Tropical and Subtropical Agroecosystems

EVALUATION OF FOUR FORAGE LEGUMES AS SUPPLEMENTARY FEED FOR KENYA DUAL-PURPOSE GOAT IN THE SEMI-ARID REGION OF EASTERN KENYA

[EVALUACIÓN DE CUATRO LEGUMINOSAS FORRAJERAS COMO SUPLEMENTO PARA CABRAS DOBLE PROPÓSITO KENIANAS EN LA REGIÓN SEMI ARIDA DE KENYA]

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SUMMARY

Two experiments were conducted to evaluate the effect of feeding four forage legumes; siratro, (Macroptilium atropurpureum), glycine (Neonotonia wightii cv. Cooper), velvet bean (Mucuna pruriens) and lablab (Lablab purpureus cv. Rongai) on liveweight changes of Kenya Dual-Purpose Goat (KDPG) fed on a basal diet of natural pastures and Napier grass. These forage legumes were compared with a basal diet (grass) without supplementation and with a feed supplement of leucaena (Leucaena leucocephala, K8) leaf meal. Group feeding (4 goats per group) was conducted for each treatment in a randomised complete block design for a period of 84 days. Chemical composition and in vitro dry matter digestibility (IVDMD) of the forage legumes supplements were determined. The quality of manure produced by the animals was also determined. Velvet bean had the highest crude protein (CP 20.41%) and glycine the lowest (13.58%). However, velvet bean had the highest lignin content (10.05%) and consequently lower IVDMD (51.30%) than lablab (65.83%), glycine (62.31%) and siratro (55.31%). The average daily weight gain for goats fed glycine and leucaena forage was significantly (P<0.05) higher than for goats fed on basal diet only. Goats that were not supplemented lost weight throughout the study period. Manure from goats that were supplemented with velvet bean and lablab contained more nitrogen and phosphorus, and lower Carbon:Nitrogen ratio than those fed on grass alone. These forage legumes have the potential as sources of animal feed in semi-arid regions of Kenya.

Key words: Kenya Dual-Purpose Goat, forage legumes, *in vitro* dry matter digestibility, liveweight gains, manure quality

RESUMEN

Se realizaron dos experimentos para evaluar el efecto de alimentar con cuatro leguminosas forrajeras; siratro (Macroptilium atropurpureum), glycine (Neonotonia wightii cv. Cooper), fríjol terciopelo (Mucuna pruriens) y lablab (Lablab purpureus cv. Rongai) en la ganancia de peso de cabras doble propósito Kenianas (KDPG) las cuales tenían como dieta basal pastos naturales y pasto Napier. Las leguminosas se compararon contra una dieta basal (pasto) sin suplementación y contra un suplemento de harina de hoja de Leucaena (Leucaena leucocephala, K8). La alimentación fue en grupos de 4 cabras por tratamiento empleando un diseño de bloques al azar con una duración total del experimento de 84 días. Se evaluó la composición química y digestibilidad in vitro de la materia seca (IVDMD) al igual que la calidad de las excretas de los animales. El fríjol terciopelo tuvo el mayor contenido de proteína cruda (20.41%) y glycine el menor (13.58%). Sin embargo, el fríjol terciopelo tuvo el mayor contenido de lignina (10.05%) y consecuentemente una menor IVDMD (51.30%) que lablab (65.83%), glycine (62.31%) y siratro (55.31%). La ganancia de peso diaria de las cabras alimentadas con glycine y Leucaena fue significativamente (P<0.05) mayor que aquellas con la dieta basal. Cabras no suplementadas perdieron peso durante el experimento. Las excretas de las cabras suplementadas con fríjol terciopelo y lablab contenía más nitrógeno y fósforo, y, una relación C:N más baja que aquellas alimentadas con solo pasto. Las leguminosas evaluadas tienen potencial como alimento animal en las zonas semi-áridas de Kenya.

Palabras clave: Cabras doble propósito kenianas, leguminosas forrajeras, digestibilidad *in vitro*, ganancia de peso, calidad de excretas.

