4	6.8
Phragmites	315.7	126.0	341.3	149	21.7	6.6
Sada Bahar 629/2002	288.0	88.9	299.5	40	10.5	8.2
Sada Bahar 637/2002	–	109.1	316.5	61	14.5	7.0
Sada Bahar 638/2002	–	121.6	343.6	75	17	8.2
Sada Bahar 639/2002	–	129.3	351.8	93	18.6	8.4
Sada Bahar 640/2002	–	132.6	341.3	66	16.4	7.8

OM = organic matter; NDF = neutral detergent fibre; ADF = acid detergent fibre; CP = crude protein; EE = ether extract; ME = metabolzable energy

TABLE IV. DRY MATTER (DM), CHEMICAL COMPOSITION (g/kg DM) AND METABOLIZABLE ENERGY (ME) OF GRASSES, TREE LEAVES AND SOME FODDERS INTRODUCED ON-FARM AS FEEDS

Description of Samples	DM	OM	NDF – ADF	CP	EE	NFE	ME (MJ/kg, DM)
Iple iple	384.1	84.2	157	199	42.8	516.8	8.7
Kochia indica	195	228.8	194.8	116	14.8	445.7	6.4
Lana	335.6	385.1	137.9	170	11.2	295.2	4.7
Acacia ampliceps	220.3	207.2	196.4	103	32.5	461.1	7.3
A. nilotica	604.3	73.8	158.2	146	30	591.4	7.1
Wild Grass	476.0	94.8	283.5	98	14	509.7	7.3
Leptochloa fusca	312.7	107.4	249.7	80	17	545.4	6.8
Brecharia grass	340.3	91.2	284.3	65	15.3	544	6.5
Mot grass	319.4	140.2	285.4	57	18	–	6.0
Eucalyptus	353	60	176.4	99	36	628.7	5.8
Sugar cane tops	378.7	95.3	258.6	67	13.4	565.8	–
Sorghum	287.6	68.4	283.4	46	16	586.3	10
Sesbania aculeata	172.1	108.4	169.8	205	48	468.2	7.9

* OM = organic matter; NDF = neutral detergent fibre; ADF = acid detergent fibre; CP = crude protein; EE = ether extract; ME = metabolzable energy

Gross energy, ME and digestibility values for the salt tolerant plants are shown in Table VI. Among these, *A. ampliceps* and *Sesbania* followed by Lana, Iple iple, *A. nilotica*, Kochia and Mot grass were considered to have the potential to be used as feeds. Gas production at 24 h ranged from 12.53 mL in Lana to 69.50 mL in *Sesbania*.

TABLE V. DRY MATTER (DM, g/kg) AND CHEMICAL COMPOSITION (g/kg DM) OF CONCENTRATE FEEDS

Description of Samples	DM	OM	NDF – ADF	CP	EE	ME (MJ/kg, DM)
(UMMB)Block	903	283.9	99.1	314.6	10.4	9.1
Sunflower Meal	895	61	137	383	77	9.3
Rape seed meal	930	83.9	116.1	371.0	81.7	9.8
Maize Gluten	929	78	13	219	70	9.1
Wheat Straw	928	122	413.1	26	11.8	5.1
Cotton Seed Cake	925	60	223	211	85	7.8
Rice Polish	926	117.6	41.6	124	159	–
Wheat bran	914	56.9	124.7	150	42.7	–
Cotton Seed Meal	863	81.6	122.2	343.2	40.5	9.8
Molasses	823	103.3	–	30.4	–	–

OM = organic matter; NDF = neutral detergent fibre; ADF = acid detergent fibre; CP = crude protein; EE = ether extract; ME = metabolzable energy

TABLE VI. ENERGY CONTENTS OF SALT TOLERANT PLANTS USED AS FODDER FOR GOAT AND SHEEP REARING AT BSRS–II, PACCA ANNA

Salt tolerant plants	Gross energy (MJ/kg, DM)	Metabolizable energy (MJ/kg, DM)	Digestibility (g/kg)
Iple iple	22.66	8.71	596.5
Prosopis juliflora	20.56	7.29	467.0
Leptochloa fusca	20.24	6.75	330.5
Kochia Indica	17.61	6.41	404.5
Lana	13.93	4.70	584.7
Acacia ampliceps	18.04	7.26	713.5
Popular	23.32	5.85	369.0
Bracharia	29.29	6.44	–
A. nilotica	25.76	7.09	589.0
Mot grass	19.66	6.02	482.0
Sesbania aculeata	22.34	7.96	700.0
Sorghum	21.59	9.91	473.0
Wheat straw (treated with urea)	16.26	6.86	359.5

4. DISCUSSION

The nutrient composition of many of the feeds tested is within the range of reported values for similar feeds [6]. Dry matter and CP contents varied widely. Factors contributing to this variation included differences in climate, application rate and time of applying of N fertilizer, time of harvest, ensiling or field drying procedures and storage. Dry matter content of Italian rye grass has been reported as varying between188 g/kg and 755 g/kg [7].

Predicted ME values were low in feeds having high fibre and low protein contents. These included some grasses and crop residues. The lowest ME values were estimated for wheat straw [8] and *Acacia* leaves. These forages are deficient in fermentable carbohydrates, reflected by the relatively low organic matter digestibility [9]. Chemical treatment, with alkali, including urea, of crop residues has been shown to increase their value as feeds [10]. While fermentable carbohydrates increase gas production, degradable N compounds added to fibre-rich feeds have been found to decrease it, due to improved capturing of nutrients and increased production of microbial protein. The carbon source is diverted from gas and short chain fatty acid production to microbial protein. [2].

Although the estimated ME values were within the range of values reported for a large number of feedstuffs [11, 12], some feeds showed a significant variation in ME values, e.g. individual varieties of sorghum ranged from 7.01 to 9.92 MJ/kg DM, possibly, in part, due to differences between farms from which they were collected. However, some of the differences in the predicted ME values are difficult to explain. The low ME content of fresh maize fodder, in comparison to mature maize, may be attributable to the early stage of harvest, before the cobs were formed.

With few exceptions, the energy values and rate of organic matter fermentation calculated from *in vitro* gas production appear comparable to values quoted in the literature. Most of the feeds evaluated are fed to sheep and goats. The plants identified as saline-tolerant have now being promoted to smallholders by extension agencies, including the Saline Agriculture Farmer Participatory Development Project (SAFPDP, a government funded project).

5. CONCLUSIONS

In vitro studies have enabled identification and evaluation of new and non-conventional plants as feed resources, suitable for growing in marginal and poor saline soils in the wastelands of Pakistan. Those plants, which performed well *in vitro* studies will be recommended and tested on-farm. The *in vitro* gas production technique is suitable for screening and ranking, at low cost, large numbers of feed samples.

6. RECOMMENDATIONS FOR FUTURE WORK

Seminars and training workshops are necessary to introduce farmers to the new forages and the necessary techniques for growing and utilizing them.

Depending on the interest of farmers in using the forages, pilot farms will be established to train them in planting nurseries, raising the crops and harvesting techniques. Farmers also need instruction in the feeding of the forages to ruminants. The forage species initially selected are *Acacia ampliceps*, *Sesbania aculeate*, *Atriplex lantiformis, Kochia indica, Leptochloa fusca* and *Prosopis juliflora.*

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EVALUATION OF LESSER-KNOWN AND LESSER-UTILIZED FEED RESOURCES IN THE PHILIPPINES

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Abstract

A study on lesser-known and lesser-utilized feed resources in the Philippines was conducted to evaluate the nutritive contents, *in vitro* digestibility using the gas production technique, and tannin contents**.** With knowledge of the tannin levels and management of the anti-nutritional components, these tanniniferous plants can be better utilized as ruminant feeds. The trees sampled were *Premna odorata, Moringa oleifera, Erythrina variegata, Gliricidia sepium, Pterocarpus indicus, Spondia purpurea, Artocarpus heterophyllus, Ficus nota, Flamengia vestita, Ipomoea aquatic, Sesbania grandiflora, Muntingia calabura, Artocarpus blancoi, Cocus nucifera, Sandoricum koetjape, Psidium guajava* and *Erythrina variegata.* The shrubs were *Desmodium intortum* and *Centrocema nucifer.* For agricultural by-products, samples of leaves of *Musa sapientum, Ipomoea aquatica, Manihot esculenta* and *cocos nucifera* were collected. The crude protein contents of tree leaves and shrubs were high, ranging from 140 to 310 g/kg dry matter (DM). Total phenols, total tannin and condensed tannins ranged from 1.8 to 16.4%, 0.4 to 8.2% and 0.03 to 9.3% respectively. The *in vitro* gas test was used as an indicator of short-chain fatty acid (SCFA) production as the gas production is substantially the result of fermentation of carbohydrates to acetate, propionate and butyrate, which is an indicator of the energy available to the animal.

An on-farm study of dry season (March–April) supplementation of cows in their 4^{th} to 5^{th} month of lactation using the combination of *Erythrina variegata, Gliricidia sepium* and *Premna odorata* at about 3–5 kg/d, in addition to the regular ration of cut-and-carry forages (20–25 kg/head/d), showed a higher average daily milk yield of 8.7 kg/d and a higher milk fat content of 41 g/kg. In the control group, the average milk yield was 7.7 kg with 31 g/kg milk fat content.

1. INTRODUCTION

The limited supply and low quality of locally available feed resources are the major constraints to livestock production by smallholder farmers. One of the limitations in the use of forage from trees and shrubs is the presence of bioactive groups of compounds such as phenolics, particularly tannins, which protect the proteins of plants from breakdown in the rumen [1].

Tanniniferous trees and shrubs are of importance to animal production because they can provide significant amounts of protein, but its concentration varies widely and unpredictably, and their effects on animals range from the beneficial through to toxicity and death [2]. The toxic and anti-nutritional effects tend to occur when a large proportion of the diet comprises tanniniferous material. The tannin content of tree leaves, shrubs and some agricultural wastes were determined, using appropriate techniques based on their chemical properties or their capability to bind substrates [2]. With knowledge of the tannin levels and management of the anti-nutritional components, these tanniniferous plants can be better utilized as ruminant feeds. The project has evaluated some of the plant species available.

2. MATERIALS AND METHODS

2.1. Identification of potential trees and shrubs

Dairy farmers in the Southern Tagalog district of the Philippines were asked to identify fodder trees, shrubs and agricultural by-products consumed by cattle in their area. Selected species were then collected for *in vitro* digestibility determination and tannin analysis. The trees sampled were *Premna odorata, Moringa oleifera, Erythrina variegata, Gliricidia sepium, Pterocarpus indicus, Spondia purpurea, Artocarpus heterophyllus, Ficus nota, Flamengia vestita, Ipomoea aquatic, Sesbania grandiflora, Muntingia calabura, Artocarpus blancoi, Cocus nucifera, Sandoricum koetjape, Psidium guajava* and *Erythrina variegata.* The shrubs were *Desmodium intortum* and *Centrocema nucifer.* For agricultural by-products, samples of leaves of *Musa sapientum, Ipomoea aquatica, Manihot esculenta* and *cocos nucifera* were collected.

2.2. Sampling

Sampling of mature leaves of the selected trees and shrubs was carried out every time the research team went into the field. These trees and shrubs grow naturally in the area and samples were collected from trees that were about 2–3 years old. The sampling procedure was similar to that used for the cut-and-carry system of harvesting forages for confined animals. The samples were placed in individually labeled sacks and transported to the laboratory. Larger leaves were cut into smaller pieces. The samples were air dried for about a day and finally dried in a forced-air convection oven at 50^{o}C.

