Supplementation of Dairy Cows with Nitrogen Molasses Mineral Blocks and Molasses Urea Mix during the Dry Season

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ABSTRACT : The effects of supplementation with nitrogen molasses mineral blocks and molasses urea mix during and immediately prior to the dry season on the production of dairy cows were studied on-station and on-farm near Morogoro, Tanzania. Supplementation of blocks to on-station cows also receiving *ad libitum* grass hay and 6 kg/d of maize bran increased milk production from 6.7 L/d to 11.2 L/d ($p<0.05$), increased dry matter intake from 10.1 kg/d to 12.0 kg/d ($p<0.05$), but did not significantly affect milk composition, intake of hay, and live weight changes. This increase in milk yield is mainly explained by increased intakes of energy and nitrogen. Supplementation with the molasses urea mix increased daily milk yield from 6.7 L/d to 8.8 L/d ($p<0.05$), but did not significantly affect the other measured production parameters. The on-farm supplementation of the blocks increased daily milk yield by 1.5 L/d in the dry season ($p<0.05$). This supplementation did not increase milk yields prior to the dry season, since quality forage was still available. Taking the production costs into account, supplementation with the blocks and supplementation with mix were cost effective if milk yields increased by 0.7 L/d. Hence supplementation with blocks and supplementation with mix were effective on-station, and supplementation with blocks was cost effective on-farm during the dry season. (***Asian-Aus. J. Anim. Sci. 1999. Vol. 12, No. 5 : 735-741***)

Key Words : Dairy Cattle, Nutrition, Dry Season, Urea, Molasses

INTRODUCTION

A major constraint on the production of dairy cows on small holder farms throughout the tropics, especially during the dry season, is that the roughage feeds provided are unbalanced in terms of energy, protein, minerals and vitamins. Also, they are lignified, and their digestibility is low (Preston and Leng, 1987). This limits feed intake, rumen fermentation, and productivity. The use of poor quality forages can be improved by satisfying the requirements of the rumen microorganisms to ensure efficient fermentation of fiber resulting in an increased production of fermentative outputs (Tiwari et al., 1990; Garg and Gupta, 1992; Sansoucy et al., 1992). This can be achieved by providing a supplement of fermentable carbohydrate, nitrogen and minerals combined with a small amount of nutrients that bypass the rumen (Preston and Leng, 1987; Sansoucy et al., 1992). Mixtures of molasses, a nitrogen source, e.g. chicken litter, urea or urine, carbohydrates and minerals are used as such supplements. Supplementation with such a mixture can increase the intake of poor quality forages by up to 40% (Sancoucy et al., 1992; Badurdeen et al., 1994; Rafiq et al., 1996).

The nitrogen molasses mineral mixture is normally prepared in a block form, and referred to as nitrogen molasses mineral blocks (NMMB). Advantages of these blocks over supplementation with the individual components are that they are easy to handle and use, and that urea can be well mixed and incorporated, thus avoiding toxicity problems. In addition, they are palatable due to the taste and smell of molasses (Sansoucy et al. 1992).

Supplementation of NMMB to cows and buffaloes fed a base feed of cereal straw, lignified grass and/or maize stover has shown to increase milk yields and reduce feed costs of cows and buffaloes in India (Leng and Kunju, 1990; Srinivas and Gupta, 1997), Indonesia, (Hendratno et al., 1991), Pakistan (Habbib et al., 1991) and Bangladesh (Saadullah, 1991). If good quality forages can be provided, then the increase due to the provision of NMMB is limited (Hendratno et al., 1991; Sansoucy et al., 1992). NMMB have been used in Tanzania, but this is not well documented. In the Tanga region the use of these blocks on small holder dairy farms resulted in a non-significant increase in milk production of between 0.2 and 1.1 L per cow per day (Msangi, 1995). The use of a liquid molasses urea mix (MUM) resulted in increased intakes of poor quality forages and increased milk production on small holder dairy farms in the Kilimanjaro region of Tanzania (Shem, 1986). A urea molasses liquid diet, preferably with a restricted amount of wheat straw, can be fed as a scarcity feed for a short period (Mehra et al., 1994; Verma et al., 1994; Dass et al., 1996). The dry season in Morogoro, Tanzania, can extend from May to November, and a second dry period commonly occurs in January and February. The use of NMMB during the dry season

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could increase the milk production at small holder farms in this region.

