Use of *Leucaena leucocephala* and *Gliricidia sepium* as Nitrogen Sources in Supplementary Concentrates for Dairy Goats Offered Rhodes Grass Hay

J. O. Ondiek, J. K. Tuitoek, S. A. Abdulrazak*[,1], F. B. Bareeba[2] and T. Fujihara[1]
Department of Animal Science, Egerton University, P.O. Box 536, Njoro, Kenya

ABSTRACT : A study was conducted to evaluate the replacement value of *Leucaena leucocephala* and *Gliricidia sepium* as nitrogen sources in commercial type supplements for dairy goats. Six crossbred (Toggenburg×Saanen) goats at late stage of lactation were allocated to three dietary treatments in a double 3×3 Latin square design. The animals were offered rhodes grass (*Chloris gayana*) hay *ad libitum* and supplemented with either Leucaena-based concentrate (LBC), Gliricidia-based concentrate (GBC) or commercial based concentrate (CC). Voluntary food intake, milk yield and composition and changes in live weight were measured. The total dry matter (DM) intake was higher ($p<0.05$) in goats fed GBC than CC (1385 vs 1331 g/d). The DM intake for LBC (1343 g/d) was similar to CC (1331 g/d). The DM intake of hay was also higher ($p<0.05$) in goats fed GBC (834 g/d) than those receiving LBC or CC (789, 782 g/d, respectively). Animals supplemented with GBC recorded positive (11 g/d) weight gain while the other groups lost weight (13, 19 g/d) for LBC and CC respectively, although these differences were not statistically significant ($p>0.05$). The composition of milk were: butterfat 58, 49 and 55 g/kg; crude protein 37.0, 35.4 and 36.1 g/kg; lactose 33, 29 and 30 g/kg; Ash 8.5, 8.5 and 7.9 g/kg and total solids 136.5, 121.9 and 129.0 g/kg, for goats fed LBC, GBC and CC respectively. There were no differences in the composition of milk due to these dietary treatments. At the end of performance trial, a digestibility trial was conducted using 6 female goats allocated to the three treatments (LBC, GBC and CC) in an incomplete randomized block design and each goat received a different supplement in each of two successive periods. There were no differences in nutrient digestibility except for DM, which was higher ($p<0.05$) in CC compared to the other treatments (615, 622, 720 g/kg for LBC, GBC and CC, respectively). Economic analysis showed that CC diet was more expensive (0.20 US$/kg) and had a lower margin over supplementation (0.11 US$) compared to LBC and GBC (0.13 vs 0.12 US$/kg and 01.5 vs 0.12 US$, respectively). It is concluded that the *Leucaena* and *Gliricidia* could contribute as nitrogen sources in compounded diet supplements without any detrimental effects on production in dairy goats. *(Asian-Aus. J. Anim. Sci. 2000. Vol. 13, No. 9 : 1249-1254)*

Key Words : Leucaena, Gliricidia, Feed Intake, Milk Yield, Nitrogen, Tropics

INTRODUCTION

Forages and grasses in the tropics are generally low in nitrogen and digestible nutrients. Animals fed exclusively on these feeds are unlikely to meet their nutritional requirements, consequently resulting in low production (Leng, 1990). Commercial concentrates are used to some extent to supplement grazing or browsing but these are sometimes not available or too expensive for small holder farmers. Forages from legume trees such as *Leucaena leucocephala* (leucaena) and *Gliricidia sepium* (gliricidia) grown in the tropics can be used as nitrogen sources in supplementary feeds (Mjema-Mweta et al., 1995). These species supply a cheap source of nitrogen to livestock and when used as supplement to low quality forages, they improve feed intake and animal performance (McMeniman et al., 1988; Abdulrazak et al., 1997). Goats are well adapted to utilize these fodder due to their high (63%) digestive capacity compared to 56% for cows, especially in the dry season when pasture grasses decline both in quantity and quality (Le Houerou, 1987). Leucaena has been used to supplement low quality diets fed to goats and sheep at levels between 30 and 60% of the total dry matter intake (Tomkins et al., 1991; Adejumo and Ademosum, 1991). Supplementation of low quality diets with Gliricidia or Leucaena has resulted in better performance of goats (Ondiek et al., 1999) and cattle (Abdulrazak et al., 1996). However, information on the use of fodder trees as nitrogen source in concentrate diets is scanty. Therefore, estimates are required for animal performance when such forages are incorporated in compounded diets for livestock. Further more, on-farm mixing of feeds, including fodder tree forages, as source of nitrogen and fermentable fiber could also lower the cost of feeding for small holder farmers in the tropics. The objective of this study was to evaluate the value of *Leucaena leucocephala* and *Gliricidia sepium* forages as nitrogen sources in concentrate based diets for dairy goats in Kenya.