2.2.1. Grinding of samples

About 500 g of oven-dried sample was ground in a Wiley standard bench laboratory Mill (Labline Instuments, Inc., Austria), through a 2 mm screen. Part of the resulting ground material was then ground through a 1 mm screen and stored to measure gas production, fibre content and for proximate analysis. The remaining material was ground through a 0.5 mm screen and stored prior to tannin analysis.

2.2.2. Dry matter (DM) determination

Five g of the air-dried material was dried at 104^{o}C until constant weight was achieved.

2.2.3. 2.2.3. Ash determination

Two g of the sample of dried and ground material, in a porcelain crucible, was placed in a temperature controlled furnace, preheated to 600^{o}C, for four hours. The residue was regarded as ash.

2.2.4. 2.2.4. Crude protein (CP) determination

The Kjeldahl method of nitrogen determination was used to determine crude protein. One g of sample was digested, with concentrated sulphuric acid, with a Kjeltabs (3.5 g potassium sulfate and 3.5 mg selenium) catalyst for 4–6 h, using a kjeldahl digestion unit. The digested samples were distilled using the Buchi distilling instrument. Ammonia was quantified by titration with standard hydrochloric acid.

2.3. *In vitro* gas technique

Triplicate samples (approx. 200 mg to 500 mg of sample) were weighed and placed at the bottom of the 100 mL calibrated syringes. The piston, greased with vaseline, was pushed into the calibrated syringes.

Rumen fluid from goats was collected from a slaughter house close to the laboratory. Collection, from the rumen, was directly after slaughter. The rumen fluid was placed in a bucket, pre-heated to 39°C and filled with CO_2 gas, homogenized, filtered through cheesecloth, and mixed with the buffer solution. The resulting solution was then added to the syringes which were placed in a water bath maintained at 39°C [5, 6]. Gas volumes were recorded after 2, 4, 8, 12, 24 and 72 h of incubation. The gas production data (mean of triplicate runs) were fitted to an exponential equation [7, 8], using the Neway/Naway software.

2.3.1. In vitro gas technique to measure true substrate degraded, microbial biomass production and partitioning factor

To measure *in vitro* gas production the sample weight was increased from 200 mg to 500 mg and the incubation volume was increased from 30mL to 40mL [5], thereby doubling the volume of the bicarbonate buffer [9, 10, 11]. Truly digested substrate and microbial mass were determined [11, 12]. For tannin rich samples, 500 mg was incubated in the absence and presence of polyethylene glycol (PEG) 6000 as described by [13]. After 24 h incubation, gas production was recorded. For the determination of true digestibility, the contents were transferred into a 600 mL beaker and the syringes were washed twice with neutral detergent solution [14] and emptied into the beaker. The contents were refluxed for 1 h and filtered through a crucible. True degradability was calculated as the weight of substrate incubated minus the weight of the residue after the neutral detergent solution (NDS) treatment. The ratio of substrate degraded (mg): gas volume (mL), termed as the partitioning factor [12], was calculated using the measured gas volume and true degraded substrate after the 24 h incubation of the feeds.

The microbial mass production was estimated after the 24 h incubation period. Gas volume at the end of the incubation period was recorded. The contents of the syringe were emptied quantitatively into the beaker, and digested for 1 h with neutral detergent solution (to solubilize the microbes and obtain only undegraded feed). The undigested feed was filtered through a Gooch crucible, number 2. The crucible with sample was dried in an oven at 100°C overnight to a constant weight. The feed that remained in the crucible gave the weight of the undegraded feed (x) in that particular syringe/sample. The crucible containing the residue was transferred into a muffle furnace and ashed. The weight of ash (y) was obtained and subtracted from the weight of residue. Microbial mass production was obtained using the formula:

$$\text{microbial mass production (mg)} = (x-y) - 2.2 \text{ net gas in mL}$$

2.4. Extraction of tannin

Tannins, which are naturally occurring polyphenolic compounds of high molecular weight, were extracted from plant material using either 70% aqueous acetone or 50% methanol prior to determination of tannin content.

The 70% aqueous acetone was used as extracting solvent for the determination of total phenolics, total tannins and condensed tannins in plant samples, except for the protein precipitable phenolics and protein precipitation assays. In these two last assays 50% methanol was used since acetone interferes with the process of complex formation. The tannin contents of the samples were then extracted [15, 16].

2.5. Tannin assays

Standard tannic acid solutions (1 mg/mL 70% acetone) were prepared using tannic acid (Merck). This solution was diluted by a factor of 10 with distilled water and was used for the generation of a standard curve for total phenol and total tannin assay. The tannin concentration in the samples was calculated using the standard tannic acid solution.

2.5.1. Total phenolics

Total phenolics were determined by the Folin-Ciocalteau method [16]. Results were expressed as tannic acid equivalent.

2.5.2. Total tannins

Total tannins were determined as the difference between total phenolics before and after polyvinylpolypyrrolidone (PVPP) treatment of plant extract. The supernatant (free of tannins) from PVPP treated extract (500 µl) was determined using the Folin-Ciocalteau assay [16] and the solution was measured using the spectrophotometer at 725 nm.

2.5.3. Condensed tannin

Condensed tannins were measured using the butanol-HCl-iron metod described by [16, 17]. The method is based on acid catalyzed oxidative depolymerization of condensed tannin into anthocyanidins. Results were expressed as per cent leucocyanidin equivalent.

2.5.4. Protein precipitation capacity

The plant extract in 50% methanol was used in the assay. The protein precipitable phenolic (tannin) was measured [16]. The bovine serum albumin fraction (BSA) was used as protein in the assay. The slope of the linear regression between BSA precipitated and mg sample in the aliquot was taken to be the protein precipitation capacity of the sample.

2.5.5. Tannin bioassay

After collection, the rumen liqueur was placed in pre-heated water bath until needed. The rumen liquor and the buffer solution were added to the samples, which were then incubated in the presence or absence of polyethylene glycol (PEG, MW 6000) [18]. Incubations were carried out in 40 mL buffered rumen fluid in a water bath at 39^{o}C. Gas production was recorded at 2 h intervals. The incubation was terminated after 24 h. Tannin activity was calculated as the percentage increase in gas produced by PEG

2.6. Supplementation of dairy cows

A short term on-farm dry season supplementation study was conducted for two months to determine the production of 12 Holstein-Friesian-Sahiwal dairy cows. The cows were in the fourth and fifth months of their third lactation. Six of the cows were offered a supplement comprising a combination of *Premna odorata*, *Erythrina variagata* and *Gliricidia sepium* at 3–5 kg/d, in addition to the regular ration of cut-and-carry forages (20-25 kg/head/d) consisting of cultivated and natural grasses. They also received UMMB. The remaining six cows did not receive the supplement of tree fodders. Live weights and body condition scores were measured twice a month. Daily milk yield and milk fat contents were also monitored.

3. RESULTS

The chemical composition of forages given by the backyard dairy farmers in Sariaya, Quezon is shown in Table I. Crude protein ranged from 140 g/kg DM to 310 g/kg DM and ash content from 50 g/kg DM to 160 g/kg DM. Tannin levels as total phenolics, total tannin and condensed tannin of tree and shrub leaves and agricultural by-products are presented in Table II.

TABLE I. DRY MATTER (DM, g/kg) AND CHEMICAL COMPOSITION (g/kg DM) OF TREE AND SHRUB LEAVES

Common Name	*Scientific Name*	*Dry Matter*	*Crude Protein*	*Ash*
Alagao	*Premna odorata*	900	150	110
Malungay	*Moringa oleifera*	900	260	110
Kakawate	*Gliricidia sepum*	910	220	100
Dapdap	*Erythrina variegata*	890	150	120
Desmodium	*Desmodium intortum*	910	180	120
Centrocema	*Centrocema nucifera*	910	260	120
Flamengia	*Flamengia vestita*	900	150	50
Narra	*Pterocarpu sindicus*	920	210	80
Siniguelas	*Spondias purpurea*	940	260	120
Kangkong Stem	*Ipomea aquatica*	900	290	120
Langka	*Artocarpus heterophyllus*	890	140	160
Tibig	*Ficus nota*	900	140	60
Katuray	*Sesbania grandiflora*	880	310	90

TABLE II. TANNIN LEVELS AS TOTAL PHENOLICS, TOTAL TANNINS AND CONDENSED TANNIN OF TREE AND SHRUB LEAVES AND AGRICULTURAL BY-PRODUCTS IN SARIAYA, QUEZON

Sample Name	Total phenol (% tannic acid equivalent)	Total tannin (% tannic acid equivalent)	Condensed Tannin (% leucocyanidin equivalent)
Musa sapientum	2.0	0.5	0.9
Manihot esculenta	6.7	4.2	0.8
Centrocema pubescens	3.0	1.0	0.5
Premna odorata	3.2	1.2	0.3
Muntingia calabura	9.0	5.4	0.1
Artocarpus blancoi	3.4	3.0	2.3
Cocos nucifera	6.1	4.5	3.6
Sandoricum koetjape	16.4	8.2	9.3
Moringa oleifera	3.7	1.3	0.1
Spondias purpurea	1.8	0.8	0.1
Ficus nota	3.1	1.6	1.1
Psidium guajava	14.9	7.4	1.6
Erythrina variagata	2.2	0.4	0.1
Desmodium intortum	3.2	2.2	0.2
Gliricidia sepium	3.0	1.6	0.2
Artocarpus heterophyllus	8.4	2.5	3.7
Flamengia vestita	6.0	3.2	1.1
Sesbania grandiflora	4.0	2.2	0.3
Ipomea aquatica	2.8	1.4	0.0

Protein precipitation capacity in relation to the per cent increase in gas production of forages is shown in Table III. *In vitro* gas production, microbial biomass production, true substrate degradability, and partitioning factor are shown in Table IV.

TABLE III. PROTEIN PRECIPITATION CAPACITY AND TANNIN ACTIVITY OF FORAGE SAMPLES IN SARIAYA, QUEZON

Sample Name	Protein precipitation capacity (µg BSA precipitated/mg leaf DM	Tannin activity (% increase in gas production
Cocos nucifera	14.2	38.6
Psidium guajava	42.1	69.7
Ficus ulmnifofia	ND	nil
Centrocema nucifera	ND	nil
Sandoricum koetjape	29.4	42.8
Musa sapientum	ND	nil
Manihot ulitissima	21.1	64.5
Muntigia calabura	49.3	73.3
Flamegia vestita	9.1	7.4

ND, not detected

TABLE IV. *IN VITRO* GAS PRODUCTION, MEASURING MICROBIAL BIOMASS PRODUCTION (MBP), TRUE SUBSTRATE DEGRADATION (TSD) AND PARTITIONING FACTOR (PF) OF TREE LEAVES AND SHRUBS COMMONLY USED IN SARIAYA, QUEZON

Sample Name	mL gas/500 mg	MBP (mg)	TSD (mg)	PF (mg/mL)
Premna odorata	30.9	48.8	116.8	3.8
Centrocema pubescens	43.3	65.1	160.6	3.7
Erythrina variagata	52.0	110.2	224.6	4.2
*Desmodium intortum**	57.6	138.2	265.9	4.6
Gliricidia sepium	48.2	88.0	194.0	4.0
Moringa oleifera	78.8	88.0	261.0	3.3
*Artocarpus heterophyllus**	43.9	170.1	267.2	6.1

* tannin-rich

Addition of PEG to tannin rich forages increased gas production and estimated short chain fatty acids (Table V).

