Chemical composition, secondary metabolites, *in vitro* gas production characteristics and acceptability study of some forage for ruminant feeding in South-Western Nigeria

*[1] K.O.Yusuf, [1] O.A Isah,. [2]O.M. Arigbede, [1]A.O. Oni and [1]C.F.I. Onwuka
[1]Animal Nutrition Department, [2]Pasture and Range Management Department, University of Agriculture, Abeokuta, Nigeria
*Corresponding Author: yomowumi@gmail.com

Abstract

Studies were conducted to evaluate the nutritive value of eight selected forages (Tridax procumbens, Merremia aegyptia, Aspilia africana, Tithonia diversifolia, Alchornea cordifolia, Alchornea laxiflora, Synedrella nodiflora, and Newbouldia laevis) consumed by ruminants in South-Western Nigeria. Chemical composition and qualitative analysis of saponins, phenol and steroids of the plants were determined. In vitro gas production (IVGP) was carried out for 72 hours on the plants. Metabolizable energy (ME), Organic matter digestibility (OMD) and Short chain fatty acids (SCFA) were predicted and methane (CH_4) was measured. Five of the plants were subjected to acceptability study using cafeteria method. The result of the chemical composition revealed that M. aegyptia had the highest value of CP (22.09 %) while Tridax procumbens had the lowest (10.50 %). A. africana had the highest content of Calcium, Phosphorus and Zinc with values of 3.10 %, 0.93 % and 39 ppm respectively. The analysis of secondary metabolites showed that A. africana, T. diversifolia and S. nodiflora were high in saponin while A. cordifolia, A. laxiflora, T. diversifolia and A. africana were implicated for condensed Tannin. N. laevis recorded a high level of steroids. Results showed significant variations in the values of IVGP, ME, OMD, SCFA and CH_4 obtained for the plants. The order of preference of the plants by the calves were M. aegyptia>A. cordifolia > N. laevis > A. laxiflora> T. diversifolia. The study revealed that the forages are rich in crude protein as well as micro and macro minerals. They are also rich in highly fermentable carbohydrates which affirm them as ruminant feed resource.

Keywords: Acceptability, chemical composition, in vitro gas production, forages , south-western Nigeria

Introduction

The dry season is a critical period for ruminant animals in sub-Saharan tropical zones as it is characterized by shortage of feed both in quality and quantity. Grasses are usually the primary and most economical source of nutrients for ruminants and in some cases, they are all ruminants need to meet their nutritional requirement (Schoenian, 2003). As grasses mature, palatability and digestibility decline. Grasses become dry, coarse, fibrous and less digestible during the dry season resulting in reduced feed intake and weight losses of the animals. Utilization of different plants and trees that exist as green foliage during this critical period of feed shortage will go a long way in addressing this problem (Agishi, 1985; Devendra, 1989 and Saadullah, 1989). Many browse plants and forbs can be fed as supplement to ruminants during this critical period and even during the wet season because of their high nutritive value.

Browse is a term referring to tender shoot, twigs and leaves of shrubs and trees that form an important component of the diet of ruminants especially when available forages for grazing these animals are inadequate. Since they remain green throughout the dry season when most grasses and legumes wither away, they form the bulk of ruminant feed in addition to forbs during this period. Forbs are broad-leaved (not grass-like) non-woody flowering plant. Ikhimioya *et al.* (2007) reported that the most widely available low-cost feeds for ruminants in the tropics are the abundant native shrubs and multipurpose tree leaves but the information on the degradation characteristics of these leaves is limiting.

Browse plants can provide about 35% of digestible crude protein requirement for cattle in the semi arid region of Nigeria and as the dry season progresses the percentage raises to about 60% (Bayer *et al*., 1987). They provide vitamins and mineral elements which are mostly lacking in grassland pasture and their year round evergreen presentation and nutritional abundance provides for year round provision of fodder (Opara, 1996, Oji and Isilebo.2000). They also enable standing feed reserve to be built so that herd can survive critical periods of shortfall or even prolonged period of dry season, without remarkable losses in weight (Odoh and Adamu—Noma, 2000).

Free choice intake (Babayemi *et al*., 2006a) and *in vitro* fermentation techniques (Babayemi and Bamikole, 2006) are known to be quick means of evaluating and revalidating nutritive value of feedstuffs.

There is paucity of information on the chemical composition, secondary metabolites, in vitro gas production and acceptability of the forages evaluated in this study by ruminants. The objective of this study was to therefore assess the acceptability of these plants by cattle and to determine their chemical composition as well as their in vitro gas production characteristics.

