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Chemical composition and *in vitro* degradation of some selected plants consumed by small ruminants

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ABSTRACT: The nutritive qualities of five selected forages, *Mangifera indica, Anacardium occidental, Gmelina aborea, Gliricidia sepium and Panicum maximum* were investigated. Chemical composition of the forages was determined, and the *in vitro* digestibility study was carried out for 24 hours. Results obtained from chemical composition showed that *Mangifera indica* had the highest (p<0.05) dry matter (DM) value of 93.40%, while the least DM content of 85.00% was obtained in *Panicum maximum.* Crude protein (CP) content ranged from 8.13% in *Panicum maximum* to 20.29% in *Gmelina aborea. Anacardium occidentale* recorded the highest significant (p<0.05) ether extract content of 17.23%, while the least value (9.34%) was obtained in *Gliricidia sepium*. Results of the *in vitro* study revealed that gas production of *Mangifera indica* was consistently high (p<0.05) throughout the incubation period from 3 to 24 hours. *Panicum maximum* had the least gas production volume throughout the period of incubation. The study concluded that the selected plants had high crude protein and dry matter contents, which would make them good protein supplements to poor-quality feeds for ruminant animals.

Keywords: Chemical composition, *In vitro* gas, metabolizable energy, plants, ruminants.

INTRODUCTION

In Nigeria, ruminants, which are animals with a four-chambered stomach (cattle, sheep and goats), are important sources of animal protein where they contribute to the cultural and socio-economic life of people (Adebayo *et al.,* 2017). A major constraint to livestock production in developing countries is the scarcity and fluctuating quantity and quality of the year-round feed supply (Olafadehan and Adewumi, 2009). The potential value of browse trees lies in the provision of protein, vitamins and also the mineral elements that are lacking in grassland pastures during the dry season (Bamikole *et al*., 2004). Attempts have been made by animal nutritionists to supplement dry season grazing with browse plants and agro-industrial byproducts (Yusuf *et al.,* 2015). A number of browse plants worldwide serve as alternative feedstuffs for livestock (Aregawi *et al.,* 2008; Fayemi *et al.,* 2011). This is due to their abundant biomass and availability all year round. Browse plants are considered palatable, highly digestible and as a result improve animal performance (Isah *et al.,* 2012). There are many forage plants that have the ability to produce high yields of biomass, but cannot be utilised for improvement of livestock production because the information on their nutrient composition is not known. *In vitro* fermentation has been used in this wise to evaluate the digestibility and nutritional value of feed as it is cheaper, less laborious and most importantly, allows experimental conditions to be achieved 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 the rumen fermentation system based on syringes (Bamikole *et al*., 2004). Therefore, this study is to investigate the nutritive qualities of five selected forages, *Mangifera indica, Anacardium occidental, Gmelina aborea, Gliricidia sepium and Panicum maximum*.

MATERIALS AND METHODS

Experimental site

The experiment was carried out in the premises of Yaba College of Technology, Epe Campus, Lagos State, characterised by hot, humid conditions year-round. The temperature ranges between 250 and 310°C, with high humidity levels and a heavy rainy season from March to October. It is situated at a latitude of 6.58°N and a longitude of 3.98°E. It is 42 m above sea level along the Epe Ijebu-ode road on km 16. Epe lies in a lowland rain forest vegetation zone within the savanna agro-ecological zone of Southwest Nigeria (Google Earth, 2025).

Collection of forages for chemical analysis

Five forages were harvested during the rainy season around the premises of Yaba College of Technology, School of Agriculture, Odoragunshin, Epe campus, Lagos State, Nigeria. The forage plants were *Mangifera indica* (Mango), *Anacardium occidental* (Cashew), *Gmelina aborea (*Gmelina), *Gliricidia sepium* (Gliricidia) and *Panicum maximum* (Guinea grass). About 500 g samples of each plant's leaves were harvested from different mature plants before flowering from several stands. All the forages were oven dried at 65°C to constant weight to determine the dry matter, crude protein, crude fibre, ether extract and ash contents. The dried samples were milled and sieved to a particle size of 1.0 mm, bulked on an individual leaf basis and stored in an air-tight container pending analysis.

Chemical composition/analysis

Five selected forage plant samples were analysed for proximate constituents according to AOAC (2000), while NDF, ADF and acid detergent lignin (ADL) were determined by the procedures of Van Soest *et al.* (1991). Hemicellulose was calculated as the difference between (NDF) and (ADF. Cellulose was also calculated as the difference between (ADF) and (ADL).

In vitro gas production

Five selected browse plants were used for the *in vitro* technique to estimate the digestibility; rumen fluid was obtained from six West African dwarf goats. The method for collection, as described (Babayemi and Bamikole, 2006), uses a stomach tube. The animals were placed on 40% DM concentrate feed and 60% DM *Panicum maximum.* The concentrate feed consisted of (as fed basis) 4%corn, 10% wheat offal, 10% palm kernel cake, 20% groundnut cake, 5% soyabean meal, 10% dried brewers' grain, 1% common salt, 3.75% oyster shell and 0.25% fish meal. The rumen liquor was collected before morning feeding into a thermos flask that was pre- warmed to a temperature of 39°C.