* Corresponding Author: S. A. Abdulrazak. Tel: +81-852-32-6584, Fax: +81-852-32-6537, E-mail: abdul@life.shimane-u.ac.jp.
[1] Laboratory of Animal Science, Shimane University, Matsue-shi 690-8504, Japan.
[2] Department of Animal Science, Makerere University, P. O. Box 7062, Kampala, Uganda.
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MATERIALS AND METHODS

The study was conducted at Tatton farm, Egerton University, Kenya between 18 March and 22 June 1996. Two trials were conducted, the first one on performance and second on digestibility. During the study period, the mean monthly temperature and rainfall were 20.1℃ and 77.7 mm respectively.

Animals

In performance trial, 6 crossbred (Toggenburg × Saanen) lactating goats at the same stage of lactation (178 days) were used. Their average initial weight and mean milk yield were 46 kg (SD 7.1) and 1.7 kg/d (SD 0.4) respectively. During the digestibility trial, 6 female goats of similar breed types to those used in performance trial, weighing 22.3 kg (SD 1.1) and 9 months old were used. Before commencement of the trial, all goats were treated against internal and external parasites and confined in individual, well-ventilated stalls. Goats were also weighed once a week.

Supplements and diet preparation

Leucaena and gliricidia fodder was harvested from mature stands from the Machakos ICRAF Field Station. Twigs of about 30 cm from the tips were collected and sundried for 2 to 3 days. In addition to either leucaena or gliricidia, the following ingredients were used to form the supplements: dry poultry waste, maize germ meal, maize bran, maize grain, fish meal and cotton seed cake (table 1). One of the supplements (CC) was formulated to be representative of a commercial concentrate. All supplements were formulated to contain about 17% crude protein (CP) to conform to the commercial requirements. Dry poultry waste was prepared by collecting poultry excreta from caged layer hens, deep stacked for 20 days then dried in the sun. All ingredients were milled into flour form and a mineral mix (Pharma[R], Kenya Ltd.) was added to all supplements. Rhodes grass (*Chloris gayana*) hay was chopped using a manual chaff cutter to about 20-30 mm length and offered as the basal diet.

Experimental procedure and design

Hay was offered *ad libitum* by giving a weighed amount twice a day, providing 20% in excess of the previous day's intake, at 08.00 h and 14.00 h so that there was always some left-over in the next feeding time. The three diets; Leucaena-based (LBC), Gliricidia-based (GBC) and commercial based (CC) concentrates were offered at the rate of 600 g in two equal parts at 05.30 h and 17.00 h daily. This was the rate at which commercial supplements were routinely offered to lactating goats in the dry season and provided N at two and a half times the maintenance requirement for these goats (AFRC, 1992). The feeds were sampled fortnightly, bulked and a sub-sample taken for nutrient analysis. During the performance trial the diets were offered in a double 3 ×3 Latin square design with each period of the experiment consisting of a 10 day adaptation and a 14 day data collection periods. During the last two days of each period, 50 ml rumen liquor was collected in the morning before feeding using a stomach tube. Fifteen milliliters of the samples was strained using a clean cotton cloth, and 1 ml 7.5 M sulfuric acid added and then stored until analyzed for rumen ammonia nitrogen (NH_3-N). In the digestibility trial, 6 goats were placed in individual metabolic cages and total daily fecal output was collected, weighed and a 10% sample taken, dried at 60℃ for 24 h and stored for chemical analysis. The three treatments, similar to those used in performance trial were offered in an incomplete randomized block design in two periods consisting of a 10-day adaptation and 5-day data collection period. Clean water and multi-mineral blocks (Afya Bora[R], Unga, Kenya Ltd.) containing (g/kg) P, 32.0; Ca, 168.0; Na, 105.3; Cl, 194.7 were available at all times.

