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Nutritional Characterization and Evaluation of Batiki Grass (*Ischaemum aristatum* var. *indicum*) and Batiki Grass-Forage Legume Mixtures with Steer Calves

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Abstract: Laboratory analyses on chemical characterization of batiki grass (BG), forage legumes - *Leucaena leucocephala* (L), or *Erythrina variegata* (E), or *Gliricidia sepium* (G) and *Calliandra calothyrsus* (C) and BG/forage legumes (L, E, G and C) mixtures were carried out. Data obtained from the chemical characterization were used to predict the nutritive value of BG, forage legumes and BG/forage legume mixtures. CP content of BG at 4.3 % was low. The CP content of the forage legumes ranged between 18.6 - 30.7 %. Various BG/legume mixtures varied from 5.6 - 25.4 % CP. Except for C, NDF and ADF decreased with subsequent increase in the level of BG/forage legume mixtures. There were numerical differences between similar levels of BG/legume mixtures in nutrient contents. Chemical characterization data predicted optimum BG/forage legume mixtures at 50:50 (BG/L); 70:30 (BG/E); 50:50 (BG/G) and 50:50 (BG/C) with CP content that ranged between 11 - 12 %. Four steer calves initial average body weight of 147.1 ± 6.95 kg and 8 - 12 m old were allotted into four treatments in a randomized 4 x 4 Latin Square design to evaluate BG, BG/L, BG/E and BG/G on dry matter (DM) intake, estimates of daily live-weight gain/loss (ADG) and apparent nutrient digestibility. DM intake of BG was numerically low, while DM intake of BG/L was numerically higher than BG/E or BG/G. BG/G had low acceptability and steer calves had preference for leaves of L and E. ADG of steer calves were 172, 375, 328 and 259 g/head/d^{-1} for BG, BG/L, BG/E and BG/G diets, respectively. ADG was relatively lower ($P<0.05$) in BG. Among the forage legumes, BG/G steer calves had the least ADG. Apparent digestibility of all the components measured was subsequently higher ($P<0.05$) in BG/L and BG/E. In conclusion chemical characterization data were used to predict the nutritive value of BG, forage legumes and BG/forage legume mixtures and optimum CP level for improved DM intake, ADG and nutrient utilization was established. *Erythrina* had the highest CP content and this influenced the daily protein intake of steer calves in BG/E mixture at 1325 g protein N/kg$^{0.75}$/d. Steer calves on BG/L had higher DMI, better ADG, apparent digestibility of DM, CP, NDF, OM, energy and nutritive value index.

Key words: Batiki grass, forage legumes, chemical characterization, steers, DMI and digestibility

Introduction

Most tropical grass species have low dry matter digestibility and intake (Minson 1971) and therefore could not support high animal productivity (Adu and Adamu, 1982). Deficiencies of nutrients in the diets of ruminants fed tropical grasses constrain animal growth (Goodchild and MeMeniman, 1994).

The agronomic characteristics of batiki grass (*Ischaemum aristatum* var. *indicum*) have been reported (Pottier 1983). It is the most propagated pasture specie for cattle in Samoa, however its competitive nature, makes it difficult to use in grass-legume mixtures (Maiava Iose Isara, 1999, personal communication). Its' low protein content is a major constraint to animal production and in the dry season period, livestock reared on batiki grass alone have problems in meeting their maintenance need (Aregheore, 2001a). It is therefore important to balance livestock grazing batiki grass alone for protein, energy and minerals through supplementation with leaves of forage legumes.

Different browse species are used today in livestock production in the tropics and temperate countries of the world. Leaves, shoots and twigs from browse and fodder trees form a major part of livestock feed in tropical countries and play an important role in improving dietary protein (Taogaga, 1995; Mandal 1997; Kaitho *et al.*, 1998) and overcoming the nutritional constraints of low quality feed (Siebert and Hunter, 1982).