TABLE V. INCREASE IN *IN VITRO* PRODUCTION OF GAS AND SHORT CHAIN FATTY ACIDS (SCFAs) FROM TREE LEAVES AND SHRUBS AFTER 24 h INCUBATION, WITH OR WITHOUT POLYETHYLENE GLYCOL (PEG)

Samples	mL gas/500 mg	% Increased gas
Premna odorata, –PEG	30.9	–
+PEG	31.3	1.3
Centrocema pubescens,–PEG	43.4	–
+PEG	46.8	7.8
Erythrina variagata,* –PEG	52.0	–
+PEG	59.2	13.9
Desmodium intortum, –PEG	57.6	–
+PEG	69.1	20.0
Gliricidia sepium, –PEG	48.2	–
+PEG	54.2	12.4
Moringa oleifera, –PEG	78.2	–
+PEG	80.9	3.4
Artocarpus heterophyllus,* –PEG	43.9	–
+PEG	62.8	43.1
Ipomea aquatica, –PEG	81.0	–
+PEG	82.0	1.2
Spondia purpurea, –PEG	65.4	–
+PEG	65.9	0.8
Sandoricum koetjape, *–PEG	46.2	–
+PEG	66.0	42.8
Psidium guajava, *–PEG	9.2	–
+PEG	20.2	119.0

*tannin–rich

On–farm supplementation with the selected tree fodders, increased daily milk yield in the supplemented group to 8.7 kg compared to 7.7 kg/d in animals that were not supplemented. Fat content of milk from the supplemented cows was 41 g/kg compared to 31 g/kg from the unsupplemented cows (Table VI).

TABLE VI. DAILY MILK YIELD (kg) AND MILK FAT (g/kg) OF COWS SUPPLEMENTED WITH COMBINATION OF LEAVES AND WITHOUT SUPPLEMENTATION

	Milk yield (kg)	Milk fat (g/kg)
With leaves	8.7 (n = 6), SD = 0.7	41 (n = 6), SD = 5.0
Without leaves	7.7 (n = 6), SD = 0.3	31 (n = 6), SD = 4.0

4. DISCUSSION

The crude protein contents of tree leaves and shrubs are high. The low levels of total tannin (<2.0%) did not precipitate protein, however, an increase in gas production (<40%) was observed for tannin–rich samples when PEG was added in the *in vitro* gas production method. The addition of PEG opened up avenues for optimizing the release of energy–producing nutrients from tannin-rich leaves in order to affect the efficiency of microbial protein synthesis [21]. *In vitro* gas tests reflect SCFA production, representing mostly the fermentation of carbohydrates to acetic, propionic and butyric acids. Gas production from protein fermentation is relatively small compared to carbohydrate fermentation [11].

Tannin–rich feeds protect dietary protein from degradation in the rumen which is beneficial to ruminants as the supply of amino acids to the small intestine is increased, thereby making protein available for milk production. The ideal concentration of condensed tannins was suggested as being 20–40 g/kg dietary dry matter, and that higher levels (76-90 g/kg) were detrimental [19]. The energy values and organic matter fermentation calculated from the *in vitro* fermentation are in agreement with published data for forages [20] Tannin–rich feeds should not be subjected to the detergent system of analysis as the tannin–complex formed during incubation causes problems with measuring truly degraded fractions [10].

The partitioning factor (PF) observed for *Desmodium intortum* and *Artocarpus heterophyllus* is beyond the theoretical value (2.5–4.41) [11], and strongly justifies the observation [21], that due to various artifacts, the PF cannot be determined for tannin–rich samples. The results obtained also showed that samples with high PF, as in the case of *Desmodium intortum* and *Artocarpus heterophyllus*, have also high corresponding values for microbial biomass production. However, due to the artefacts the values of microbial mass for these two tannin–rich forages is not expected to be the 'true' values. The PF is a measure of efficiency of microbial mass production or efficiency of microbial protein production. The higher the partitioning factor, the higher is the efficiency for microbial biomass production as proportionally more of the degraded matter is incorporated into microbial mass [11].

5. CONCLUSIONS

A wide range of lesser–known and lesser–utilized tree fodders are abundantly available in the Philippines. They are protein–rich and when fed singly or in combination have proved to be beneficial in increasing the quantity and the quality of milk produced. Knowledge of the digestibility and tannin content of these tree fodders will allow optimum use to be made of them as ruminant feeds.

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EVALUATION OF LESSER-KNOWN FEEDS FOR RUMINANTS TO IMPROVE AND SUSTAIN ANIMAL PRODUCTIVITY DURING DRY PERIODS

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Abstract

Seven species of tree forage (*Azadirechta indica, Bahunia recemosa, Enterolobium saman, Moringa olecifera, Morus alba, Prosopis juliflora* and *Tithonia diversifolia*) that grow in the dry and intermediate zones; and brewery waste were evaluated for their feed quality. For tree forages, the proximate composition, *in vivo* digestibility, nitrogen balance and order of preference were evaluated. Brewery waste was ensiled with either 0, 2.5, 5 and 7.5% of molasses and 0.5% urea. Ensiling characteristics, pH, crude protein, intake and digestibility were determined. All forage species were protein-rich (>170 g/kg dry matter) and digestibility ranged from 45 to 68%. The goats fed tree forages maintained a positive nitrogen balance. The most preferred species of tree forage was *Morus alba* and the least *Azadirecta indica*. Ensiled brewery waste exhibited satisfactory ensiling characteristics, measured by pH and total and individual volatile fatty acids. Lactic acid content also indicated high quality silage. The level of molasses added influenced fermentation characteristics of the ensiled brewery waste by lowering the pH of the fermented silage and improving the crude protein, acetic acid and propionic acid production. Addition of molasses during ensiling improved the organic and dry matter digestibility by 15–20%.

1. INTRODUCTION

Feeding livestock with good quality feed is essential if livestock productivity is to be improved. This is a crucial issue in the dry areas of Sri Lanka, where 66% of the land is used for livestock, which includes over 75% of the countries cattle and buffalo [1]. There are many unevaluated and underutilized feedstuffs possibly suitable for ruminant feeding, in particular forages and agro-industrial by-products. Farmers traditionally use the conventional feeds and are not interested in alternative feeds [2]. Tree forage plays an important role in providing good quality green biomass and supplementary nitrogen when low quality roughage is the only bulk feed available for ruminants [3]. During dry seasons, enormous quantities of tree forage are available, both from leguminous and non-leguminous plants, either growing naturally, or planted for purposes other than feeding but producing usable forage.

In addition to these forages, many agro-industrial by-products are also available for livestock feeding, many of them only being suitable for ruminants and available at no, or very little, cost. One of these products is brewery waste, which has high moisture content and is perishable. The crude protein and fermentable energy content is high. Large quantities are wasted due to underutilization because farmers are reluctant to use it due to the high cost of transport and low shelf life. By adopting appropriate conservation techniques, this by-product can be converted into a valuable livestock feed, suitable for use as a sole feed or as a supplement.

2. MATERIALS AND METHODS

2.1. Tree forages

Two experiments were conducted to evaluate lesser-known feed stuffs for ruminants. These involved tree forages and brewery waste.

2.1.1. Evaluation of lesser-known tree forages

Seven species of tree forages (*Azadirechta indica, Bahunia recemosa, Enterolobium saman, Moringa olecifera, Morus alba, Prosopis juliflora* and *Tithonia diversifolia*) which are not extensively used as fodder, were evaluated in *in vitro* and *in vivo* studies. Samples were collected from plants growing naturally or plants forming live fences (*M. olecifera*) or used as an ally crop (*Morus alba*) in the Mid-country and dry zones of Sri Lanka. The forage samples contained all edible material (leaves and twigs) usually consumed by grazing and browsing ruminants. The species selected, with their vernacular name and the present major use, are given in Table I.

TABLE I. BOTANICAL AND VERNACULAR NAMES OF POTENTIAL FODDER SPECIES

Name of the forage species		Region of presence	Present use
Botanical	Vernacular		
Azadirechta indica	Neem	Dry and Intermediate	Timber
Bahunia recemosa	Maila	Dry	Natural
Enterolobium saman	Raintree	Intermediate and Wet	Shade
Moringa olecifera	Moringa	Dry and Wet	Food
Morus alba	Mulberry	Wet	Industrial
Prosopis juliflora	Masquite	Dry Saline soils	Invasive
Tithonia diversifolia	Wild sunflower	Intermediate and Wet	Green Manure

2.1.2. Proximate analysis

Proximate analyses of seven forage species were performed according to the methods described [4]. Forage samples were analysed for dry matter (DM), crude protein (CP), acid detergent fibre (ADF), lignin and acid insoluble ash (AIA).

2.1.3. Digestibility Trial

An *in vivo* trial was conducted to evaluate the digestibility of the seven forages species, fed as sole feeds, using 28 cross-bred goats (Sannan x Jamnapari) with an average initial live-weight of 15 kg. Four replicates were used for each forage species. The goats were housed in individual metabolism cages. The experiment consisted of a 10-day transition period, 15 days adaptation to the feeds and a 10-day total collection period. During the experimental period fresh forages were provided twice daily and clean water was provided *ad libitum*. During the total collection period, feed offered and refused was recorded. Faeces and urine were collected daily, measured and sampled; the daily samples were pooled for further analysis. Apparent dry matter digestibility was calculated from the difference between dry matter intake and output.

2.1.4. Nitrogen balance trial

Following the digestibility trial, after a rest period of three weeks, a nitrogen balance trial was conducted in the same manner as the digestibility trial, using all seven forages. In this trial the animals were randomly reallocated to a different forage species. As with the digestibility trail, this consisted of 15 days adaptation and 10 days total collection period. For each treatment (forage) there were three replicates (goats). Forages were offered in the fresh form twice daily and clean water was provided *ad libitum*. Daily forage intake, faecal output and urine output were recorded. Urine was acidified by the addition of 25 mL of 2 N Sulphuric acid to the urine collection bucket every morning. Subsamples of forage were dried at 60°C and stored daily. Urine was collected once daily, measured and a subsample frozen for storage. Faeces were also collected once daily, measured and a subsample dried and stored under room conditions. All stored samples were later used for chemical analysis. Daily total nitrogen intake and total nitrogen output (faeces and urine) were measured. Nitrogen balance was calculated by the difference between total nitrogen intake and output.

2.1.5. *Preference trial*

A preference trial was conducted using goats in an adapted *"cafeteria method",* where all animals had equal opportunity and access to all forages, which, with drinking water, was provided *ad libitum*. A total of 12 animals were used, split into three groups of four goats each to prevent competition and dominance. The experiment consisted of a 10-day adaptation period and 10-day observation period. Preference was evaluated based on the amount of feed dry matter eaten per kg body weight.

2.2. Brewery waste

2.2.1. Evaluation of ensiled brewers grains

Brewers grains perish within two days of collection from the brewery, however, ensiling can increase both its shelf-life and quality.

2.2.2. Ensiling of brewery waste

Fresh brewery waste was ensiled in 160-L plastic barrels, double lined with polythene. Prior to ensiling the waste, it was allowed to drain, onto a clean cement floor, to remove the excess liquid. To improve the fermentation either 0, 25, 50 or 75 g/kg molasses were added. Urea, at the rate of 0.5g/kg of fresh brewers grain, was added to all treatments. The ensiling period was eight weeks.

