

## Nutritional Evaluation of Some Semi-arid Browse Forages Leaves as Feed for Goats

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**Abstract:** An experiment was conducted to determine the feed value of an indigenous browse plants in Borno state of Nigeria. Sixteen bucks of mixed breeds (Borno white x Sokoto red) weighing on the average  $12.19 \pm 0.31$  kg were divided into four groups with four animals per group. Each group was randomly assigned to one of the dietary treatments in a Complete Randomized Block Design. The diets compared were *Acacia nilotica*, *Balanites aegyptiaca*, *Khaya senegalensis* and *Ziziphus mauritiana*. The results showed that the average daily gain (ADWG), average dry matter intake (ADMI), dry matter intake per metabolic weight ( $0.07 \text{ kg day}^{-1}$ ,  $641.37 \text{ kg day}^{-1}$ ,  $74.58 \text{ g day}^{-1}$ ) and feed conversion ratio (0.12) were significantly ( $P < 0.05$ ) better with animals on diet T<sub>4</sub> (*Ziziphus mauritiana*). The result also revealed that T<sub>3</sub> had the best in terms of feed cost per kg gain (N60.49) and percent reduction in feed cost (N53.04%). From the results, it can be concluded that feeding of *Ziziphus mauritiana* to growing goats at 30% level of inclusion is beneficial.

**Key words:** Ruminant • Nutrients • Digestibility • Nitrogen

### INTRODUCTION

Feed potential of browse in the diet of herbivores in Nigeria is reflected in report of [1]. Browse plants play a significant role in nutrition of ruminant livestock in tropical regions. Browse species, because of their resistance to heat, drought, salinity, alkalinity, drifting sand, grazing and repeated cutting, are the major feed resources during the dry season [2]. Some parts of browse species can be found during the dry season including pods, fruits and leaves. Most trees/shrubs produce their leaves during wet season, thus browse is more available during the spring (August to May) [3]. The nutritional importance of browse is especially significant for free ranging goats in extensive communal system of production. Unfortunately, many tropical tree fodders and shrub legumes contain high concentrations of secondary compounds, particularly tannins [4,5] that can be reacting negatively with other nutrients [6] and could have detrimental or beneficial effects on animal nutrition [5, 7]. Special attention is paid to toxins or anti-nutritional factors such as tannins, which can strongly limit fodder

utilization [8, 9]. Although the digestive tract of goats is anatomically similar to that of sheep and cows, goats have a large physiological capacity to adapt to high tannin levels in the diet. *In vivo* and *in vitro*, conducted studies revealed that goats are more efficient than sheep digesting feed stuffs with low nitrogen, high fibre or high tannin contents of tree fodders and shrubs [4, 10].

Goats thrive well in the semi-arid regions of Nigeria due to their ability to feed on different types of plant species, mainly browses and grasses. Goats have a great tendency to change their diet according to seasonal feed availability and growth rate of plants. Goats can express their optimum genetic potential in terms of productivity if supplementary feeds are available. According to McDonald *et al.* [11] supplementation of crop residues in the diet of goats with cassava residue, leaves of mango and pawpaw promote optimum growth as well as improved reproductive characteristics. The objective of the study is to test the effect of some selected browse forages use as feed for goats in semi-arid area of Borno state, Nigeria.

## MATERIALS AND METHODS

**Experimental Site:** The study was conducted at the Ramat Polytechnic Teaching and Research Farm. Maiduguri is located at 11.05° North and 30.05° East and at an elevation of about 364m above sea level in the North Eastern part of Nigeria. The ambient temperature is 31°C by August and as high as 40°C or more by April and May [12]. The hottest period occurs from March to June, while it is cold between November and February. Rainfall varies from 150-600mm with a relative humidity [12].

**Experimental Animals:** Sixteen male goats of mix breeds (Borno white and Sokoto red) and aged between 10 to 11 months  $11.50 \pm 0.21$  were used for the feeding trial. The animals were purchased from local livestock market in Maiduguri.

**Experimental Design and Treatment:** The animals were randomly assigned to four dietary treatments in a 4 x 4 latin square design with periods of 3 weeks duration. The dietary treatments consist of browse foliage *Acacia nilotica*, *Balanites aegyptiaca*, *Khaya senegalensis* and *Ziziphus mauritiana* which was harvested from the study area.