Materials and Methods

Location, collection and preparation of samples

The studies were carried out at the Animal Nutrition Laboratory and Cattle unit of the Teaching and Research Farm, University of Agriculture Abeokuta Ogun state in the South-Western part of Nigeria. The selected forages (*Newbouldia laevis, Alchornea cordifolia, Merremia aegyptia Synedrella nodiflora, Tithonia diversifolia, Aspilia africana, Tridax procumbens and Alchornea laxiflora,*) were harvested from at least ten stands per specie randomly selected from five locations within the study area (which is a derived savanna zone with an annual mean temperature of 34.7^{0}c and a relative humidity of 82%. It is in the region of 70m above sea level, latitude 7^{0}5'-7^{0}8'N and longitude 3^{0}11.2'. Plant samples were collected in the early dry (November, 2007), late dry (January, 2008) and early wet (April, 2008) seasons. The harvested samples were pooled for each plant species. Harvesting of only the leaves was done for *Newbouldia laevis, Alchornea cordifolia*, *Tithonia diversifolia,* and *Alchornea laxiflora* while it was done with the stem for *Merremia aegyptia*, *Aspilia Africana, Tridax procumbens,* and *Synedrella nodiflora*. Generally, *Newbouldia laevis* can be classified as tree, *Alchornea cordifolia*, *Tithonia diversifolia* and *Alchornea laxiflora* can be classified as shrub while *Merremia aegyptia*, *Aspilia Africana, Tridax procumbens,* and *Synedrella nodiflora* can be classified as forbs.

The samples were oven dried at 60^{0}C for three (3) days to constant weight to determine the dry matter. Dried samples were milled to pass through 2.0 mm sieve and stored in an air tight container pending analysis.

Chemical Analysis

Crude protein, crude fibre, ether extract and ash contents of the plants were determined according AOAC (2000). The fibre (cell wall) factions such as Neutral detergent fibre (NDF), Acid detergent fibre (ADF) and Acid detergent Lignin (ADL) were determined according to Van Soest *et al.* (1991) method. Sodium (Na), K and Ca were determined with the flame photometer while P, Zn and Fe were assayed according to the AOAC (2000) method of analysis. Saponins, phenols and steroids were qualitatively determined as established by Babayemi *et al* (2004a).

In vitro gas production study

Rumen fluid was obtained with stomach tube from three West African dwarf goats that were fed with 40% concentrate (composition = 40% corn, 10% wheat offal, 10% palm kernel cake, 20% groundnut cake, 5% soybean meal, 10% dried brewer's grain, 1% common salt, 3.75% oyster shell and 0.25% fish meal) and 60% *Panicum maximum* at 5% body weight. Incubation procedure was as reported by Menke and Steingass (1988) using 120 ml calibrated transparent glass syringes with fitted silicon tube and clipped. The samples weighing 200mg were carefully dropped into the syringes and thereafter 30 ml inoculum containing cheese cloth strained-rumen liquor and buffer (g /liter) of 9.8 $NaHCO_3$ + 2.77 Na_2HPO_4 +0.57 KCl + 0.47 NaCl + 2.16 $MgSO_4.7H_2O$ + 0.16 $CaCl_2.2H_2O$ (1:4 v/v)(under continuous flushing with CO_2 were dispensed using another 50 ml glass calibrated syringe. Incubation was carried out at 39 ± 1^0C in a water bath and the volume of gas production was measured at 3, 6, 9, 12, 15, 18, 21, 24, 30, 36, 42, 48 and 72 hours. At post incubation period 4ml of NaOH (10M) was introduced to estimate methane production as reported by Fievez *et al.* (2005). The average of the volume of gas produced from the blanks was deducted from the volume of gas produced from sample. The blanks contained only the inoculum and buffer. Metabolizable energy (ME, MJ/Kg DM) and organic matter digestibility (OMD %) were estimated as established (Menke and Steingass, 1988) and short chain fatty acids (SCFA (µmol) was calculated as reported (Getachew *et al*., 1998).

ME = 2.20 + 0.136GV + 0.057CP + 0.0029CF

OMD = 14.88 + 0.889GV + 0.45CP + 0.651 XA

SCFA = 0.0239GV – 0.0601

Where GV, CP, CF, and XA are net gas production (ml/200mg DM), crude protein, crude fibre and ash of the incubated samples respectively.

Acceptability Study

Based on the results obtained from the analyses of chemical composition, secondary metabolites and *in vitro* gas production, and availability of the plants throughout the year, five forages that have potential as ruminant feed were selected for acceptability study, they were *Newbouldia laevis, Merremia aegyptia, Alchornea cordifolia, Alchornea laxiflora and Tithonia diversifolia*. Twenty-four crossbred calves were used for this study. The forages were cut and offered wilted (i.e. after 24 hours of harvest) for 14 days in a cafeteria arrangement. The forages (20kg each) were placed side by side in plastic bowls and the animals were allowed access to the browse plants at the same time for three hours each day under close observation. The positioning of the bowls containing the browse plants was pre-determined for each day and did not follow the same pattern.