Table 1. Feed ingredient (g) and composition of leucaena-based (LBC), gliricidia-based (GBC) and commercial-based (CC) concentrate used in the trials

Feed ingredients	Supplement		
	LBC	GBC	CC
Gliricidia meal	-	300	-
Leucaena meal	300	-	-
Dry poultry waste	150	150	-
Maize germ meal	180	180	340
Maize bran	200	260	50
Maize grain	-	-	280
Cotton seed cake	150	90	260
Fish meal	-	-	50
Mineral mix*	20	20	20
Analyzed composition (g/kg DM)			
Dry matter	938	918	916
Ash	84	94	54
Crude protein	174	175	175
Acid detergent fiber	190	174	105
Neutral detergent fiber	439	511	256

* Composition of mineral mix from Pharma[R] (g/kg): Ca, 170; P, 85; Na, 126.7; Cl, 197.4; I, 0.31; Zn, 2.3; Mn, 1.5; Cu, 2.0; Co, 0.15; S, 2.5.

Analytical methods

Dry matter (DM) and CP in feed and feces and the composition of milk (CP, ash, butterfat, total solids (TS), and lactose) were determined according to the methods of AOAC (1990). Neutral detergent fiber

(NDF) and acid detergent fiber (ADF) were determined by the method of Goering and Van Soest (1970). Rumen NH_3-N was determined as described by Preston and Leng (1987).

Statistical analysis

Analysis of variance using General Linear Models of SAS (SAS, 1989) was done for all data. The data for liveweight and feed intake were analyzed according to an analysis of covariance model using the initial weight as the covariate and the diet as the main effect. The digestibility data were analyzed according to a one way analysis of variance. Where treatment means were different at a 5% level they were then separated using Duncan's New multiple range test (Steel and Torrie, 1980).

RESULTS

The animals remained healthy throughout the trials. Leucaena and gliricidia based supplements contained either 30% of leucaena or gliricidia meal respectively and replacing fishmeal and maize grain. The DM of the supplements ranged from 916 to 923 g/kg and the CP from 174 to 175 g/kg DM. The LBC and GBC diets contained higher ADF and NDF content than the CC diet. The CP content of hay was lower (43 g/kg DM) than 192 or 234 g/kg DM for leucaena and gliricidia meals respectively. Table 2 shows the mean daily feed, energy intake, average daily gain (ADG) and rumen NH_3-N concentrations for goats fed the three supplements. Whereas goats readily consumed the commercial type supplement, they took between 2 to 4 days to completely consume the leucaena and gliricidia based supplements. The animals given the GBC consumed significantly ($p<0.05$) more hay (834 g/d) than those fed the CC (782 g/d). A similar trend was observed for total DM intake although it was not significantly different from the groups offered the LBC or CC diets. The energy values of the feeds offered to the goats were estimated using AFRC (1993) formulae. The energy intake of the goats supplemented with the LBC were lower (3.4 ME MJ/day) compared to the other two groups that consumed 3.9 and 3.8 MJ ME/head/d for the GBC and CC respectively. The digestible CP intake for the goats offered the different supplements were essentially similar at approximately 130 g/d.

Goats offered the GBC diet gained 11 g/d while those on the LBC and CC diet lost 13 and 19 g/d, respectively, although these were not statistically different ($p>0.05$). The rumen NH_3-N concentrations tended to be higher in goats offered the GBC diet. Concentrations of 16, 18 and 15 mg N/100 ml were recorded in rumen fluid of animals offered LBC, GBC and CC respectively.