**Feeding and Management:** During the experimental period, the animals were housed in pens with concrete floors and roofed with asbestos sheet. The walls have wide windows. The pens were cleaned morning and evenings. The animals were dewormed before trial, there was free access of water and mineral licks. The study will comprise of 14 days of feed adaptation, followed by 84 days measurement period. Feed was offered twice daily at 8:00hrs and 15:00hrs. The daily output of faeces and total urine voided was recorded from each animal and sampled for chemical analysis. Samples of feed offered was taken daily during the measurement period for chemical analysis. Body weight of the animals was weighed once weekly.

**Digestibility Trial:** One animal from each treatment was randomly selected for the digestibility trial. The metabolism cages used were made of metal. The animals were weighed and caged individually and fed their treatment diets for 14 days adaptation period and 7 days measurement period. Fresh clean water and mineral salt lick were provided ad-libitum. Nutrient digestibility of the feed was calculated using the formula.

$$\text{Apparent Nutrient digestibility} = \frac{\text{feed consumed} - \text{faecal output} \times 100}{\text{feed consumed}}$$

**Statistical Analysis:** Data obtained will subjected to statistical analysis using ANOVA procedure of SAS [13]. Significant treatment means will be compared by Duncan option [13].

## RESULTS

**Chemical Composition of the Experimental Feeds:** Chemical composition and fibre analysis of the five semi-arid browses used in the feeding trial is shown in Table 1. Significant difference ( $P < 0.05$ ) were observed in the crude protein (CP) values for all the browse forages with highest value observed in *Ziziphus mauritiana* ( $182 \text{ g Kg}^{-1} \text{ DM}$ ) and significantly least value observed in *Acacia nilotica* ( $97.70 \text{ g Kg}^{-1} \text{ DM}$ ). The NDF and ADF were significantly ( $P < 0.05$ ) higher in *acacia nilotica* leaves ( $524.90$  and  $425.10 \text{ g Kg}^{-1} \text{ DM}$ ) and lowest in *Balanites aegyptiaca* ( $486.30$  and  $392.30 \text{ g Kg}^{-1} \text{ DM}$ ). The ash content of the browse forages were higher in  $T_2$  (*Balanites aegyptiaca*) than in the other treatment groups with lowest  $T_4$  (*Ziziphus mauritiana*) value ( $30.0 \text{ g kg}^{-1}$ ). The result also show no significant difference ( $P > 0.05$ ) among the browse forages for acid detergent lignin and organic matter.

**Growth Performance:** The growth performance of goats fed selected semi-arid browses is shown in Table 2.

The average of initial livebody weights of the animals in the different dietary treatments did not vary significantly ( $P < 0.05$ ) indicating a close weight of the test animals at the start of the experiment. However, the final livebody weights significantly ( $P < 0.05$ ) differed with animals on diet  $T_4$  (*Ziziphus mauritiana*) being the heaviest on the average with a weight value of  $17.63 \text{ Kg}$ . The lowest mean final livebody weight value ( $14.50 \text{ Kg}$ ) was recorded with animals on  $T_1$  (*Acacia nilotica*). Metabolic mass of the animals differed significantly ( $P < 0.05$ ) between the diets. It ranged from a low value of  $7.43 \text{ LW}^{0.75}$  to a high of  $8.60 \text{ LW}^{0.75}$ . This does not follow the same pattern in terms of statistical significance in total weight gained by the animals. The average daily dry matter intake ( $641.37 \text{ g}$ ) was significantly higher ( $P < 0.05$ ) in  $T_4$  (*Ziziphus mauritiana*). The dry matter intake ( $\text{g Kg}^{-1} \text{ W}^{0.75}$ ) was higher for  $T_3$  ( $77.22 \text{ g Kg}^{-1} \text{ W}^{0.75}$ ) (*Khaya senegalensis*) and lowest for  $T_1$  ( $59.92 \text{ g Kg}^{-1} \text{ W}^{0.75}$ ) (*Acacia nilotica*). Feed conversion rate was best in  $T_4$  (*Ziziphus mauritiana*) poorer in animals on diet  $T_1$  (*Acacia nilotica*).