Chemical composition data can be used to predict the feeding value of browse/fodder tree species (Van Soest, 1965). This could also be applied to assess grass species and grass/forage legume mixtures. It has been observed that when batiki grass is fed alone, animal response is low, but, when combined with forage legumes, improvement in feed intake, growth rate and nutrients utilization were reported for growing goats (Aregheore, *et al.*, 2002).

There is dearth of information on the nutritive value of batiki grass and batiki grass/forage legume mixtures in the diets of beef cattle in the Pacific Island countries (PICs). The objectives of this investigation are (1) to use chemical characterization data to predict the nutritive value of batiki grass (BG), forage legumes

(*Leucaena leucocephala, Erythrina variegata or Gliricidia sepium* or *Calliandra calothyrsus*) and batiki grass/forage legumes (BG/FL) mixtures and (2) evaluate BG grass and BG/FL mixtures (*L. leucocephala, E. variegata or G. sepium*) on dry matter intake, estimates of daily live-weight gain/loss and nutrient utilization of growing steer calves in the dry season.

Materials and Methods

Experiment 1: Laboratory analyses - Chemical characterization of batiki grass and batiki grass - forage legume mixtures:

Batiki grass/legume collections: Batiki grass (BG) and leaves of four forage legumes (*Leucaena leucocephala, Erythrina variegata, Gliricidia sepium* and *Calliandra calothyrsus*) were harvested. BG was harvested from the University of the South Pacific, School of Agriculture pasture farm situated at Lalaonea, some 12 kilometers from Alafua, while the forage legumes were harvested within the School of Agriculture, Alafua Campus, Apia, Samoa (Latitude 13.5^{o}S, longitude 172.5^{o}W). The samples were harvested fresh from materials usually harvested for hand feeding of goats. Others were clipped from standing forage legumes to be either grazed or harvested for feeding in a manner designed to obtain herbage representative as possible of that selected by animals. The leaves, stalk and twigs were taken and processed. Batiki grass was chopped into about 3-5 cm in length and mixed with leaves of the different forage legumes in the following appropriate proportions below. These were then processed for analysis.

From each of the forage legumes, four mixtures each were obtained, processed and later chemically characterized for nutritional content and quality. The mixtures were as follows:

100 % Batiki grass (control).

Leucaena leucocephala

(2) 90 % batiki grass: 10 % *L. leucocephala*
(3) 70 % batiki grass: 30 % *L. leucocephala*
(4) 50 % batiki grass: 50 % *L. leucocephala*
(5) 20 % batiki grass 80 % *L. leucocephala*
(6) 100 % *Leucaena*

Gliricidia sepium

(7) 90 % batiki grass: 10 % *G. sepium*
(8) 70 % batiki grass: 30 % *G. sepium*
(9) 50 % batiki grass: 50 % *G. sepium*
(10) 20 % batiki grass 80 % *G. sepium*
(11) 100 % *Gliricidia sepium*

Erythrina variegata

(12) 90 % batiki grass: 10 % *E. variegata*
(13) 70 % batiki grass: 30 % *E. variegata*
(14) 50 % batiki grass: 50 % *E. variegata*
(15) 20 % batiki grass 80 % *E. variegata*
(16) 100 % *E. variegata*

Calliandra calothyrsus

(17) 90 % batiki grass: 10 % *C. calothyrsus*
(18) 70 % batiki grass: 30 % *C. calothyrsus*
(19) 50 % batiki grass: 50 % *C. calothyrsus*
(20) 20 % batiki grass 80 % *C. calothyrsus*
(21) 100 % *Calliandra calothyrsus*

Experiment 2: Nutritional evaluation of batiki grass and batiki grass/*Leucaena leucocephala* (L), or *Erythrina variegata* (E), or *Gliricidia sepium* (G) mixtures in steer calves diets.

