Least Cost Production and Evaluation of Multi-Nutrient Block for Lactating Crossbred Dairy cows Fed on a Basal Diet of Oats Straw

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Abstract

The activity was initiated with major objective to replace cost inducing agro-industrial by-products in the conventionally recommended urea-molasses multi-nutrient block (UMMB) with locally available but cheaper feed resources. Economic analysis was conducted to know cost of production of the blocks and the cost-benefits incurred in supplementing the control and the various treatment blocks to lactating crossbred cows fed on a basal diet of oats straw. Replacing cement with lime as a binding agent on partial or complete bases (W/W) did not maintain block physical hardness and consistency. On the other hand, partial (50%) replacement of cement by clay soil as a binding agent worked out very well. Partial replacement (W/W) of the crude protein (CP) in the control block by CP obtained from locally available, cheaper conventional and non-conventional sources resulted to decreased CP concentrations in the treatment blocks compared to control blocks. Production cost per a kg of the UMMB indicated that the newly manufactured blocks have better comparative advantages over the control block. Feed intake was highly variable; however, there is no noticeable change ($P>0.05$) between the control and the newly formulated blocks for daily total dry matter and basal feed intake. The daily amount of block and CP intake was lower for cows supplemented with a poultry litter based block. Daily milk production was also similar among all the cows except those supplemented with a poultry litter based UMMB that produced inferior milk compared to cows on the control groups. Furthermore, cost-benefit analysis indicated that there was, in general, little or no difference in daily profit obtained from cows on the control and treatment blocks. It is hence, recommended that partial replacement (W/W) of the costly agro-industrial byproducts with locally available feed resources and binding agents pay off the cost involved in the production of the newly formulated blocks without, in fact, a compromise in the daily performance of lactating crossbred cows.

Key words: *Urea-molasses block, binding agent, cost-benefit, agro-industrial by-product, UMMB formulae*

Introduction

Grazing and crop residues constitute the major livestock feed resources in the central highlands of Ethiopia. These feeds are characterized by an imbalanced array of nutrients, of which fermentable nitrogen is usually the first limiting; organic matter digestibility is also usually below 50%. In line with this, Preston (1987) reported considerably lower rumen ammonia level (<200mg/l of rumen liquor) than that required for maximum cellulose digestion in cattle and sheep grazing during the dry season in Ethiopia. To rectify the situation feeding strategy should be geared towards maximizing fibre degradability in the rumen, optimize microbial protein synthesis and promote escape of dietary protein and lipid supplements from the rumen fermentation. Supplementation with MNB is a simple and effective method of improving rumen function when the basal diet is dominated by low, poor quality fibrous materials as would be the case in Ethiopia. Besides providing easily fermentable energy and nitrogen; the block could be used as a carrier of micro-nutrients. Various reports indicated that MNB can be efficiently utilized to boost ruminant productivity (Cheva and proma, 1995; Hossian *et al*., 1995; Bheekhee *et al*., 1999). In Ethiopia as well some research has been conducted to promote it both on-station and on-farm (Tekeba *et al*. 2013; Tamirat and Getu, *2014*). Results are in general very much encouraging although research efforts have so far been mainly focusing on analyzing biological responses like; milk yield, feed intake and fattening potentials UMMB supplementations.

Though the technology involved in block making is both simple and practicable, factors such as ingredients used, mixing techniques and environmental factors affect the block stability. The state of hardening is of particular interest from the point of view of transportation and consumption by the animals. Moreover, the accessibility and sky-rocketing prices of major ingredients in the block posed negative setbacks in the dissemination of the block for wider use. It can be said that no emphasis has so far been given to address the problems. Consequently, an investigation was carried out to study the biological and economic feasibility of manufacturing least cost multi-nutrient block leaks from locally available feed and binding resources for ruminant animals maintained on low quality basal feeds under local conditions.

Materials and Methods

The study site

The trial was conducted between 2008 – 2010 at Holetta Agricultural Research Center. The center is located at about 30 km west of the Addis Ababa along the main road to Ambo.