The objectives of this study were i) to investigate the effect of supplementation with NMMB and MUM during the dry season on productivity of dairy cows in Central Tanzania in a controlled study on station, ii) to conduct a cost/benefit analysis of supplementation with NMMB and MUM and iii) to introduce and investigate the effect of supplementation with NMMB during the dry season on productivity of dairy cows on peri-urban small holder dairy farms in Central Tanzania.

MATERIALS AND METHODS

Preparation of MUM and NMMB

The compositions of the MUM and the NMMB used are given in table 1. For the preparation of the NMMB the cold process described by Sansoucy et al. (1992) was used with the modification that the content of maize bran was increased and that of molasses was decreased. Next to these components, fertilizer grade urea, lime stone, salt, and bone meal were included. Building cement was used as a binder to solidify the blocks. All solid components were mixed by hand. The salt was ground and mixed with water. The water and salt mixture was added to the molasses. The liquid mixture was added to the solid mixture, and mixed thoroughly by hand. The resulting mixture was transferred into wooden molds (0.25 m×0.2 m×0.2 m) and pounded with wooden poles until satisfactory consistency was obtained. Following this, the blocks were removed from the molds and air dried for at least two days.

Table 1. Composition of molasses urea mix (MUM) and nitrogen molasses mineral blocks (NMMB) (% inclusion by weight)

Component	MUM	NMMB
Molasses	80	28
Urea	3	9.3
Limestone	0	4.6
Cement	0	13
Salt (NaCl)	0	2.3
Bone meal	3	2.3
Maize bran	0	33.5
Water	14	7

On-station trial

The study was conducted at the Magadu Dairy Farm of the Sokoine University of Agriculture in Morogoro between July 11 to August 29, 1997. The experiment involved 15 dairy cows, which were crosses between non-indigenous breeds, including Friesian, Ayrshire and Jersey. The average live weight of these cows was 390 (±10.9) kg. They ranged in body condition score from 2.5 to 3.5 with an average of 2.9 (±0.12) on a scale 1-5 according to Edmonson et al. (1989).

Cows were blocked according to milk yield prior to the experiment and randomly assigned to three treatments, including supplementation with NMMB or MUM, and a control. All cows received grass hay (*Urochloa mosambicensis*) twice daily *ad libitum* after each milking. At each milking all cows received 3 kg of maize bran. Cows in the NMMB group received a maximum of 2 kg of NMMB per day. This was achieved by providing a quarter of a block weighing between 1.7 and 2.4 kg after each morning milking. Cows in the MUM group received 1 L of MUM mixed with grass hay after each milking.

Cows were milked twice daily around 7 am and 5 pm. Milk yields were determined daily for each cow at both milkings. Milk fat and protein contents were determined weekly by the Gerber method (Marshall, 1992) and by Kjeldahl method using a Kjeltec system 1002 (Tecator AB, Hoganas, Sweden), respectively, in samples collected during an afternoon milking. Live weight was measured weekly using a weighing scale. Intakes of hay (or hay mixed with MUM) were determined daily for all cows. Ort samples were collected daily from all cows and a pooled sample for each week for each treatment group was produced.

All feed samples were analyzed for dry matter (DM) by drying them to constant weight in an oven at 60℃ for 48 hrs. The samples were then ground. Nitrogen (N) contents were analyzed by the Kjeldal method (AOAC, 1990) using a semi-automated N analyzer (Kjeltec system 1002, Tecator AB, Hoganas, Sweden). Crude protein (CP) was derived from the N content. Acid detergent fiber (ADF) and neutral detergent fiber (NDF) were determined according to the methods described by AOAC (1990) and Goering and van Soest (1970), respectively. Ash contents were determined as described by AOAC (1990). Minerals including Ca, P, Na, K, and Mg were analyzed using inductively coupled plasma spectroscopy (AOAC, 1990) using a Perkin Elmar Optima 3000 spectrophotometer.