The behaviour and selectivity of the animals on the forages were observed. Consumptions were measured by deduction of remnants from the amount served. The browse plants preferred were assessed from the calculated Relative Preference Index (PI) using Van Dyne and Headly (1995) as:

PI= Amount of feed intake
Amount of feed offered

Based on the dietary preference index the browse plants were classified into the following preference class (Lamidi *et al.* 2005)

High preference (hp) 0.77-1.00
Moderate preference (mp) 0.56-0.76
Fair preference (fp) 0.45-0.55
Low preference (lp) 0.26-0.44
No preference (np) <0.26

Statistical Analysis

Data collected were subjected to One-way Analysis of Variance (ANOVA) and significant differences between means were compared using Duncan multiple range test (SAS, 1995).

Results

Table 1 shows the chemical composition of the forages. There were significant differences ($P < 0.05$) in all the parameters determined. The forages recorded lower values of DM which ranged from 17.20% in *Synedrella nodiflora* to 44.95% in *Newbouldia laevis.* Crude protein values were different ($P < 0.05$) with *Tridax procumbens* recording the lowest crude protein value of 10.5%. *Merremia aegyptia* recorded the highest crude protein value of 22.09%. The ash value was highest (19.0%) in *Tithonia diversifolia followed by Synedrella nodiflora (18.5%)* and lowest in *Tridax procumbens* (4.5%). The NDF values obtained for *Newbouldia laevis* was the highest (67.50%) and *Tithonia diversifolia* had the lowest value of 45%. The ADF values ranged from 48.0% in *Aspilia africana* to 28.87% in *Alchornea cordifolia.* The ADL value was highest in *N laevis* (36.84%) and lowest in *A. cordifolia* (valueƐƐƐ). All the forages were rich in minerals as shown in Table 2. *Merremia aegyptia* had the highest concentration of Fe (790 ppm) followed by *Alchornea laxiflora* (670 ppm) and *Aspilia africana* (600 ppm). The Ca content of *Aspilia africana* (0.89%) was the highest followed by *Merremia aegyptia* (0.62%) and *Newbouldia laevis* (0.55%). P was also highest in *Aspilia africana* (0.93%) followed by *Newbouldia laevis* (0.29%) and *Merremia aegyptia* (0.21%).

Qualitatively determined saponin, phenols and steroids of the plants are shown in Table 3. *Tridax procumbens* contained no saponins while *Aspilia africana, Tithonia diversifolia and Synedrella nodiflora* were high in saponins. *Alchornea laxiflora* and *Alchornea cordifolia* have moderate content of saponins. *Aspilia africana, Tithonia diversifolia, Alchornea laxiflora and*

Table 1: Chemical composition (%) of the Selected Forages

Browse Plants	Dry Matter	Crude Protein	Ether Extract	ASH	NDF	ADF	ADL	ellulose	Hemicellulose
Tridax Procumbens	18.87^{e}	10.50^{h}	5.09^{g}	4.50^{h}	64.50^{c}	32.50^{g}	13.95^{g}	8.55^{h}	32.00^{a}
Merremia aegyptia	18.39^{g}	22.09^{a}	7.35^{c}	11.50^{d}	54.00^{h}	38.50^{e}	25.97^{e}	12.53^{d}	15.50^{f}
Aspilia africana	22.66^{d}	20.19^{d}	7.43^{b}	13.00^{c}	60.00^{d}	48.00^{a}	35.59^{b}	12.41^{e}	12.00^{g}
Tithonia diversifolia	18.82^{f}	19.67^{e}	4.92^{h}	19.00^{a}	45.00^{i}	33.00^{f}	34.19^{c}	8.81^{g}	12.00^{g}
Newbouldia laevis	44.95^{a}	20.78^{c}	13.18^{a}	11.50^{d}	67.50^{b}	47.50^{b}	36.84^{a}	10.66^{f}	20.00^{e}
Synedrella nodifolia	17.20^{h}	21.34^{b}	6.83^{d}	18.50^{bc}	54.50^{g}	44.00^{d}	31.82^{d}	12.81^{c}	10.00^{h}
Alchornea laxiflora	25.46^{c}	16.38^{g}	6.22^{f}	7.50^{f}	59.00^{e}	29.00^{h}	20.59^{f}	8.41^{i}	30.00^{b}
Alchornea cordifolia	37.27^{b}	16.55^{f}	6.53^{e}	5.00^{g}	55.79^{f}	28.87^{i}	11.97^{i}	16.90^{b}	26.92^{c}
Panicum maximum	30.70^{d}	9.55^{i}	6.52^{e}	10.00^{e}	69.78^{a}	45.00^{c}	12.85^{h}	32.15^{a}	24.78^{d}
SEM	2.00	0.75	0.51	1.08	1.36	1.56	1.92	0.57	1.71

abcdefghi-Means in the same column having different superscripts are significantly different ($P < 0.05$).

