



Evaluation of Nutritive Value of Selected Browse Plants for Dry Season Supplementation in Semi-Arid Nigeria

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Abstract

An experiment was conducted at the University of Maiduguri Teaching and Research Farm, to evaluate the nutritive value of some browse plants for supplementation during the dry season. The browses were leaves of Acacia nilotica, Adansonia digitata, Khaya senegalensis, Ficus polita, Moringa oleifera, Ziziphus spinochristi, Guiera senegalensis, Anogeissus leiocarpus as well as Ziziphus spinochristi pods. The results of the proximate analysis showed that the dry matter content of the browse plants differed ($P < 0.05$) significantly and ranged from 82.36 % in Acacia nilotica to 95.40 % in Guiera senegalensis. Moringa oleifera leaves recorded the highest ($P < 0.05$) crude protein content of 24.85% while the least value of 8.89 % was in Ziziphus spinochristi. There was an increase in dry matter degradability as the incubation time increased in all the browse plants. Dry matter degradability at 48, 72 and 96 hours of incubation were high ($P < 0.05$) in most browses except for Guiera senegalensis and Anogeissus leiocarpus leaves. The soluble dry matter fraction (a) was higher ($P < 0.05$) in Moringa oleifera leaves. The insoluble but degradable fraction (b) were high ($P < 0.05$) among the browse plants. Lower ($P < 0.05$) values of rate of degradation (c) were recorded except for Ziziphus spinochristi pods. Potential degradability (a + b) were significantly ($P < 0.05$) high in all browse plants. The highest ($P < 0.05$) in vitro gas production of 48.30 ml at 24 hours was recorded for Moringa oleifera leaves. Similarly, values of insoluble but fermentable fraction b (165.73 ml), metabolizable energy (10.23 MJ/kg DM), organic matter digestibility (76.90%) and short chain fatty acid (1.094 mmol) in Moringa oleifera leaves were significantly ($P < 0.05$) higher than the other browse plants. The study showed that the leaves of the browse plants had reasonable amount of nutrients and as such can serve as potential supplement for ruminants during the dry season in Nigeria.

Keywords: Proximate, degradability, gas production, browse

Introduction

Feed scarcity in the dry season especially energy and protein sources affects the production and reproductive capacity of different classes of livestock. In the dry season, the available energy and protein feedstuffs are unbalanced in nutrients and are highly lignified and this is considered to be the main reason for their low digestibility and consequently low utilization by ruminant animals. This condition necessitates the need for sourcing for an alternative and locally available means of feeding ruminant animals to increase their productivity

while contending with the problem of insufficient conventional feed resources (Uguru, 2014). Attention of ruminant nutritionists in recent years has shifted to cheaper and locally available alternative supplements which should be nutritionally viable, non-toxic and of little or no dietary value in human diets (Topps, 1992). Improved utilization of crop residues can be achieved either through appropriate supplementation or treatment and both of which facilitate microbial breakdown in the rumen. Browse plants are found in abundance in the Semi-arid region of Nigeria and have the potential to be used

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as ruminant feeds. Their nutrients can provide supplements to improve the productivity of livestock fed on low quality forages and crop residues (Aganga and Tshwenyane, 2003). The objective of this study therefore was to evaluate the nutrient content, degradation characteristics and effective degradability of dry matter and *in vitro* gas production of selected browse plants as a way of providing information regarding their use in the strategic dry season supplementation of ruminant diets in the Semi-arid regions of Nigeria.

Materials and Methods

Experimental site

The experiment was conducted at the Livestock Teaching and Research Farm and the Laboratory in the Department of Animal Science University of Maiduguri. Maiduguri, the capital of Borno State is located on Latitude 11°5' N, Longitude 13°09' E and at an altitude of 354 m above sea level. The area falls within the Sahelian Region (Semi-arid zone) of West Africa which is noted for great climatic and seasonal variations. It is characterized by short duration of erratic rainfall of about 3 - 4 months with 645.9 mm as annual rainfall and a very long dry season of about 8 - 9 months. The mean ambient temperature is low in December to January ranging from 15 - 19 °C and high in March to June, ranging from 33 - 44 °C. The relative humidity is usually 45 % in August and drops to about 5 % in December and January. Day length varies from 11 - 12 hours (Encarta, 2009).