Percentage compositions of feed ingredients in the blocks

The control block used in the trial was the one previously tested on-station and promoted to users via extension and developmental organizations. Least cost intervention blocks had their major agro industrial byproducts partially or completely replaced (W/W) by locally available cheaper, non-conventional feed ingredients. The new ingredients that replaced urea in the least cost blocks were: dried and ground tagasaste leaf, air dried, sieved poultry litter and brewery dry grains. The wheat bran in the former control block was replaced by ground pod of *Prosopis juliflora*. Similarly, clay soil and lime (ground calcium carbonate) were tested as binding agents in the newly formulated and manufactured blocks. Either partial or complete replacement was made by weight basis (W/W) for each ingredient used in the manufacturing of the least cost block leaks. In general, sixteen different combinations were tested against the control block (F1) for their efficacy using various evaluation techniques that involve steps ranging from testing block physical strength to animal response trials using lactating crossbred dairy cows.

Table 1. Percentage compositions of ingredients used in making the feed blocks

Ingredients	Block manufacturing Formulae (% basis)																
	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17
Molasses	36	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40
Wheat bran	25																
P. juliflora		25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
Urea	10	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
Noug cake	13	6	6	6	6	6	6	6	6					6	6	6	6
Tagasaste		11	11	11	11					17	17	17	17				
PL						11	11	11	11								
BDG														11	11	11	11
Salt	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
M. mix	3																
Cement	10	5		5		5		5		5		5		5		5	
Lime				5	10			5	10			5	10			5	10
Clay soil		5	10			5	10			5	10			5	10		
Total %	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

PL=poultry litter; BDG=brewery dry grain; M.mix=mineral mix; F1=control block

The procedures that were adopted to mix up the experimental ingredients were as shown through step 1to5 below.

1. Urea was mixed thoroughly with molasses for about 20 minutes
2. Salt, mineral mix and biding agents (cement, soil, lime) were added and mixed in to water in the ratio of 2:1
3. Ingredients under items 1&2 were thoroughly mixed
4. Similarly, protein sources (noug cake, poltry littre, brewery dry grains, ground tagasaste leaf) were mixed in to the past made in step 3 above
5. The energy sources (wheat bran, *Prosopis juliflora* pod flour) were added and mixed in to the above paste indicated by step 4. The paste was then molded in to a block which was made to be properly dried in the air and under shade.

Table 2. Chemical compositions and *In-vitro* digestibility of individual feed ingredients used in manufacturing experimental block leak (g/kg DM)

Feed ingredient	DM	Ash	OM	CP	DOMD	NDF	ADF	Lignin
Molasses	723.5	0	0	290.0	0	37.0	NA	NA
Wheat bran	882.5	48.0	952.0	166.2	726.6	422.7	128.0	27.9
Prosopis pod flour	884.2	54.5	945.5	145.9	615..0	462.7	279.8	88.1
Urea	NA	NA	NA	NA	NA	NA	NA	NA
Noug cake	926.0	111.0	889.0	300.3	689.6	406.4	297.3	77.3
Ground Tagasaste leaf	917.9	49.1	950.9	225.9	680.6	576.5	378.8	53.4
Poultry litter	927.3	167.2	832.8	212.5	582.9	435.5	284.4	65.9
Brewery dry grain	934.4	39.2	960.8	263.9	588.2	591.2	280.0	65.5

DM=dry matter, OM=organic matter, CP=crude protein, NDF=neutral detergent fiber, ADF=acid detergent fiber, DOMD=digestible organic matter in the dry matter, NA=not analyzed

All samples from feed ingredients above were analyzed for DM, Ash, OM, and CP according to AOAC (1990) procedures. NDF, ADF and permanganate lignin were determined by the methods of Van Soest and Robertson (1985). *In vitro* organic matter digestibility was determined using the procedures outlined by Tilley and Terry (1963).

Measuring block physical hardness and consistency

Three trained personnel gave their subjective judgments about the strength of the block when the blocks were assumed to be adequately dried. The newly produced least cost blocks were then compared and judged against the control block that was used as reference block throughout the trial. Major criteria that were considered were:

1. Block strength as measured through sticky molasses that felt after finger pressing and fragility test (test after a 55 kg weighing load was placed up on the dried block)
2. Block solubility test was made after submerging the block in to a bucket full of water for about 2 hours and checking whether the shape of the block has remained intact or not.
3. Density of the block as measured through the volume and mass (weight) of the block up on sufficient drying
4. Average length of days taken for complete drying

Testing the block for chemical composition

All blocks were subjected to chemical analysis after representative samples were randomly taken and analyzed in the laboratory for DM, CP, and NDF using standard analytical laboratory procedures.