INTRODUCTION

Livestock is a very important component of the mixed small-holder farming systems of Kenya. In semi-arid eastern Kenya, livestock have traditionally been a mean of raising cash when needed (Simpson et al. 1996) apart from providing meat, milk, manure and draft power. However in this region, livestock production is constrained by poor nutrition resulting in low productivity. Animals depend on natural pastures primarily grasses and crop residues from cereals and grain legumes (Njarui et al. 1998). Thairu and Tessema (1987) reported that the crude protein (CP) of grasses drops to 2-4 % in the dry season after post flowering The alternative is the use of commercial stage. concentrates but these are expensive to the small-holder farmers and sometimes are not available. Tropical forage legumes offer a considerable potential to alleviate and complement the low feeding value of natural pastures and crop residues. They generally contain a mean of 17.2 % CP (Minson 1970) representing a highly nutritious feed resource for livestock.

Evaluation work conducted in the past identified herbaceous forage legumes that were well adapted to climate and soils of the semi-arid eastern Kenya (Njarui 1990). Among these legumes are velvet bean (Mucuna pruriens), lablab (Lablab purpureus cv. Rongai) glycine (Neonotonia wightii cv. Cooper) and siratro (Macroptilium atropurpureum). Njarui et al. (1998) reported yield of up to 4, 5 and 2 t DM ha⁻¹ for lablab, glycine and siratro, respectively. The potential of some of these legumes has been pointed out in other farming systems; as cover crops in central and North America and several countries of Asia (Flores 1993). In Kenya, lablab and velvet bean are gaining importance as green manure legumes for cereal production (Mureithi et al., 1999). The legumes produce high biomass yields and dry matter production of 8 and 7 t ha⁻¹ after 3 months of growth (Gachene et al., 2002, Gitahi and Mureithi, in press). Muinga et al. (2002) reported milk yield of 6.8 and 6.3 kg day⁻¹ from jersey dairy cows when supplemented with lablab and velvet bean, respectively at the coastal Kenya. These yields were similar to the yield obtained from dairy cows fed on the recommended gliricidia supplement at the coastal region (Muinga et al., 1992). In another study, Abdulrazak et al. (1996) recorded weight gains when steers on a maize stover basal diet were offered legume supplements. Mureithi et al. (1995) reported improved quality and quantity of fodder in alley farming system based on Napier grass grown with leucaena. The objectives of the studies were to evaluate the chemical composition of selected herbaceous legumes and assess their effects on growth of Kenya dual-purpose goats KDPG). Two experiments were conducted; the first one evaluated the effect on liveweight, of supplementing herbaceous legumes sirato and glycine to KDPG males. The second experiment evaluated the effect of lablab and velvet bean on liveweight of the goats. In each experiment leucaena was included for comparison since considerable information is available on its chemical composition and feeding quality in Kenya (Tesema and Emojong 1984; Muinga 1992. Mureithi *et al.* 1994)

MATERIALS AND METHODS

Site

The studies were carried out at Kenya Agricultural Research Institute (KARI), National Dryland Farming Research Centre (NDFRC)-Katumani (1⁰58'S; 38⁰28'E) within the semi-arid region of eastern Kenya. The elevation is 1600 m above sea level, and mean temperature is about 19.6°C. The experiments were conducted between July and October; 1998 and 1999.

Animals

Uncastrated growing KDPG males whose average group weight ranged from 17 - 22 kgs were used for each study. The KDPG is a synthetic breed composed of equal proportions of two selected and adapted local goats, the East African and the Galla and two exotic dairy goats, the Toggenburg and Anglo-Nubian (Mwandotto *et al.* 1992) and was bred for meat and milk. The goats used were selected from a large herd based at NDFRC-Katumani. They were housed in well ventilated open timber pens, which are extension of a brick house. They were locked at night to protect them from wind. Dry grass was used for beddings and both the feeding and sleeping areas were disinfected before the goats were brought in.

Feeds

Four legume feed supplements were bulked for the feeding trial. Siratro (*Macroptilium atropurpureum*) and glycine (*Neonotonia wightii* cv. Cooper) forages were grown under irrigation in another KARI Centre at Kiboko in 1997. They were grown on acidic (pH 5.8) rhodic ferralsol soil. Lablab (*Lablab purpureus* cv Rongai) and velvet bean (*Mucuna pruriens*) forages were planted in October during the short rains of 1998 at NDFRC- Katumani. These legumes were grown on a chromic luvisol soil with pH 6.8. All the forage legumes were cut back with a sickle to about 10 cm height at about 50% flowering. They were chopped into small pieces using a machete, dried under shade for a week and bagged for the feeding.