Rumen degradability measurements of the grass hay and the maize bran were made using the nylon bag techniques (Ørskov et al., 1980) in the rumen of a non-lactating Holstein Friesian cow and a Hereford steer fitted with permanent rumen cannula. Both animals were fed grass hay *ad libitum*. For each feed, 2 g were weighed in duplicate into labeled nylon bags and incubated for 3, 6, 12, 24, 48, 72, 96 and 120 h. After each incubation time, the bags were removed from the rumen and hand washed in luke warm water for 15 min. Also, two bags containing 2 g of feed were soaked in warm water for 1 h and then washed to determine washing losses. The residues in the bags were then dried for 48 h at 70℃ and the DM loss was determined. The rumen DM degradabilities of the feeds were fitted to the exponential equation p=a+B (1+e-ct) (McDonald, 1981), where p=the degradation loss at time (t), a=the zero time intercept of the fitted curve, a+b=the asymptote of the curve at infinite t, and c is the degradation rate constant. The curve fitting was conducted using the SAS Nonlinear regression procedure (SAS, 1990).

The first week of the trial was regarded as an adaptation period to the diets. Analysis of variance was carried out using the SAS General Linear Models procedure with the repeated measurement statement (SAS, 1990). Treatment means were compared using Duncan multiple range tests at the 5% level of significance (Steel and Torrie, 1960).

On-farm trial

The trial was conducted between July 5 and September 27, 1997, and included 37 cows kept on 14 peri-urban dairy farms around Morogoro. Farms kept between two and four dairy cows. Cows were of the Friesian or Ayrshire breed or crosses between these and other non-indigenous breeds. The average live weight of these cows was 315±9.1 kg, and body condition scores ranged between 2 and 3.5 (±0.1) (scale 1-5). Farms were blocked by geographic location and randomly assigned to treatment. The design consisted of five blocks. Treatments included provision of NMMB and control. NMMB were provided to the farmers as from July 22. Farmers were asked not to alter existing feeding practices with the exception that farmers receiving NMMB were requested to feed a maximum of 2 kg of block per day (a quarter of a block) individually to all lactating cows.

Animals were milked twice daily. Milk yields at all milkings were recorded by the farmer or the farm assistant. Live weights were recorded biweekly using a weighing tape. Forage and supplement samples were collected biweekly from one farmer per geographic location chosen at random. Feed samples were analyzed for DM, N, NDF, and ADF as described in the on-station trial. Farmers were visited at least weekly to monitor the implementation of the protocol and scrutinize the data recording.

Production data were averaged for each cow before the introduction of the blocks, after the introduction of the blocks, and between August 27 and the end of the trial on September 27. Analysis of variance was conducted with these averages using the SAS General Linear Models procedure (SAS, 1990) using the average milk yield before the introduction of the blocks as a covariate.

RESULTS AND DISCUSSION

On-station trial

The chemical composition of the feeds used in this trial is given in table 2 and the rumen degradability characteristics of the grass hay and the maize bran are given in table 3. A comparison between table 2 and figure 1 shows that the grass hay used in the on-station trial had a similar low CP content of 5 % and similar high ADF and NDF contents, i.e. 39.8% and 73.4% than the forage used on the small holder farms during the dry season.

Table 2. Composition of feeds on dry matter (DM) basis

Component	Grass Hay	Maize bran	NMMB	MUM
DM (%)	88.3	90.9	93.0	60.3
N (CP/6.25, %)	0.8	1.8	6.0	1.9
ADF (%)	39.8	7.2	3.6	0
NDF (%)	73.4	30.1	9.4	0
Ash (%)	7.3	2.4	25.2	*
Ca (%)	0.27	0.01	8.56	0.58
P (%)	0.18	0.63	0.92	0.28
K (%)	0.87	0.81	1.57	1.74
Mg (%)	0.15	0.29	0.34	0.24
Na (%)	0.02	0.01	1.02	3.4
NE_l (Mcal/kg DM)	0.9[a]	1.7[b]	1.0	1.5

*=not determined.
[a]=value estimated from NRC (1989).
[b]=value estimated from FAO (1992).
NMMB=nitrogen molasses mineral block.
MUM=molasses urea mix.