On-Station feeding trial on early lactating crossbred cows

Blocks that were found to be similar and/or above the control using lab. chemical and bioassay techniques were promoted to feeding trial on-station. The experiment was conducted on crossbred cows (50%) of same genotypes, stage of lactation (15±8 days after parturition), live weight (352±28Kg), previous lactation performance (10-12kg/d/cow). The animals only varied in parity which ranged between 1 and 4. After the animals were adapted to leaking block for 7days, they were offered with *adlibitum* oats straw, water and treatment blocks. Concentrate composed of 67% wheat bran, 32% cotton seed cake and 1% salt offered at the rate of 0.5kg /Lt of milk production. It should, however, be remembered that 25% of the daily concentrate allowance was deducted from all the treatments to offset the price incurred due to additional block supplementation. The treatment set-up for the tested blocks is shown in the Table 3 below.

Table 3. Feed Ingredients compositions for control and treatment blocks used for the feeding trial

	T1(Control)	T2	T3	T4	T5
Ingredients	% inclusion	% inclusion	% inclusion	% inclusion	% inclusion
Molasses	36	40	40	40	40
Wheat bran	25	0	0	0	0
Prosopis pod	0	25	25	25	25
Urea	10	6	6	6	6
Noug cake	13	6	6	0	6
Tagasaste leaf	0	11	0	17	0
Poultry litter	0	0	11	0	0
Brewery Grains	0	0	0	0	11
Salt	3	2	2	2	2
Mineral mix	3	0	0	0	0
Cement	10	5	5	5	5
Clay soil	0	5	5	5	5
Total	100	100	100	100	100

Data collection

Types of data collected included: Block physical strength & consistency; block chemical compositions; intake (block, concentrate, basal feed and total DM intake); milk yield and quality; all variable costs related to input and output prices are considered in calculating the cost- benefit ratios.

Statistical data analysis

While subjective judgments from an average result of three trained personnel were used to judge block strength, CRD model using SAS, 2002 was used to compare the new blocks against the control using various chemical and bioassay techniques. A 5x5 simple Latin Square Design using SAS, 2002 was used to analyze data set from animal response trial. Cost-benefit ratio was computed using simple partial budget analysis.

Results and Discussions

Measuring block physical strength and consistency

This is part of the study that ensures whether the different ingredients in a block were combined in the manner that could allow the blocks to be sufficiently dried so that they can easily been transported, stored and fed without any limitation in block and basal feed intakes. The result for the different parameters used to judge block hardness and consistency are indicated in Table 4 below. It should be noted that the table displays the result of only those block formulae which have already been qualified and promoted to the feeding trial based on the pre-set criteria to judge the strength and consistency of the newly formulated blocks against the control blocks.

Table 4. Physical strength of blocks as measured through the different parameters

Ingredients	Block manufacturing formulae (% basis)				
	Control block	Treatment blocks			
	F1	F2	F6	F10	F14
Molasses	36	40	40	40	40
Wheat bran	25				
Prosopis pod		25	25	25	25
Urea	10	6	6	6	6
Noug cake	13	6	6		6
Tagasaste		11		17	
Poultry litter			11		
Brewery dry grain					11
Salt	3	2	2	2	2
Mineral mix	3				
Cement	10	5	5	5	5
Lime					
Clay soil		5	5	5	5
Total %	100	100	100	100	100
Block strength					
a. finger press	G	G	G	G	M
b. Fragility	G	G	M	M	M
Block solubility	G	G	M	G	M
Density(kg/m^3)	826	690	650	670	620
Drying duration (h)	72	96	96	96	120