The incubation procedure involved 120ml calibrated transparent plastic syringes with a fitted silicon tube. Each milled sample weighing 200 mg (0.2 g) was carefully put into an incubation bag, sealed with the aid of a sealing machine and dropped into the syringe, and thereafter 30ml of inoculum containing cheese.

Cloth strained rumen liquor and buffer 1g per litter

($NaHCO_3$+$3Na_2HPO_4$+KCl+NaCl+$MgSO_4.7H_20$+$CaCl_2.2H_20$) was dispensed using another 50ml plastic calibrated syringe. The syringes were tapped and pushed upward by the piston in order to eliminate air in the inoculum. The silicon tube in the syringe was then tightened by a plastic and metal clip to prevent the escape of gas. The syringes were carefully arranged in the incubator and maintained at a temperature of 390°C. Incubation was carried out at 39$\pm$1°C, and the volume of gas production was measured at 3, 6, 9, 12, 15, 18, 21, and 24 hours. At the post-incubation period, 4 mL of NaOH was introduced to estimate methane production (Fievez *et al.,* 2005). The mean volume of gas produced from the blank syringe was deducted from the volume of gas produced from the sample. After estimating methane, bags containing residue were dried in the oven at 600°C for 24 hours, weighed and digestibility was calculated as follows:
Metabolizable energy (ME, MJ/Kg DM) and organic matter digestibility (OMD %) were estimated according to the method of Menke and Steingass (1988), and short-chain fatty acids (SCFA (µmol) was calculated according to the method of Getachew *et al.* (2002).

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

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

$$SCFA = 0.0239GV – 0.0601$$

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

Proximate and fibre compositions of the browse plants and grass

Crude protein, crude fibre, ether extract and ash contents of the browse plants and *Panicum maximum* were determined according to AOAC (2005). The fibre fractions, Neutral detergent fibre (NDF), Acid detergent fiber (ADF) and Acid detergent Lignin (ADL) were determined according to Van Soest *et al*. (1991). Cellulose and

Table 1. *In vitro* gas production (ml/200mgDM) of the selected plants incubated at Twenty-four hours period of incubation(hour)

Samples	3	6	9	12	15	18	21	24
P. maximum	1.00^{b}	2.00^{b}	3.67^{b}	5.33^{b}	7.33^{b}	8.33^{c}	9.33^{c}	9.67^{d}
Mangifera indica	2.00^{a}	4.00^{a}	6.00^{a}	9.00^{a}	13.00^{a}	15.00^{a}	17.33^{a}	20.67^{a}
Gmelina aborea	1.00^{b}	3.33^{ab}	5.33^{ab}	7.00^{ab}	8.33^{b}	9.33^{bc}	10.00^{c}	12.33^{cd}
Anacardium occidentale	1.67^{ab}	3.67^{ab}	5.67^{ab}	6.33^{b}	8.33^{b}	9.67^{bc}	11.33^{bc}	13.33^{bc}
Gliricidia sepium	1.67^{ab}	3.33^{ab}	4.33^{ab}	6.67^{ab}	8.00^{b}	11.33^{b}	13.00^{b}	16.00^{b}
SEM	0.13	0.27	0.33	0.42	0.59	0.68	0.82	1.07

^{sabcd} Means along the same column with different superscripts are significantly different (p<0.05); SEM = Standard error of mean.

Table 2. Short chain fatty acid (SCFA), Organic matter digestibility (OMD), Metabolisable energy (ME) and Methane gas production (CH_4) of the selected plants

Samples	SCFA (mmol)	OMD (%)	ME (MJ/KgDM)	CH_4
P. maximum	0.17^{d}	34.24^{c}	4.04^{d}	4.00^{d}
Mangifera indica	0.43^{a}	45.70^{a}	5.62^{a}	9.00^{a}
Gmelina aborea	0.23^{cd}	42.93^{ab}	5.10^{bc}	5.00^{cd}
Anacardium occidentale	0.26^{bc}	42.83^{ab}	4.70^{c}	5.50^{c}
Gliricidia sepium	0.32^{b}	42.93^{ab}	5.33^{ab}	7.00^{b}
SEM	0.03	42.25^{b}	0.16	0.49

^{abcd} Means along the same column with different superscripts are significantly different (p<0.05); SEM = Standard error of mean.

hemicellulose were derived from NDF, ADF and ADL by simple calculation as follows: Hemicellulose = NDF - ADF, while Cellulose = ADF – ADL

Statistical analysis

Data collected was subjected to one-way Analysis of Variance (ANOVA), and significant differences among means were compared using Duncan Multiple Range test (SAS, 2005)

RESULTS

In vitro gas production (ml/200mgDM) of the selected plants incubated for twenty-four hours