Table 3. Rumen degradability characteristics of feeds from the equation p=a-b (1-e-ct) (McDonald, 1981) in which A=washing loss, A+B=potential degradability, B=(a+b)-A, and c=rate constant (h-1)

	Feed	
	Grass hay	Maize bran
A+B (%)	48.3	91.5
B (%)	35.6	
c (h-1)	0.034	0.056
24 hr degradability	32.6	75.8
48 hr degradability	41.4	87.4
Residual S.D.	2.7	2.3

Hence, the on-station trial was able to simulate a dry season feeding scenario on small holder farms. Net Energy Lactation (NEl) values of the feeds were not measured, but estimated from NRC (1989). For the grass hay the NEl value of Pangola grass, sun cured, 43-56 days growth, on dry matter basis 5.5% CP, 77% NDF, 46% ADF, was used (NRC, 1989). For the maize bran the NEl value of hominy feed given by FAO (1992) was used, as this was thought to give the best available estimate for the maize bran used in this study. The NEl values of NMMB and MUM were estimated on the basis of the NEl values of their components. The rumen degradability of the maize bran was high, and only slightly lower than the 94.6 % DM degradability after 48 hr reported by FAO (1992) for corn grain. The rumen degradability of the grass hay was very low, the potential degradability was only 48.3%. This was lower than all the potential degradabilities for Tanzanian forages reported by Shem et al. (1995), and in the range of the rumen DM degradabilities reported by FAO (1992) for straws.

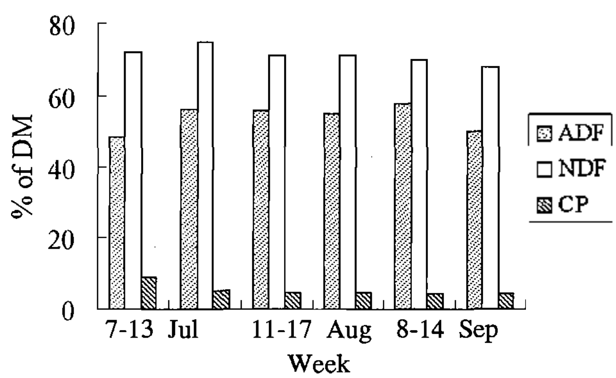

Figure 1. Composition of base feed on-farm study

The group averages for production parameters are given in table 4. This table shows that supplementation with NMMB and MUM resulted in substantial increases in milk production ($p<0.05$) of 4.5 L/d and 2.1 L/d, respectively, but that live weight changes were not affected. Also, the NMMB group had a significantly higher average milk production than the MUM group ($p<0.05$). The milk fat content of the NMMB group was lower than that of the other groups, but this was not significant. Milk protein levels were not affected by treatment.

The cows receiving NMMB consumed on average 1.6 kg DM of block per day. Hence, supplementation with NMMB, without consideration of a possible effect on the intake of hay, increased the intake of NEl and N by 1.6 Mcal/d and 96 g/d, respectively. This increased intake of macro-nutrients could result in an increase in milk yield (3% fat) of 2.5 kg/d (NRC, 1989), provided other nutrients did not limit the response. Hence, the increased milk production due to the supplementation with NMMB is mainly explained by the increased intakes of energy and nitrogen. The cows receiving MUM received on average 1.15 Mcal/d and 22 g N/d with the mix. Supplementation with MUM could, therefore, without consideration of the possible effect on the intake of hay, result in an increase in milk production (3% fat) of 1.8 kg/d (NRC, 1989). Hence, the increased milk production by cows receiving MUM is also mainly explained by increased energy and nitrogen intakes.