PL=poultry litter; BDG=brewery dry grain; M.mix=mineral mix; G=Good, M=medium,

Block physical strength

It was measured by observing sticking molasses that have been left after finger pressing and a fragility test after a 55 kg weighing person was allowed to stand on the dried block. This was done for 4 replicated blocks per treatment from day one to three after the blocks were molded and allowed to dry under shade in a three sided opened shelter. Compared to the control block the newly formulated and manufactured blocks maintained their physical hardness and consistency when cement was only partially replaced (50%) by clay soil **(**Table 4**) i**ndicating that the ingredients used were held together reasonably well and that they did not crumble thereafter and were therefore not crushable. This has the advantage of ensuring transportation over long distances and storage of such blocks over very long periods of time. Simultaneous increase in the levels of molasses and binding agent have some negative relation on block strength, with that assumption in mind the level of molasses was kept constant to see the degree of block strength by only varying the level of replacements for the binding agents. Ordinary clay or bentonite has also reported elsewhere to be much efficient when used as a binding agent for block making (Chen *et al.,* 1993b; Guan *et al.,* 1998). Lime did not worked out well as binding agent in the current trial though there are reports earlier that hardness/strength and consistency of blocks were maintained well over cement when lime in its slaked form was used at levels ranging between 4-15% (Hassoun1989; Aarts *et al.* 1990; Hadjipanayiotou *et al.*, 1991). The inconsistency with the present finding may be attributed to the difference in the level of molasses and the type and quantity of lime used (powdered CaCO3 in the current trial as opposed to CaO and Ca $(OH)_2$ in the previous research reports). Among the three binding agents, clay soil can be relatively accessed by smallholder farmers at no or low cost and hence has considerable practical significance for use under on farm conditions. The selection of the binder, therefore, has to depend upon price and availability. From the current study, however, it is difficult to conclude that complete replacement of cement by clay soil and/or both replacement levels of cement for lime did not worked out well since replacements were made only on weight basis. Moreover, all exhaustive options including levels higher than that used in the control blocks need to be cheeked.

Block solubility

Blocks were submerged in to a bucket full of water for about 2 hours to check whether or no the shape of the block remains intact. This is also a test used to ensure gradual release of urea and molasses to provide a constant source of degradable nitrogen throughout the day to promote growth of rumen microbes in ruminants fed poor quality forage. If otherwise, urea and molasses toxicity will occur, as noted by Preston and Leng (1990). When soaked in water, the blocks for which the cement was partially replaced with clay soils did not dissolve until the end of the second hour (Table 4). It worth good to note here that for ruminants to have access to the nutrients in salt, mineral or molasses blocks, licking action with their tongues is important i.e. a sort of abrasion. Their saliva would not therefore soak the blocks, unnecessarily dissolve the nutrients and, by so doing, oversupply urea or molasses to the animals. The reason behind the relatively poor solubility of block made by partial replacement of urea with poultry litter and BDG may be associated to the higher bulk density (see table 4 above) of these ingredients and the relatively smaller amount of molasses used to soak up these ingredients. In line with this, Hadjipanayiotou *et al*. (1991) also added that blocks with poultry litter would require higher level of binding agents (>10%).

Density of the block

Density was calculated from measured mass (weight) and volume of the block up on sufficient drying. The density of blocks was found to decrease with increasing contents of bulky materials replacing urea and wheat bran. The density (kg/m^3) of blocks made is shown in Table 4. Block density was affected by the types of ingredients used and the method of pressing. For instance, less pressing was applied to prepare a block made by partial replacement of urea and wheat bran with various protein and energy sources resulting in the formation of less dense blocks than that of the control block. In general, it can be said that the calculated density of the finished block (see Table 4) was found to be closely related to the bulk density of the ingredients used. The finding from this study is in agreement with the report of Hadjipanayiotou *et al*. (1993). In some cases, in the current trial the number of blocks produced for same kg of mix was higher for formulae where urea has been fully replaced by bulky protein feeds like tagasaste leaf, BDG and poultry litter and/or when wheat bran was fully replaced by prosopis pod flour even though densities for such blocks were smaller and also that such block would require longer days to attain sufficient drying compared to the control blocks.

Length of days required for complete drying

Depending up on the levels of replacements used for urea, wheat bran and cement, 3 to 5 days were required for complete drying of the control and experimental blocks under shade conditions. Since the level of molasses in all except the control block was similar the difference in the duration of drying between the different treatment blocks may have probably emanated from the variation in the partial replacement of the cement in the control block by clay soil. Control block attained sufficient drying within three days while it has taken 5 days for block on formulae 14. This could be attributed to the bulky nature and high contents of fiber (Table 1) which in turn has led to the difficulty in the molding process. Obviously, more days would have been required for adequate drying than that recommended in Table 4 above if same experiment would have been repeated during the rainy season due to the fall in temperature and relative humidity. Hardening of urea-molasses block increased with advancing drying period. However, care should be taken in drying blocks for longer period since longer drying periods would result in extremely hard blocks that could reduce block solubility and intake. It is preferred that urea-molasses blocks are made at a time prior to their use so that they would reach the desired degree of hardness at the time required. However, when long storage period is inevitable, wrapping and/or storing the blocks in polyethylene sheets/bags will maintain the desired hardness. Fortunately, no mold growth was observed in any one of the blocks even when stored for over more than two months after preparation in this study. Based on these observations, it can be concluded that the urea molasses multi-nutrient block so prepared could be preserved in a dry environment at room temperature for a reasonable period.