A steady increment in the *in vitro* gas production of the selected plants was observed as the incubation period progressed from 3 to 24 hours of incubation, as shown in Table 1. After 3 hours of incubation, there was significant (p<0.05) variation in the volume of gas produced in all of the plants assessed. Gas production of *Mangifera indica* was consistently high (p<0.05) throughout the incubation period from 3 to 24 hours. *Panicum maximum* had the least gas production volume throughout the period of incubation. *Panicum maximum* and *Gmelina aborea* recorded the lowest significant (p<0.05) gas production value of 1.00 ml/200mg at 3 hours of incubation. After 6 hours of incubation, *Gmelina aborea* and *Gliricidia sepium* had similar significant (p<0.05) gas production values of 3.33 ml/200mg. At 15 hours of incubation, *Anacardium occidentale* and *Gmelina aborea* had a similar gas production value of 8.33 ml/200mg.

Metabolizable energy (ME, (MJ/KgDM), organic matter digestibility (OMD. %), short chain fatty acid (SCFA, mmol) and Methane production of the selected plants

The metabolizable energy, organic matter digestibility, short chain fatty acid and methane production of the selected plants are presented in Table 2. *Mangifera indica* had the highest ME value (5.62 MJ/KgDM) while the lowest value (4.04 MJ/KgDM) was observed in *Panicum maximum.* The least organic matter digestibility value (34.24%) was obtained in *Panicum maximum,* while the highest significant value (45.70%) was observed in *Mangifera indica.* Significant variations were recorded in the SCFA values of *Panicum maximum* (0.7mmol) and *Mangifera indica* (0.43 mmol), as well as those of *Anacardium occidentale* (0.26 mmol), *Gliricidia sepium* (0.32 mmol) and *Gmelina aborea* (0.23 mmol). *Mangifera indica* had the highest SCFA value (0.43 mmol). *Panicum maximum* produced the least volume of methane gas (4.00 ml/200mgDM), followed by *Gmelina aborea* (5.00 ml/200mgDM), while *Mangifera indica* produced significantly (p<0.05) the highest volume of methane gas (9.00 ml/200mgDM).

Chemical composition of the forages

Presented in Table 3 are the proximate composition and fibre contents of the selected forages. *Mangifera indica*

Table 3. Chemical composition of the selected plants.

Selected plants	DM	CP	EE	Ash	CF	OM	NFE	NDF	ADF	ADL	Cellulose	Hemicellulose
P. maximum	85.00 [b]	8.13 [d]	10.92 [c]	2.33	21.35 [b]	89.08 [b]	57.26 [a]	56.70 [b]	42.42 [b]	21.97 [b]	20.45	14.28 [c]
Mangifera indica	93.40 [a]	9.80 [c]	12.35 [b]	2.67	17.53 [d]	87.65 [c]	57.65 [a]	56.80 [b]	37.60 [d]	16.67 [d]	20.93	19.20 [a]
Gmelina aborea	92.87 [a]	20.29 [a]	12.21 [b]	3.00	21.50 [b]	87.79 [c]	42.99 [c]	57.60 [b]	41.23 [b]	20.17 [c]	21.07	16.43 [b]
Anacardium occidentale	92.78 [a]	10.83 [c]	17.23 [a]	2.80	24.20 [a]	82.77 [d]	44.93 [c]	61.30 [a]	44.70 [a]	23.83 [a]	20.87	16.60 [b]
Gliricidia sepium	92.66 [a]	15.70 [b]	9.34 [d]	2.83	19.20 [c]	90.66 [a]	52.93 [b]	56.40 [b]	39.30 [c]	18.80 [c]	20.50	19.10 [a]
SEM	1.00	1.20	0.72	0.10	0.63	0.72	1.66	0.50	0.69	0.68	0.17	0.55

[abcd] Means along the same column with different superscripts are significantly different (P<0.05). **Keys:** DM= Dry matter; CP = Crude protein; CF = Crude fibre; OM = Organic matter; NFE = Nitrogen free extract; NDF = Neutral detergent fibre; ADF = Acid detergent fibre; ADL = Acid detergent lignin; SEM = Standard error of mean.

had the highest (p<0.05) dry matter (DM) value of 93.40%, while the least DM content of 85.00% was obtained in *Panicum maximum.* Crude protein (CP) content ranged from 8.13% in *Panicum maximum* to 20.29% in *Gmelina aborea. Anacardium occidentale* recorded the highest significant (p<0.05) highest ether extract content of 17.23%, while the lowest value (9.34%) was obtained in *Gliricidia sepium*. Crude fibre ranged from 17.53% in *Mangifera indica* to 24.20% in *Anacardium occidentale.* Organic matter (90.66%) was higher in *Gliricidia sepium* when compared to other forages. *Anacardium occidentale* recorded the highest value of 61.30% in NDF, while the lowest value (56.70%) was observed in s*Panicum maximum*. ADF values ranged from 37.60 to 44.70% in *Mangifera indica* and *Anacardium occidentale,* respectively. Cellulose was the least (p>0.05) in *Panicum maximum* (20.45%), and the highest content was obtained in *Gmelina aborea* (21.07%). The least significant (p<0.05) hemicellulose value (14.28) was recorded in *Panicum maximum,* while the highest value (19.20) was obtained in *Mangifera indica.*