Table 1: Chemical composition of experimental rations (g/kg DM)

Nutrients	T <sub>1(an)</sub>	T <sub>2(be)</sub>	T <sub>3(ks)</sub>	T <sub>4(zm)</sub>	SEM
Dry matter	949.70	955.00	945.00	946.00	95.33 <sup>NS</sup>
Crude protein	97.70 <sup>d</sup>	118.20 <sup>c</sup>	132.50 <sup>b</sup>	182.40 <sup>a</sup>	13.27*
Ether extract	48.00 <sup>a</sup>	23.30 <sup>b</sup>	46.70 <sup>a</sup>	23.30 <sup>b</sup>	3.50*
Crude fibre	215.00 <sup>a</sup>	166.70 <sup>b</sup>	200.00 <sup>a</sup>	176.70 <sup>b</sup>	18.96*
Ash	60.00 <sup>a</sup>	65.00 <sup>a</sup>	46.70 <sup>b</sup>	30.00 <sup>b</sup>	5.04*
Nitrogen Free Extract	529.70 <sup>b</sup>	581.80 <sup>a</sup>	519.10 <sup>b</sup>	533.60 <sup>b</sup>	54.10*
Organic matter	889.70	890.00	908.30	916.00	90.10 <sup>NS</sup>
NDF	524.90	486.30	502.40	506.30	50.48 <sup>NS</sup>
ADF	425.10	392.30	401.10	412.40	40.07 <sup>NS</sup>
ADL	98.40	97.30	96.30	101.10	9.82 <sup>NS</sup>
TCT	0.12	0.23	0.21	0.21	0.06 <sup>NS</sup>

NDF=Neutral detergent fibre, ADF=Acid detergent fibre, ADL=Acid detergent lignin;  
 TCT=Total condensed tannin mg/g DM; a, b, c, means in the same row with different superscript differ significantly (P<0.05); SEM=Standard error of means; NS=Not Significant;  
 \* = Significant

Table 2: Performance of goats fed semi-arid browses

Parameters	Treatments				SEM
	T <sub>1(an)</sub>	T <sub>2(be)</sub>	T <sub>3(ks)</sub>	T <sub>4(zm)</sub>	
Initial weight (Kg)	12.25	12.25	12.13	12.13	NAS
Final weight (Kg)	14.50 <sup>d</sup>	16.00 <sup>c</sup>	16.75 <sup>b</sup>	17.63 <sup>a</sup>	0.04*
Metabolic mass (Kg <sup>0.75</sup> )	7.43 <sup>c</sup>	8.00 <sup>b</sup>	8.28 <sup>a</sup>	8.60 <sup>a</sup>	1.11*
Body weight gain (Kg)	2.25 <sup>d</sup>	3.75 <sup>c</sup>	4.62 <sup>b</sup>	5.50 <sup>a</sup>	0.02*
Average daily body weight gain (Kg)	0.03 <sup>d</sup>	0.05 <sup>c</sup>	0.06 <sup>b</sup>	0.07 <sup>a</sup>	0.003*
Average daily Dry matter intake (g)	445.23 <sup>d</sup>	548.81 <sup>c</sup>	639.40 <sup>b</sup>	641.37 <sup>a</sup>	1.21*
Dry matter intake (g/Kg W <sup>0.75</sup> )	59.92 <sup>d</sup>	68.60 <sup>c</sup>	77.22 <sup>a</sup>	74.58 <sup>b</sup>	0.25*
Feed conversion ratio	0.20 <sup>b</sup>	0.15 <sup>a</sup>	0.14 <sup>a</sup>	0.12 <sup>a</sup>	0.004*

a, b, c, means in the same row with different superscript differ significantly (P<0.05); SEM=Standard error of means; \* = Significant; NAS=Not analyzed statistically

Table 3: Nutrients digestibility of goats fed semi-arid browses (% DM)