Table 2 Mineral Compositions of the Forages (%)

Browse Plants	Na	K	Ca	P	Zn ppm	Fe ppm
Tridax procumbens	0.050	1.13	0.57	0.08	10	520
Merremia aegyptia	0.080	1.06	0.62	0.08	15	790
Aspilia africana	0.140	1.14	3.10	0.93	39	600
Tithonia diversifolia	0.030	0.21	0.89	0.21	15	556
Newbouldia laevis	0.210	1.22	0.55	0.29	40	350
Synedrella nodifolia	0.050	1.10	0.32	0.09	39	400
Alchornea laxiflora	0.077	0.80	0.26	0.13	54	670
Alchornea cordifolia	0.050	1.11	0.32	0.09	39	400

Alchornea cordifolia were all implicated for condensed tannin. *Newbouldia laevis* was implicated for a high level of steroids but has no tannin and saponin.

Table 4 shows the *in vitro* gas production of feed samples during the hours of incubation. Gas production increases as incubation progresses and there were significant differences ($P < 0.05$) in gas production among substrates. Gas production was lower in the browse plants implicated for condensed tannin i.e *A. cordifolia, A. laxiflora, A. africana and T. diversifolia. S. nodiflora* had the highest gas production (58.75ml/200mg DM).

Metabolizable energy (ME) (MJ/kg), Organic matter digestibility (OMD) (%), Short chain fatty acids (SCFA) (µmol) and methane (CH_4) (ml/200mg/DM) production of the forages are presented **in** Table 5. The values of ME, OMD, SCFA and CH4 of the plants were in the range of 7.25-10.44, 51.87-80.19, 0.74-1.22 and 29.75-48.50 respectively. There were significant differences ($P < 0.05$) in the parameters among the browse plants. In all parameters, *A. africana* was observed to have the lowest and *S. nodiflora had* the highest value.

Table 6 shows acceptability of some selected browse plants by cross-bred calves. *Alchornea cordifolia* and *Merremia aegyptia* were highly preferred. The animals generally showed willingness to consume these plants from days 1 to 7. The animals were observed to pay no attention to the consumption of *Newbouldia laevis* and *Alchornea laxiflora initially* but from the third day they started consuming them. There was poor acceptability of *Tithonia diversifolia* despite its high content of CP. This could be due to its bitter taste. Some calves just took a bite of it and walked away.

Table 3: Qualitatively Determined Secondary Metabolites of Some Selected Forages

PLANTS		**Saponins**	**Phenol**			**Steroids**
	Foam(mm)	Comments	Colour Change	Comments	Colour Change	Comment
Tridax procumbens	2	Nil	No colour change	Nil	Nil	Nil
Merremia aegyptia	5	Low	No colour change	Nil	Faint green	Very low
Aspilia africana	16	High	Light green	CT	Light green	Low
Tithonia diversifolia	17	High	Light green	CT	Nil	Nil
Newbuldia laevis	2	Nil	No colour change	Nil	Deep green	High
Synederella nodiflora	18	High	No colour change	Nil	Faint green	Very low
Alcharnea laxiflora	12	Medium	Light green	CT	Light green	Low
Alcharnea cordifolia	11	Medium	Light green	CT	Nil	Nil

CT- Condensed Tannin

Table 4: In vitro Gas Production of the Forages during Hours of Incubation (ml/200mgDM)

PLANTS	Hours of Incubation						
	6	12	24	36	48	60	72
Tridax procumbens	9.00^{b}	15.00^{bc}	31.00^{c}	40.25^{c}	47.50^{bc}	50.5^{bc}	51.75^{bc}
Merremia aegyptia	8.75^{bc}	17.25^{ab}	34.00^{b}	43.75^{b}	50.00^{b}	51.50^{b}	53.75^{b}
Aspilia africana	9.75^{b}	13.75^{bc}	24.00^{e}	36.50^{d}	40.50^{c}	42.25^{d}	43.50^{d}
Tithonia diversifolia	8.75^{bc}	15.75^{b}	28.25^{d}	37.75^{d}	44.75^{c}	47.75^{c}	49.25^{c}
Newbouldia laevis	7.25^{cd}	11.75^{c}	24.25^{e}	33.50^{de}	40.00^{c}	42.50^{d}	43.50^{d}
Synedrella nodiflora	12.25^{a}	21.00^{a}	39.25^{a}	48.75^{a}	55.00^{a}	57.75^{a}	58.75^{a}
Alchornea laxiflora	10.25^{b}	15.65^{b}	25.00^{e}	31.00^{e}	39.00^{d}	43.50^{d}	46.
Alchornea cordifolia	6.50^{d}	11.25^{c}	23.00^{e}	31.75^{e}	38.00^{d}	41.50^{d}	43.50^{d}
SEM	0.34	0.70	1.20	1.21	1.31	1.26	1.30

^{abcde}-Means in the same column having different superscripts are significantly different (P<0.05).

Table 5: Metabolizable Energy (MEMJ/kg DM), Organic Matters Digestibility (OMD %), Short Chain Fatty Acids (SCFAµmol) and Methane production (CH_4) (ml/200mgDM) of the selected forages.