DISCUSSION

The results of *in vitro* gas production characteristics (ME, OMD and SCFA) of the various selected plants estimated from gas production revealed that metabolizable energy (ME) values obtained in this study ranged from 4.04 – 5.62 MJ/kgDM, which fell below the reported energy value by Babayemi (2007) when *Leuceana leucocephala* (8.31 MJ/kgDM), *Gliricidia sepium* (11.88 MJ/kgDM) and *Centrosema pubescens* (9.95 MJ/kgDM) were assessed. Adebayo *et al.* (2019a,b) observed 7.57, 7.67, 6.47 and 9.22 MJ/kgDM in the sun-dried *Gmelina arborea*, *Leuceana leucocephala, Mangifera indica* and *Moringa olifeira* respectively.

The predicted ME profiles, as shown in Table 2, were close to each other in the selected plants. Menke and Steingass (1988) reported a strong correlation between ME values measured *in vivo* and predicted from 24h *in vitro* gas production and chemical composition of feed. Metabolizable energy (ME) values obtained in this study compared favourably with the reported ME values for some non-leguminous browse plants (Ogunbosoye and Babayemi, 2010); however, these values fell below the reported values by Babayemi (2007) for *Leuceana leucocephala*, *Gliricidia sepium* and *Centrosema pubescens*. Metabolisable energy is a good index for measuring the quality of feeds, particularly forages. Lower ME reported when compared with other reports mentioned could be ascribed to certain secondary metabolites in the selected plants, as corroborated by Aregheore and Abdulrazak (2005).

The values of SCFA of the selected forages predicted from gas production fell within the reported values for some browse forages (Ogunbosoye and Babayemi, 2010 and Akinfemi and Ladipo, 2014). SCFA is an indicator of energy availability to the animal, and since higher values were predicted from the selected forages, that suggests more energy potential for the selected plants.

The result of the methane gas production in the current study conformed with the submission of Babayemi (2007) that in most cases, feedstuff that shows high capacity for gas production is also observed to be synonymous with high methane production, which agreed with the result of this finding, as the higher methane production was observed in *Mangifera indica* which had earlier recorded highest gas production across the selected plants. The ranges of methane gas values recorded in this current research were higher than the reported values by Adebayo (2015).

The range of dry matter values in the present study for the selected forages was similar to the reported values by Omoniyi *et al.* (2013) for *Mangifera indica*, *Newbouldia laevis* and *Ficus thonnigii,* respectively. The present DM values were higher when compared with those of

Acroceras zizanoides (70.68%), *Eurphorbia heterophylla, Mariscus alternifolius and Phyllanthus amarus* reported by Akinfemi and Ladipo (2014). Isah *et al.* (2012) reported DM values of 32.04, 19.39, 16.38 and 15.88% in *Azadirachta indica, Ficus exasperata, Synedrella nodiflora* and *Boerhavia diffusa,* respectively. However, Ikhimioya (2008) reported a DM content of 38.7% for selected leaves of shrubs and trees in Nigeria. The DM content (85.00%) observed in *P. maximum* was higher than the reported value of 46.21% (Omoniyi *et al.,* 2013). The differences observed in the DM values could be a result of the seasonal or climatic factors, drying method, stage of growth, maturity, soil types, species or variety, as well as the ambient temperature and growth environment, as supported by Agriculture (2011).

The lowest CP value observed in the *P. maximum* among the selected forages was above 8% required to satisfy the maintenance requirement for ruminants (Norton, 1998) and also above the 7% CP requirement for ruminants, which will provide ammonia required by rumen microorganisms to support optimum microbial activity (Norton, 2003 and McDonald *et al*., 2002) and also for adequate intake of forages. The use of browse forages has been justified (Norton, 2003) in small quantities in order to supplement poor-quality pastures and crop residues.

The high CP content of browse species is well documented and is one of the main distinctive characteristics of browse compared to most grasses (Omoniyi, 2014). The range of the CP content in the present study fell within the reported range of CP content of semi-arid browse forages (Njidda, 2010). The highest CP value observed in *Gmelina aborea* was higher than the reported value for *Merremia aegyptia* (Isah *et al.,* 2013), and 174.80 and 174.30 g/kg in *Balanites aegyptiaca* and *Maerua angolensis,* respectively (Njidda *et al.*, 2013). Disparity observed in the CP content can be explained by inherent characteristics of each species related to the ability to extract and accumulate nutrients from soil and/or to fix atmospheric nitrogen, which is the case for legume plants, as corroborated by Njidda *et al.* (2013). The other factors causing variation in the chemical composition of browse forages include soil type (location), the plant part (leaf, stem, pod), age of leaf and season.