2.2.3. Silage quality of brewery waste

The quality of the silage was evaluated in the laboratory. Moisture, crude protein and pH were determined by electrometrically using a Fisher brand pH meter [5]. Total volatile fatty acids (TVFA) and volatile fatty acids (VFA) were determined by the distillation and GLC method respectively [6].

2.2.4. Brewery waste silage feeding trial

A feeding trial was conducted to evaluate the intake and digestibility of ensiled brewery waste. Sixteen cross-bred (Sannan x Jamnapari) goats with an average body weight of 15 kg were allocated to the four treatments, giving four replicates for each. A transition period of 15 days was followed by a 15-day adaptation period, after which the goats were offered the silages *ad libitum* for 10 days to measure intake. During this period, faeces were collected daily to assess digestibility. Feed offered and refused was recorded to estimate daily intake. Clean water was provided *ad libitum*.

3. RESULTS

The forage species evaluated in this study are all perennials with the potential to produce large amounts of forage [7]. They can be offered to livestock as sole feeds or used to supplement poor quality roughages (for details refer to Table I).

3.1. Forages

3.1.1. Proximate analysis

The proximate composition of the forages is given in Table II. All forages had a crude protein (CP) content above 170 g/kg DM, indicating their potential as a protein supplement for ruminants receiving diets based on poor quality roughages [4]. Lignin content was within the acceptable range of 100–170 g/kg DM.

TABLE II. PROXIMATE COMPOSITION (g/kg DM) OF FORAGE

Forage species	Crude protein	Acid detergent fibre	Lignin	Acid insoluble ash
Azadirechta indica	185	384	142	42
Bahunia recemosa	213	423	164	67
Enterolobium saman	202	436	176	53
Moringa olecifera	244	337	102	21
Morus alba	174	342	145	24
Prosopis juliflora	242	384	159	43
Tithonia diversifolia	201	347	135	24
Mean	209	379	146	39
SD ±	25	39	22	16

3.1.2. Digestibility, nitrogen retention and forage preference

Animal preference for a particular forage depends on the nutritive value and the contents of secondary compounds that are present in that forage [6]. Of all the forages tested, the most preferred forage was *M. alba*. The least preferred was *A. indica*. The preference for forage is related to composition and digestibility. The dry matter digestibility (DMD) of the forages ranged from 450 to 680 g/kg, which is similar to values recorded elsewhere in Sri Lanka [7] (Table III).

TABLE III. *IN VIVO* DIGESTIBILITY, NITROGEN BALANCE AND PREFERENCE (1 = HIGH; 7 = LOW), SHOWN BY GOATS, FOR SELECTED TREE FORAGES

Forage species	*In vivo* dry matter digestibility (g/kg)	Nitrogen balance (g/d)	Order of preference
Azadirechta indica	450 ± 70	2	7
Bahunia recemosa	480 ± 100	5	6
Enterolobium saman	500 ± 70	3	5
Moringa olecifera	600 ± 80	10	3
Morus alba	680 ± 90	8	1
Prosopis juliflora	540 ± 90	6	4
Tithonia diversifolia	650± 100	12	2
Mean	580	6	
SD ±	90	4	

All the forages supported positive nitrogen balance, although the amount of N retained varied. *Tithonia diversifolia*, although not a legume, supported the highest rate of N retention. Similar results have been observed in other experiments [5]. Animal preference is another important criterion in determining nutrient intake. In this study, digestibility and nitrogen balance of the forages, in addition to chemical composition and physical form, were associated with preference.

3.2. Brewery waste silage

3.2.1. Evaluation of ensiled brewery waste

When the silage bins were opened no mould formation was observed in the silage, other than in the 75 g/kg molasses silage, where some superficial mould was evident. This could have been caused by insufficient compaction, resulting in trapped air at the time of ensiling [8]. All silages, including the treatment without molasses, had a satisfactory aroma and a fine texture. No effluent was detected, possibly because the DM of the silages was relatively high (Table IV).

TABLE IV. CHEMICAL EVALUATION OF BREWERY WASTE SILAGE

Item	Level of molasses in silage (g/kg)			
	0	250	500	750
Moisture (g/kg)	620 ± 120	680 ± 150	690 ± 170	690 ± 140
pH	5.8 ± 0.7	5.1 ± 0.5	4.7 ± 0.4	4.5 ± 0.6
Crude protein (g/kg dry matter)	240 ± 30	220 ± 30	210 ± 30	200 ± 40
Total Volatile fatty acids (VFA, mol/mL)	228 ± 64	256 ± 56	278 ± 60	302 ± 58
Individual VFA (g/kg)				
Acetic	104 ± 23	128 ± 36	153 ± 37	174 ± 42
Propionic	12 ± 3.2	24 ± 2.4	38 ± 4.5	41 ± 3.5
Butyric	32 ± 6.4	28 ± 6.6	28 ± 7.2	30 ± 6.4
Lactic acid (Meq/100 g)	0.06 ± 0.001	0.12 ± 0.001	0.16 ± 0.002	0.18 ± 0.003

The pH of the silage was satisfactory, especially in the silages with 50 and 75 (g/kg) molasses. In other treatments the pH was a little higher than recommended, possibly because the soluble carbohydrate content of the brewery waste was low [9]. The CP content of all silages was 200 g/kg DM or above. Generally, in untreated brewery waste, without additives, CP in the DM is between 160 and 200 g/kg DM [10]. The level of CP in all the silages was more than sufficient to maintain an optimum rumen ammonia level for effective rumen microbial activity [11].

The total volatile fatty acid (TVFA) and individual VFA contents of all silages were indicative of effective ensiling characteristics. Increasing the acetic acid from 100 to 170 g/kg and propionic acid from 10 to 40 g/kg reflected the quality of silage when molasses was added. Further, the high proportion of lactic acid with increased molasses is an indication of the keeping quality of the silage. Under local conditions, molasses has been found to be the best source of fermentable carbohydrate to add during the ensiling process [8].

3.2.2. Intake and digestibility of ensiled brewery waste

All the silages exhibited satisfactory physical, chemical and nutritional characteristics. Intake was increased from 420 g/kg with no molasses to 548 g/kg of body weight at the higher levels, possibly helped by the aroma and taste of the molasses. The intake of silage when expressed as a percentage of body weight represented 2.1% without the addition of molasses, to 3.0% with 50 g/kg of added molasses (Table V). The amount of lactic acid present would also have contributed to the level of intake and digestibility of the silages [12].

TABLE V. INTAKE AND DIGESTIBILITY OF BREWERY WASTE SILAGE

Parameter	Level of molasses in silage (g/kg)			
	0	25	50	75
Dry Matter (DM) Intake:				
kg/100 kg Body Weight (BW)	2.1 ± 0.3	2.20 ± 0.32	3.0 ± 0.4	3.20 ± 0.04
g/kg BW	420 ± 38	442 ± 42	548 ± 44	643 ± 50
g/ $kg^{0.75}$ BW	884 ± 110	930 ± 121	1154 ± 134	1354 ± 136
Digestibility				
Dry Matter (g/kg DM)	580 ± 87	643 ± 89	688 ± 78	702 ± 72
Organic Matter (g/kg OM)	622 ± 88	683 ± 92	708 ± 96	727 ± 101

4. DISCUSSION

The results of this study of lesser-known feeds indicate that some of the species tested should be regarded as alternative feed resources for ruminants. Tree forages are regarded as important in Sri Lanka. *Tithonia diversifolia* is one of the major non-leguminous forages used by the Mid-country farmers, together with *Panicum maximum* grass, to feed their cattle. In the dry zone, especially when the basal roughage diets are highly matured or scanty, *B. recemosa* and *A. indica* is fed as a green forage supplement. *Morus alba* is cultivated as an industrial crop for the sericulture industry, to provide feed for silkworm larva, but during the pruning season the green biomass available from this crop is considerable. *Moringa olecifera* is generally used as a vegetable for human consumption. This tree is extensively grown in the dry zone and needs little attention. *Moringa* could also be grown in the dry zone wastelands and along rice bunds of the newly opened irrigated agricultural lands. *Tithonia diversifolia, M. alba,* and *M. olecifera* can be easily adopted into 'Sloping agriculture land technology' (SALT) [3].

Tithonia diversifolia and *A. indica* have benefits beyond their nutritional value when fed to ruminants, in that they contain anthelmintic properties for the control of internal parasites [13]. All the tree species tested, except for *E. saman* and *M. alba,* are used as indigenous medicines for livestock.

In the dry states of India, *P. juliflora* is considered as an important tree fodder species and is often used as a dry season fodder bank [14]. It grows densely on the sand dunes and saline soils found in the south of Sri Lanka, but its value as a fodder is not fully appreciated and it is often considered as an alien invasive species. The results of this study show that *P. juliflora* is a valuable multi-purpose plant and is a useful source of protein and fodder.

In the wet region of Sri Lanka, forage for ruminants is in excess during the rainy season, although during the inter-monsoon dry period, ruminants are often underfed. However, in these regions brewery waste is available in abundance as an industrial by-product. This study showed that brewery waste can be successfully ensiled provided an additive of fermentable carbohydrate is combined with the waste at the time of ensiling. If the carbohydrate is added later, due to the high moisture content of brewery waste spoilage from fungal formation may have started. The addition of molasses also improves the quality and the availability of fermentable carbohydrates, thus improving rumen activity. Organic matter and dry matter digestibility were increased as the level of molasses in the silage was increased. This may have been due to the presence of a readily available soluble carbohydrate and an adequate supply of fermentable N, as urea, thus generating an effective medium in the rumen for optimum digestion and formation of microbial protein [6].

5. CONCLUSIONS

Livestock production by smallholder farmers is not the major source of income in Sri Lanka. However, livestock does provide a steady and low risk source of income to meet daily household expenditure. Dairy farmers, especially, could improve their output and income if the forage supply was improved, particularly in the dry season. Farmers need assistance in identifying potential, locally available, feed resources and incorporating them into diets. The studies reported here contribute to the data bank for dissemination by the State Extension Division and other NGO's, who are working towards poverty alleviation through rural pro-poor programmes. The research team will assist with the field extension activities, in both training and monitoring of activities.

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EVALUATION OF LESSER-KNOWN FEED SUPPLEMENTS FOR DAIRY CATTLE IN THE NORTH-EAST OF THAILAND

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Abstract

Fodder tree plants, namely the coral tree and *leucaena* together with cassava have been introduced and recommended to farmers as high protein feed for dairy cattle supplementation, particularly in the dry season. The coral tree (*Erythrina subumbrans*) and *leucaena* (*Leucaena leucocephala*) were introduced to dairy farmers as tree fodders and to provide shade for grazing cattle. Cassava hay production to provide a supplementary feed for dairy cows was recommended to smallholder dairy farmers. Cassava (*Manihot esculenta*, Cranzt) was planted in a 0.32 ha plot and intercropped with two types of legumes, cowpea and stylosanthes, to improve soil fertility on 24 smallholder dairy farms. The dry matter (DM) yield of cassava hay was 6.83 ton/ha, while the yield of cowpea pods, residues and stylosanthes were 6.95 (fresh weight), 0.89 and 3.51 ton DM/ha, respectively. On each of the 24 farms the cassava hay was fed as a supplement, at 2 kg/h/d to two milking cows for a 60-day period, with another two milking cows being a non-supplemented control. Milk yield in cows supplemented with cassava hay (13.8 kg/h/d) tended to be higher than in the control group (12.4 kg/h/d). Milk fat (35.6 g/kg) from the supplemented cows was also higher ($P < 0.05$) than from the control group (29.8 g/kg). Cassava hay supplementation as the forage diet improved milk yield and quality, especially during the dry season. It is, therefore, recommended that these feed resources be established on-farm to ensure sustainable dairy production.