Diets:

Batiki Grass and Forage Legumes: Batiki grass was manually chopped with a bush knife into pieces (6-7 cm rough estimate). Leaves of L, E and G were harvested from mature trees in the morning for feeding in the afternoon with some allowed to wilt overnight for feeding the next morning. Stems were removed from the forages to ensure that the fodder composition was uniform. The leaves of the forage legumes were chopped to a similar size as BG. BG and the leaves of L, E and G were thoroughly mixed separately for each treatment and offered as a whole diet to the steers to prevent selective eating.

The amount of BG and BG/forage legume mixtures offered were calculated as percentage of total *ad libitum* daily forage allowance. The four diets used consisted of the following combinations (in %) of batiki grass (first value) and forage legume (second value): T1 -100 % batiki grass (BG); T2 - 50% batiki grass: 50 % *Leucaena leucocephala* (BG/L); T3 - 70 % batiki grass: 30 % *Erythrina variegata* (BG/E) and T4 - 50 % batiki grass: 50 % *Gliricidia sepium* (BG/G).

Animals, Experimental Design and Management: Four steer calves (two Holstein-Friesian and two Droughtmaster), initial body weight range of 140 - 156 kg (mean 147.1 ± 6.9 kg) and 9 - 12 m old were allotted into four treatments in a randomized 4 x 4 Latin Square design after having balanced the groups for age and weight. These steer calves were used to measure dry matter (DM) intake, apparent nutrient digestibility and to give rough estimate of average daily live weight gain (ADG)/loss.

The steers were allowed to feed on each dietary treatment for 36 d before the treatment was changed. The first 7 d were preliminary period designed to allow the steers to adjust to the feeding regime, 24-d and 5 d for data and fecal collection, respectively. The diets were offered on an *ad libitum* basis (10 -20 % refusal) and twice a day to ensure constant availability. BG and

BG/forage legume mixtures were sampled once a week for dry matter (DM) determination. Feeds offered were recorded on a daily basis to estimate DM intake.
Live weights recorded at the end of each experimental period were used to calculate the amount of the mixture to be offered during the subsequent period. The steer calves were housed individually in pens under a common roof. Fresh ample drinking water and mineral supplement were made available.
At early morning feeding, refusals of previous day were collected together. These refusals were carefully separated into batiki and forage legume components. Each component was weighed and sampled. Cleaning of the pens and removal of leftovers from the previous day were done daily before supplying the day's diet.

Weighing and Body Condition Scoring of Animals: Body weights of the steer calves were determined on the first 3 days of each experimental period and the last 2 days of each subsequent period and body weight change was calculated by the difference between mean body weights at the beginning and end of each period. Body condition scores (BCS) was evaluated visually on day 0 for each of the steers and subsequently at the beginning and end of each treatment period using a 1 through 9 condition scoring system with increments of 0.25 (Herd and Sprott, 1986). BCS of the steers were evaluated according to treatment.

Digestibility Study: At the end of each experimental period the steer calf in each diet was used for metabolic studies. The total fecal collection method was used for feces and the daily fecal output for each steer was weighed before a 25 % sample was removed for processing. The feces were later dried in a forced-air oven at 70°C for 48 h. Daily samples of feces and diet of the steer calf in each treatment were then bulked separately and milled with a simple laboratory mill and stored in air tight bottles until required for analyses.

Analytical Methods: The AOAC (1995) method was used for nutrient contents of BG, FL, BG/forage legume mixtures, diets and feces. Dry matter was determined by drying at constant weight at 70° C for 48 h in a forced-air oven, ash by incineration at 600° C for 2 h, protein by the micro-Kjeldahl procedure (N x 6.25). Fibre fractions (neutral detergent fibre (NDF), acid detergent fibre (ADF), acid detergent lignin, cellulose and hemicellulose were determined by the procedures of Van Soest *et al.* (1991). The NDF was assayed with sodium sulfite, without alpha amylase and was expressed with residual ash. The gross energy (MJ/kg) value of the BG, leaves of L, E and G, BG/forage legume mixtures, diets and fecal samples were determined using a bomb calorimeter (Adiabatic bomb, Parr instrument Co., Moline, IL, USA) with thermochemical benzoic acid as the standard. All analyses were carried out in triplicate.