Browse Plants	ME	OMD	SCFA	CH4
Tridax procumbens	9.08^{bc}	69.55^{b}	0.94^{bc}	48.50^{b}
Merremia aegyptia	9.46^{b}	71.20^{b}	0.99^{b}	39.00^{c}
Aspilia africana	7.25^{e}	51.87^{e}	0.74^{d}	41.25^{c}
Tithonia diversifolia	8.69^{c}	70.55^{b}	0.88^{c}	46.00^{b}
Newbouldia laevis	8.19^{d}	63.22^{d}	0.74^{d}	32.25^{d}
Synedrella nodifolia	10.10^{a}	80.19^{a}	1.11^{b}	53.25^{a}
Alchornea laxiflora	9.49^{b}	68.47^{c}	1.22^{a}	33.00^{d}
Alchornea cordifolia	9.09^{bc}	64.26^{d}	0.98^{b}	29.75^{e}
SEM	0.18	1.46	0.03	1.45

^{abcde}- Means in the same column having different superscripts are significantly different (P < 0.05).

Table 6: Relative Preference of the Selected Forages by Crossbred Calves

Browse Plants	Preference Class
Merremia aegyptia	high preference (1.00)
Alchornea cordifolia	high preference (0.98)
Newbouldia laevis	moderate preference (0.65)
Alchornea laxiflora	moderate preference (0.56)
Tithonia diversifolia	low preference (0.27)

Discussion

The chemical compositions of the forages evaluated were comparable to those reported in literatures. The dry matter value of 44.95% for *Newbouldia laevis* obtained in this study was very close to the value of 42.24% reported by Ikhimioya and Imasuen (2007), however the value of crude protein (20.78%) obtained was higher than 15.57% reported by the same authors while that of ether extract (13.18%) was also closer to 13.59% that they reported. The crude protein value of 16.55% obtained for *Alchornea cordifolia* was closer to 16.10 reported by Ahamefule *et al* (2006) while those obtained for crude fibre, ether extract, ash, NDF, and ADF respectively (10.00%, 6.22%, 7.5%, 59% and 29%) were higher than 2.10%, 5.6%, 5.2%, 42.50% and 42.50% reported. The crude protein value of 10.50% obtained for *Tridax procumbens* was lower than 17.80% reported by Ahamefule *et al* (2006). The crude protein, crude fibre and ether extract values obtained (i.e 20.19%, 18% and 7.43%) for *Aspilia africana* were higher than those reported (14.70%, 7.5% and 6.4%) by Ahamefule *et al* (2006) and (11.26%, 9.58% and 1.8 %) reported by Adegbola and Mecha (1988).The variations observed might be due to differences in geographical location, age of the plant and time of harvesting. *Merremia aegyptia* had the highest crude protein value of 22.09%. The crude protein content except in *T. procumbens* were well above the minimum requirement of 11.9% and 12.4% recommended for growth and lactation of a 400kg cow (NRC, 1989).The forages could therefore be used to supplement grasses and crop residues. Mecha and Adegbola (1980) reported that herbs, shrubs and trees of southern Nigeria were richer in crude protein than grasses.

The presence of mineral elements in animal feed is vital for the animals' metabolic processes. Mineral deficiencies or imbalance in soils and forages account partly for low animal production and reproduction problems (Akinsoyinu and Onwuka, 1988). All the browse plants are rich in minerals. According to Oji and Isilebo (2000) browse plants provide vitamins and frequently minerals, which are lacking in grassland pastures. The values of Ca, P, K and Na obtained in this study for *Newbouldia laevis* were comparable with those reported by Ikhimioya and Imasuen (2007).The values of Ca and P obtained for *Aspilia africana* were higher than those reported by Adegbola and Mecha (1988) and this differences could be due to age of harvesting, soil characteristics or season. The values obtained for *Alchornea cordifolia* were comparable to the values reported by Akinsoyinu and Onwuka (1988).

All the forages evaluated contained one or more secondary metabolites except *Tridax procumbens* that contain none. Steroid was not implicated in *Tridax procumbens,Tithonia diversifolia and Alchornea cordifolia.* This is in contrary to what was reported by Babayemi *et al* (2004a) that steroid is always present in plants but the quantity may differ depending on the nature of the plant. *T. diversifolia, A. Africana, A. cordifolia and A. laxiflora* were implicated for condensed tannins which was also reported by Babayemi *et al*. (2006a) to be an added advantage as tannins is a natural additive in the diets of ruminants. Forages or feed containing tannins have potential of forming complexes with protein as by-pass protein in the rumen (Barry and McNabb, 1999) by diminishing rumen protein digestibility thus, improving on the availability of protein to ruminant at the lower gut. D'Mello (2000) also reported that at moderate level tannin resulted in nutritional gain in respect of increased by_pass protein and bloat suppression in cattle. All the forages except *T. procumbens* and *Newbuoldia laevis* were implicated for saponin which is also an added advantage being beneficial to ruminant (Babayemi *et al*, 2006b). Feed stuffs containing saponin had been reported to have defaunating agents (Teferedegne, 2000) and capable of reducing methane production (Bababyemi *et al,* 2004a) which is energy loss to the animal.