1. INTRODUCTION

Feed resources are important for ruminant feeding in both the wet and dry seasons. However, during the dry season, feed availability is scarce and quality usually low. The use of on-farm feeds including fodder trees and other foliages are of utmost importance.

2. ON-FARM/LOCAL FEED SOURCES FOR CATTLE SUPPLEMENTATION

The leaves of the Coral tree (*Erythrina subumbrans*) and *Leucaena leucocephala* are protein-rich (Table I) and available to use as a supplement for dairy cattle particularly in the dry season. However, in North-East Thailand these leaves are rarely regarded as a feed source, although feed is often scarce. Therefore, coral trees and leucaena have been introduced to dairy farmers and are mainly grown between paddocks as fencing and to provide shade for cattle to reduce heat stress. The leaves are a useful feed supplement.

TABLE I. CHEMICAL COMPOSITION OF (g/kg DRY MATTER) THE LEAVES OF THE CORAL TREE (*ERYTHRINA SUBUMBRANS)* AND LEUCAENA (*LEUCAENA LEUCOCEPHALA)*

Items	Coral tree leaves	*Leucaena* leaves
Crude protein	267.1	272.1
Ash	135.2	67.7
Crude fibre	262.7	131.6
Ether extract	30.6	49.8
Nitrogen-free-extract	304.4	478.9
Neutral detergent fibre	402.7	268.0
Acid detergent fibre	269.3	126.5
Acid detergent lignin	52.6	58.1

Cassava or tapioca (*Manihot esculenta*, Crantz) is an annual tuber crop grown widely in tropical and sub-tropical areas. It can easily thrive in sandy-loam soil with low organic matter, receiving low rainfall and high temperatures. It is, therefore, a cash crop cultivated by smallholder farmers within the existing farming systems in many countries [1].

Cassava tubers contain high levels of energy and minimal levels of crude protein and have been used as readily fermentable energy in ruminant rations. Cassava leaves have been used as a protein source when collected at tuber harvesting time. However, intake and digestibility are low due to the high level of condensed tannins [2, 3]. The role of tannins in tropical animal production has been documented [4, 5]. Harvesting of cassava at an early growth stage (three months) to make hay (cassava hay) could reduce the condensed tannin content and increase protein content (25% of DM) (Table II), resulting in a higher nutritive value. Therefore, cassava hay production was introduced and recommended to farmers in order to produce an on-farm protein supplement for their cattle.

TABLE II. CHEMICAL COMPOSITION OF CASSAVA (*MANIHOT ESCULENTA*, CRANZT) HAY

Items	Cassava hay
Chemical compositions (g/kg dry matter)	
Crude protein	249
Ash	66
Neutral detergent fibre	344
Acid detergent fibre	270
Acid detergent lignin	38
HCN, mg/kg	34.8

Source: [6]

3. DISSEMINATION OF TECHNOLOGY OF CASSAVA HAY PRODUCTION AND SUPPLEMENTATION TO SMALLHOLDER DAIRY FARMERS

On-farm research, involving farmer participation, was conducted on twenty-four smallholder farms in the North-East region of Thailand. Cassava hay production and cassava hay supplementation were recommended for improving dairy productivity in smallholder dairy farms.

On each farm, cassava was planted in a 0.32 ha plot to produce hay, together with two intercropped legumes, cowpea and stylosanthes (Fig. 1). The main objectives were to increase soil fertility, and as “Food-Feed” the cowpea pods are a vegetable for humans and the residues can be used as animal feeds. At about three months after planting, and subsequently every two months, depending on the growing condition, the green top part of the cassava was cut at about 20 cm above the ground, leaving 8–10 leaves to encourage regrowth. After harvesting the cassava, it is recommended that manure or fertilizer is added to the remaining crop. Weeding is necessary especially in the rainy season. The yield of cassava foliage and intercropped legumes are shown in Table III.

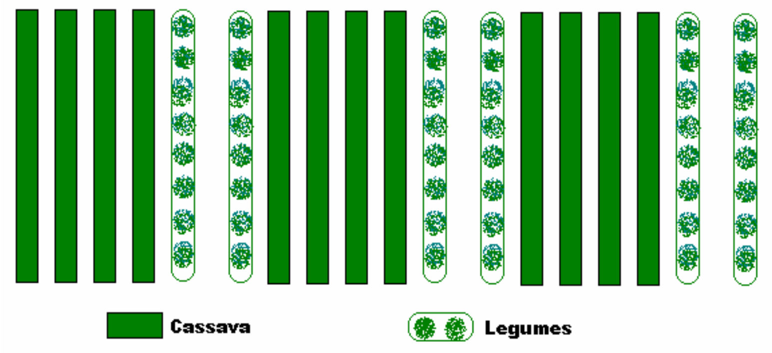

FIG. 1. Layout of cassava plot intercropped with legumes.

TABLE III. YIELDS OF CASSAVA (MANIHOT ESCULENTA, CRANZT) HAY, COWPEA PODS AND RESIDUES AND STYLOSANTHES FODDER PRODUCED ON SMALLHOLDER DAIRY FARMS IN NORTH-EAST THAILAND

Items	Yields
Cassava hay, ton dry matter (DM)/ha	6.83
Green cowpea pods[1], ton/ha	6.95
Cowpea residues, ton DM/ha	0.89
Stylosanthes, ton DM/ha	3.51

[1]In fresh weight

Sun-drying the cassava for 2–3 days is the simple and practical way to decrease moisture and HCN content. Drying the crop whole requires least time and labour. However, sun-drying, after chopping by hand or by machine into 2–3 cm lengths requires a shorter drying time, is easier to feed or use in concentrate, has a longer shelf-life and requires less storage space. To solve the problem of drying in the rainy season, a simple solar-dryer was demonstrated. Farmers are now constructing these solar-dryers using local materials.

Cassava hay was fed as a supplement, at 2 kg/h/d, to two milking cows on each farm for 60 days. Two other milking cows per farm were selected to be a non-supplemented control. The results of cassava hay supplementation are shown in Table IV. Milk yield in cows supplemented with cassava hay tended to be higher than in the control group. Milk fat in the supplemented group was significantly higher than in control group ($P < 0.05$). Supplementation with cassava hay production and supplementation could improve the quality of feed offered and thereby improve milk yield and quality, especially during the dry season. Cassava hay can be produced on smallholder dairy farms.

TABLE IV. EFFECT OF CASSAVA (*MANIHOT ECULENTA,* CRANZT) HAY SUPPLEMENTATION ON MILK YIELD AND MILK COMPOSITIONS IN LACTATING DAIRY COWS

Items	Group 1	Group 2	SEM
Milk yield, kg/h/d	12.14	13.8	0.66
Milk compositions, (g/kg)			
Fat	29.8^{a}	35.6^{b}	0.04
Protein	29.5	29.8	0.05
Lactose	48.3	47.3	0.01
Total solid	114.7	114.7	0.03
Solids-not-fat	84.8	84.8	0.04

^{ab} Means in the same row with different superscripts differ (P <0.05)
Group 1 = control group, Group 2 = supplemented group (2 kg/h/d of cassava hay)

4. CONCLUSIONS

Establishment and development of on-farm feed resources have been successfully disseminated to, and adopted by, farmers in the North-East region of Thailand. Feeding cassava hay to dairy cows as a supplement has resulted in improved milk yields and quality. It is, therefore, recommended that these feed resources be established on-farm to ensure sustainable dairy production.

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EVALUATION OF YIELD AND FEEDING EFFICIENCY OF SOME LESSER-KNOWN PLANTS AS NEW FEED RESOURCES FOR LIVESTOCK UNDER SMALLHOLDER CONDITIONS IN VIETNAM

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Abstract

Three agronomic experiments have been conducted on slopping land, at Bavi District of Hatay Province, Vietnam, to evaluate biomass productivity of five species of lesser-known plants (*Trichantera gigantea, Flemingia Macrophylla, Leucaena K636, Morus alba* [Mulberry] *and Phaseolus calcaratus*) as new feed resources for livestock belonging to smallholder farmers. To investigate feeding efficiency of these lesser-known plant species, edible biomass was evaluated by chemical analysis, the *in vitro* gas production test, *in sacco* trials, and feeding studies.

Flemingia macrophylla produced a large quantity of biomass, both as a monoculture and when intercropped. However, its nutritive value was low. *Morus alba*, *P. calcaratus*, and *Leucaena* were all rich in crude protein content, but their biomass yield was low. *Trichantera gigantea* was the most promising of the species evaluated, as judged by biomass yield and nutritive value. *Flemingia* foliage could supply 20–25% of the crude protein coming from concentrates in the diets for lactating and growing goats. With this level of inclusion, the cost : benefit ratios were 1 : 1.52 (for lactating goats) and 1 : 1.89 (for growing goats). Feeding trials with *T. gigantea* indicated that the optimum inclusion rate in diets for lactating goats was 33–38% of the dry matter (DM), and at this level the cost : benefit ratio was 1 : 2.35. For growing rabbits and growing pigs, inclusion rates and cost : benefit ratios were 50–55% and 1 : 1.96 and 33–38% and 1 : 2.52, respectively. For fattening ducks the best performance was from 70 to 80 g/head/d of fresh leaf. For laying hens, the optimum inclusion rate of *Trichantera* foliage was 6% of the dietary DM as leaf meal. A total 1258 farmers in 31 Provinces (1063 farmers in 28 provinces in the north of the country and 195 farmers in three provinces in the south of the country) were introduced to these lesser-known feed resources, of which *T. gigantea* was the most acceptable, with 1097 farmers in 19 Provinces adopting it.

INTRODUCTION

In Vietnam livestock farming is of immense importance for farmers. In many rural areas, including the Red River Delta, North and South Central Coast and the Mekong River Delta, farmers derive most of their income from animal production. However, productivity of smallholder livestock is low. The main reasons for this are the poor quality and scarcity of forage, the supply of which fluctuates throughout the year.

In order to improve productivity of livestock farming in the rural sector, a programme of poverty reduction was introduced in the 1990s, in which farmers are given access to credit, improved livestock and training in husbandry techniques from extension workers.

In conjunction with the government poverty reduction programme, the IAEA/RCA Project (RAS/5/035, from 1999 to 2004) has assisted with the identification, propagation and utilization of unknown or lesser-known plants able to grow in poor and degraded soils. This review reports the results of the laboratory and on-farm studies undertaken by the IAEA/RCA project.

2. MATERIALS AND METHODS

2.1. Evaluation of yield of lesser-known plants

2.1.1. Experiment I. Yield of Trichantera gigantea, Flemingia Macrophylla, Leucaena leucocephala K636 and Morus alba (Mulberry) grown as monocultures on slopping land

An experiment was conducted from August 2001 to September 2002 in Bavi, Hatay Province, on two plots, each of 800 m^2. Each plot was divided into 16 blocks (50 m^2 per block) for growing four species (*T. gigantea, F. macrophylla, Leucaena K636* and *M. alba*), giving four blocks of each species arranged in a Latin square 4 x 4 design.

