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Full Length Research Paper

Potential values of some non-leguminous browse plants as dry season feed for ruminants in Nigeria

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A study was conducted to assess the nutritive potential of some tropical non-leguminous multipurpose trees: *Bombax glabra, Adansonia digitata, Ceiba pentandra, Kigelia africana, Newbouldia leavis, Treculia africana, Milicia exselsa, Mangifera indica, Spondia mombin, Terminalia superba, Terminalia catappa, Tabebuia rosea* and *Ficus thonningii.* A wide variation was observed in the chemical composition, secondary compounds and gas production characteristics. Crude protein (CP) concentration ranged from 6.35 – 16.41 g/100g DM. The ash content varied between 5.27 and 12.46 g/100g DM. The content of neutral detergent fibre (NDF), acid detergent fibre (ADF) and lignin ranged from 40.49 - 69.31, 28.39 - 52.62 and 6.14 - 16.83 g/100g DM, respectively. At least each possessed steroid as anti-nutrient as revealed from the study. It was observed that five browse species had tannins while eight showed traces of saponin. The degradability of the browse spp can be grouped into 3: High fermentation (> 20.00 ml) for *S. mombin, B. glabra, A. digitata, C. pentandra, K. africana* and *M. exselsa*; moderate fermentation (17.00 - 19.00 ml) for *T. superba, T. catappa, T. rosea, F. thonningii, T. Africana* and *M. indica*; low fermentation (< 16) was observed in *N. leavis.* The highest potential gas production, rate of gas production, metabolizable energy and short chain fatty acid were observed in *S. mombin*. From the result obtained, it is suggested that some of the browse species could be utilized by ruminants as feed supplement during both wet and dry seasons. *S. mombin* being high in gas production could be supplemented with energy rich feed like guinea grass in order to sustain livestock production.

Key words: Characteristic, gas production, multipurpose, nutritive, secondary compounds.

INTRODUCTION

Inadequate feed supply is a major constraint to ruminant production during the dry season in the tropics. This has been the basic reason for poor performance of livestock. Tropical grass fodder and crop by-products available during dry season in tropics have a low nutritive value due to their low protein and fermentable energy though they grow rapidly during the period of heavy rainfall and high temperature and this leads to grass maturing early and so contains high level of lignin. Forage quality and availability vary greatly from season to season which however, affect the output of the animals (Reference needed here).

The nutritive value of pastures fall rapidly with maturity and, during the dry season, the available feed is lignified. The nutritive value of any feedstuff is determined by its chemical composition and degradability and this is related to the forage and its environment. The rate of acceptability of forage is related to the readiness to which the forage is selected and consumed. Leguminous forages and the foliage of multipurpose trees which are found in Africa are promising sources of protein if used as a supplement to ruminants receiving low-quality forages (Devendra, 1990). Likewise, the potential value of browse trees lies in the provision of protein, vitamins and also the mineral elements that are lacking in grassland pastures

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Abbreviations: DM, Dry matter; **CP**, crude protein; **EE**, ether extract; **CF**, crude fibre; **NDF**, neutral detergent fibre; **ADF**, acid detergent fibre; **ADL**, acid detergent lignin; **MW**, methanol-water; **WAD**, West African dwarf; **ME**, metabolizable energy; **OMD**, organic matter digestibility; **SCFA**, short chain fatty acid.

during the dry season (Bamikole et al., 2004). There are many forage plants that have the ability to produce high yields of biomass, but could not be utilized for improvement of livestock production because the information on their nutrient composition is not known. *In vitro* fermentation has been used to evaluate digestibility and nutriational value of feed as it is cheaper, less laborious and most importantly, allows experimental conditions more accurately than the *in vivo* techniques (Getachew et al., 2002; Ajayi and Babayemi, 2008). It also allows a large number of feed samples to be handled simultaneously. It is based on the quantification of substrate degraded and of gas produced in rumen fermentation system based on syringes.