Leucaena, K8 was harvested from a fodder bank of about 15-16 years old growing in the same soil as lablab and velvet bean at NDFRC-Katumani. The stems were cut,

Tropical and Subtropical Agroecosystems 3 (2003): 65 - 71 sun dried for 2 -3 days, threshed to obtain leaves and young succulent tips and then stored in sisal bags for later feeding. The basal diet in Experiment 1 was the natural pastures and Napier grass (*Pennisetum purpureum* cv. Bana) while in Experiment 2 it consisted of natural pastures only. The dominant grasses in the natural pastures were themeda (*Themeda triandra*), buffel grass (*Cenchrus ciliaris*), rhodes grass (*Chloris gayana*), and star grass (*Cynodon dactylon*). The grasses were cut using a sickle during the month of June and July at post flowering stage and conserved as hay by hand baling. Napier was usually cut from the field for the feeding as required.

Experimental design and treatments

The goats were stratified according to live-weight into four groups of 4 goats each so that the mean weight of the group were similar. Group feeding was conducted for each treatment in a randomised complete block design. In each feeding trial, four feeds (diets) were evaluated which included leucaena (supplement) as a positive control diet.

Experiment 1. - Evaluation of two herbaceous legumes on growth of KDPG

The two herbaceous legumes evaluated in this experiment were siratro and glycine. There were four treatments consisting of a basal diet (Napier grass and natural pastures) and basal diet supplemented with either siratro, glycine or leucaena leaf meal.

Experiment 2.-Evaluation of two green manure legumes on growth of KDPG

The treatments consisted of a basal diet (natural pasture only) and basal diet supplemented with either velvet bean, lablab (the green manure legumes) or leucaena leaf meal.

Goat management and measurements

The legume supplements were offered in the morning and thereafter the grass was provided ad libitum. The Napier grass was reduced to small sizes by cutting with a hand chopper and put in trough while the other grasses from natural pastures were hanged with a string. The daily dry matter requirement for goats was taken as 3.5% of the body weight. Legume supplements were offered at a rate of 30% of the total daily feed requirements. The amount offered was adjusted weekly in line with body weight change. All the goats had free access to mineral block licks and water ad libitum. The goats were drenched with an anthelmintic at the start of the experiment to control endo-parasites and dipped in acaricide once every week to control ecto-parasites. An adaptation period of 14 days was allowed before data recording was started. Data was collected for 84 days

during which the goats were weighed weekly (fasting weight-before any feed was offered) at around 10.00 am. In the second experiment faeces was collected in the morning before feeding and watering during the last 7 days of the experiment for manure quality analysis.

Feed and manure composition analyses

After preparation of legume supplements, about 2 kg was sampled after thorough mixing. The grass hay was sampled on a weekly basis and all samples bulked, thoroughly mixed and then sub-sampled. All the samples were oven dried at 65°C for 48 hours and ground to pass through a 1 mm screen for chemical analysis. Dry matter (DM), ash and crude protein (CP) were determined according to AOAC (1984) procedures.

Neutral detergent fibre (NDF), acid detergent fibre (ADF), lignin, and *in vitro* dry matter digestibility (IVDMD) were determined according to the procedure of Goering and Van Soest (1970). The polyphenols were determined using a gravimetric technique according to Reed *et al.* (1985). In Experiment 2, the manure collected from each treatment was mixed thoroughly and samples analysed for nitrogen, phosphorus, potassium and carbon. Total N was determined by the salicylic acid modification of Kjeldahl method described by Bremner and Mulvaney (1982). Total P, K and organic carbon were determined according to the methods described by Okalebo *et al.*, (2002).

Statistical analyses

Live-weight changes of the goats were calculated as the difference between the starting and the final experimental weight and averaged in each group. Average weight change at the end of experiment and daily weight change was subjected to an analysis of variance using Minitab software and means separated by LSD (Steel and Torrie 1981).

RESULTS

Experiment 1

Chemical composition of the feeds

As expected, the CP of leucena meal was the highest followed by the herbaceous legumes. The grasses had the lowest CP, which was on average 4.3 times lower than that of the herbaceous legumes. Also as expected the grasses had the highest fiber content which was reflected in its low IVDMD. The polyphenol content of *leucaena* forage was the highest but this did not seem to influence animal performance.