The soil was uniformly prepared by ploughing and harrowing. Organic manure was applied at planting, at a rate of 10 tons per ha. *Flemingia Macrophylla* and *Leucaena* were planted as seeds, and *M. alba* and *T. gigantea* were planted as stem cuttings in rows 50 cm apart with an in-row spacing of 20 cm.

The first foliage was harvested when the average height of the plants was 120 cm. The stems were cut at a height of 50 cm from the ground. The 50 cm height from the ground was maintained throughout the harvesting period.

2.1.2. Experiment II. Yield of Flemingia Macrophylla intercropped with cassava on slopping land

An experiment was conducted at the Goat and Rabbit Research Centre (GRRC) of NIAH from February 2001 to December 2002 on slopping land. The experimental plots were each 10 x 20 m, arranged in a 3 x 3 Latin square design, with three treatments and three replications. The treatments were: *F. macrophylla* grown as a monoculture (FM); Cassava grown as a monoculture (CS); and *F. macrophylla* intercropped with cassava (FM–CS).

For all treatments the between row spacing was 50 cm. The cassava was planted with 15 cm between stem-cuttings within rows, both as a monoculture and when intercropped. The *F. macrophylla* seeds were planted at a within row spacing of 5 cm, both as a monoculture and as an intercrop. The *F. macrophylla* was planted 14 days before the cassava.

Cattle manure was applied before planting at the rate of 2 kg/m^2. The first foliage was harvested when the cassava reached a height of 100 cm (about three months after planting). All the foliage was removed above 30 cm from ground level. In the intercropped plot and pure stand, *F. macrophylla* was harvested at 30 cm above ground level at the same time as the cassava. In each plot, five randomized sub-plots (2 x 2 m = 4 m2) were used to estimate biomass yield.

2.1.3. Experiment III. Yield of Nhonhe pea (Phaseolus calcaratus) when intercropped with cassava on slopping land

The experiment was carried out from January to November 2003 on slopping land, in Bavi District, Hatay Province, in a completely randomized block design with four treatments and four replicates. The experimental plots were each 10 x 10m and the treatments were:

Treatment 1: Cassava grown as a monoculture (40 cm between rows; 15 cm between stem cuttings).

Treatment 2: One row of cassava intercropped with one row of Nhonhe pea (cassava: as in Treatment 1; Nhonhe pea 40 cm between rows and 5 cm between seeds).

Treatment 3: Two rows of cassava intercropped with one row of Nhonhe pea.

Treatment 4: One row of cassava intercropped with two rows of Nhonhe pea.

The land was ploughed three months before planting and cattle manure applied before planting at the rate of 2 kg/m^2.

The first foliage was harvested three months after planting. Cassava was removed above 30 cm from ground level. The cassava was separated into leaf and stem and the fresh weight recorded. Subsequent harvests were at two-month intervals. Cassava roots and the Nhonhe pea foliage were collected at the end of the year.

2.1.4. Statistical analysis

The data from the three experiments were subjected to analysis of variance [1]. Treatment means which showed differences (P <0.05) were compared using Tukey's paired-wire comparison procedure.

The statistical model used in the analysis was:

$$Yij = \mu + T_i + B_j + (TB)_{ij} + e_{ij}$$

where: Yij = Biomass yield; μ = Overall mean; T_i = treatment; B_j = block; $(TB)_{ij}$ = Interaction between treatment and replications; e_{ij} is the experimental error.

2.2. Evaluation of the nutritive value of edible material of the lesser-known plants

2.2.1. Sampling

Samples of the edible material of each lesser-known plant were taken during harvesting (2.1 above). The samples (edible part of each plant including soft branches and leaves) were weighed immediately and then dried at 60°C for 48 h. One portion of each sample was milled through a hammer mill (1.0 mm sieve) for chemical analysis and *in vitro* gas production. The remainder was ground through a 2.5 mm screen and used to measure dry matter (DM) degradation *in sacco*.

2.2.2. Chemical analysis

Dry matter (DM) was determined by drying the samples at 105°C overnight. For ash determination, a sample of dry material was put in a crucible and placed in a muffle furnace, run at 525°C for 8 h. Nitrogen content was measured by the automated Kjeltec System Analyser and crude protein was calculated as N*6.25. Neutral detergent fibre (NDF) was also determined [2].

2.2.3. DM degradation in sacco

Dry matter degradation was determined by incubating about 2.5 g of dry sample in nylon bags in the rumens of three rumen fistulated cattle for 96 h [3]. The degradation curve of the feed was described by fitting the DM loss values to an exponential equation [4]:

$$p = a + b(1 - e^{-ct})$$

where: 'p' is the per cent of DM degraded at time 't'; 'a' is the intercep, 'b' is the amount which in time 't' will be degraded, 'c' is the degradation rate constant and 'e' is the natural logarithm.

The degradation characteristics of the samples were defined as: A = washing loss (representing the soluble fraction of the feed); B = (a + b) – A (representing the insoluble but fermentable materials); and *C* = the rate of degradation of B.

2.2.4. In vitro gas production

Triplicate samples of each plant were incubated *in vitro* with rumen fluid in calibrated glass syringes [5]. However, the amount of sample used was increased from 200 to 500 mg and the amount of buffer increased two-fold. The samples of *Flemingia* and *Leucaena* were incubated with equal weights of polyethylene glycol (PEG 4000, Sigma Chemical. Co., UK) or without PEG.

The volume of gas produced (mean of three samples) for each incubation time were fitted to the exponential equation [4]:

$$p = a + b(1 - e^{-ct})$$

where *p* represents gas production at *t* time, (*a* + *b*) the potential gas production, and *c:* the rate of gas production.

Organic matter digestibility of the samples was calculated based on determination of undegraded substrate after 24 h of incubation using the NDF digestion method [2].

Metabolizable energy (ME) values of edible biomass of the plants were calculated based on gas production data, according to the equation [5]:

$$\text{ME (MJ/kg DM)} = 2.20 + 0.136\ \text{Gv} + 0.057\ \text{CP}$$

(CP = crude protein in % DM; Gv = net gas production in mL from 200 mg DM after 24 h of incubation).

2.3. Feeding trials to test the potential for using the foliages of some lesser-known plants as feed resources for livestock

To investigate the efficacy of using the foliages of lesser-known plants as feed resources for livestock, a series of feeding trials were conducted at the National Institute of Animal Husbandry (NIAH), GRRC (North Vietnam) and Can tho University (South Vietnam).

For *F. macrophylla* foliage, two experiments were conducted at GRRC, Bavi Hatay [6, 7]. The first was carried out using 40 growing goats (20 males and 20 females). Initial live weights of the animals were between 11.1 and 12.4 kg and their age ranged from 3.0 to 3.5 months at the beginning of the experiment. Two goats of similar weight, age and sex were penned together. Eight goats (four male, four female) were allocated to each of five treatments according to a completely randomized block design (4 replicates of each). The concentrate was replaced by *F. macrophylla* foliage at five levels of inclusion in the diet: 0; 25; 50; 75 and 100% based on the protein content in the feeds. At the beginning of the experiment a basal diet, consisting of 100 g DM of chopped whole sugar cane (CWSC) and 350 g DM of Para grass, was fed to all animals. The animals at the zero level of *Flemingia* were given 150 g DM of concentrate/d in addition to the basal diet. When the goats reached 15 kg of body weight the CWSC, Para grass and concentrate were increased to 150, 400 and 175 g DM per day respectively. The CWSC and Para grass were given in three equal amounts daily: at 07:00 h together with 50% of the *F. macrophylla* foliage; at 12:00 h together with the concentrate; and in the afternoon (18:00 h) together with the rest of the *F. macrophylla*. The foliages were given as small bunches hanging above the feeding troughs.

The second trial was carried out on 45 lactating goats. The goats were of the bachthao (15), Beetal (10), Barbary (10) and Jamnapary (10) breeds, and initially weighed between 30 and 45 kg; they were in their first, second or third lactation. The animals were individually penned and nine lactating goats were allocated to each of the five groups in a completely randomized block design. The basal daily diet for all animals consisted of CWSC (280 g DM), Para grass (650 g DM) and dried chopped cassava root (460 g). The control group was given 500 g DM of concentrate daily, containing 125 g crude protein in addition to the basal diet. In groups II, III and IV the concentrate was replaced by 20, 40, 60 and 80% by *F. macrophylla* foliage based on the protein content in the feeds. The foliage was given as small bunches hanging above the feeding troughs.

Trichantera gigantea was used in trials at both GRRC and Can tho University. For laying hens, *T. gigantea* leaves were fed as a dry meal, with different ratios in the diets. In experiments on fattening ducks, growing pigs, growing rabbits and goats *T. gigantea* foliage was fed fresh.

2.4. Transfer of information to farmers

In order to introduce lesser-known plant species to farmers, the government agricultural extension service, together with some non-governmental organization (NGO) projects (e.g. FAO/TCP/VIE/6613; SAREC-SIDA; CP/VIE/023/BEL), have held many farmers' visits and training courses at GRRC. Farmers and their advisers have been instructed in the growing and utilization of lesser-known forages. Some pilot farms, at Bavi District, Hatay Province, where these plants have been introduced, are being used as demonstration sites.

3. RESULTS

3.1. Yield of lesser-known plants, grown as monocrops or as intercrops

Yields of some lesser-known plants (*F. macrophylla, T. gigantea, Luecaena K636* and *M. alba*) grown on slopping land at Bavi, Hatay are showed in Table I. *F. macrophylla* had the highest yield. Yield of *T. gigantea* was moderate and *Leucaena* the lowest. The amount of crude protein produced by the three species followed the same order as that of DM.

TABLE I. YIELD OF *FLEMINGIA MACROPHYLLA*, *TRICHANTERA GIGANTEA*, *MORUS ALBA* AND *LEUCAENA* K636 GROWN ON SLOPPING LAND

	F. macrophylla	*T. gigantea*	*Leucaena*	*M. alba*	SE
Total yield (tonnes/ha/year):					
Fresh matter	35.2^{d}	24.1^{c}	8.7^{a}	11.3^{b}	0.301
Dry matter	9.61^{d}	5.59^{c}	2.24^{a}	2.77^{b}	0.092
Crude Protein (tonnes/ha/year)	1.68^{d}	0.85^{c}	0.41^{a}	0.45^{b}	0.011

[a, b, c] Means within a row with different superscripts differ significantly (P <0.05)

With the intercropped forages, total yield of *F. macrophylla* and cassava (root and foliage) was increased compared with cassava or *F. macrophylla* grown alone (Table II), when the average yield from both monocultures equaled 78.8% of that of the intercrop. In the first year, biomass yield of *F. macrophylla* was low but increased in the second year. The yield of cassava decreased in the second year in the monoculture plots.