Generally, most farmers utilizing some of these multipurpose trees may encounter problem as they contain one or two anti-nutrients, such as saponins, tannins, phytate, etc, which are either toxic to rumen microbes or to the animal (D'Mello, 1992; Lowry et al., 1996). However, recent studies revealed that antinutrients found in most foliage leaves have beneficial effects at low concentration (Hess et al., 2003; Babayemi et al., 2004).

Therefore, the objective of this study is to assess the nutritional composition of some non leguminous multipurpose trees by their chemical composition and *in vitro* fermentation characteristics.

MATERIALS AND METHODS

Forage collection

Non-leguminous browse plants were collected from the field gene bank of National Centre for Genetic Resources and Biotechnology (NACGRAB), Moor Plantation, Ibadan. The location is 7° 27´N and 3°45´E at an altitude of between 200 – 300 m above sea level, with mean temperature of 25 - 29°C and an average annual rainfall of about 1250 mm. The plants species collected were above seven years.

Chemical composition

Each fresh sample consists of leaves and small part of stems. The samples were oven-dried to constant weight at 105°C to determine dry matter (DM) and later ground to pass through 1 mm sieve for later use. Crude protein (CP), ether extract (EE), crude fibre (CF), ash content of the fodders were determined as outlined (AOAC, 1990). Neutral detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent lignin (ADL) were analyzed (Van Soest et al., 1991).

Qualitative determination of secondary metabolites

The secondary metabolites in the plant species were determined (Babayemi et al., 2004). 2 g of each milled sample were weighed in duplicates into extraction bottles, using two extraction solvents, (methanol and petroleum ether). Methanol-water (MW) was prepared using 9: 1(v/v). Equal amount (30 ml) of each solvent was added into the sample and mixture was agitated using the mechanical shaker (Gathehamp, Germany) at 2000 rpm for 90 min. The agitated solution was immediately filtered and rinsed using separating funnel. Two layers were distinctly formed; lower MW and upper petroleum ether fractions. These were separated into 50 ml flask each. Out of the MW fraction, 1 – 67 ml of each sample was dispensed into 9 ml distilled water. 1 ml of it was pipette into calibrated test tube (duplicates). The content was shaken for 30 s, the agitated test-tube was allowed to stand for 15 min, after which the height of the foam (mm) in the test- tube was measured and recorded as: 5 mm or less = negative, 5 – 9 mm = low saponin, 10 - 14 mm = medium saponin and 15 mm or more = high saponin. 1 ml of MW fraction was again pipette into two bottles each, after which the prepared solutions of 1% $FeCl_3$ (w/v) at 1 ml were dispensed into the two bottles. A characteristic colour change was used in detecting the presence of hydrolysable or condensed tannins (phenols) and recorded as: No change = No phenols or tannins; dark blue = water – soluble or hydrolysable tannin; dark green = condensed tannins. From the petroleum ether fraction, 10 ml was measured into test tube (n = 2) using a calibrated measuring cylinder. This was later shaken together under warm water, after which 0.5 ml chloroform, 0.25 ml acetic acid anhydride and 0.125 ml concentrated H_2SO_4 was added. The solution was later shaken together for 30 s and the colour reaction was inferred: Blue or green = steroids; pink, red or purple = triterperoids; light yellow = saturated steroids or triterperoids.