The *in vitro* gas production differs significantly among the plants. These differences in gas production could be due to proportion and nature of their fibre (Rubanza *et al.,* 2003). *S. nodiflora* had the highest gas production despite being high in saponin which according to Babayemi *et al* (2004a), is known to deter the activities of bacterial in the rumen. However, according to Newbold *et al.* (1999) some bacteria are able to adapt to saponin and finally degrade and inactivate them. This and its content of low steroids and absence of tannin could be responsible for its high gas production (Salem, 2005). Gas production was lower in the forages implicated for condensed tannin and this was in line with the report of Salem *et al.,* 2007 that secondary compounds affect ruminal fermentation and forage degradability. A non-availability of tannin in some of the sample suggests that some of them can be valuable protein supplement in ruminant diets (Aganga and Mosase, 2001).

There were significant differences in metaboliozable energy (ME) (MJ / KgDM), Organic matter digestibility (OMD) (%), Short chain fatty acids (SCFA) (µmol) and methane CH_4 (ml/200mgDM) values among the plants. The ME and OMD values were highest in *S. nodiflora* and lowest in *A. africana* which was implicated for condensed tannin. This is in line with what was reported by Min *et al* (2002) that the presence of condensed tannin inhibits degradation, caused low OMD and therefore resulted in reduced ME. Waghorn and Shelton (1997) also reported that tannin cause reduction in OMD. Dietary tannin adversely affect rumen metabolism by bacteriostatic and bacteriodal activities and by inactivating several enzymes e.g. carboxymethyl cellulase, protease, glutamate dehydrogenase. The availability of sulphur and iron becomes important to the animal consuming tannin rich tree leaves. Prolonged consumption of tannin rich leaves was reported to induce toxicity in sheep (Kumar and Vathiyanathan, 1993). Blood (1989) also reported that experimental administration of tannic acid to goat produce anaemia.

Methane production has negative effect on the animals as it is an energy loss to the animals and when accumulated in the rumen, it results in bloat. Methane value was highest in *S. nodiflora* and lowest in *A. cordifolia* which also contained condensed tannin and saponin. This could not be unconnected with the fact that anti-nutritional factors inactivate some micro organisms in the rumen hence reduce the fermentation activities and invariably gas production. Also, secondary metabolites like tannin binds to nutrients in feeds making them undegradable by microbes. According to Asiegbu *et al.* (1995) phenolic acid has been found to decrease methane, acetate and propionate production. Saponin in some tropical fruit was also observed as an active compound responsible for the suppression of methanogenesis in faunanted and defaunated rumen fluid (Hess *et al,* 2003). This could be responsible for low methane production in some forage plants that were implicated for saponn (i.e *A. africana and T. diversifolia*). According to Babayemi *et al* (2004a), high methane implies an energy loss to the animal. Hence, those with low methane values could be said to be advantageous to the animals. Although the amount of methane produced did not relate to the extent of digestibility (Babayemi *et al*., 2005). The SCFA values were high but highest in *S. nodiflora.* Higher SCFA suggests a potential to make energy available to ruminants. Higher gas production and the eventual preponderance of SCFA showed an increase proportion of acetate and butyrate but may mean a decrease in propionate production (Babayemi *et al.,* 2004b). Fermentation gases are produced mainly when feedstuffs are fermented to acetate and butyrate with propionate yielding gas only due to buffering of the acids. Thus feed that produce high amount of propionate yield lower gas volumes (Beuvink *et al.,* 1992).

In this study *M .aegyptia* had the highest preference by the cross bred calves. Closely following *M. aegyptia* in acceptability is *A .cordifolia* and *N. laevis.* The high preference of *M .aegyptia* and *A. cordifolia* could be due to lack of any smell that could discourage the animals. The least preferred of all the selected five forages was *T. diversifolia*. The animals smelt it, had a bit and abandoned it. The low preference might be associated with its very bitter taste and also to its content of anti-nutritional factor (*Sesquiterpene lactone*) identified in the leaf (Dutta *et al.,* 1986). The low acceptability could also be that the forage is new to the animals

Arnold (1981) reported that several deterrent compounds such as sugar, organic acid, tannin and alkaloids may affect palatability. However, this might have been partially loss due to wilting (Raaflaub and Lascano, 1995).

Conclusion

The chemical composition of the forage showed that they are rich in crude protein as well as macro and micro minerals. The *in vitro* gas production revealed that the plants are rich in highly fermentable carbohydrates. They are high in OMD and SCFA which affirm them as ruminant feed resources. Hence they could be used as supplements to grasses during the rainy and dry seasons to increase the productivity of the animals throughout the year.

References

AOAC 2000. Official Methods of Analysis,Association of official Analytical Chemists, Washington D.C 17th ed

Arnold, G.W. 1981 Grazing behaviour in : Grazing Animals (eds. F.H.W. Morley) pp Elsevier Scientific publishing Co. Amstermdam, Oxford New York.