Feeds	СР	NDF	ADF	Ash	Polyphenol	Lignin	IVDMD
Siratro	14.71	43.86	30.18	13.31	1.43	8.41	55.31
Glycine	13.58	46.93	35.62	13.65	1.75	8.99	62.31
Leucaena	23.73	33.90	15.92	8.75	4.93	8.25	57.83
Napier	4.63	72.14	45.77	13.40	1.26	5.24	50.36
Natural pasture	3.38	76.61	54.14	11.13	0.45	8.50	34.11

Table 1. Chemical composition (% of DM) and *in-vitro* dry matter digestibility (IVDMD) of feed supplements.

Growth performance

Experiment 2

Chemical composition of the feeds

Results on the average and daily live-weight changes for the goats are given in Table 2. Daily live-weight gain of 16.37 g attained from supplementing with glycine was higher than those supplemented with siratro (3.97 g day⁻¹) although not significant (P <0.05) but was significantly higher than the control. The unsupplemented goats had net weight loss. The standard supplement; leucaena gave the highest gain but was not significantly different from the test legumes supplements.

Table 3 shows that velvet bean had higher CP than lablab. Lablab had lower lignin content (6.83%) than velvet bean (10.05%) and consequently a higher IVDMD (65.83% cf. 51.30%). The standard supplement; leucaena had higher CP than both the test legumes.

Table 2.	Kenva dual-	purpose male	goats	performance	from	four	legume	feed	supplements	
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	Basal	Basal Basal diet supplemented with			_	
	diet [*]	siratro	glycine	leucaena	P<0.05	s.e.d.
	(control)			leaf meal		
Initial average wt (kg)	20.38	20.50	20.25	20.25		
Final average wt (kg)	18.38	21.50	21.63	22.88		
Average wt change (kg/84 days)	-2.00	0.33	1.38	2.63	3.10	1.35
Average daily gain/loss (g)	-23.81	3.97	16.37	31.25	36.94	16.02

*Basal diet consisted of a mixture of natural pasture and Napier grass

Table 3. Chemical composition (% of DM) and in-vitro dry matter digestibility (IVDMD) of feed supplements.

Feeds	СР	NDF	ADF	Ash	Polyphenol	Lignin	IVDMD
Velvet bean	20.41	53.62	39.20	12.80	1.62	10.05	51.30
Lablab	16.09	45.03	34.75	10.34	1.47	6.83	65.83
Leucaena	23.73	33.90	15.92	8.75	4.93	8.25	57.83
Natural pastures	3.38	76.61	54.14	11.13	0.45	8.50	34.11

Growth performance

Live-weight changes in the male goats were not significantly affected by diets. Average and daily live-weight change for goats supplemented with velvet bean and lablab were similar and both were not significantly different from those fed on grass alone (Table 4). Leucaena produced a higher live-weight gain than the test legumes but the differences were not significant (P<0.05). However the control group registered a daily loss in weight and therefore average weight change at the end of the experiment was negative.

Manure quality

Manure from goats supplemented with lablab and velvet bean had similar amount of N but the P and C content was different (Table 5). Those supplemented on velvet bean had more C hence higher Carbon:Nitrogen (C:N) ratio than those fed on lablab. Goats fed on grass (control) produced manure with the lowest N, and K but the amount of C was comparable to those fed on legumes. Consequently the C:N ratio was the highest.

	Basal	_				
	diet [*]	lablab	velvet bean	leucaena	P<0.05	s.e.d
	(control)			leaf meal		
Initial average wt (kg)	18.38	18.12	18.75	18.62		
Final average wt (kg)	17.75	19.75	19.88	21.50		
Average wt change (kg/84 days)	-0.6	1.63	1.13	2.90	n.s.	1.08
Average daily weight gain/loss (g)	-7.44	19.34	13.39	34.23	n.s.	12.90

Table 4. Kenya dual-purpose male goats performance from four legume supplements.

*Basal diet was the natural pastures

Table 5. Composition of manure from goat fed velvet bean, lablab, leucaena leaf meal and grass hay (% DM).

Feeds	Ν	Р	K	С	C:N
Velvet bean	1.45	0.18	0.41	45.3	31:1
Lablab	1.34	0.45	0.69	37.0	28:1
Leucaena	1.61	0.14	1.13	41.5	26:1
Grass hay	0.96	0.15	0.57	42.1	44:1

DISCUSSION

The CP and lignin content of siratro and glycine were similar but glycine had a higher IVDMD (Experiment 1). Mean CP content of siratro and glycine of 14.91 and 13.58% are within the ranges of 6.8-26.6% and 12.8-24.8%, respectively, reported by Skerman *et al.* (1988). The supplemented goats had higher weight gains than those fed on grass alone. Weight gains from siratro supplement were (lower) marginal compared to glycine although it had more CP. However overall, this legume was more fibrous (ADF) and less digestible than glycine and this may have contributed to its lower response. Goats offered grass alone lost weight due to its low CP, high fibre and poor digestibility (Table 1).