In vitro gas production technique

Preparation of the buffer and rumen liquor was carried out as described by Menke and Steingass (1988). The substance was placed in a calibrated gas tight plastic syringe fitted with a piston. Rumen fluid was collected through suction tube from the mouth into the rumen (Babayemi and Bamikole, 2006) of three West African dwarf (WAD) goats that were previously fed *Panicum maximum* with *Gliricidia sepium* and compounded feed consisting of 20% corn, 20% wheat bran, 25% corn bran, 20% palm kernel cake, 8% ground nut cake, 3% soya beans, 3% oyster shell, 0.75% table salt and 0.25% fish meal, sieved with a four layered cheese cloth mixed with sodium buffer (9.8 g $NaHCO_3$ + 2.77 g $(Na_2)HPO4$ + 0.57 g KCl + 0.47 g NaCl + 0.12 g $MgSO_4.7H_2O$ + $CaCl_2.2H_2O$ per 1000 ml) in a ratio of 1: 2 v/v. About 30 ml of buffered rumen liquor was taken into syringes containing 200 mg DM each sample. The syringes were incubated in triplicate under continuous flushing with CO_2 at 39°C. A blank (rumen fluid + buffer) sample was incubated at the same time. Gas production was recorded at 3, 6, 9.12, 15, 18, 21 and 24 h and after 24 h of incubation, 4 ml of NaOH (10 M) was introduced into the incubated samples as reported (Fievez et al., 2005) to estimate the amount of methane produced. The volume of gas produced at interval was plotted against the incubation time and from the graph, the gas production characteristics were calculated using the equation (Qrskov and McDonald, 1979).

$$Y = a + b\,(1-e^{-ct})$$

Where, Y = Volume of gas produced at time 't'; a = initial gas produced; b = gas produced from insoluble but degradable fraction; c = gas production rate constant for b; t = incubation time.

Metabolizable energy (ME, MJ/kg DM) and organic matter digestibility (OMD %) were also determined as outlined (Menke and Steingass, 1988) while short chain fatty acid (SCFA, mmol) was also estimated as reported (Getachew et al., 1999).

Statistical analysis

Data collected were subjected to analysis of variance (ANOVA) and means separations where there were significant differences was by Duncan multiple range and F-test Statistical Analysis System (SAS, 1998) package.

Table 1. Chemical composition of some non-leguminous browse species (g /100 g DM).

Plant species	DM	CP	CF	Ash	EE	NDF	ADF	ADL
B. glabra	28.81h	16.41a	33.15e	9.60e	11.82b	58.36e	42.46d	11.36e
A. digitata	41.44c	13.54c	26.41j	6.24h	14.72a	57.42f	39.79e	6.96h
C. pentandra	31.64g	16.19a	30.48h	10.15d	9.31ef	58.09ef	41.65d	14.16b
K. Africana	32.19f	9.01e	38.31b	12.46a	7.69g	69.31a	52.62a	16.83a
N. leavis	43.07b	9.89d	41.13a	8.46f	12.25b	66.57b	48.36b	12.93c
T. rosea	35.27e	13.32c	41.75a	5.27i	6.10h	58.12ef	39.96e	6.07j
T. africana	38.33d	9.19e	30.41h	10.98c	11.25c	55.75i	29.95g	6.59i
M. excelsa	38.11d	8.00f	29.25i	11.51b	9.92d	40.49j	28.39h	6.14j
M. indica	43.79a	6.35h	32.05f	7.05g	9.19f	58.63e	37.70f	13.06c
S. mombin	32.22f	15.45b	31.28g	8.63f	11.07c	54.65h	39.96e	7.85g
T. superba	26.58i	15.45b	26.18j	9.83d	9.74ed	56.60g	38.92ef	9.88f
T. catappa	25.85	7.22g	37.04c	9.50e	9.80d	62.47d	44.81c	12.00d
F. thonningii	21.63k	13.54c	35.49d	12.12a	10.10d	64.06c	47.65b	12.18d
SEM	0.14	0.57	0.18	0.17	0.15	0.28	0.46	0.09

a, b, c, d, e, f, g, h, i, j and k: means with the same letters within the column are not significantly different (P >0.05).