Table 4. Group averages for production parameters and levels of significance (P)

Parameter	NMMB	MUM	Control	P
Milk yield (L/d)	11.2[a]	8.8[b]	6.7[c]	0.0001
Milk fat (%)	2.7	3.2	3.1	0.23 (ns)
Milk protein (%)	2.6	2.7	2.7	0.55 (ns)
DMI (kg/d)	11.9[a]	10.4[b]	10.0[b]	0.01
Weight change (kg/d)	0.29	0.23	0.15	0.51 (ns)
Hay intake (kg DM/d)	4.9	nd	4.6	0.10 (ns)

Note: Means within a row with no common superscripts are significantly different ($p<0.05$)
nd=not determined as MUM was mixed with hay
ns=not significant

The average milk production prior to the experiment was 13.3 kg. Hence, all cows, including those receiving NMMB, dropped in milk yield during the trial. This was expected, as the study was to simulate a dry season feeding scenario on small holder farms. To achieve this, it was required that less supplements and a much poorer quality base feed were provided than what was common on the Magadu dairy farm.

The NMMB cows had a significantly higher dry matter intake ($p<0.05$) than the control and the MUM cows. This was due to the intake of blocks, as the intake of hay was not significantly different between the NMMB and the control group. This is not in agreement with the results of Sansoucy et al. (1992), Badurdeen et al. (1994), and Rafiq et al. (1996) who observed increase in the intake of poor quality forage due to the supplementation with NMMB. This can be explained by a better quality of the grass hay compared to the forage used by these authors, and the provision of maize bran. The nutritive quality of the feeds provided in the current study was better than that used in the previous studies. Hence, in the current study the impact of supplementation with NMMB on microbial fermentation will not have been so great as in the previous studies. This could explain why NMMB supplementation did not result in a substantial increase in hay intake in the current study. MUM did not result in an increase in DM intake.

The animals in the control group, which only received grass hay and maize bran, had intakes of Ca and Na of 20.0 g/d and 1.6 g/d respectively. The requirements for these animals based on their levels of production (table 4) and requirements (NRC, 1989) were 35 g/d and 22.8 g/d respectively. Hence, these cows were deficient in these minerals. However, signs of such deficiencies were not observed during the experiments. The P, K, and Mg intake of the animals in the control group were 44 g/d, 91 g/d, and 24 g/d, respectively, which were equal to or slightly higher than NRC (1989) requirements. The NMMB had a much higher Ca and Na content than the hay and maize bran, and supplementation with these blocks will have removed the deficiencies in these minerals. Due to the inclusion of limestone and cement in the NMMB, the Ca content of the blocks was high (8.6% on DM basis). However, due to its source, the availability of this Ca seemed to be low. Supplementation with MUM alleviated the Na deficiency, but did not entirely remove the Ca deficiency.

On-farm trial

The CP, ADF, and NDF contents of the base feeds fed on the small holder farms are given in figure 1. At the beginning of the trial this base feed consisted mainly of grass, whereas towards the end of the trial it consisted mainly of maize stover. The average ADF and NDF contents of the DM in the base feeds were very high ranging from 47.5 % to 58.5%, and between 67.6% and 71.4%, respectively. The average CP content of these feeds was 9.0 % on a DM basis in the second week of July, but this dropped to 3.1% in late September. On all farms cows received a supplement on top of the base feed. Supplements included maize bran, brewer's spent grain, cotton seed cake, and rice polishings. The amount of supplement given depended on availability, price and preference of the farmer. It was not possible to accurately record the amounts of supplements fed.

The average milk yields for the farms using NMMB and the control farms are given in figure 2.