The crude fibre content of the various plants in the present study compared favourably to the recommended values of 15 – 20% for improved intake and production in finishing ruminants (Buxton, 1996). The CF values observed in all the selected forages were higher than the CF 12.38 g/100gDM in *Newbouldia laevis* (Ikhimoya and Imasuen, 2007).

The ether extract contents of the selected plants fell within the range of 4 – 10% fat recommendation for goats (Campbell *et al.,* 2006). The appreciable content of fat in some of the tested samples is an indication of a higher energy level for small ruminants (Babayemi and Bamikole, 2006; Odedire and Babayemi, 2008), and this is a major form of energy storage in plants, which is being utilised by the animals for body maintenance and production. The range of ash contents observed among the selected forages is below the reported values of 5, 7, 8 and 9% in *Albizia odoratissima, Spondia mombin, Gliricidia sepium* and *Leuceana leucocephala,* respectively (Ogunbosoye and Babayemi, 2012). Ash represents the mineral level in a feed which contains mainly phosphorus, calcium or potassium and a large amount of silica (Verma, 2006). The OM values observed in this study are similar to those in *Ficus polita, Ficus thonningii, Kigalia africana and Ziziphus abyssinica*) as reported by Njidda (2010). Fadiyimu *et al*. (2011) reported OM values of 83.3, 83.6 and 88.9% in *Ficus exasperata, Ficus thonningii* and *A. africana,* respectively. Anatomical differences between plant species, which, according to Phuc (2006), depend on the effect of plant development and on leaf: stem ratio, could be a reason for the discrepancies.

The values reported for the NDF of the selected forages in the current research fell within the reported values of Njidda (2010) for some selected browse forages, as the values were higher compared to the reported values of NDF for *Leuceana leucocephala* (29.21 g/100g), *Moringa oleifera* (26.31 g/100g) and *Gliricidia sepium* (29.61 g/100g) by Asaolu *et al.* (2011). Abegunde *et al.* (2011) reported higher values of 67.0 and 88% for *Ficus polita* in the dry season and in the wet season, respectively, which were higher than the reported values in this study.

The range of the NDF values in the present study was lower than the safe upper limit of 60% (Meissner *et al*., 1991) for forage intake by sheep, except in *Anacardium occidentale,* which has a similar value to the reported safe upper limit value. NDF actually determines the rate of digestion because it is inversely related to digestibility (McDonald *et al.,* 1995; Gillespie, 1998).

The range of ADF value reported in the present study compared favourably with the reported values of ADF for some non-leguminous browse plants (Ogunbosoye and Babayemi, 2010). These values, however, exceeded the reported values for *Syzygium cumuni* (23.00%), *Ziziphus jujuba* (17.00%) and *Acacia nilotica* (16.00%) by Uzman *et al.* (2011). Matlebyane *et al.* (2009) reported lower values of NDF of 17.7, 23.3 and 26.7 g kg^{-l} for *Vangueria cyanescens; Acacia karoo* and *Cynodon dactylon,* respectively. The selected species had a high lignin content when compared with the reported values in the literature. For example, Akinfemi and Ladipo, (2014) reported 7.21, 7.28, 9.66 and 6.88 g/100g for *Phyllanthus amarus, Sida corymbosa, Pteridium aquilinum* and *Gomphrena celosioides* respectively, Isah *et al.* (2012) reported ADL value of 6.2% for *Azadiracta indica* and 7.8% for *Ficus exasperata* while Ogunbosoye and Babayemi (2010) reported 6.96% for *Adansonia digitata* and similar value of 12.96% in *T.catappa* with the reported value of 12.93% for *Newbouldia laevis* (Ogunbosoye and Babayemi (2010).

Lignin is a component of the cell wall, and is deposited as part of the cell wall-thickening process (Boudet, 1996).

Lignin is, in general, higher in browse than in herbaceous plants. The content varies according to species, age and the plant parts. The browse forages had low to moderate content of fibre. This is a positive attribute of the browse forages since the voluntary DM intake and digestibility are dependent on the cell wall constituents (fibre), especially the NDF and lignin (Bakshi and Wadhwa 2004). Cellulose is closely associated with lignin, thus the observed relatively high lignin content in the examined plant leaves in the present study may have resulted in the high cellulose levels in the forages. In other words, the concentration of cellulose provides an insight into the level to which the forage has been lignified. The high level of lignin in the studied leaves could be adduced to their maturation. This is likely so because, according to Wilson and Light (1986), environmental factors, particularly temperature, significantly influence the content and digestibility of the cell wall in forage through faster tissue maturation.

The cell wall content (hemicellulose) appeared quite low compared to some reported values in the literature. These hemicelluloses in the plants may be at acceptable levels, although rumen microbes are incapable of adequately degrading this fibre component of plants. Going by the observations of Roger *et al.* (1996), who noted that sun drying affects the chemical composition of tree legumes, the high hemicellulose content of the leaves in the current study may have probably been due to the drying of samples of the plants before they were analysed. The range of hemicellulose observed in the selected forages was lower when compared with the value (29.26%) reported by Okoli *et al.* (2003) for *Diodia scandens* and 25.15 % for *M. aegyptia* (Omoniyi, 2014). These values fell within the reported values of 10.2 and 15.0% for *Morus alba* and *Ziziphus jujuba* leaves (Uzman *et al.*, 2011), as well as 11.07 and 13.49% reported for *A. saman and N. laevis* (Omoniyi, 2014). Odedire and Babayemi (2008) reported a higher value of cellulose compared with those in the present study. Variability in the fibre constituents could probably be due to differences in species, climatic and edaphic factors as supported by Fadiyimu *et al.* (2012).