Statistical Analysis : Data on voluntary dry matter intake, estimates of body weight change (gain/loss), body condition score, apparent nutrient digestibility coefficients and other calculated parameters were analyzed with ANOVA using individual steer calf as a replicate (Steel and Torrie, 1980). Where significant differences were observed treatment means were compared with Duncan's multiple range tests.

Results and Discussion

Experiment 1 Chemical characterization of batiki grass - forage legume mixtures: Chemical composition of fresh BG and forage legumes used in the preparation of the dietary treatments is shown in Table 1. Crude protein content of BG at 4.3 % is similar to the value reported by Aregheore, *et al.* (2002) but lower compared to 8.3 % CP earlier reported (Aregheore, 2001) for BG during the dry season period in Samoa. Soil characteristics of the different sites from which BG grass was obtained and stage of maturity might have contributed to the differences in CP contents. Compared to other tropical grasses the CP content of BG at 4.3 % is low. This is below the 11 - 12 % and 10.3 - 11.8 % CP suggested as optimal for growth of goats and steer calves, respectively (NRC, 1981 and 1984).
The stage of maturity of BG was also observed to affect the fibre fractions. As plant advance in maturity, their leaf/stem ratio decreases and the cell-wall concentration within stems and usually that within leaves increases and the proportion of cell solubles decreases due to stage of maturity (Buxton, 1996).
Chemical composition values of forage legumes studied are comparable to values obtained in other tropical countries (Bayer, 1990; Kaitho *et al.*, 1998). CP content was particularly high in the forage legumes and they possess high potential as protein supplements in BG based diet. CP content of individual forage legumes was far above recommended values for optimal growth of ruminant livestock at 11 - 12% CP for growing goats (NRC, 1981) and 10.3 - 11.1 % CP for growing steers (NRC, 1984) therefore they could serve as cheap protein source in ruminant diets.
Several nutritional advantages have been attributed to the usage of forage legumes in diets for ruminant livestock. They provide variety in the diet, have low fibre, contain some aromatic compounds and other compounds of medicinal value (Mecha and Adegbola, 1980), ensure appetite and reduce the requirement for other supplements. Besides, they reduce the requirements for commercial protein supplements and

act as protein, energy, minerals and vitamins reserve during the period of scarcity (Devendra, 1988).
The energy content of BG, forage legumes and BG/forage legumes are consistent with published estimates for forages fed to ruminant livestock in other tropical and sub-tropical countries (Butterworth, 1964).
Table 2 presents chemical composition of BG and BG/forage legumes mixtures. CP content of the various mixtures improved with increased level of forage legume added to BG. However, NDF and ADF decreased with subsequent increase in the forage legume mixtures. There were numerical differences between similar levels of BG/legume mixtures in nutrient contents. The subsequent increase/decrease in specific nutrients in the mixtures gave the optimum level at which any of the forage legumes can be mixed with BGs for cattle, goats or sheep in an on-farm feeding situation.
Karda and Dryden, (2001) reported that an important aspect of legume supplementation in general and of shrub and tree fodders in particular was to identify the optimum level of inclusion in the diet. Devendra (1990) and Norton (1994) recommended that the optimum level of forage legume leaf supplements is in the range of 30 -50 % of the diet on a dry matter basis or 0.9 - 1.5 % as a percentage of animal live-weight. Reports on the relationship between chemical composition and nutritive values of browse plants have not always been consistent (Wilson, 1977), however, the data obtained for BG, forage legumes and BG/forage legume mixtures in this experiment were used to predict their nutritive values.
Chemical characterization data predicted optimum batiki grass/forage legume mixtures as 50:50 (BG/L); 70:30 (BG/E); 50:50 (BG/G) and 50:50 (BG/C). At these combinations, the CP content of 11 - 12 % was attained. The results supports Schneider *et al.* (1952); Van Soest (1965), Mecha and Adegbola, (1980); Devendra, (1990, 1995) who used chemical composition data to predict the nutritive value of grasses and forage legumes for ruminant livestock. The values presented will assist in identifying appropriate level at which the forage legumes can be used as supplement to livestock grazing BG, which has low CP content.
Optimum level of BG/forage legume mixtures reached in this trial is in agreement with those used in Vanuatu, for beef cattle production. Beef cattle production in Vanuatu is based on pasture only; and a grass/legume mixture of 70:30 is used (Edwin Garae, personal communication, 2001). The grass species available in Vanuatu are Koronivia (*Brachiaria humidicola*), Signal (*Brachiaria decumbens*), buffel (*Cenchrus ciliaris*) and elephant grass (*Pennisetum purpureum*), while the legumes are Centro (*Centrosema pubescens*), Hetero (*Desmodium heterophyllum*), Glycine (*Glycine wightii* cv *Tinaroo*), Sirato (*Macroptilium atropurpureum*) and leucaena. The grass species used in the mixture are higher in nutritive value than BG.