Nutrients digestibility (%)	Treatments				SEM
	T <sub>1(an)</sub>	T <sub>2(be)</sub>	T <sub>3(ks)</sub>	T <sub>4(zm)</sub>	
Dry matter	92.49 <sup>d</sup>	93.74 <sup>c</sup>	94.37 <sup>b</sup>	95.28 <sup>a</sup>	0.56*
Crude protein	22.58 <sup>b</sup>	68.27 <sup>a</sup>	20.62 <sup>b</sup>	22.86 <sup>b</sup>	1.01*
Ether extract	25.63 <sup>b</sup>	15.21 <sup>d</sup>	42.83 <sup>a</sup>	18.84 <sup>c</sup>	0.77*
Crude fibre	71.30 <sup>a</sup>	19.94 <sup>c</sup>	13.35 <sup>d</sup>	26.37 <sup>b</sup>	1.12*
Ash	37.50 <sup>a</sup>	31.43 <sup>b</sup>	32.27 <sup>b</sup>	33.40 <sup>b</sup>	0.98*
Organic matter	54.99 <sup>b</sup>	62.31 <sup>a</sup>	62.10 <sup>a</sup>	56.88 <sup>b</sup>	0.93*
Neutral detergent fibre	32.84 <sup>bc</sup>	36.29 <sup>a</sup>	27.89 <sup>c</sup>	29.82 <sup>c</sup>	1.01*
Acid detergent fibre	40.23 <sup>bc</sup>	43.99 <sup>a</sup>	34.90 <sup>d</sup>	39.31 <sup>c</sup>	0.56*
Acid detergent lignin	59.35 <sup>a</sup>	46.25 <sup>b</sup>	33.23 <sup>c</sup>	32.84 <sup>c</sup>	1.21*
Acid detergent insoluble ash	4.56 <sup>a</sup>	4.21 <sup>b</sup>	1.80 <sup>d</sup>	3.83 <sup>c</sup>	0.02*
Cellulose	10.17 <sup>d</sup>	15.37 <sup>b</sup>	11.76 <sup>c</sup>	17.40 <sup>a</sup>	0.01*

a, b, c, means in the same row with different superscript differ significantly (P<0.05); SEM=Standard error of means; \* = Significant

Table 4: Nitrogen utilization (g/day)

	Treatments				SEM
	T <sub>1(an)</sub>	T <sub>2(be)</sub>	T <sub>3(ks)</sub>	T <sub>4(zm)</sub>	
Nitrogen intake (g/day)	17.75 <sup>a</sup>	17.55 <sup>b</sup>	24.38 <sup>d</sup>	29.39 <sup>e</sup>	0.09*
Nitrogen in faeces (g/day)	1.47 <sup>c</sup>	2.56 <sup>a</sup>	1.44 <sup>c</sup>	2.29 <sup>b</sup>	0.002*
Nitrogen in urine (g/day)	4.39 <sup>b</sup>	3.28 <sup>c</sup>	5.04 <sup>a</sup>	1.67 <sup>d</sup>	0.06*
Nitrogen absorbed (g/day)	16.28 <sup>c</sup>	14.99 <sup>d</sup>	22.94 <sup>b</sup>	27.10 <sup>a</sup>	0.001*
Nitrogen retained (g/day)	11.89 <sup>c</sup>	11.71 <sup>c</sup>	17.90 <sup>b</sup>	25.43 <sup>a</sup>	0.08*
Nitrogen absorbed as % N <sub>2</sub> intake	91.72	85.41	94.09	92.20	10.65 <sup>NS</sup>
Nitrogen retained as % N <sub>2</sub> intake	66.99	66.72	73.42	86.52	9.70 <sup>NS</sup>

a, b, c, means in the same column with different superscript differ significantly (P<0.05); SEM=Standard error means; NS=Not Significant

Table 5: Cost/Benefit analysis of feeding selected semi-arid browses to goats

	Treatments				SEM
	T <sub>1(an)</sub>	T <sub>2(be)</sub>	T <sub>3(ks)</sub>	T <sub>4(zm)</sub>	
Number of goats	4	4	4	4	-
Initial weight (Kg)	49.00	49.00	48.50	48.50	-
Final weight (Kg)	58.00 <sup>d</sup>	64.00 <sup>c</sup>	67.50 <sup>b</sup>	70.50 <sup>a</sup>	0.004*
Total weight gain (Kg)	9.00 <sup>d</sup>	15.00 <sup>c</sup>	19.0 <sup>b</sup>	22.00 <sup>a</sup>	0.02*
Total Feed intake/goat (Kg)	37.40	46.10	53.71	53.88	-
Feed cost/Kg feed (N)	31.00	28.90	26.80	24.70	-
Total feed cost (N)	1159.40	1332.29	1439.43	1330.84	-
Feed cost/Kg gain (N/Kg)	128.82	88.82	75.76	60.49	-
% reduction in feed cost (%)	-	31.05	41.19	53.04	-

a, b, c, means in the same column with different superscript differ significantly (P<0.05); SEM=Standard error means; \* = Significant