Adegbola T.A. and Mecha I.1980. A note on the chemical composition, Intake and Digestibility of some Dry Season Forages Fed to Goats. *Nig. J. Anim Prod*. 15:71-75

Aganga, A.A. and Mosase, K.W. 2001. Tannin content, nutritive value and dry matter digestibility of *Louchocarpus cassa ,Zizyphus mucronata, Sclerocarya birrea, Kirkia acuminate* and *Rhus lancea* seeds. *Anim. Feed Sci. Tech.* 91:107-113.

Agishi, E.C. 1985. Forage resources of Nigeria rangelands. Proceedings of National Conference on small Ruminant Production Zaria Nig. 6 – 10 Oct. 1985. pp 115 – 140.

Ahamefule, F.O., Obua, B.E., Ibeawuchi, J.A. and Udosen, N.R. 2006. The Nutritive Value of some plants Browsed by cattle in Umudike

Southeastern Nigeria. *Pakistan Journal of Nutrition* 5(5): 404 – 409.

Akinsoyinu A.O. and Onwuka, C.F.I. 1988. Mineral constituents of some browse plants used in ruminants feeding in Southwestern Nigeria. *J. of Anim. Prod.* 15;57-62

Asiegbu, F.O., Raferson, A., Morrison, I.M. and Smith, J.E.1995. Effect of Cell wall phenolics and fungal metabolites on methane acetate production under *in vitro* conditions. *J. Gen Appl. Microb.* 41: 475-485.

Babayemi, O.J., Hamzat, R.A., Bamikole, M.A., Anurudu, N.F. and Olomola, O.O. 2006a. Preliminary studies on spent tea leaf: in vitro gas production as affected by chemical position and secondary metabolites. *Pakistan Journal of Nutrition* 5(5):497-500.

Babayemi, O.J. and Bamikole, M.A. 2006. Effects of *Tephrosia Candida* leaf and its mixture with Guinea grass on *in vitro* fermentation changes. *Pakistan J. Nutri*. 5(1): 14 – 18.

Babayemi, O.J., Ajayi, F.T., Taiwo, A.A., Bamikole, M.A., Fayimi, A.K. 2006b. Performance of West African Dwarf goats fed *Panicum maximum* and concentrate diets supplemented with lablab, leucaena and Gliricida foliage. *Nig. J. Anim. Prod.* 33(1); 102 -111

Babayemi, O.J., Bamikole, M.A., Odedire, J.A., Ogunbosoye, D.O and Otukoya, F.K., 2005. Nutritive value and *n vitro* Gas Production of six Aquatic Weeds in Southwestern Nigeria. Proceeding of 10th Annual Conference of Animal Science Association of Nigeria (ASAN). Sept. 12 – 15. University of Ado-Ekiti Nigeria. Pp 210-212

Babayemi, O.J., Demeyer, D. and Fievez, V. 2004a. Nutritive value and qualitative assessment of secondary compounds in seeds of eight tropical browse, shrubs and trees. Comm. Appli. Biol. Sci. Ghent University 69/1:103-110.

Babayemi, O.J., Demeyer, D. and Fievez, V. 2004b. *In vitro* fermentation of tropical browse seeds in relation to their content of secondary metabolites. *J. Anim. Feed Sci. Tech.* 13 suppl. 1: 31-34.

Barry, T.N. and McNabb, W.C. 1999 The Implications of Condensed Tannins on the Nutritive Value of Temperate Forages Fed to Ruminant. *British Journal of Nutrition* ,81:263-272.

Bayer, W., Suleiman, H., Kaufmann, R. and Waters – Bayer, A. 1987.Resources used and strategies for development of pastoral systems in sub-humid West Africa the case of Nigeria *Q.J. Int. Agric.* 26: 58 – 71

Beuvink, J.M.W., Spoelstra, S.F. and Hogendrip, R.J. 1992. An automated method of measuring time-course of gas production of feed stuff incubated with buffered rumen fluid. *Neth. J. Agric. Sci,* 40: 401-407.

Blood, D.C. (ed) 1989. Veterinary Medicine. A textbook of the disease of cattle Sheep, pig, goat and horses Bailliere Tindall limited. London.

Devendra C. 1989. Shrubs and Tree Fodder for farm Animals. In: proc. of a workshop in Denpasar, Indonesia pp 42 – 56

D'Mello, J.P.F. 2000. Anti-nutritional factors and Mycotoxins In: D'Mello, J.P.F. (Ed). Farm Animal Metabolism and Nutrition, CAB International, Wallingford, UK. Pp. 383-403.