RESULTS

Chemical compositions

Table 1 presents the chemical composition of different types of non-leguminous browse trees grown in southern part of Nigeria. Significant differences were obtained among the browse species with respect to dry matter DM, CP, CF, Ash, EE, NDF, ADF and ADL. DM ranging between 21.63 g/100 g DM in *Ficus thonningii* and 43.79 g/100 g DM in *Mangifera indica*. CP varied from 6.35 g/100g DM in *M. indica* to 16.41 g/100g DM in *Bombax glabra*. Among the plant spp, only *Mangifera spp* exhibited CP value below the critical protein requirement level (7%) for ruminant. It then means that for animal to be fed with such plant, it has to be supplemented with high protein feed resources. CF likewise varied significantly ($p < 0.05$) from 26.18 g/100 g DM in *Terminalia superba* to 42.13 g/100 DM in *Newbouldia leavis*. Ash and EE contents followed the same trend (5.27 and 12.46) and EE (6.10 to14.72), respectively. The fibre fractions were also significantly different ($p < 0.05$). NDF, ADF and ADL ranged from 40.49 to 69.31, 29.95 to 52.62 and 6.07 to 16.83, respectively. However, *Kigelia africana* had the highest contents of NDF, ADF and ADL while *Milicia exelsa* had the least value of NDF and ADF but *Tabebuia rosea* had the lowest ADL content. ADF fractions took the larger proportion of the NDF which gave an indication of high level of cell wall contents of the plant species.

Table 2 shows the result of the quantitatively tested plants. Nearly all the trees shared the presence of one or two secondary metabolites. It was also observed that steroid appeared in all the forages under this study. This is an indication of the present of fatty acids that may be found in these tested samples. This study was unable to quantitatively determine the antinutrients to really ascertain the amount present in them. This will be carried out in another study.

The *in vitro* gas production pattern of the non-leguminous browse plants over a period of 24 h is presented in Figure 1. There was a significant variation ($p < 0.05$) in the gas volume produced at every interval of time. Similar observation was recorded at the net gas production. The least value of total gas produced was observed in *N. leavis* (16.00 ml) while the highest was found in *Spondia mombin* (26.33 ml).

Figure 2 presents the methane production at the end of the fermentation. The volume of methane produced was significantly different ($p < 0.05$) ranging from 8.33 ml in *Treculia africana* to 18.17 ml in *S. mombin*. It was observed that the volume of methane produced was high compared with the net gas produced.

Also, the result of calculated parameters: ME (MJ/Kg DM), OMD (%) (SCFA) is shown in Table 3. Statistically, there was no significant difference ($p > 0.05$) in these parameters among the plant species.

Table 4 shows the result of the *in vitro* gas production characteristics of the tested plants. It was observed that the parameters varied significantly ($p < 0.05$). The wide variations are expected since the trees are not of the same types. The initial gas produced (a) ranged from 0.00 ml (AD, ME, TC, TA and KA) to 3.00 ml (MI). The insoluble but degradable fractions (b) were also variable

Table 2. Qualitative assessment of secondary metabolites in leguminous plants.

Plant species	Saponin		Phenol/tannins		Steroids	
	Foam length (mm)	Comment	Colour change	Comment	Colour change	Comment
B. glabra	2.00	Negligible	Green	Positive	Green	Positive
A. digitata	3.00	Negligible	Green	Positive	Green	Positive
C. pentandra	2.00	Negligible	Nil	Negative	Green	Positive
K. Africana	Nil	Negative	Nil	Negative	Green	Positive
N. leavis	Nil	Negative	Nil	Negative	Green	Positive
T. rosea	1.5	Negligible	Nil	Negative	Green	Positive
T. africana	3.00	Negligible	Green	Positive	Green	Positive
M. excelsa	2.00	Negligible	Nil	Negative	Green	Positive
M. indica	1.5	Negligible	Nil	Negative	Green	Positive
S. mombin	Nil	Negative	Green	Positive	Green	Positive
T. superba	2	Negligible	Green	Positive	Green	Positive
T. catappa	Nil	Negative	Nil	Negative	Green	Positive
F. thonningii	Nil	Negative	Nil	Negative	Green	Positive

Table 3. Metabolizable energy (ME, MJ/kg DM), organic matter digestibility (OMD, %) and short chain fatty acids (SCFA, mol) of the non leguminous plants.