### Nutrients Digestibility of Goats Fed Selected Semi-arid

**Browses:** The nutrient digestibility of selected semi-arid browses fed to goats is shown in Table 3. Nutrient digestibility for the different browses varied significantly (P<0.05) between the diets. The nutrients digestibility were generally low except for dry matter. There were significant differences (P<0.05) among treatments. Animals on diet T<sub>2</sub> (*Balanites egyptiaca*) had the highest Crude protein, organic matter, neutral detergent fibre and acid detergent fibre digestibility. Digestibility values obtained for acid detergent insoluble ash and cellulose varied significantly at 4% and 18% respectively between the dietary treatments. There were high variation in nutrient digestibility.

**Nitrogen Utilization:** The results of nitrogen utilization by goats fed selected semi-arid browses is shown in Table 4. Nitrogen intake differ significantly (P<0.05) and was the highest for diet T<sub>4</sub> (29.39 g day<sup>-1</sup>) (*Ziziphus mauritiana*). Faecal nitrogen output was also significantly different (P<0.05) with highest T<sub>4</sub> (*Ziziphus mauritiana*) value (2.29 g day<sup>-1</sup>). Urinary nitrogen (N) output values recorded for

the different diets are 4.39 g day<sup>-1</sup>, 3.28 g day<sup>-1</sup>, 5.04 g day<sup>-1</sup> and 1.67 g day<sup>-1</sup> for T<sub>1</sub>, T<sub>2</sub>, T<sub>3</sub> and T<sub>4</sub> respectively and differ significantly. Nitrogen absorbed and retained differ significantly (P<0.05) among treatments which ranged from 85.41% to 94.09% and 66.72% to 86.52% respectively.

### Cost/benefit Analysis of Feeding Selected Semi-arid

**Browse to Goats:** Values for the cost/benefit analysis is shown in Table 5. Feed cost /Kg feed (N) ranged from N24.70 in T<sub>4</sub> (*Ziziphus mauritiana*) to N31.00 in T<sub>1</sub> (*Acacia nilotica*). The total feed cost was highest (N1439.43) in T<sub>3</sub> (*Khaya senegalensis*) and lowest (N1159.40) in T<sub>1</sub> (*Acacia nilotica*). Feed cost per Kg gain (N/Kg) decreased from T<sub>1</sub> to T<sub>4</sub>. Reduction percent in feed cost was higher in T<sub>4</sub> (53.04%) and lowest in T<sub>2</sub> (31.05%).

## DISCUSSION

**Chemical Composition of Browse Forages:** The result obtained for chemical composition of the browse forages is similar to those reported by [14, 15].

Generally all browse forage used in the current study had a CP content of above 7% DM which can support optimum microbial growth. The result of the fibre fraction shows that NDF, ADF and ADL are high and can affect digestibility. Higher levels of NDF and ADL have been reported to have negative effect on DM intake DM digestibility [16]. Several reports [14, 15, 17] shows that semi-arid browses of North eastern Nigeria are generally high in fibre and lignin during the dry season.