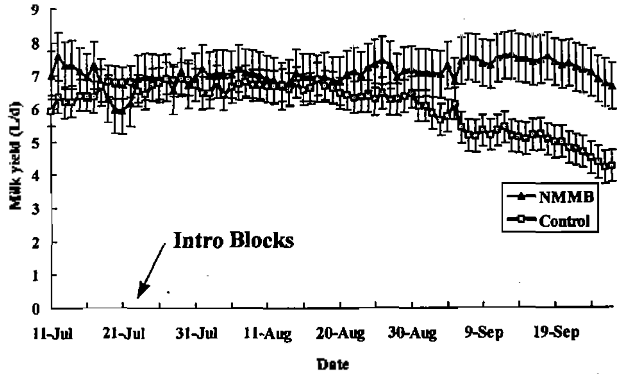

Figure 2. Average milk yields on farm study

Prior to August 27, no significant difference was observed in milk yield between NMMB and control. However, during the last month of the trial, i.e. between August 27 and September 27, the average milk yield on NMMB farms was 7.0±0.3 L/d (mean ±SE) and that on control farms was 5.5±0.3 L/d. On average, cows on NMMB farms had a 1.5 L/d higher daily milk yield than those on control farms ($p<0.05$) higher production than the control farms. The average weight increase of cows on NMMB farms (0.19±0.05 kg/d) was significantly ($p<0.05$) higher than that on control farms (-0.04±0.04 kg/d).

The increase in milk production due to the provision of NMMB during the on-farm study was much lower than that observed in the on-station study, but close to that reported by Habbib et al. (1991), Hendratno et al (1991) and Msangi (1995) who reported increases of up to 1.6, 1.9, and 1.1 kg/d, respectively. A reason for the lack of response during the first part of the experiment is that the dry season and the accompanying decrease in the quality of the base feed had not yet started. This is illustrated by the CP content of the base feed at the beginning of the trial. Also, although it was not possible to record the amount of supplement fed, it is believed that farmers on average provided more supplements than given during the on-station trial, and that farmers receiving the NMMB substituted other supplements for the blocks. Some cows on the small holder farms had very low milk yields, down to 2 L/d. The cows of the on-station trial all had a higher level of milk production before the trial, with an average of 13.2 L/d, which is 2.1 L/d higher than the average milk production of the NMMB cows. The average milk production on farm prior to the introduction of NMMB was 6.8 kg. Hence, prior to the introduction of blocks, cows on station had a substantially higher milk yield. This was probably due to a combination of better nutrition and potential of cows. This could explain why cows on station were able to have a higher response to the supplementation of NMMB. Farms within treatment differed significantly in milk yield and live weight changes. This was expected, as farmers varied in their feeding practices, disease prevention, age, production potential and reproductive performance and stage of lactation of the cows.

Financial considerations

The cost/benefit analyses for supplementation with NMMB and MUM are given in table 5. Under the costs that occurred to the project supplementation with NMMB and supplementation with MUM are cost-effective if the increase in milk production is higher than 0.7 kg/d. Both in the on-farm trial and the on-station trial NMMB increased milk production more than this. However, in the on-farm trial such an increase was only observed after August 20, i.e. when reduction of the quality and availability of the base feed due to the dry season had become evident. Also, several cows in the on-farm study had milk yields as low as 2 L/d. In these animals a cost effective increase in milk yield due to the supplementation with NMMB cannot be expected. Hence, if NMMB can be provided on a cost-recovery basis, then providing these blocks to cows during the dry season can be recommended. Supplementing outside of the dry season or giving the blocks to cows with very low milk yields will not be cost effective. If blocks cannot be provided on a cost recovery basis by a farmers cooperative, but if they are produced by a commercial company that needs to include a profit margin, then the cost effectiveness of the NMMB could be jeopardized as this could increase the break even production to a level similar to the production observed on the small holder farms.

Table 5. Cost-benefit analyses of supplementation with nitrogen molasses mineral block (NMMB) and molasses urea mix (MUM)

Source	
Cost NMMB (US $/kg)	0.17
Cost of feeding 1.6 kg/d NMMB (US $)	0.27
Cost of feeding 2 L/d MUM (US $)	0.28
Milk price (US $/kg)	0.41
Break even milk production increase (L/d)	0.7
Observed milk production increase NMMB on-station (L/d)	4.5
Observed milk production increase NMMB on-farm (L/d)	1.7
Observed milk production increase MUM on-station (L/d)	2.1

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