Nutritive values of experimental blocks

The nutritive values determined through proximate, detergent analysis and *in-vitro* digestibility of the different formula blocks are presented in Table 5 below. In general, it can be said that for all nutrient profiles, the blocks were significantly different (P<0.05) when comparison was made both among the newly manufactured blocks and/or when these blocks were compared with the control block. The control block had the highest CP (P<0.05) followed by blocks on treatment 2 & 4 where the urea has been partially replaced by tagasaste leaf and brewery dry grain (BDG). Blocks prepared with partial replacement of urea with poultry litter had the lowest CP. The organic matter digestibility (DOMD) of the blocks ranged from 619 g/kg in poultry litter based block to 684.1g/kg DM tagasaste leaf powder based blocks. Blocks with tagasaste leaf powder (T2 &T4) had the highest (P<0.05) DOMD while those based on poultry litter had the lowest (P<0.05) DOMD. Metabolizable energy contents of experimental block as expressed through Mega joule per kilogram DM followed same trend as for DOMD of the blocks. The NDF contents of the blocks differed from 325.9 g/kg DM in BDG based block to 227.3 g/kg DM in the control blocks. The control blocks had the lowest (P<0.05) NDF followed by blocks on tagasaste leaf powder and poultry litter based blocks. The composition of ADF on the other hand was highest for BDG and poultry litter based blocks (P<0.05) while it was recorded to be lowest (P<0.05) for blocks on the control and tagasaste leaf powder (T2) based blocks. The lignin contents of the blocks were similar (P>0.05) for treatment blocks. The control block had the lowest (P<0.05) lignin content of all the blocks.

The difference in the nutritive value among the different experimental blocks is quite expected owning to the difference in the type and quantity of ingredients used in manufacturing of the blocks. The difference in the nutritive value of constituent feed ingredients (see Table 2 above) used in the manufacturing of each treatment block might have further influenced the nutrient profiles in the experimental blocks. Previous research workers in this regard have also reported same result (Kakkar and Makkar, 1995; Aganga, *et al*., 2005). The highest urea level and the low contents of fiber in the component ingredient feeds in the control block positively contributed to the considerably higher contents of CP and lowest contents of the fiber components. The way poultry litter has been dried and stored and the nature and type of the substances used as litter perhaps affected the nutritive value of the block compared to blocks on the control and other treatments.

Table 5. Chemical compositions and *in-vitro* digestibility of supplemental block leaks

Variable (g/kg DM)	Treatment					Mean±SEM	CV%
	F1	F2	F6	F10	F14		
DM	938.3[c]	938.3[c]	954.0[a]	954.4[a]	943.8[b]	945.7±1.41	0.21
Total ash	256.1[b]	222.7[d]	273.4[a]	209.0[e]	234.1[c]	239.1±2.07	1.78
OM	743.9[d]	777.3[b]	726.6[e]	791.0[a]	765.9[c]	760.9±2.07	0.56
CP	423.8[a]	318.3[b]	307.4[d]	313.3[c]	318.8[b]	336.3±0.95	0.27
DOMD	638.1[c]	675.6[a]	619.0[d]	684.1[a]	656.6[b]	654.6±3.35	1.71
ME (MJ/Kg DM)	10.21[c]	10.81[a]	9.91[d]	10.94[a]	10.50[b]	10.47±1.34	1.71
NDF	227.3[d]	263.7[c]	293.5[b]	279.8[b]	325.9[a]	243.9±4.93	9.98
ADF	117.9[c]	168.8[c]	210.7[a]	189.6[b]	213.5[a]	188.7±3.02	4.82
Lignin	31.1[b]	38.9[a]	40.8[a]	42.2[a]	54.3[a]	39.4±2.21	12.39

Despite partial replacement of urea in the control block by different locally available non-conventional protein sources, the drop in CP contents were not large enough to affect ideal rumen environments for fiber digestion. Whitman (1980) reported that the critical CP level to support optimum rumen function was 7%, which indicates the adequacy of CP from all the supplemental blocks used in the present studies.