Plant species	ME	OMD	SCFA
B. glabra	6.22	48.67	0.50
A. digitata	5.61	42.60	0.39
C. pentandra	5.45	44.07	0.36
K. Africana	5.83	47.10	0.48
N. leavis	4.99	39.06	0 32
T. rosea	5.17	38.43	0.33
T. africana	4.98	40.72	0.33
M. excelsa	5.87	46.73	0.50
M. indica	5.50	41.21	0.45
S. mombin	6.46	48.07	0.57
T. superba	5.40	43.61	0.35
T. catappa	4.90	38.93	0.35
F. thonningii	5.80	47.15	0.45
SEM	0.52	3.41	0 .09

within the plants examined, ranging from 14.33 ml (NL) to 22.33 ml (AD).The gas production rate (c) varied between 0.07h^{-1} (TS) to 0.86 h^{-1} (TC) and their volume of gas produced at time t(y) was highly variable, however, ranging from 13.00 ml (NL and TS) to 17 ml (ME). Likewise, incubation period (t) varied between 15.00 h (SM, NL, BG, TS, TR, FT and AD) and 18.86 h (TC). a + b which is the potential degradability were variable within the samples examined, ranging from 18.00 ml (TA and MI) to 22.67 ml (SM).

DISCUSSION

The crude protein, ash and dry matter contents of the browse species recorded in this study agree well with the

Table 4. *In vitro* gas production characteristics of fermented browse species.

Forage	a (ml)	b (ml)	Y (ml)	c(h^{-1})	t (h)	a + b
M. indica	3.00a	15.00g	15.00c	0.06	18.00a	18.00e
B. glabra	1.67b	20.66b	14.67d	0.09	15.00b	22.36a
S. mombin	1.67b	20.96b	17.33a	0.10	15.00b	22.67a
N. leavis	1.67b	14.33h	13.00e	0.08	15.00b	16.00g
T. superba	1.67b	17.00f	13.00e	0.07	15.00b	18.66d
T. rosea	1.67b	15.33g	16.67b	0.06	15.00b	17.00f
C. pentandra	1.33c	18.67d	14.00e	0.07	18.00a	20.00c
F. thonningii	1.33c	17.00f	13.33e	0.08	15.00b	18.31d
A. digitata	0.00d	22.33a	15.00c	0.07	15.00b	22.33a
M. excelsa	0.00d	21.00b	17.00b	0.09	18.00a	21.00b
T. catappa	0.00d	18.67d	14.00e	0.06	18.60a	18.67d
T. africana	0.00d	18.00e	14.00e	0.06	18.00a	18.00e
K. africana	0.00d	20.00c	14.67d	0.07	18.00a	20.00c
SEM	0.15	0.40	0.24	0.04	0.25	0.34

a, b, c, d, e and f = means with the same letters within the column are not significantly different ($p > 0.05$).