Sources of feed and preparation

The samples of the browse plants were sourced locally within Maiduguri and its environs. Fresh samples were properly sundried for a period of 7 days. All samples were ground to pass through 1 mm sieve for proximate analysis and were

stored in labelled polyethene bags for the study.

Proximate analysis

Samples of the feed ingredients were analysed for Dry matter (DM), Crude protein (CP), Crude fibre (CF), Ether extract (EE), Nitrogen Free Extract (NFE) and ash, using the methods of AOAC (2002).

Rumen degradability study

Three (3) bulls weighing on average 250 kg aged 3 - 4 years fitted with a rumen cannula of 90 mm size (internal diameter) were used for the rumen degradability studies. The bulls were confined in pen and offered a basal diet of grass hay *ad-libitum* and supplemented with 2 kg concentrate mixture (50 % wheat bran, 40 % cowpea husk and 10 % cotton seed cake) twice daily in equal parts to maintain a relatively stable rumen environment. Mineral salt lick and water were provided *ad-libitum* throughout the study period.

Feed sample preparation and incubation

Sample of each feed ingredient collected was ground to pass through 2.0 mm sieve for the rumen degradability study. The nylon bags made from nylon filter cloth with pore size of about 45µm and 140 x 90 mm sizes were labelled for easy identification using a permanent marker. Five grams (5 g) of each feed ingredient were weighed in replicates into the nylon bags. The bags containing the feed ingredients were incubated in replicates in the rumen of the cannulated bulls for 3, 6, 12, 24, 48, 72 and 96 h. All bags were placed in the rumen at the same time and removed at the required time (Ørskov *et al.*, 1980).

Degradability was calculated as follows;

$$DMD = \frac{DMD \text{ in feed} - DM \text{ in residue}}{DM \text{ in feed}} \times 100$$

Where DMD = dry matter degradability and DM = dry matter.

Processing of degraded samples

The withdrawn string with the attached nylon bags were immediately placed in a bucket of cold water to prevent further fermentation and to wash off the feed particles adhering to the outside of the bags. The bags were taken to the laboratory and washed under running cold water until the water is clear. The bags with the contents were air-dried and thereafter oven-dried at 105° C for 24 hours for determination of the amount of dry matter loss (McDonald *et al.*, 1995 and Ørskov *et al.*, 1980). The soluble portion of the feed was determined by weighing five grams (5 g) of each feed sample into nylon bags in replicates, the bags were marked and washed under running cold water until clear water is obtained. The bags were oven dried at 105 °C for 24 hours (Ørskov *et al.*, 1980).

In vitro study

Experimental procedure

In vitro gas production was conducted using the method described by Menke and Steingass (1988) modified by Blummel *et al.* (1997). Approximately 200 mg of feed was weighed and placed into a 100 ml graduated glass syringe fitted with a

piston. Buffer and mineral solution (35.0 g NaHCO₃ + 4.0 g (NH₄)HCO₃ + 5.7 g (Na₂)HPO₄ + 0.57 g KCl + 0.47 g NaCl + 0.6 g MgSO₄·7H₂O + CaCl₂·2H₂O per 1000 ml) were prepared and placed in a water bath at 39 °C under continuous flushing with CO₂. Rumen fluid (i.e. liquid and fine particles) was collected from cannulated bulls that were fed on a roughage (70%) and concentrate (30%) diet into a pre-warmed thermos flask, and then filtered through three layers of cheese cloth and flushed with CO₂. The mixed and CO₂-flushed rumen fluid was added to the buffered mineral solution (1:2 (v/v)) and maintained in a water bath at 39 °C. Buffered rumen fluid (30 ml) was pipetted into each syringe containing feed samples and were immediately placed into water bath maintained at 39 °C. The syringes were incubated in a water bath covered with a Perspex lid fitted with holes to hold the syringes upright in the water bath (Blummel *et al.*, 1997). Three syringes with only buffered rumen fluid were incubated and considered as the blank incubation to correct for gas production in the absence of a substrate. The syringes were shaken by hand, twice in the first hour and four times daily at later times. Gas production was recorded at 3, 6, 12, 24, 48, 72 and 96 hours (Blummel *et al.*, 1997).