The mean CP concentrations of lablab and velvet bean are slightly lower than the values of 22.18 and 21.81% reported by Muinga *et al.* (2002) respectively (Experiment 2). The higher lignin content for velvet bean than lablab indicate that velvet bean is more fibrous than lablab hence less suitable feed. Although lablab had lower CP than velvet bean, its higher IVDMD and lower lignin may have resulted to a slightly higher weight gains than velvet bean. Muinga *et al.* (2002) found out that cows supplemented with velvet bean lost weight compared to those fed on lablab. The lack of significant difference between the legume supplements (velvet bean and lablab) and grasses on weight gains was not expected given that the legumes had a higher CP and were more digestible.

These studies have shown that apart from leucaena, velvet bean ranks high amongst the other legumes in

terms of crude protein content (Tables; 1 and 3) while glycine had the lowest. The CP concentrations for the legumes evaluated ranged between 13-24%. The mean CP of tropical legumes is 17.2% (Minson 1970). Velvet bean was the only legume that had a higher CP than the mean CP of tropical legumes. Nevertheless, all the legumes contained more than the minimum CP requirement of 6-8% for livestock production and defined by Minson (1981) as the minimum needed to ensure that no reduction in intake occurs and rumen digestion is not impaired. In semi-arid region, grasses are more abundant than legumes and form the major feed for livestock. They are of low quality (2-4% CP) for most of the year around (Thairu and Tessema 1987) especially after post flowering stage. Further, they contain high fibre and are poorly digested by animals. Leng (1990) defined low quality forage as those with CP of less than 8% and suggested supplementation of such forages with appropriate nutrients to achieve high levels of animal production. The proportion of potentially digestible components declined as the fibrous content increased (Tables1 and 3). Velvet bean was the only legume with over 50% ADF and lignin of over 10% and consequently the lowest IVDMD.

All the test legumes showed improved weight gains when used as supplements to the goats compared to the control with lablab giving the highest response. Siratro gave marginal live-weight gains although the chemical composition were similar to that of lablab except that lablab had a higher IVDMD and this may have contributed to more weight gains. Positive response to legumes has been reported by other workers including Abdulrazak *et al.* (1996) and Patridge and Wright

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(1992). It has been reported that yield of lablab, siratro, velvet bean ranges from 2000 - 4000 kg DM ha⁻¹ yr⁻¹. (Njarui *et al.* 1998) This amount is sufficient to supplement 42 goats of average live-weight of 30 kg for 5 -10 months at 13.3 kg DM day⁻¹.

In all experiments, the live-weight gains from leucaena were higher than of all test legumes, siratro, glycine, lablab and velvet bean and could be attributed to its higher CP. Leucaena has been found to have high proportion of by-pass protein (McNeill *et al.* 1988), which can cause faster weight gains in livestock. The live-weight for goat fed on natural pastures and Napier was less than the initial weight in Experiment 1; an indication that dry grass does not provide maintenance requirements for the goat when fed alone. The mean CP for Napier grass and natural pastures used as basal diet was less than minimum amount (CP 6-8% DM) required for animal maintenance.

The results also showed that when livestock are fed on leguminous plants, they are likely to produce manure of a higher N and P for crops growth than when fed on grass alone. Nitrogen is the most limiting nutrient in many farming system of semi-arid eastern Kenya (Simpson *et al.* 1996). In general legume based feeds would provide manure that would mineralise faster than those fed on grass alone considering the C:N ratio. Where C:N is high, N is immobilised by microbial population (Nguluu *et al.* 1996) and thus making it unavailable to crops. The C:N ratio below which net mineralisation occurs is about 25 (Stevenson 1986).

CONCLUSION

From the results it is clear that the legumes, siratro, glycine, lablab and velvet bean, are high quality feeds and are as good as leucaena for livestock supplementation in the semi-arid region of eastern Kenya. The manure produced is of good quality for crop growing and this is useful to the small scale farmers who practice mixed crop-livestock farming.

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