#### **Growth Performance of Goats Fed Semi-arid Browses:**

The different mechanisms involved in determining feed intake allow understanding the differences observed in intake of the studied browse fodders. Concerning the browse leaves intake of *A. nilotica* can be explained by the high NDF and lignin content. The explanation regarding CP and fibre content could be valid for the difference observed in intake. Apart from *Z.mauritiana*, the result indicates that the studied forages could constitute the main component of goat rations and would be well consumed. The animals increased in weights, especially with *Z.mauritiana* leaves, which could indicate efficient utilization of these feed. The intakes expressed in g/kg  $W^{0.75}$  were high compared to the estimation of Devendra McLeroy [18] for tropical goat breeds. The low DMI of  $T_1$  can be explained by the high NDF content, while the low CP content could be the limiting factor for intake in  $T_1$ . The high DM intake observed in  $T_4$  was probably due to a better balance between energy and protein as more OM (916.00 g  $kg^{-1}$ ) was consumed from leaves diet. The small size of the leaves of *Ziziphus mauritiana*, mostly small leaflets around 5mm long, could have influenced intake, in so far as goats are shown to be extremely sensitive to diets poor in fibre and rich in concentrate or forage characterized by small particle size, which decreases the rumen pH, resulting in a fall in intake [19]. However, increased dietary NDF is shown to decrease DM intake linearly in growing goats [20]. Many other factors, including particles size, chewing frequency and effectiveness, particle fragility, indigestible fraction, rate of fermentation of the potentially digestible NDF and characteristics of reticular contractions are also involved. Apart from  $T_1$ , the result indicated that the forage studied could constitute the main component of goat diets and would be well consumed. The intakes expressed in g/kg  $w^{0.75}$  were high compared to the estimation of Devendra and McLeroy [18] for tropical goat breeds. The weight gain by all goats was lower than expected as nutrient intakes from all diets were higher in protein (97.70 to 182.40 g  $kg^{-1}$  CP) than in the estimated requirements

(74.30 g  $kg^{-1}$  CP). The difference can be explained either by the inadequacy of the requirement estimates for other breeds, or the breeds, or the low genetic potential of Sahelian goats marked by low capacity for growth or low efficiency of nutrient utilization. The ADG varied from 0.03 to 0.07kg  $day^{-1}$  and the control diet  $T_1$  had the lowest ADG (0.03kg/day), suggesting a low efficiency in utilization of the experimental diet. The weight gains were somewhat similar compared to the result obtained by Njidda *et al.*[14] in Nigeria. Almost all literature on the use of shrub and tree fodders to supplement either natural grasses or crop residues have shown positive responses with respect to the productivity of cattle, sheep and goats [21].

#### **Nutrient Digestibility of Goats Fed Semi-arid Browses**

**Forages:** Studies on the digestibility of browse fodders are very important as they allow the estimation of nutrients really available for animal nutrition. The main progress has been in the quantity of information on the ingestibility, digestibility and nutritive value of these fodders. Results on milk or growth performance are often given since digestibility values cannot always be interpreted in performance results [9, 22]. The *in vivo* technique is the classical and direct method for estimating feed digestion by animals. However, due to difficulties in its application, indirect methods are frequently used. Most of the studies on digestibility of browse fodders used the *in vitro* technique, which provides a comparative estimate of DMD and can be used to rank the quality of the feed. However, the significance of the method is limited as it does not take into account the intake of forage by the animal. The *in sacco* method has the advantage of measuring the rate of digestion of different feed components (protein and starch) through nylon bags suspended in the rumen and can also be used to rank feeds. The *in sacco* method is known to usually overestimate *in vivo* digestibility [23]. In the present study the *in vivo* method was applied using goats, owing to their preference for browse forages. The comparison of the results with other data is uncertain due to different experimental conditions: the method used, animal species used and the level of browse fodder in the diet. The leaves were used with a fix amount of hay at a minimum level, since it was anticipated that leaves could not be fed alone due to possible anti-nutritive factors, while the pods were fed as a single feed. The factors involved in the variation in digestibility among browse fodders include the concentration of N, cell wall content, especially lignin and tannins. A low level of CP (less than 80 g/kg DM) is

shown to depress digestibility, as it is not sufficient to meet the needs of the rumen bacteria [21]. On the other hand, low NDF content (20 to 35%) has been shown to be resulted in high digestibility, while lignification of the plant cell wall decreases the digestibility of plant material in the rumen. Many studies [24] have reported a negative correlation between lignin concentration and cell wall digestibility by its action as a physical barrier to microbial enzymes. Negative correlations between tannin and protein or DM digestibility have also been studied [25, 26]. Hence information on the NDF, ADF, lignin and tannin content of tree foliage is essential for the assessment of their digestibility. Luginbuhl [20] noted that goats are not able to digest cell walls as well as cattle because the feed stays in their rumen for a shorter period of time. On the other hand, [19] reported similar retention time of feed particles in the whole digestive tract of sheep and goats eating the same quantity of good quality forage, but the retention time of goats receiving poor quality forage was longer. Hence sheep and goats have similar patterns of digestion of moderate to high quality forages, but goats are better in digesting forages rich in cell walls and poor in nitrogen. This seems to be related to their ability to recycle urea nitrogen [27].