Experiment 2: Nutritional evaluation of batiki grass and batiki grass/*Leucaena leucocephala* (L), *Erythrina variegata* (E) and *Gliricidia sepium* (G) mixtures with steer calves :
Table 3 presents the chemical composition of the diets used in the experiment. The diets had CP value that ranged between 11 - 12 % and had appreciable contents of fibre and energy. Batiki grass competitive nature makes it difficult to use in legume-grass mixtures in pastures therefore the best option was to provide an optimum level at which it could be combined with forage legumes in intensive grazing or in cut-and-carry production systems to sustain beef cattle during the dry season and this is exactly what this experiment aims to achieve.
Table 4 presents data on dry matter (DM) intake, average daily live-weight gain (ADG), daily protein intake and body condition score (BCS) of steer calves in BG and BG/forage legume mixtures. Forage quality is usually determined by animal performance when it is fed to livestock. It is a function of nutrient concentration, amount of forage consumed, digestibility and partitioning of metabolizable products within animals (Buxton, 1996).
DM intake of BG sole diet was numerically low compared to BG/L and BG/E. Among the forage legumes, the intake of BG/L was numerically higher compared to BG/E or BG/G. BG/G had low acceptability compared to BG/L and BG/E. The intake of BG/G was similar to BG. The unpleasant odor and low palatability of G may be implicated for the similarity in DMI between BG and BG/G diets. The high total DMI of the steer calves in the BG/L diet could be associated with faster outflow of particulate matter. Bamualim *et al.* (1984) and Abdulrazak, *et al.* (1996) reported reduced retention time of particulate following supplementation with leucaena in the diets of sheep and steers, respectively.
There was a marked variation among the steer calves in their preference for leaves of the forage legumes over BG (Table 4). The steer calves had preference for leaves of L and E. Steer calves in BG/L and BG/E consumed more of their forage legume portions than BG and this observation supports the reports of Forbes, (1995); Mero and Uden, (1997a and 1997b) and Charmley, (2002) that ruminants select leaves in preference to stems when given sufficient feed to allow choice to be expressed.
Available CP in the diets influenced daily protein intake of the steer calves. Daily protein intake was

Table 1: Chemical composition of batiki grass and forage legumes used in the experiment

	Nutrients							
Feeds	DM	CP	NDF	ADF	ADL	Hemicellulose	Cellulose	OM	GE (MJ/kg)
Batiki	34.9	4.3	52.2	32.2	19.8	20.0	12.4	94.1	11.7
Leucaena	40.7	24.1	46.2	30.8	20.4	15.4	10.4	93.3	15.4
Erythrina	40.2	30.7	46.2	30.8	18.3	15.4	12.5	91.7	16.8
Gliricidia	37.1	21.7	48.5	30.2	19.5	18.3	10.7	92.6	17.2
Calliandra	47.5	18.6	57.9	42.4	29.5	15.5	12.9	95.6	18.9

* DM - Dry matter; CP - Crude protein; NDF - Neutral detergent fibre; ADF - Acid detergent fibre; ADL - Acid detergent lignin; OM - Organic matter; GE - Gross energy.