Table 2. Intake, daily gain and NH_3-N in goats offered rhodes grass hay supplemented with leucaena-based (LBC), gliricidia-based (GBC) or commercial-based (CC) concentrates

	Supplement			
	LBC	GBC	CC	SE
Feed intake (g DM/d)				
Hay	789[ab]	834[a]	782[b]	18.0
Supplement	554	551	549	-
Total	1343[ab]	1385[a]	1331[b]	44.0
Energy intake (ME MJ/head/d)	3.4	3.9	3.8	-
Daily gain (g/d)	-13[a]	11[a]	-19[a]	13.1
NH_3-N (mg/100 ml)	16[a]	18[b]	15[a]	1.0

[a,b] Means within a row with different superscripts are significantly different ($p<0.05$).

The milk yield and composition are shown in table 3. The yields were similar across treatments with daily production ranging from 0.5 to 0.6 kg. The composition of milk was also not affected ($p>0.05$) by dietary treatments.

Table 3. Milk yield and composition of lactating goats offered hay and supplemented with leucaena-based (LBC), gliricidia-based (GBC) or commercial-based (CC) concentrates

	Supplement			
	LBC	GBC	CC	SE
Milk yield (kg/d)	0.6[a]	0.5[a]	0.6[a]	0.04
Milk composition (g/kg)				
Butterfat	58.0[a]	49.0[a]	55.0[a]	4.0
Crude protein	37.0[a]	35.4[a]	36.1[a]	0.2
Lactose	33.0[a]	29.0[a]	30.0[a]	1.8
Ash	8.5[a]	8.5[a]	7.9[a]	0.1
Total solids	136.5[a]	121.9[a]	129.0[a]	6.0

Table 4 shows the results of the effect of supplements on nutrient digestibility. The digestibility ranged between 714 and 756 g/kg DM for CP, 489 and 584 g/kg DM for NDF, and 332 to 396 g/kg DM for ADF. The digestibility of CP, ADF and NDF were similar for all treatments except for DM which was higher ($p<0.05$) in CC diet.

The estimated cost of supplements, price of milk and margin over supplementation of the three diets is presented in table 5. The fodder based supplements were relatively cheaper, subsequently giving a higher margins over supplementation compared to the commercial based concentrate. Fishmeal and maize grain were added in the commercial type concentrate to represent the product in the market and these were replaced in the other supplements with poultry waste and either leucaena or gliricidia meals.

Table 4. Nutrient digestibility (g/kg DM) of DM, CP, ADF and NDF in goats offered hay supplemented with leucaena-based (LBC), gliricidia-based (GBC) or commercial-based (CC) concentrates

	Supplement			
Nutrient	LBC	GBC	CC	SE
Dry matter	615[b]	622[b]	720[a]	34.3
Crude protein	714[a]	732[a]	756[a]	51.0
Acid detergent fiber	332[a]	390[a]	396[a]	57.5
Neutral detergent fiber	557[a]	584[a]	489[a]	56.5

[a,b] Means within a row with different superscripts are significantly different ($p<0.05$).

Table 5. The economics of offering fodder based supplements to dairy goats fed on rhodes grass hay

	Supplement		
	LBC	GBC	CC
Cost of supplement/100 kg	13.05	11.50	19.85
Cost of supplement/kg	0.13	0.12	0.20
Daily income from milk	0.23	0.19	0.23
Cost of supplementation	0.08	0.07	0.12
Margin over supplementation	0.15	0.12	0.11

[1] Farm gate price of milk=US$ 0.38/litre, (1 US$=60 KShs).