Conclusion

The browse species evaluated in the current study had high crude protein and dry matter contents, which would make them good protein supplements to poor-quality feeds (grasses, roughages, crop residues), especially during the period of feed scarcity, without any adverse effect on small ruminants. The highest *in vitro* gas production volume (20.67ml/200mg) was recorded in *Mangifera indica* at 24 hours of incubation.

Recommendations

Based on the findings of this study, it is therefore recommended that:

1. Selected forages can be included in the diet of ruminants when fed high or low-quality forage grass to improve the performance and nutrient intake of ruminants.
2. Though browse forage species are useful in providing animals with feed during the dry season, attempts should be made to process them thoroughly before use to reduce their negative effects on rumen microbes.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

REFERENCES

Abegunde, T. O., Babayemi, O. J., & Akinsoyinu, A. O. (2011). Nutritive value assessment of Ficus polita and Panicum maximum at varying proportions using an in vitro gas production method in the dry and wet seasons. *Pakistan Journal of Nutrition*, *10*(1), 35-39.

Adebayo, B. J. (2015). Nutritional assessment of five selected forage species as supplement to elephant grass (*Pennisetum purpureum*) for West African Dwarf Goat. MSc. Agric. Dissertation, Department of Animal Nutrition, Federal University of Agriculture, Abeokuta. Nigeria.

Adebayo, B. J., Isah, O. A., & Omoniyi, L. A. (2019a). Nutritional composition and secondary metabolites of some selected forages consumed by small ruminants. *Nigerian Journal of Animal Science*, *21*(2), 195-201.

Adebayo, K. O., Aderinboye, R. Y., Isah, O.A., & Onwuka, C. F. I. (2017). Rumen fermentation characteristics of West African dwarf goat fed enzyme supplemented total mixed ration in the dry season. *Animal Research Internation*, *14*(3); 2867-2875.

Adebayo, K. O., Akinbode, R. M., Ojo, V. O. A., Aderinboye, R. Y., & Onwuka, C. F. I. (2019b). Effect of different processing methods on chemical composition and *in vitro* gas production of some browse plants for ruminant feeding. *Nigerian Journal Animal Science*, *21*(2), 165-174.

Agriculture (2011). Potatoes: Factors affecting dry matter. Department of primary industries, Victoria, Australia. Agriculture Note AG0324.

Ajayi, F. T., & Babayemi, O. J. (2008). Comparative in vitro evaluation of mixtures of Panicum maximum cv Ntchisi with stylo (*Stylosanthes guianensis*), Lablab (*Lablab purpureus*), Centro (*Centrosema pubescens*) and Histrix (*Aeschynomene histrix*). *Livestock Research for Rural Development*, *20*(6). Retrieved from https://lrrd.cipav.org.co/lrrd20/6/ajay20083.htm.

Akinfemi, A., & Ladipo, M. K. (2014). Nutritional potential of some selected weed species in north central Nigeria Using *in vitro* gas production technique. *International Journal of Agri. Science, 4*(4), 214-217.

AOAC (2005). Official Methods of Analysis, 16th edition. Association of Official Analytical Chemists. Arlington, Virginia, U.S.A.

Aregawi, T., Melaku, S., & Nigatu, L. (2008). Management and utilisation of browse species as livestock feed in semi-arid district of North Ethiopia. *Livestock Research for Rural Development*, *20*(6), 86.

Aregheore, E. M., & Abdulrazak, S. A. (2005). Estimation of organic matter digestibility and metabolizable energy content of agro-industrial wastes using in vitro gas production. *Nigeria Journal of Animal Production, 32*, 79-87.

Babayemi, O. J. (2007). In vitro fermentation characteristics and acceptability by West African dwarf goats of some dry season forages. *African Journal of biotechnology*, *6*(10), 1260-1265.

Babayemi, O. J., & Bamikole, M. (2006). Supplementary value of *Tephrosia bracteolate, Tepphrosia candida, Leucaena leucocephala* and *Gliricidia sepium* hay for West African dwarf goats kept on range. *Journal of Cent. European Agriculture* 7(2): 323-328.

Babayemi, O. J., Demeyer, D., & Fieves, V. (2004). Nutritional value of qualitative assessment of secondary compound in seeds of eight tropical browse, shrub and pulse legumes. *Common Applied. Biological Science* Ghent University, *69*(1), 103-110.