Dutta, P., Bhartacharyya, P.R., Rabha, I.C., Bordolon, O.N., Barna, N.C., Chowdhurry, P.K., Sharma, R.P.

and Barna, J.N. 1986. Feed deterrents for *Philosamia ricini* (samia Cynthia, sub.rp.Ricini) from *Tithonia diversifolia. Phytoparasitica* 14 (1):77-80

Fievez, V., Babayemi O.J., and Demeyer, D. 2005 Estimation of direct and indirect Gas production in syringes: a tool to estimate short chain fatty acids production requiring minimal laboratory facilities. *Anim. Feed Sci. Tech.* (123-124): 197 –210

Getachew, G., Blummel, M., Makkar, H.P.S. and Becker, K. 1998. In vitro gas measuring technique for assessment of nutritional quality of feeds. A review. *Anim. Sc .Feed Tech.* 72: 261 – 281

Hess, H.D., Kreuzer, M., Diaz,T.E., Lascano, C.E., Carnulla, J.E.,Soliva, C.R. and Machmullar, A. 2003. Saponin rich tropical fruits affect fermentation and methanogenesis in faunated and defaunated rumen fluid. *Animal Feed Science Technology.* 109:79-84.

Ikhimioya I. and Imasuen J.A. 2007. Blood profile of West African Dwarf goats fed *Panicum maximum* supplemented with *Afzelia Africana* and *Newbouldia laevis*. *Pakistan Journal of Nutrition* 6(1):79-84.

Kumar, R. and Vaithyanathan, S. 1993 Occurrence, nutritional significance and effect on animal productivity of tannins in leaves. *Anim. Feed Sci. Tech*. 44: 281 – 287

Lamidi, O.S., Jibril, A., Adeyinka, I.A. 2005. Preference studies and short – term intake of Browse mixtures by cattle. *ASSET Journal* Series A 5 (1): 45 – 52.

Mecha I and Adegbola, T.A. 1980. Chemical composition of some Southern Nigerian Forages eaten by goats. In Le Houerou H.N. (Ed) Browse in Africa, the current state of knowledge International Livestock centre for Africa Addis Ababa.

Menke, K.H and Steingass H. 1988. Estimation of the energetic feed value obtained from chemical analysis and in vitro gas production using rumen fluid. *Animal Research Development* 28: 7 – 55.

Min, B.R., Attwood, G.T., Barry, T.N. and McNabb, W.C. 2002. *The effect of condensed tannin s on the nutrition and health of ruminant fed fresh temperate forages. Journal of Animal Science*. 80 (suppl. 1) 1602.

Newbold,C.J., Hassan S.M.E., Wang, J., Ortega, M.E. and Wallace, R.J. 1999. Influence of foliage from African multi-purpose trees on activity of rumen protozoa and bacteria. *Brit. J. Nutrition.* 78: 237-249.

Odoh, S.O. and Adamu – Noma H. 2000. A survey of browse species in Benue north

Agricultural Zone. Benue State Nigeria

Oji, U.I. and Isilebo, J.O. 2000. Nutrient characteristics of selected browse plants of humid tropics. Proceedings of the 25th annual conference of NSAP 19 -23rd march 2000, Umudike, Nig. Pp 54 -56

Opara C.C. 1996. The use of *Alchornea cordifolia* leaf meal as feed ingredient in poultry diet. M.Sc. Thesis. Fed. University of Technology, Owerri 89pp

Raaflaub, M. and Lascano, C.E., 1995. The Effect of Wilting and Drying on Intake Rates and The Acceptability by Sheep of the Shrub legume *Cratylia argeltea. Tropical Grasslands,* 29:97-101

Rubanza, C.D.K., Shem, M.N., Otysina,

R., Ichinohe, T. and Fujihara, T. 2003. Nutritive evaluation of some browse tree legume foliages native to semi-arid area in Western Tanzania. *Asian-Aust. Journal of Animal Science* 16:1429-1437.

Saadullah, M. 1989. Shrubs and tree fodder for farm animals. In. Devendra (ed) Proceeding of a workshop in Denpasar, Indonesia 24 -29 July 1989, Pp. 221

Saleem, M.A, Oyetogun O.M and Chedda H.R. 2005. Nutritive value of browse plants in the Sudan Savannah of North West Nigeria. *Nig J. Anim. Prod.* 6: 3-7

Salem, A.Z.M., Robinson, P.H., El-Adawiy, M.M. and Hassan, A.A. 2007. *In vitro* fermentation and microbial protein synthesis of some browse tree leaves with or without addition of polyethylene glycol. *Anim. Feed Sci. Tech.* 138: 318-330.

Schoenian .S. 2003. An Introduction to Feeding Small Ruminants. Bulletin of Western Maryland Research and Education centre Maryland Co-operative Extension University of Maryland.

Statistical Analysis systems (SAS) Institute Inc. 1995. SAS. STAT Program cary, NC:Institute Inc.4th edition

Teferedgne, B. 2000. New perspective on the use of tropical plants to improve ruminant nutrition. Proc. Nutr. Soc. 59:209-214.

Van Dyne, G.A. and Headly, H.F. 1995. Botanical composition of sheep and cattle diets on a mature annual range. Hilgardia, 36:465-492.

Waghorn, G.C. and Shelton, I.D. 1997. Effects of condensed tannin in *Lotus corniculatus* on the nutritive value of pasture for sheep. *Journal of Agric. Sci. Cambr.* 128:365-372.

Received: 11th June, 2012
Accepted: 10th January, 2013