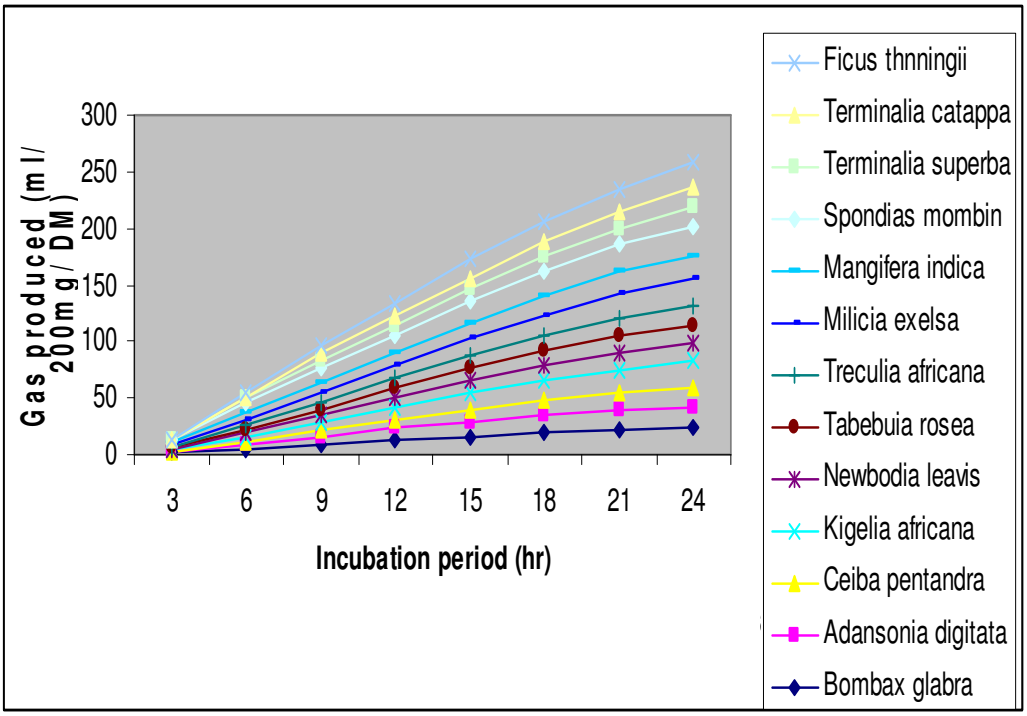

Figure 1. *In vitro* gas production of some non-leguminous trees.

values reported for five species of Ficus by Bamikole et al. (2004). The level of CP was, however, consistent with the reported CP browsed in tropical West Africa (Le-Houerou, 1980). The CP values obtained from this study were however, lower than those CP valued reported for some browse species in south-west Nigeria (Larbi et al., 1998) and also lower than the CP values obtained for *Acacia* spp. (Abdulrazak et al., 2000) and multipurpose

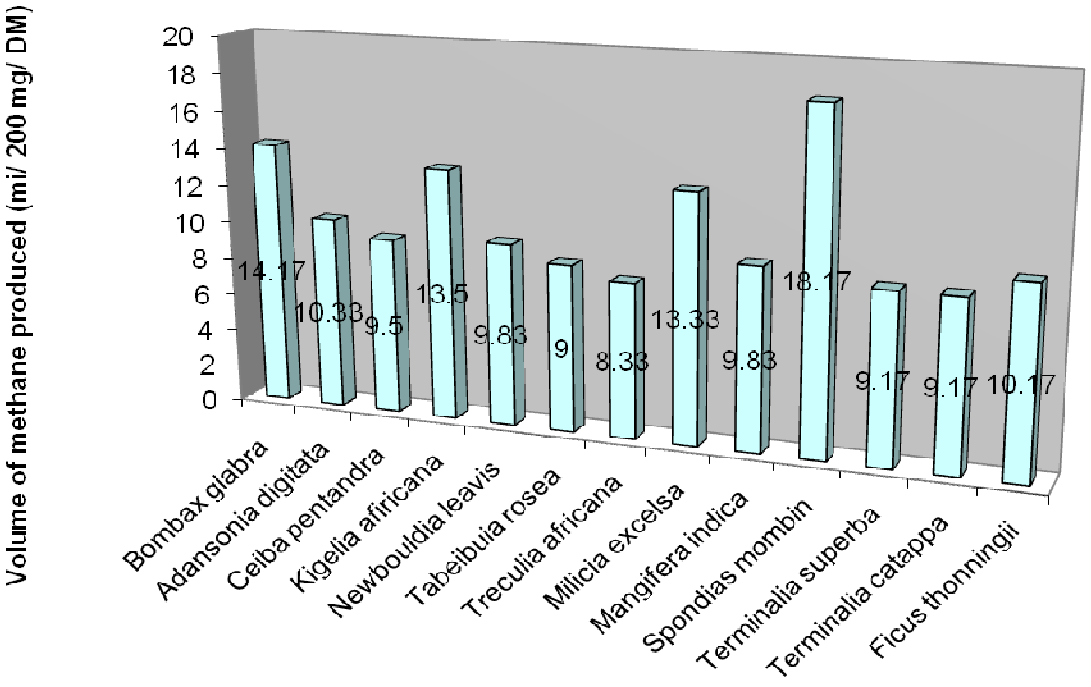

Figure 2. Methane production of some non-leguminous trees.

trees in Ethiopia (El-hassan et al., 2000). The variations could be due to leaf to petiole ratio, plant variety, agro climatic conditions, or even stages at maturity (Makkar and Becker, 1997; Bamikole et al., 2004).