DISCUSSION

The mean CP content of leucaena and gliricidia meals was within the values reported in the literature (Smith and van Houtert, 1987; Topps, 1992) and their high CP content warrants them to be used as protein supplements. The voluntary food intake, when expressed as a percentage of liveweight for dairy goats in the tropical environment, ranges from 2.5-3.9% (Devendra and Burns, 1983). In this study, the daily total DM intake was between 1331 and 1385 g/d, which were approximately 3.0% of body weight of the goats. Mtenga and Shoo (1990) reported intakes of between 2.2 and 4.0% in goats offered rhodes grass hay supplemented with leucaena forage. The animals fed on GBC consumed more feed and gained weight compared to those on the LBC or CC diet. Lactating dairy goats are expected to closely maintain their body weight when their nutritional requirements are met. However, weight loss indicates greater mobilization of body reserves to support milk production. The results on weight gain indicate that gliricidia based supplement supported milk production and even resulted in positive weight gain. in contrast to the other supplements. The rumen NH_3-N concentration may reflect the status of nitrogen available for microbial protein synthesis. The levels obtained in this study were above the critical level of 5.0 to 8.0 mg/100 ml for efficient rumen function (FAO, 1986) although a higher value of 23.5 mg/100 ml would be required when using a high energy diet, for maximum feed degradation (Mehrez et al., 1977). The levels of rumen NH_3-N were considered adequate for microbes given that the values obtained were taken in the morning before feeding was done. Abdulrazak et al. (1996) reported a higher value of rumen NH_3-N in rumen fluid of cattle offered gliricidia than those offered leucaena as supplement, and attributed it to the higher degradation rate of gliricidia in the rumen. In the present study, rumen NH_3-N tended to be higher for goats offered the GBC. Microbial protein supply to the small intestine was not measured in this study, but it could be possible that GBC resulted to higher flow of microbial protein resulting to better performance.

The daily milk yields reported in this study were low considering that at peak lactation, these goats have been observed to produce 2.5 kg of milk per day. The goats were on their 178[th] day of lactation at the beginning of the experiment and had passed the period of peak production, and were approaching the end of lactation. However, there were no treatment differences among milk yields of goats offered the three supplements.

The observed composition of milk in this experiment is similar to that reported by Richards et al. (1994) except for fat content. It is possible that the diets resulted to a rumen environment in favor of more acetic acid which subsequently led to an increase in fat synthesis and hence more milk fat (Morrand-Fehr et al., 1991). There was no dietary influence on milk composition in this study. The observed low lactose content, may be associated with the stage of lactation of the goats used in the experiment. Banda et al. (1992) observed a decline in milk lactose in goats as lactation progressed in the first twelve weeks of lactation.

Nutrient digestibility in the three diets were similar across the treatments except for DM, which was higher ($p<0.05$) in CC than the LBC or GBC diets most probably because of the lower fiber content in the commercial type concentrate. The values reported in this study agree with those of Phiri et al. (1992) for goats fed maize husks and supplemented with leucaena. Despite the apparently high DM digestibility in commercial type concentrate, the performance of dairy goats offered this diet was unaffected.

The energy value of the diets consumed by the goats were approximately 5.7 MJ ME/kg DM. The energy intakes varied from 3.4 to 3.9 MJ ME/kg DM for the animals offered the LBC and GBC, respectively. Animals offered the GBC consumed apparently more energy and this may further explain the better weight gains in contrast to those offered the LBC. The relatively poor weight gains observed for goats offered the commercial type supplement could partly be explained by differences in the proportions of bypass protein. It is likely that the commercial type supplement had more rumen degradable and less by pass protein compared to the other supplements. Higher live weight gains have been reported when animals are supplemented with forages rich in bypass protein (Abdulrazak et al., 1996).

The estimate costs of the supplements indicated that the fodder based supplements were cheaper than conventional concentrate based supplement and therefore resulted in higher profit margins over supplementation. Fishmeal is an expensive component, while maize is a staple food for many people in East Africa. These factors contributes to the high cost of conventional commercial concentrate. Replacing fishmeal and maize reduced the cost of fodder based supplements (US$ 13.05 and 11.50/100 kg) and gave higher margins over supplementation (US$ 0.15 and 0.12, for LBC and GBC, respectively) at a farm-gate milk price of US$ 0.38. On the other hand the cost of CC diet was US$ 19.85/100 kg and produced a margin of US$ 0.11.

The results suggests that tree fodder could be used in combination with other locally available feed resources in formulating on farm diets supplements for dairy goats.

It is therefore concluded that *Leucaena leucocephala* and *Gliricidia sepium* can be used as cheap nitrogen sources in commercial type concentrates without causing any detrimental effects on performance of dairy goats.

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