Bakshi, M. P. S., & Wadhwa, M. (2004). Evaluation of forest tree leaves of semi-hilly arid region as livestock feed. *Asian-Australasian Journal of Animal Sciences*, *17*(6), 777-783.

Bamikole, M. A., Ikhatua, U. J., Anota, B., & Omaduvie, F. 2004. Feed intake, feed utilization and weight gain of West African dwarf goats fed varying proportions of *Ficus religosia* and *Panicum maximum*. Proceedings 28th Annual Conference of Nigerian Society for Animal Production, at I.A.R.&T, Obafemi Awolowo University, Moor Plantation, Ibadan, March 16 – 20, 2003. Pp. 274-278.

Boudet, A. M., & Pettenati, J. G. (1996). Lignin genetic engineering. *Molecular Breeding, 2*, 25-39.

Buxton, D. R. (1996). Quality-related characteristics of forages as influenced by plant environment and agronomic factors. *Animal Feed Science and Technology*, *59*(1-3), 37-49.

Campbell, K. L. I., Garforth, C., Heffernan, J., Morton, R., Paterson, C., Rymer, C., & Upton, M. (2006). *Small stock in development.* Natural resources International limited, Aylesford, Kent, UK.

Fadiyimu, A. A., Fajemisin, A. N., & Alokan, J. A. (2012a). Chemical composition of selected browse plants and their acceptability by West African Dwarf sheep. *Livestock Research for Rural Development, 23*(12), 129-133.

Fadiyimu, A. A., Fajemisin, A. N., Arigbede, M. O., & Alokan, J. A. (2012b). Rumen dry matter degradability and preference by West African Dwarf goats for selected multipurpose trees in Nigeria. *Livestock Research for Rural Development 24*(1).1057-1068.

Fayemi, P. O., Onwuka, C. F. I., Isah, O. A., Jegede, A. V., Arigbede, O. M., & Muchenje, V. (2011). Effects of mimosine and tannin toxicity on rabbits fed processed *Leucaena leucocephala* (Lam) De Wit. leaves. *African Journal of Agricultural Research*, *6*(17), 4081-4085.

Fievez, V., Babayemi, O. J., & Demeyer, D. (2005). Estimation of direct and indirect gas production in syringes: a tool to estimate short chain fatty acid production requiring minimal laboratory facilities. Animal Feed Science Technology (123 – 124): 197-210.

Getachew, G.E., DePeters and Robinson, P.H. (2002). *In vitro* gas production provides effective methods for assessing ruminant feeds. Research article, *California Agriculture*, 58(1): 54-58.

Gillespie, J. R. (1998). *Animal Science*. Delmar Publishers, International Thompson Publishing Company, p. 1204.

Google Earth (2025). Google Earth. Retrieved from https://www.google.com/earth.

Ikhimioya, I. (2008). Acceptability of selected common shrubs/trees leaves in Nigeria by West African dwarf goats. *Livestock Research for Rural Development, 20*(6). Retrieved from http://www.lrrd.org/lrrd20/6/ikhi20090.htm.

Isah, O. A, Fayemi, P. O, Gazaly, M. B., & Aderinboye, R. Y. (2012). Nutritional characteristics of four browse plants consumed by free-ranging ruminants in western part of Nigeria. *African Journal of Agricultural Research*, 7(12). 1944-1949.

Isah, O. A., Omoniyi, L. A., Taiwo, O. O., Afolabi, A. D., & Fernandez, A.J. (2013). Dry matter and crude protein digestibility of WAD Sheep fed *Newbouldia laevis, Ficus thonnigii* and *Mangifera indica* as supplement to *Panicum maximum* during the dry season. *Proceedings of the British Society of Animal Science and the Association of Veterinary Teaching and Research Work includes papers from the Rare Breeds Survival Trust. 40th Anniversary Seminar and the Colloquium for Equine Reproduction.* Nottingham, U.K. (16 – 17 April, 2013).

Matlebyane, M. M., Ng'ambi, J. W. W., & Aregheore, E.M. (2009). Relationships between chemical composition and *in vitro* digestibility of some common forage species used for ruminant livestock production in three chief areas of Capricorn Region, Limpopo Province, South Africa. *Research Journal of Agriculture and Biological Sciences, 5*(2), 138-149.

McDonald, P., Edwards, R. A., GreenHalgh, J. F. D., & Morgan, C.A. (1995). Animal nutrition, 5th edition, Longman, U.K., 607 pp.

McDonald, P., Edwards, R. A., Greenhalgh, J. F. D., & Morgan, C. A. (2002). Animal nutrition, 5th edition, Longman, U.K., 607 pp.

Meissner, H. H., Viljoen, M. O., & van Niekerk, W. A. (1991). Intake and digestibility by sheep of Antherphora, Panicum, Rhodes and Smooth finger grass. In: *Proceedings of the IVth International Rangeland Congress,* September 1991, Montpellier, France, pp. 648-649.

Menke, K. A., & Steingass, H. (1988). Estimation of the energetic feed value from chemical analysis and *in vitro* gas production using rumen fluid. *Animal Research and Development 28,* 7-55.