TABLE II. YIELD OF *FLEMINGIA MACROPHYLLA* (FM) AND CASSAVA (CS) GROWN ALONE AND AS AN INTERCROP (CS–FM)

	CS	FM	CS–FM	SE
Year 2001				
Dry matter, tonnes/ha	9.47	4.7[a]	8.34[b]	0.137
– *Flemingia* foliage	–	4.70[a]	2.84[b]	
– Cassava foliage	9.47	–	5.50	
Crude protein,tonnes/ha	1.54	0.66[a]	1.39[b]	0.022
– *Flemingia* foliage	–	0.66[a]	0.42[b]	
– Cassava foliage	1.54	–	0.97	
Year 2002				
Dry matter, tonnes/ha	9.02	14.9[a]	15.17[b]	0.229
– *Flemingia* foliage	–	14.9[a]	7.90[b]	
– Cassava foliage	6.44	–	4.98	
– Cassava Root	2.58	–	2.29	
Crude protein, tonnes/ha	1.14	2.21[a]	2.00[b]	0.031
– Flemingia foliage	–	2.21[a]	1.10[b]	
– Cassava foliage	1.08	–	0.85	
– Cassava Root	0.06	–	0.05	
Total for 2 years				
– Dry matter, tonnes/ha	18.49	19.6[a]	23.51[b]	0.305
– Crude protein, tonnes/ha	2.68	2.87[a]	3.38[b]	0.043

[a, b, c] Mean within a row with different superscripts differ significantly ($P < 0.05$)

The yield of Nhonhe pea and cassava intercropped on slopping land is shown in Table III. Yield of Nhonhe pea depended on its density. Where one row of cassava was intercropped with 2 rows of Nhonhe pea, yield of Nhonhe was 1.5 times higher than when two rows of cassava were planted with one row of Nhonhe pea.

TABLE III. THE TOTAL YIELD (DM, Tonnes/ha) OF CASSAVA AND NHONHE PEA (SEE TEXT FOR TREATMENT DETAILS)

	Treatment 1 (CS)	Treatment 2 (1CS*1NN)	Treatment 3 (2CS*1NN)	Treatment 4 (1CS*2NN)	SE
DM, tonnes/ha					
Nho Nhe pea	–	1.53[a]	1.1[b]	1.67[c]	0.012
Cassava foliage	1.2[a]	0.71[b]	0.91[c]	0.53[b]	0.003
Cassava root	12.74[a]	9.76[c]	11.05[b]	7.71[d]	0.142
Total	13.94[a]	12.01[b]	13.09[a]	9.91[c]	0.210

Mean within a row with different superscripts differ significantly ($P < 0.05$)

Where cassava was intercropped, yield of foliage and roots decreased with increasing density of Nhonhe pea.

3.2. Chemical composition, gas production and *in sacco* degradability of the edible components of lesser-known plants

The organic matter (OM), crude protein (CP) and neutral detergent fibre (NDF) contents of the edible biomass are shown in Table IV. The OM content varied within a narrow range, and was lowest in *T. gigantea*. The NDF content was relatively high in *Flemingia* and relatively low in Nhonhe pea. The CP content was highest in *T.gigantea* and lowest in Nhonhe foliage.

TABLE IV. DRY MATTER (DM, g/kg) AND CHEMICAL COMPOSITION (ORGANIC MATTER (OM), CRUDE PROTEIN (CP), NEUTRAL DETERGENT FIBRE (NDF) AND ACID DETERGENT FIBRE (ADF); g/kg DM) OF THE EDIBLE BIOMASS OF *TRICHANTERA GIGANTEA*, *MORUS ALBA*, *FLEMINGIA MACROPHYLLA* AND *LEUCAENA* K636

	Chemical composition				
	DM	OM	CP	NDF	ADF
F. macrophylla	273	937	175	598	406
T. gigantea	232	876	153	452	261
Leucaena K636	258	927	185	447	315
M. alba	245	936	165	514	306
Nho nhe pea	244	954	251	435	324

In sacco DM disappearance and degradability of the plants are shown in Tables V and VI. Edible biomass of *M. alba* had the highest degradability values at all incubation periods. *Trichantera gigantea* had the highest DM degradability at the 48 and 72 h incubation periods and degradability values of this tree were lower than those of *M. alba*, but much higher than those of *Leucaena* K636 and *F. macrophylla*. The lowest degradability values at all incubation periods were found in edible biomass of *F. macrophylla*.

TABLE V. *IN SACCO* DRY MATTER DISAPPEARANCE (%) OF EDIBLE BIOMASS OF *TRICHANTERA GIGANTEA*, *MORUS ALBA*, *FLEMINGIA MACROPHYLLA* AND *LEUCAENA* K636

	Incubation time (h)						
	4	8	12	24	48	72	96
F. macrophylla.	24.8[a]	26.2[a]	27.3[a]	28.7[a]	34.0[a]	35.4[a]	34.8[a]
T. gigantea	34.7[b]	36.5[b]	51.5[b]	56.5[b]	72.4[c]	82.0[c]	79.2[c]
Leucaena K636	26.7[a]	27.5[a]	27.3[a]	31.0[a]	44.0[b]	46.9[b]	47.2[b]
M. alba	36.2[b]	45.1[c]	63.9[c]	65.5[c]	79.0[d]	82.6[c]	82.4[c]
SE of differences	1.03	1.22	1.87	2.66	2.91	3.01	3.22

Mean within a column with different superscripts differ significantly ($P < 0.05$)

The washing losses and the potentially degradable fraction (a+b) of *M. alba* were similar to those of *T. gigantea*, and both were higher than the values for *F. macrophylla*. The rate constant (*c*) was highest in *M. alba*. The longest lag time was with *Leucaena* and the lowest with *M. alba*.

TABLE VI. *IN SACCO* DEGRADABILITY PARAMETERS OF THE EDIBLE BIOMASS OF *TRICHANTERA GIGANTEA*, *MORUS ALBA*, *F. MACROPHYLLA MACROPHYLLA* AND *LEUCAENA* K636

	a	b	a+b	c	L	RSD	ED*
F. macrophylla	24.9	11.7	36.6	0.027	5.1	0.96	28.1
T. gigantea	32.8	51.1	84.0	0.034	4.0	2.86	49.7
Leucaena K636	26.4	29.3	55.7	0.017	7.4	2.95	31.4
M. alba	31.1	52.6	83.7	0.047	1.3	4.9	54.8

* ED = Effective degradability with an outflow rate of= 0,05/h; L = Lag time in h

3.2.1. In vitro gas production

The volume of gas produced *in vitro* (mL/200 mg DM) after 6, 12, 24, 48, 72 and 96 h of incubation is shown in Table VII, and the gas production kinetics in Table VIII.

TABLE VII. GAS PRODUCTION AT 6, 12, 24, 48, 72 AND 96 h OF INCUBATION (mL/200 mg DRY MATTER) OF EDIBLE BIOMASS OF *TRICHANTERA GIGANTEA*, *MORUS ALBA*, *FLEMINGIA MACROPHYLLA* AND *LEUCAENA* K636

	Incubation time (h)					
	6	12	24	48	72	96
F. macrophylla	6.4	9.8	13.3	17.2	19.4	20.3
F. macrophylla + PEG	8.9	15.0	21.4	27.5	29.5	31.2
Leucaena K636	6.3	10.4	17.5	22.3	24.2	25.1
Leucaena K636 + PEG	8.9	16.1	26.0	31.0	33.0	34.0
T. gigantea	7.6	13.2	26.2	37.0	39.3	40.5
M. alba	16.2	33.3	46.1	52.1	53.6	54.2

Gas production was highest at all incubation intervals for *M. alba*, followed by *T. gigantea* and *F. macrophylla*. Inclusion of Polyethylene glycol (PEG) 4000 increased gas produced in *F. macrophylla* by up to 60.9% at 24 h, 59.9% at 48 h, and 53.7% at 96 h of incubation. For *Leuceana* K636 increases at the same time intervals were 48.6%, 39.0% and 35.5% respectively.

TABLE VIII. GAS PRODUCTION CHARACTERISTICS OF EDIBLE BIOMASS OF *TRICHANTERA GIGANTEA*, *MORUS ALBA*, *FLEMINGIA MACROPHYLLA* AND *LEUCAENA* K636

	a	b	a + b	c	RSD
F. macrophylla	2.7	17.7	20.4	0.0386	0.457
F. macrophylla + PEG	1.6	29.2	30.8	0.0482	0.539
Leucaena K636	–0.3	25.4	25.1	0.0479	0.333
Leucaena K636 + PEG	–1.3	35.1	33.8	0.0576	0.677
T. gigantea	–2.3	43.5	41.2	0.0423	1.662
M. alba	–9.3	62.9	53.6	0.0897	0.834

Organic matter digestibility (OMD) and the estimated ME value of *M. alba*, *T. gigantea*, *F. macrophylla*, Nhonhe pea and *Leucaena* followed the same pattern as the gas production (Table IX). *Morus alba* edible biomass had the highest organic matter digestibility and ME values. These values for Nhonhe pea were significantly lower than *M. alba*, but higher than *T. gigantea*. Edible biomass of *F. macrophylla* and *Leucaena* K636 had the lowest organic matter digestibility and ME values.

TABLE IX. ORGANIC MATTER DIGESTIBILITY (OMD) AND METABOLISABLE ENERGY (ME) VALUES OF EDIBLE BIOMASS OF *TRICHANTERA GIGANTEA*, *MORUS ALBA*, *FLEMINGIA MACROPHYLLA*, NHONHE PEA AND *LEUCAENA* K636

	OMD	ME (MJ/kg DM)
F. macrophylla	0.336[a]	5.0[a]
Leucaena K636	0.396[a]	5.6[a]
T. gigantea	0.467[b]	6.6[b]
M. alba	0.652[d]	9.4[d]
Nhonhe pea	0.543[c]	7.9[c]
SE of differences	0.036	0.323

Mean within a column with different superscripts differ significantly ($P < 0.05$)

3.3. Potential for utilization of lesser-known plant foliages as feed resources for livestock

Feed intake and growth of growing goats fed diets in which part of the concentrate was replaced with *F. macrophylla* foliage are shown in Table X.

TABLE X. FEED INTAKE AND GROWTH OF GROWING GOATS FED *FLEMINGIA MACROPHYLLA* FOLIAGE AS A REPLACEMENT FOR CONCENTRATES IN THE DIET

	Replacement rate (% *F. macrophylla* foliage as concentrate.)					
	0	25	50	75	100	SE
Dry Matter (DM) intake, total (g/h/d)	502	488	459	462	440	7.6
F. macrophylla intake (g DM/h/d)	0[a]	70[b]	130[c]	168[d]	180[e]	0.8
DM intake, % of body weight	3.7[a]	3.6[b]	3.4[c]	3.7[a]	3.7[a]	0.1
Initial weight, kg	11.8	11.2	11.4	12.4	11.0	0.7
Final weight, kg	16.0	15.8	15.6	15.2	13.7	1.0
Average daily gain (g)	56[a]	49[b]	31[c]	25[d]	22[d]	1.6
*FCR (kg DM/kg LWG)	9.0[a]	10.0[b]	14.8[c]	17.0[d]	20.0[e]	1.9
Cost : benefit ratio	1 : 1.72	1 : 1.89	1 : 1.92	1 : 2.29	1 : 2.62	–

[a,b,c,d,e] Mean within a row with different superscripts differ significantly ($P < 0.05$)
*FCR = Feed conversion ratio

There were no significant differences in total feed intake or intake expressed as a percentage of body weight, although intake was slightly higher when all concentrates were offered. Daily gain decreased ($P < 0.05$) as the percentage of *F. macrophylla* in the diet increased. Feed conversion efficiency of goats given diets with high levels of *F. macrophylla* foliage was low. At the highest level of replacement (100%) feed conversion ratio was 2.2 times higher than that in the group without *F. macrophylla*. However, the cost : benefit ratio increased with increasing *F. macrophylla* foliage in the diet.

The responses of lactating goats to different levels of *F. macrophylla* foliage in the diet are shown in Table XI. The DM intake decreased as of the level of *F. macrophylla* increased. Milk yield decreased markedly at the highest level of *F. macrophylla* inclusion ($P < 0.05$). The feed conversion ratio worsened as *F. macrophylla* foliage increased in the diet ($P < 0.05$).