Table 2: Chemical characterization of batiki grass and batiki/forage legume mixtures*

	Mixtures												
	Baitiki/Leucena					Batiki/Erythrina				Batiki/Gliricidia			
Nutrients (%)	Batiki	+10L	+30L	+50L	+80L	+10E	+30E	+50E	+80E	+10G	+30G	+50G	+80G
Dry matter	34.9	40.1	42.7	47.8	55.5	35.4	36.5	37.6	39.1	35.3	35.6	36.0	36.7
Crude protein	4.3	7.0	8.4	11.2	15.1	6.9	12.2	17.5	25.4	5.6	8.1	10.7	14.5
NDF	52.2	51.0	50.4	49.4	47.4	51.6	50.4	49.2	47.4	51.8	51.1	50.4	49.2
ADF	32.2	31.9	31.8	31.5	31.1	32.1	31.8	31.5	31.1	32.0	31.6	31.2	30.6
ADL	19.8	19.9	21.1	20.1	20.3	19.7	19.4	19.1	18.6	19.9	19.0	19.7	19.6
Hemicellulose	20.0	19.1	18.6	17.7	16.3	19.5	18.6	17.7	16.3	19.8	19.5	19.2	18.6
Cellulose	12.4	12.0	11.8	11.4	10.8	12.4	12.4	12.5	12.5	12.2	11.9	11.6	10.96
OM	94.1	94.2	93.8	93.7	93.7	93.9	93.9	92.9	92.9	93.9	93.7	93.4	92.6
GE	11.7	12.4	12.8	13.6	14.7	12.2	13.2	14.5	15.8	12.3	13.4	14.5	16.1

+L - with Leucaena; +E with Erythrina; +G - with Gliricidia; +C - with Calliandra

*The highlighted mixtures were the four with CP content of between 11-12%. The first three were used for growth and digestibility studies.

NDF - Neutral detergent fibre; ADF - Acid detergent fibre; ADL - Acid detergent lignin; OM - Organic matter; GE - Gross energy (MJ/kg DM)

Table 3: Chemical composition of batiki grass and batiki grass/forage legume mixtures used in the experiment

	Diets			
Nutrients (%)	T1	T2	T3	T4
Dry matter	34.9	47.8	36.5	36.0
On DM basis (%)				
Crude protein	4.3	11.2	12.2	11.0
Neutral detergent fibre	52.2	49.4	50.4	50.4
Acid detergent fibre	32.2	31.5	31.8	31.2
Acid detergent lignin	19.8	20.1	19.4	19.7
Hemicellulose	20.0	17.7	18.6	19.2
Cellulose	12.4	11.4	12.4	11.6
Organic matter	94.1	93.7	93.4	93.4
Gross Energy (MJ/kg DM)	11.7	13.6	13.2	14.5

Diets[1]

T1-100%batiki grass (BG)

T2-50%batiki grass :50% Leucaena (BG/L)

T3 - 70% batiki grass: 30% Erythrina (BG/E)

T4-50% batiki grass:50%Gliricidia (BG/G)

Table 4: Intake and performance of calves fed batiki grass and batiki grass/forage legume mixtures