Daily feed and major nutrient intake

The basal roughage used for this feeding trial was oat straw collected immediately after grain harvest for seed production from on-station forage trial sites. Hence, oat straw used in the current trial was of low nutritional quality that it is not expected to meet daily requirements of experimental cows yielding 10-12 lt. Feed intake of experimental cows maintained on a basal diet of oat straw supplemented with the different treatment blocks and cotton seed cake based concentrate was as shown in Table 6 below. Daily basal feed and total dry matter intake were non-significant (P>0.05) for all cows leaking the different blocks and the control block. There was no considerable change in basal feed and total feed intake associated to the change in block formulation even among the newly manufactured block leaks.

Table 6. Effect of supplemental block leak and concentrate mix on feed intake of experimental cows

Variable (kgd^{-1})	Treatment					Mean±SEM	CV%
	1	2	3	4	5		
Oat straw intake	8.00[a]	8.06[a]	8.14[a]	8.20[a]	8.16[a]	8.11±1.05	13.63
Concentrate mix	3.32[c]	3.41[b]	3.54[a]	3.41[b]	3.55[a]	3.44±0.42	5.32
MNB intake	0.946[ab]	1.07[a]	0.657[b]	0.983[a]	1.06[a]	0.942±0.62	35.15
TDM intake	12.26[a]	12.54[a]	12.33[a]	12.59[a]	12.77[a]	12.50±1.13	10.23
CP intake	1.77[a]	1.74[ab]	1.64[b]	1.72[ab]	1.78[a]	1.73±0.45	15.30
MEI (MJ/Kg DM)	113.16[b]	116.57[ab]	113.62[b]	116.94[ab]	118.53[a]	115.77±3.43	10.17

For details on each block formulation, see Table 3 above

Despite the observed change in the daily supplemental block and concentrate mix intake (P<0.05), cows on all treatment diets tended to have consumed similar amount of dry matter implying the possibility of producing blocks from whatever local feed resources available within the proximity of the small holder farmers. Moreover, it is in line with the very objective of this trial that block of same quality to that of the conventionally recommended can be manufactured with a least cost without, in fact, any negative effect on the performance of the animals. The absence of difference for basal feed intake between cows maintained on the control and the newly manufactured blocks on the other hand is a reflection of the fact that the demand for ideal ruminal environment (rumen NH3-N & PH) for roughage digestion has equally been met for experimental cows maintained on both block leaks types. In general, the overall improvement in the basal and total feed intake in the present trial could also partly be associated to the supplemental concentrate mix which was composed of an escape nitrogen source cotton seed cake and wheat bran. Improvement in the basal diet due to UMMB and cotton seed cake based concentrate mix supplementation has been well established and may vary widely depending on quality of basal feed and feeding system (Bheekhee *et al*., 2002; Singh and Singh 2003).

Experimental cows also varied ($P<0.05$) in the daily amount of nutrient they have consumed. Accordingly, experimental cows except those maintained on the poultry litter based block leak consumed similar amount of CP. The lower CP contents of poultry litter (Table 2) might have resulted to the observed low intake. Similarly, great disparities were observed among experimental cows in terms of daily metabolisable energy intakes. Consequently, cows leaking experimental block under treatments 2, 4 and 5 received greater ($P<0.05$) amount of daily metabolisable energy compared to their counter parts on the remaining blocks. It can be seen from the Table 6 above that the differences in the intakes of both nutrients among the experimental cows didn't happen to influence feed dry matter intake for the basal and total daily feed intake. The reason could be explained by the fact that all cows were on the positive CP and energy balance compared to the requirement (97.6MJ, ME/d and 866.5 gm/d of total protein) of a 352±28Kg weighing cows that daily produces 10-12 kg of milk with 5% butter fat according to Kearl (ARC, 1990). Increased intakes of dry matter, organic matter, crude protein, metabolisable energy, neutral-detergent fiber and acid- detergent fiber with UMMB lick supplementation has also been reported earlier by several researchers (Mohini, 1991; Gupta and Malik, 1991)