Njidda, A. A. (2010). Chemical composition, fibre fraction and anti-nutritional substances of semi-arid browse forages of North-Eastern Nigeria. *Nigeria Journal of Basic and Applied Science*, *18*(2), 181-188.

Njidda, A. A., Ikhimioya, I., & Isidahomen, C. E. (2013). In situ crude protein degradation and mineral composition of browse forages of semi arid Nigeria. International Journal of Agriculture and Biosciences, *2*(5), 286-296.

Norton, B. W. (1998). The nutritive value of tree legumes. In: Gutteridge, R. C., & Shelton, H. M. (eds.), *Forage trees legumes in Tropical Agriculture*. CAB International, pp. 177-191.

Norton, B. W. (2003). Tree legumes and dietary supplements. In: *Forages Tree legumes in Tropical Agriculture,* Gutteridge, R. C., & Shelton, H. M. (eds.) CAB International, Wallingford, Oxon, pp. 192-201.

Odedire, J. A. and Babayemi, O. J. (2008). Comparative studies on the yield and chemical composition of *Panicum maximum* and *Andropogon gayanus* as influenced by *Tephrosia candida* and *Leucaena leucocephala, Livestock Research for Rural Development* 19(9). Retrieved from http://www.lrrd.org/lrrd19/9/oded19128.htm.

Ogunbosoye, D. O., & Babayemi, O. J. (2010). Potential values of some non-leguminous browse plants as dry season feed for ruminants in Nigeria. *African Journal of Biotechnology,* 9(18), 2720-2726.

Ogunbosoye, D. O., & Babayemi, O.J. (2012). The utilisation of some tropical browse plants by pregnant West African Dwarf goats in southern Nigeria. *International Journal of Environmental Sciences* 1 (4) Pp 224-229.

Okoli, I. C., Ebere, C. S., Uchegbu, M. C., Udah, C. A., & Ibeawuchi, I. I. (2003). A survey of the diversity of plants utilized for small ruminants feeding in South Eastern Nigeria. *Agricultural Ecosystem and Environment*, *96*, 147-154.

Olafadehan, O. A., & Adewumi, M. K. (2009). Productive and reproductive performance of strategically supplemented free grazing prepartum Bunaji cows in agropastoral farming system. *Tropical Animal Health Production, 41*, 1275-1281.

Omoniyi, L. A. (2014). *Nutritional assessment of selected forages and their effects on ruminal bacteria and blood parameters of West African dwarf sheep*. PhD Thesis, Department of Animal Nutrition, Federal University of Agriculture, Abeokuta, Nigeria.

Omoniyi, L. A., Isah, O. A., Taiwo, O. O., Afolabi, A. D., & Fernandez, A. J. (2013). Assessment of nutritive value of some indigenous plants consumed by ruminants in the humid and sub-humid region of Nigeria using *in vitro* technique. *Pacific Journal of Science and Technology*, *14*(1), 413-421.

Phuc, B. H. N. (2006). Review of the nutritive value and effects of inclusion of forages in diets for pigs. In: Forages for Pigs and Rabbits. Proceedings of a workshop-seminar held 21-24 August, 2006. MEKARN-CelAgrid. Retrieved from http://www.mekarn.org/proprf/phuc.htm.

Roger, C. M., Pond, K. R., Burns, J.C. & Fisher, D. S. (1996). Condensed tannins in *Callliandra calothysus* and their effects on feeding value. In: Proceedings of a Workshop on Forest, Farm and Community Tree Research Reports (Special Issue). 23-27 January 1996. Winrock International, Morrilton, Arkansas, USA, pp. 222-233.

SAS. (2005). Statistical Analytical Systems, 9.4 for Windows x64 Based Systems. SAS Institute Inc., Cary, NC 27513, USA.

Uzman, B. C., Javed I. S., Asif, J., Parvis, A. and Muhammad, S. (2011). Chemical composition, mineral profile and *in situ* digestion kinetics of fodder leaves of four native trees. *Pakistan Journal of Botany*. 43(1), 397-404.

Van Soest, P. J., Roberston, J. B., Lewis, B. A. (1991). Methods for dietary fibre, neutral detergent fibre and non-starch polysaccharides in relation to animal nutrition. *Journal of Dairy Science,* 74, 3583-3597.

Verma, D. N. (2006). A *Textbook of Animal Nutrition*, Kalyani Publishers, New Delhi-110 002: 126-132.

Wilson, R. T., & Light, D. (1986). Livestock Production in Central Mali, economic character and productivity indices for traditionally managed goats and sheep, *Journal of Animal Science, 62*, 567-575.

Yusuf, K. O., Adebesin, O. A., Sanni, A. Y., Aderinboye, R. Y., Oni, A. O., Adelusi, O. A., & Isah, O. A. (2015). Performance of West African dwarf goats fed maize stover based diets supplemented with ROXAZYMEG2 in the dry season in Abeokuta, Nigeria. *Nigerian Journal of Animal Production, 42*, 174-179.