	Diets[1]				
Parameters	T1	T2	T3	T4	±SEM
Dry matter intake (DMI) (kg/d-1 DM)					
Batiki grass	4.9	2.6	2.2	2.9	1.0
Forage legume	-	3.6	2.9	1.9	0.9
Total DMI	4.9	6.2	5.1	4.8	0.7
DM consumed ($kg/Wkg^{0.75}$)	3.3	3.9	3.4	3.2	0.3
Percentage (%) DMI/day from batiki grass	100	41.9	43.1	60.4	23.5
Percentage (%) DMI/day from forage legume	-	58.1	56.9	39.6	8.4
Daily protein N x 6.25) intake (g protein $N/kg^{0.75}/d$)	696^b	1265^a	1325^a	995^a	0.25
Feed efficiency (feed/gain)	28.5	16.5^b	15.5^b	18.5^b	5.2
Body condition score	4.6	7.6	7.2	5.8	1.7
Average daily gain (g/d^{-1})	172^c	375^a	328^a	259^b	0.8

Diets[1]
T1-100% batiki grass (BG)
T2-50% batiki grass: 50% Leucaena (BG/L)
T3-70% batiki grass: 30% Erythrina (BG/E)
T4-50% batiki grass: 50% Gliricidia (BG/G)
[a,b,c,] Values within rows with different superscript differ significantly ($P<0.05$)
SEM - Standard error of the mean

Table 5: Apparent digestibility coefficients of batiki grass and batiki/forage legume mixtures

	Diets[1]				
Nutrients	T1	T2	T3	T4	±SEM[2]
Dry matter	50.2^b	65.1^a	63.9^a	60.3^{ab}	5.8
Crude protein	48.3^b	70.6^a	67.9^a	58.1^b	8.7
Neutral detergent fibre	42.6^b	64.0	61.8^a	51.6^{ab}	8.6
Acid detergent fibre	35.9	44.1	43.5	38.3	3.5
Organic matter	55.0^b	69.8^a	67.0^a	62.0^{ab}	5.6
Energy	33.0	48.6	44.6	37.2	6.1
Digestible energy (MJ/kg DM)	3.63	6.61	5.89	5.10	1.1
Nutritive value index ($KJ/kg^{0.75}/d$)[3]	189^b	408^a	302^a	245^b	80.9

Diets[1]
T1-100% batiki grass (BG)
T2-50% batiki grass: 50% *Leucaena* (BG/L)
T3-70% batiki grass: 30% *Erythrina* (BG/E)
T4-50% batiki grass: 50% *Gliricidia* (BG/G)
[a,b,] Values within rows with different superscript differ significantly ($P<0.05$)
[2]SEM - Standard error of the mean
[3]Nutritive value index: relative intake x percent energy digestibility (Crampton *et al.*, 1960)

numerically highest in BG/E and lower in BG ($P<0.05$). ADG were 172, 375, 328 and 259 g/d^{-1} for BG, BG/L, BG/E, BG/G, respectively. ADG was relatively lower ($P<0.05$) in BG compared to BG/L, BG/E and BG/G. Among the forage legumes, G was lower in ADG. Daily protein intake in BG, BG/L, BG/E and BG/G diets (Table 4) were above NRC (1984) requirements for steer calves used in this trial (weighing between 150 - 200 kg) however their daily protein intake did not equate to average daily gains.

The low ADG of steer calves in BG at each of the experimental periods was due to poor nutrient quality. It was of interest however, to not that despite the low nutritive quality of BG, steer calves on it at each experimental period maintained their live-weight. This observation tends to agree with Robinson and Stewart (1968) who stipulated that tropical cattle were efficient in using low quality protein diets as they evolved from environment with frequently limited protein supply in forages.

Consequently, the improvement in ADG of steer calves on BG/forage legume mixtures above BG sole diet justifies the need for its supplementation to improve nutrient quality and enhance animal performance. Ash *et al.* (1992) and Aregheore *et al.* (2002) reported improved performance in goats when BG was supplemented with forage legumes.

The improved ADG in steer calves fed BG/L and BG/E may partly be attributed to high intake of N and energy as a result of increased organic matter intake. Subsequently, the low live-weight obtained in steers in the BG/G diet may be associated with initial rejection factor characterized by the presence of coumarin and flavanol that resulted in low intake due to palatability. The low intake therefore affected its utilization for growth. Little and Wadsworth, (1964) reported that G leaves are of low palatability and digestibility to cattle.