Daily milk yield and compositions

The milk yield and composition of experimental cows are shown in Table 7. Daily milk yield, milk protein and total solids contents were shown to have significant ($P<0.05$) differences among cows supplemented with the different treatment blocks. Compared to cows supplemented with the control and other treatment blocks both daily milk yield and qualities (except fat contents) were inferior ($P<0.05$) for experimental cows leaking the poultry litter based blocks. Generally speaking cows supplemented with the newly manufactured blocks can be sustained equally or even considerably more than cows maintained on the control block since additional benefits for the small holder dairy farmer can be achieved from reduced cost of block production and extra savings obtained from daily concentrate allowances of lactating cows maintained on such newly formulated blocks. The comparable daily milk yield and milk compositions with cows on the control block may be speculated to the fact that the ME/CP ratio of the treatment rations might have been balanced leading to subsequent maintenance of NH_3-N content in the rumen. This in turn might have led to an improved ruminal environment for micro-organisms, increased digestibility and dry matter intake of oat straw. The finding from the current study is also in line with earlier reports that addition of UMMB to a rice straw based ration increased straw digestibility, feed intake, total nutrient absorption and protein: energy ratio in the nutrients absorbed (Wanapat, 1985; Preston and Leng, 1987; Leng, 1991).

Table 7. Effect of different block supplementations on milk yield and compositions

Variable (kgd^{-1})	Treatment					Mean±SEM	CV%
	1	2	3	4	5		
Milk yield	11.83^{ab}	11.64^{b}	11.39^{c}	11.99^{a}	11.89^{a}	11.75±0.63	5.10
Milk protein (%)	2.84ab	2.95a	2.71b	2.80ab	3.03a	2.87±0.55	10.34
Milk fat (%)	3.86a	3.95a	3.77a	4.26a	4.07a	4.01±0.73	13.30
Total solids (%)	12.99b	13.40ab	11.30c	13.25ab	13.78a	12.77±0.96	7.18

For details on each treatment block formulation see Table 3

Moreover, the inclusion of cotton seed cake in the concentrate mix might have helped to save the concentrate mix and satisfy the total protein requirement of experimental cows. Other authors (Leng *et al*., 1991; Singh and Singh 2003; Misra and Reddy 2004) also reported same result with cotton seed and fish meal inclusion in the ration of high yielding crossbred cows. Though differences for fat contents of the milk among experimental cows were non-significant (P>0.05) it appears that supplementation with the blocks substantially improved fat contents. These enhancements were similar to those reported by Sivayoganathan *et al*. (2001) and Misra *et al*. (2006). Comparable fat content of milk with the control group, presumably due to high acetic acid fermentation in the rumen of treatment blocks associated with increased digestibility of CF and improved energy intake. This is also in consistent with previous findings by (Sivaiah and Mudgal 1983; Sudhakar *et. al*., 2002).

Cost-Benefit ratio

Cost of manufacturing and the relative advantage of the different treatment blocks over the control block are presented in Table 8 below. Calculations were based on price data set collected for each treatment block at the time of manufacturing of the respective blocks.

Taking production cost/kg of the urea-molasses multi-nutrient block in to account the newly manufactured blocks have strong comparative advantages over the control block minimizing the cost of block manufacturing between 39 and 45% (Table 8). Block manufactured under T4 was produced with the least cost followed by blocks manufactured under T2, 3 and 5, respectively. The gained benefit in cost reduction, however, might not be sustained over a very long period since the cost of buying of each ingredient at any given time in Ethiopia is highly subjected to change owning to change in the seasonal availability of the ingredients. On the other hand, economic returns were calculated for experimental cows receiving the different block leaks (Table 9). A partial budget analysis measures those items of income and expenses that change (Stemmer *et al*., 1998). Therefore, the costs of UMMB, concentrates and dry roughages were considered since all other variable costs (labor, electricity, water etc.) were the same for both the groups.