The cost : benefit ratio increased as the level of *F. macrophylla* foliage replacement increased from 0% to 40%, but decreased at the higher levels of replacement (60 and 80%). At 80% replacement level, the ratio was about 90% of that of the control group.

TABLE XI. MILK PRODUCTION AND FEED CONVERSION RATIO (FCR) IN LACTATING GOATS FED *FLEMINGIA MACROPHYLLA* FOLIAGE (FMF) AS A REPLACEMENT FOR PROTEIN IN THE DIETARY CONCENTRATES

	Replacement rate with *F. macrophylla* (%)					
	0	20	40	60	80	SE
DM intake, total (g/h/d)	1552[a]	1533[a]	1581[a]	1536[a]	1434[b]	9.7
FMF intake (g DM/h/d)	0[a]	111[b]	190[c]	242[d]	293[e]	2.5
DM intake % of BW	4.4[a]	4.3[a]	4.7[b]	4.3[a]	4.1[c]	0.0
Milk production (g/d)	1742[a]	1642[b]	1596[b]	1463[c]	1215[d]	21
FCR (kg DM/kg milk)	0.90[a]	0.94[a]	1.00[b]	1.05[b]	1.18[c]	0.05
Cost : benefit ratio	1:1.28	1:1.52	!:1.56	1:1.44	1:1.16	–

[a,b,c,d,e] Mean within a row with different superscripts differ significantly ($P < 0.05$)

Results of feeding *T. gigantea* to lactating goats, growing rabbits, growing pigs, fattening ducks and laying hens are summarized in Table XII (cost : benefit ratios are given).

TABLE XII. SUMMARY OF RESULTS OF FEEDING TRIALS IN USING *TRICHANTERA* FOLIAGES AS A NEW FEED RESOURCE FOR LIVESTOCK IN VIETNAM

Species of animal used for trial	The optimum level of TG in diet	Responses of animals (+)	Cost : Benefit ratio	References
Lactating goats	33–38% of diet (on DM bases)	750–800 mL of milk/d	1 : 2.35	Nguyen thi Duyen, et al., 1996. (NIAH) [8]
Growing rabbits	50–55% of diet (on DM bases)	ADG* : 21 g	1 : 1.96	Le Thu Ha et al., 1996. (NIAH) [9]
Growing pigs	33–38% of diet (on DM bases)	ADG : 436 g	1 : 2.52	Nguyen Thi Hong Nhan, et al., 1999. (Can tho University) [10]
Fattening ducks	70–80 g of leaves/duck/d	ADG : 30.7 g	1 : 2.40	Nguyen Thi Hong Nhan, et al., 1996. (Can tho University) [11]
Laying hen	6% of Trichantera leaf meal in diet	Egg production: 75.4%	1 : 1.73	Nguyen Thi Hong Nhan, et al., 1996. (Can tho University) [11]

*ADG: Average daily gain

3.4. Promotion of lesser-known plants to farmers

Responses to dissemination of some lesser-known plants as feed resources for livestock are summarized in Table XIII.

TABLE XIII. NUMBERS OF FARMERS (F) IN PROVINCES (P) IN THE NORTH AND SOUTH OF VIETNAM TO WHOM LESSER-KNOWN PLANTS HAVE BEEN INTRODUCED

	North		South		Total	
	P	F	P	F	P	F
T. gigantea	16	902	3	195	19	1097
F. macrophylla	7	96	–	–	7	96
Leuceana K 636	3	23	–	–	3	23
Nhonhe pea	2	42	–	–	2	42
Total	28	1063	3	195	31	1258

In the North of the country *T. gigantea* is of most interest for use on sloping land, and in the South (in the Mecong River Delta). *F. macrophylla*, *Leucaena* and Nhonhe pea are all gaining acceptance. To encourage uptake of these feed resources, the National Institute of Animal Husbandry and Can tho University have organized training courses on propagation and utilization of these plants for farmers and extension workers. A total 36 training courses were held in GRRC, NIAH, Cantho University from 2000 to 2004; in the North there were 22 training courses and in the South 14 training courses (Table XIV). The total number of man days of training provided was 454 for farmers and 259 for technicians.

TABLE XIV. TRAINING COURSES (TC) ON PROPAGATION AND UTILIZATION OF LESSER-KNOWN PLANTS AS FEED RESOURCES FOR LIVESTOCK

	Total			Northern Vietnam			Southern Vietnam		
	2000–2001	2002–2004	Total	2000–2001	2002–2004	Total	2000–2001	2002–2004	Total
For farmers:									
Training courses	17	7	24	11	4	15	6	3	9
Man days	320	134	454	203	71	274	117	63	180
For technicians:									
Training courses	8	4	12	5	2	7	3	2	5
Man days	177	82	259	121	43	164	56	39	95

4. DISCUSSION

4.1. Yield of lesser-known plants

F. macrophylla is native to Asia, but is also found in sub-Saharan Africa. It is a woody leguminous, deep rooting shrub growing to about 2.5 m in height. The government of Vietnam is promoting cultivation of *F. macrophylla* as it is considered to be an excellent plant for soil conservation [12]. Agronomic studies have been conducted to test its adaptability and measure yield. In Vietnam *F. macrophylla* has adapted well to acid (pH = 3.5) soils, giving yields between 45 and 64 tonnes/ha/year [13]. In our study (2001–2002) fresh matter yield of *F. macrophylla* was around 35 tonnes/ha/year, lower than reported elsewhere [14], possibly due to differences in soils, fertilizer regime and harvesting frequency.

Intercropping with cassava led to a decrease in yield of both cassava and *F. macrophylla*, but total biomass was increased (Table II), confirming that intercropping can give some assurance against crop failure, often missing when single crops are grown [15, 16].

Trichantera gigantea, a multi-purpose tree, found in the Andean foothills of Colombia and in the neighbouring countries of Central and South America, adapts readily to a wide range of tropical ecosystems, and was introduced in Vietnam in 1991 [11]. Fresh biomass production of *T. gigantea* of 53 tonnes/ha/year, has been reported [11]. In Vietnam, harvesting time, fertilizer regime, and cropping regime (monoculture or intercopping) have affected yield [17]. In the first year of growth yield is lower than in subsequent years. *T. gigantea* grows well in the shade of other trees such as banana or Jackfruid.

Leucaena grows naturally in many regions of Vietnam, but local varieties are low yielding and rich in tannins and other anti-nutritional compounds. *Leucaena K636* was introduced recently [7].

Morus alba is a well known species in Vietnam, but until now it has been grown mainly for the silk industry. It is now being promoted as a feed resource for ruminants.

Nhonhe pea is a leguminous plant found mainly in the mountainous areas in northern Vietnam. It grows well in upland, poor and acid soils. It is usually intercropped with cassava and maize because it is a climbing plant that needs other plants to support it. Its seeds are used as human food and its leaves for livestock. However, Nhone pea is intercropped, total biomass yields are low, probably a reflection of the type of soil favoured by this plant (Table III).

4.2. Chemical composition and nutritive value of lesser-known plants foliages

The CP content in the foliage of the plants evaluated was relative high. Three of the species, *F. macrophylla*, *Leucaena* K 636 and Nhonhe pea, are leguminous and accepted as protein-rich (Table IV). In our experiment, the CP of *F. macrophylla* was similar to that reported earlier [18], and higher than that found elsewhere [14]. Although not leguminous trees, *Trichantera gigantea* and *Morus alba* were also judged to be protein-rich (Table IV). According to [19], the CP content in *T. gigantea* foliage (leaves and young stem) is in the range 16.7 to 20% in the DM. *In sacco* measurements and gas production suggested that *T. gigantea* and *M. alba* foliages do not contain anti-nutritional factors and have a higher nutritive value than *F. macrophylla* and *Leucaena*. In preliminary tests for anti-nutritional compounds, no alkaloids or condensed tannins were found in *T. gigantea* foliage [20]. The response to PEG, in the gas production test, from *F. macrophylla* and *Leucaena* indicated the presence of tannins. Total tannins in *F. macrophylla* foliage are 3.1% of DM [6]. Of the species tested, *T. gigantea* appears the most promising.

4.3. Lesser-known plant species as livestock feed

Decreases in DM intake with increasing levels of *F. macrophylla* foliage in both feeding trials (Tables X and XI), especially at the higher replacement rates, may be due to increasing levels of NDF and tannin in the ration. Voluntary intake of low quality roughage is generally restricted both by chewing and rumen capacity [21], and also by lower rumen microbial activity due to insufficient degradable protein [22]. Rate of passage through the rumen is reduced, thus reducing feed intake. These trials indicated that the older lactating goats were able to tolerate higher levels of *F. macrophylla* than younger growing goats, optimum rates of replacement of concentrates with this foliage being 17% of DM for growing goats and 21% of DM for lactating goats. Compared to *F. macrophylla*, palatability of *T. gigantea* foliages is better, optimum inclusion rates being: up to 38% of DM for lactating goats; 55% for growing rabbits; and 38% for growing pigs (Table XII). *T. gigantea* leaves can form a substantial part of the diet of several species of animals such as rabbits, guinea pigs, pigs, poultry, sheep and goats [19].

In Vietnam, foliage of *T. gigantea* and *F. macrophylla* is now being actively encouraged as livestock feed by NIAH and Cantho University. Farmers are particularly interested in *Trichantera*, because it is relatively easy to grow and feed and is accepted readily by livestock.

5. CONCLUSIONS

From this study the following conclusions can be made:

- Five lesser-known plants (*F. macrophylla, T. gigantea, L. leucocephala, M. alba* (Mulberry) and *P. calcaratus*) have been identified and propagated as potential new animal feed resources for farmers' to grow and use.

- Edible biomass of the five plants has been evaluated for nutritional value by *in vitro* and *in sacco* methods. The most promising species were *T. gigantea, L. leucocephala*, *M. alba* and *P. calcaratus.*

- On-farm the highest growth rates of growing goats were achieved when *F. macrophylla* foliage replaced 25% of the crude protein in the concentrate. For the lactating goats, the highest milk yield was achieved when *F. macrophylla* foliage replaced 20% of the crude protein in the concentrate For *Trichatera* foliage the optimum inclusion rates in the diets were: up to 38% of DM for lactating goats; 55% for growing rabbits; and 38% for growing pigs.

- Using *F. macrophylla* and *T. gigantea* foliages for livestock feeding led to increased cost : benefit ratios (on average : 1 : 2.25 for growing goats; from 1 : 1.36 to 1 : 2.35 for lactating goats; 1 : 1.96 for growing rabbits; 1 : 2.52 for growing pigs; 1 : 2.4 for fattening ducks and 1 : 1.73 for laying hens).

- The use of these lesser-known plants has been widely disseminated in 31 Provinces, with 1258 farmers being involved. A total of 36 training courses have been successfully held for farmers and extension workers.

6. RECOMMENDATIONS

Five species of lesser-known plants (*F. macrophylla, T. gigantea, L. leucocephala, M. alba* and *P. calcaratus*) with potential as livestock feed have been introduced to farmers throughout the country. In order to sustain dissemination, the following is required:

- The most promising plants should be promoted commercially.

- More pilot farms should be established.

- Development and dissemination of these plants should continue.

- More training courses on propagation and utilization of these plants, both for farmers and extension workers, should be organized.

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