The general low crude protein values of these plants in this study may be because the tested samples are non legumes while the other reported studies were legumes. Meanwhile, all the browse species in this study have their crude protein level within the acceptable range (7 - 14%) for ruminant performance (NRC, 1981), except *M. indica* which fell short of the critical level of 7% below which the feed intake will be depressed (ARC, 1980; Minson, 1990). The low level of crude protein found in *M. indica* may be attributed to maturity stage of the plant at the time of cutting. Some of the fodders with high level of protein may be utilized as a protein supplement to low quality feed such as grasses and crop residues.

Plant materials contain a group of substances, insoluble in water and organic compounds like ether. They are referred to as lipids and act as stores of energy (Verma, 2006). Ether extract is the lipid component and the energy derived from it is utilized by the animal for body maintenance and production. The higher value of ether extracts in some of the tested samples is an indication of higher energy level for the animal (Babayemi and Bamikole, 2006; Odedire and Babayemi, 2008) and this is a major form of energy storage in plants which is being utilized by the animals for body maintenance and produc-tion. The ash values recorded in this study were within the range of 7.9 - 12.6 g/kgDM obtained for tree fodders (Carlos et al., 2005). It represents the mineral level in a feed, which contains majorly phosphorus, calcium, or potassium and large amount of silica (Verma, 2006).

The fibre fractions (NDF and ADF) agreed with values reported for some browse species in Nigeria (Larbi et al., 1998). The results obtained also corroborated with the study carried out on shrub species from a mountain area in northern Spain (Frutos et al., 2000) with just little variations. Generally, NDF and ADL values obtained from these plant species were high; results were similar to reported values (Ngamsaeng et al., 2006). High contents of cell wall and lignin are typical of tropical forages (Van Soest, 1982) which have serious implication on the digestibility of forages. NDF actually determines the rate of digestion because it is inversely related to digestibility (McDonald et al., 1995; Gillespie, 1998).

The spot test assessment of secondary compounds required low laboratory equipment. It is used to screen large number of samples simultaneously and yet not laborious. This test affirmed the presence of anti-nutrients such as tannin, steroids and saponin in the samples. The presence of tannin and saponin in some of the plant samples revealed that they could be of benefit to ruminant as there will be rumen protein bye-pass into the lower gastro intestinal tract of the animal, this agrees with earlier work (Babayemi et al., 2004).

The values of net gas produced in this study were similar to those reported for leaves from tropical trees and shrubs (Brender et al., 1997). Low values of net gas production connote low digestibility of forages. The low digestibility observed in this study may be due to the

presence of condensed tannins found in most of the plant species (Barry and McNabb, 1999) and high level of fibre fractions of the forages most especially NDF content. It was observed that *S. mombin* with highest gas volume produced highest methane. The methane produced would have been reduced if it contains saponin (Babayemi et al., 2004). Methane produced during ruminal fermentation represents a loss of 10 - 11% of gross energy intake (McCrabb and Hunter, 1999) and this may be reduced with inclusion of saponin rich feed thereby maintaining or improving the energy intake in ruminants.

It could be concluded that non legumes could be used to replace *Gliricidia sepium* and *Leuceana leucocephala* that have been extensively utilized. Moreover, there is need to broaden the feed base because of the increased livestock production in the tropics. The protein level in them is moderate to support ruminants during the lean period. The presence of secondary compounds; tannin and saponin in some of these non leguminous plants could be useful as they will improve rumen by-pass protein.

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