Table 8. Production cost (Eth. Birr) per kg of the different supplemental block leaks

Ingredients	Control (T1)		T2		T3		T4		T5	
	%	Cost	%	Cost	%	Cost	%	Cost	%	Cost
Molasses	36	1.44	40	1.60	40	1.60	40	1.60	40	1.60
Wheat bran	25	0.60								
*Prosopi*s pod			25	1.00	25	1.00	25	1.00	25	1.00
Urea	10	1.25	6	0.75	6	0.75	6	0.75	6	0.75
Noug cake	13	0.57	6	0.26	6	0.26			6	0.26
Tagasaste			11	0.07			17	0.10		
PL					11	0.11				
BDG									11	0.22
Salt	3	0.12	2	0.08	2	0.08	2	0.08	2	0.08
M. mix	3	2.40								
Cement	10	0.23	5	0.12	5	0.12	5	0.12	5	0.12
Clay soil			5	0.00	5	0.00	5	0.00	5	0.00
Labor		0.17		0.17		0.17		0.17		0.17
Total	100	6.92	100	4.05	100	4.09	100	3.82	100	4.20
% change over the control			41.47		40.90		44.80		39.31	

1 US dollar~20 Eth. Birr, BDG=brewery drain grain, PL= poultry litter, M.mix=mineral mix

Despite differences in the cost of the different blocks manufacturing (Table 8) UMMB supplementation of dairy cows indicated that there was little or no difference in terms of daily profits obtained from cows leaking the control and the newly produced blocks. The reason can be ascertained to the smallest daily amount of block intake that doesn't exert substancial influence on daily feed cost (Table 6). Moreover, similar total dry matter and nutrient intakes that existed between the treatment cows and the control cows might explain the reason. Furthermore, it was observed that the cost: benefit ratio was highest for cows in the T4 group (1:1.46), with a total profit of ETB 71.17/cow/day (Table 9). Compared to cows maintained on the control block profits obtained from cows leaking blocks manufactured under treatment 2 & 3 were smaller by 0.4 and 2.8 ETB/cow/day. This could be attributed to the relatively lower milk production response of cows leaking these blocks.

Table 9. Economic benefit obtained from lactating crossbred cows leaking the different supplemental blocks (Eth. Birr) *1 US dollar~20 Eth. Birr*

Variable	Control (T1)	T2	T3	T4	T5
Milk yield (Ld^{-1})	11.83	11.64	11.39	11.99	11.89
Concentrate (kgd^{-1})	3.32	3.41	3.54	3.41	3.55
Supplemental block leak kgd^{-1})	0.946	1.07	0.657	0.983	1.06
Oat straw (kgd^{-1})	8.00	8.06	8.14	8.20	8.16
Total feed cost/cow/d	50.37	48.74	47.88	48.73	49.76
Total income/cow/d	118.30	116.4	113.90	119.90	118.9
Total profit/cow/d	67.93	67.66	66.02	71.17	69.14
% change in profit over the control		-0.4	-2.8	4.8	1.8
Benefit : cost ratio	1.35	1.39	1.38	1.46	1.39

In general, the result from the current trial is in agreement with the findings of several other authors (Leng *et al.* 1991; Singh and Singh 2003; Misra and Reddy 2004) in that the use of multi-nutrient block plus a concentrate ration mainly formulated from escape nitrogen based supplement (Cotton seed cake & wheat bran in the current trial) can help save the daily concentrate allowance by 30 to 40% without any loss in animal production. The saving from the present trial was 25%.

In view of the above, the economic returns may be higher if the positive long-term impact of supplementing the newly manufactured block leaks on the general body condition and reproduction would have been taken into account. By and large, considering the present cost of feed supplement and the market price of milk, supplementation with the formula blocks was found to be both economical and cost effective.

Conclusions

In conclusion, the most important finding from the present study was that supplementation of the diet with UMMB made from cheaply but locally available non-conventional feed resources and binding agents can significantly improves the productivity of dairy cows without a compromise in the daily milk yield and compositions of lactating crossbred cows. The present findings also demonstrated that UMMB technology is a cost-effective approach to maximizing the utilization of locally available feed resources for better animal productivity during the dry season and may perhaps constitute an innovative feeding strategy for other species of livestock as well, where concentrate feeding is not a common practice, particularly in rearing of small ruminants. Nonetheless, it must be mentioned that there is a need for long-term studies on the response to these newly produced blocks on animals' productive and reproductive performance under smallholder condition that may yield information beyond the short-term responses observed in the present study. To confirm whether ideal ruminal fermentation can be met for efficient roughage utilization, these blocks shall be supported by trials that test the adequacy of rumen NH_3-N concentration and PH. In similar future research works the blocks shall also be investigated for their adequacy in meeting the mineral requirements of lactating crossbred cows.

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