The amount of fat deposited on an animal's body contributes to what is referred to as body condition. Visually and meaningfully, the best indicators of body condition are the amount of fat on the backbone, hips and ribs and around the base of the tail (i.e., at the junction of the tail with body) and the prominence of the pin bones. Body condition scores (BCS) followed the pattern of ADG of the steers. The differences obtained between the treatments suggested variation in the efficiency of utilization of energy released during digestion. Also the low BCS for BG and BG/G suggested a repartitioning of nutrients from body fat to other tissue compared to BG/L and BG/E steers.

Apparent nutrient digestibility coefficients data is presented in Table 4. The digestibility of all the components measured was subsequently higher ($P<0.05$) for BG/L and BG/E than BG/G and BG. Comparatively; BG/forage legume mixtures were significantly higher in the digestibility of DM, CP, NDF, OM and nutritive value index than BG alone. It could be suggested that the higher digestibility and better nutritional characteristics of BG/forage legume mixtures compared to BG alone resulted in higher DM intake and greater live-weight gain ($P<0.05$). The extent of response in terms of DM intake or live-weight gain was influenced by type of forage legume in the mixture. The relatively high apparent digestibility of CP suggested low tannin levels in the leaves of L and E used in the present study.

There was a marked response of steer calves in ADG when BG/forage legume mixtures were offered and this was achieved through increased feed utilization efficiency. Daily protein intake and digestible energy were influenced by forage legume type. The increased forage OMD and greater protein intake of BG/forage legume mixtures compared to BG fed steer calves may help to explain the ADG of the steer calves. Although, the steer calves on BG were able to maintain their live-weight, their performance comparatively demonstrated that both protein and energy were deficient since higher improved animal performance was noted with batiki grass/forage legume mixtures. The greatest response was with the BG/L followed by BG/E.

Conclusion

The objectives of this experiment were to predict the nutritive value of batiki grass and batiki grass/forage legumes mixtures through chemical characterization; and evaluate batiki grass and batiki grass/forage legume (*Gliricidia sepium* or *Erythrina variegata* and *Leucaena leucocephala*) mixtures on DM intake, estimates of daily live-weight gain (ADG)/loss and nutrient utilization of growing steer calves during the dry season period when forage quality is low. The results confirmed the low nutrient quality of BG. BG/forage legume mixtures gave varying nutrient quality. From the different combinations of BG/forage legume mixtures, optimum CP level was established with a range of 11 - 12 % at 50:50 (BG/L); 70:30 (BG/E); 50:50 (BG/G) and 50:50 (BG/C).

ADG were 172, 375, 328 and 259 g/d^{-1} for BG, BG/L, BG/E and BG/G, respectively. Live-weight was relatively lower ($P<0.05$) in BG compared to other treatments. Among the forage legumes, G had the least ADG compared to L and E. The poor nutrient quality of BG was responsible for the low ADG of steer calves. Batiki grass/forage legume mixtures were significantly higher in the digestibility of DM, CP, NDF, OM and nutritive value index than BG sole diet. Among the forage legumes, E had the highest CP content and this influenced the daily protein intake of steer calves in the BG/E mixture at 1325 g protein N/kg$^{0.75}$/d. However, the steers on BG/L mixture had higher DMI, better ADG and digestibility of DM, CP, NDF, OM and energy.

In conclusion this study has demonstrated that chemical characterization data could be used to predict the nutritive value of BG, forage legumes and BG/forage legume mixtures. The optimum level at which BG/forage legume mixtures could be used for improved animal performance in terms of DM intake; ADG and nutrient utilization was established. This study also established that despite the low nutrient quality of BG, steer calves could maintain ADG in the dry season period however, supplementation with forage legumes improved DM intake, ADG, feed efficiency and apparent nutrient digestibility of the steer calves.

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