A wide range of variation in digestibility is reported in tropical browse species. Breman and Kessler [28] showed a mean OMD of 0.53 in Sahelian and Sudanian zones of West Africa. Le Houerou [29] reported a mean DCP of 510 g/kg for West African browses, with 760 g/kg for legumes. Fall [30] reported large variations in DMD, ranging from 0.26 to 0.88 between species and plant parts. In the present study OMD (54.99 to 62.23% DM) was high and CPD (20.62 to 22.86% DM) was low except for *Balanites aegyptiaca* (68.27% DM).

#### **Live Weight of Goats Fed Semi-arid Browses Forages:**

In spite of the adaptation to harsh environments and poor quality feeds, goats require for optimum growth, an efficient utilization of nutrients that supply adequate energy and protein. Knowledge of nutrient requirements is therefore important for the estimation of genetic potential of the animals. It is well documented that the nutrient requirement depends on body size and growth rate or production potential of animals, environmental conditions (temperature, humidity, ...) and the quality of the feed [31, 32]. The Sahelian goats, also known as the West African long-legged goats, are well adapted in the semi-arid zones. The weight gain by all goats was lower than expected, as nutrient intakes from all diets were higher in protein (97 to 182 g/kg) than the estimated

requirements (74.3 g). The difference can be explained either by the inadequacy of the estimated requirement for other breeds, or the low genetic potential of Sahelian goats marked by low capacity for growth or low efficiency of nutrient utilization. The ADG varied from 30 to 70 g/day and the diet with *A. nilotica* leaves resulted in the lowest performance, suggesting a low efficiency in utilization of this forage type. When used as a sole feed in the voluntary intake trial, the weight gains were somewhat moderate to high compared to the results of Sawe *et al.*[33] supplementing goats (57 to 68 g/day) with tree leaves and pods in Kenya. Similar results to the present study were obtained by Mtenga and Kitaly [34] with indigenous goats in Tanzania.

**Feed Conversion Ratio:** The feed conversion ratio was low for T<sub>1</sub> than the other treatments. Hence the leaves of *Z.mauritiana* and *K. senegalensis* could be an alternative because of the high FCR and availability in the area where the foliage can be collected and stored for stall-feeding. The aim of this study was to compare different types of browse forages in terms of digestive utilization, economic and their effect on animal performance. They were then used *ad libitum*, though the economic feasibility of this technique was considered.

However, *ad libitum* feeding of the browse forages should be limited if the high CP content of browse fodders is to be exploited and it will require large amount of forages to store. Since the leaves of these browse forages are sold in the local market, this could limit the availability. The use of these browse species as a supplement should be evaluated and the levels that allow optimum growth at lower cost must be assessed.

#### **Nitrogen Retention in Goats Fed Semi-arid Browses Forages:**

Nitrogen retention is considered a better criterion of measuring protein quality than digestibility. Nitrogen retention is associated with the amount of Nitrogen used for protein deposition and biological value is a measure of protein quality [35]. The browse forages offered gave a positive N balance. Ruminants can use dietary or non-protein nitrogen (N) to meet protein requirements largely because of the symbiotic relationship between the host and its rumen microbes [27]. This demonstrated that the browse forages was efficiently used as a fermentable nitrogen source for microbial growth in the rumen. Moreover, rations that are well balanced in energy, protein and minerals result in reduced N and P excretion [36]. Such excretion is an ever-increasing problem due to its effect on environmental

maintenance. The values for the N balance were higher than the values reported by Wampana *et al.*[37] who fed agro-industrial by-product.

**Cost/benefit Analysis:** On economic ground T<sub>4</sub> ((30% *Ziziphus mauritiana*) was better than the other diets in terms of feed cost/kg feed (N24.70), feed cost per kg gain (N60.49) and reduction percent in feed cost (N53.04) (Table 3). Therefore diets containing *Ziziphus mauritiana* could be fed to growing goats without compromising the growth and economic performance.

In conclusion, based on the protein content, the leaves of all the browse forages are suitable as supplements to poor quality rations. However, *G. senegalensis*, with the lowest crude protein and highest fiber and lignin content, had low intake characteristics and this resulted in low weight gain during the experimental period. The browse forages could be used as alternative low cost sources of protein in livestock feeding.

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