The metabolizable energy (MJ/kg DM), organic matter digestibility (OMD) and short chain fatty acid (SCFA) were calculated using the following equations as follows;

OMD (%) = 14.88 + 0.889 GV + 0.45 CP + 0.651XA (Menke and Steingass, 1988)

SCFA (mmol) = 0.0239 GV – 0.0601 (Getachew *et al.*, 1997)

ME (MJ/kg DM) = 2.20 + 0.136 GV + 0.057 CP + 0.0029 CF (Menke and Steingass, 1988).

Where GV, CP, CF and XA are total gas volume at 24 hours, crude protein, crude fibre and ash.

Statistical analysis

Dry matter degradability data obtained were fitted to the exponential model

$p = a + b(1 - e^{-ct})$ (Ørskov and McDonald, 1979 and Ørskov *et al.*, 1980), (where, p

is the potential disappearance at time *t* (%); *a* is the fraction of material that is soluble (%); *b* is the fraction that is potentially degradable in the rumen (%); *c* is the constant rate of degradation of

fraction b (h^{-1}); e is the natural logarithm and t is the time (h)), using the Non Linear Regression Model (NLR) of the Statistical Package for the Social Sciences (SPSS, 2006 version 20). The effective degradability (ED) of the feeds were calculated using the formula as shown below where k is the fractional ruminal outflow rate. The variables a , b and c were as defined above. Effective degradability was calculated with an estimated solid outflow rate from the rumen (k) of 2%, 3%, 5% and 8% /h (Orskov and McDonald, 1979).

$$ED = a + \frac{bc}{k+c}$$

Cumulative gas volume were fitted to the exponential model given by McDonald (1981): $Y = b(1 - \exp^{-ct})$, (where Y is the cumulative volume of gas produced at time ' t ', b is the potential gas production from the insoluble fraction (ml); c is the gas production rate constant for the insoluble fraction (b) and t is the incubation time (h)) using the Non Linear Regression Model (NLR) of the Statistical Package for the Social Sciences (SPSS, 2006 version 20).

Data obtained were subjected to analysis of variance (ANOVA) using the Statistical Package (Statistix 10.0). Significant differences between means were separated using Least Significant Differences (LSD).

Results and Discussion

The proximate composition of the browse plants are shown in Table 1. Dry matter content of the browse plants differed ($P < 0.05$) significantly and ranged from 82.36 % in *Acacia nilotica* leaves to 95.40 % in *Guiera senegalensis* leaves. Gidado *et al.* (2013) reported lower DM values of 89.06, 84.73 and 86.66 % for *Khaya senegalensis*, *Adansonia digitata* and *Ficus polita*, respectively. Similar DM values of 85.73 % and 89.07 % for *Adansonia digitata* and *Khaya*

senegalensis leaves, respectively were reported by Liman *et al.*, (2016). The differences in DM content might be attributed to factors such as season, maturity and the part of the plant that was analysed.

The highest value of CP was recorded for *Moringa oleifera* (24.85 %) while the least was obtained in *Ziziphus spinachristi* leaves (8.89 %). The crude protein content recorded for *Moringa oleifera* (24.85 %) and *Ficus polita* leaves (16.93 %) were lower compared with CP values of 29.60 % (*Moringa oleifera* leaves) and 20.74 % (*Ficus polita* leaves) reported by Ogunbosoye *et al.* (2015). Liman *et al.* (2016) reported CP values of 17.77 and 19.87 %, respectively for *Khaya senegalensis* and *Adansonia digitata*. Norton (1998) reported a CP range values of 12 – 30 % for tropical tree legumes and recommended the use of browse leaves in small quantities as supplement to poor quality pastures and crop residues. The CP contents recorded for the browse plants in this study were above the minimum level (7 %) required for microbial activities in the rumen (Norton, 1998) and the range of 12 – 18 % required by lactating cows (Moran, 2005).

The crude fibre values obtained in this study ranged from 15.39 % - 32.99 %. The highest CF content of 32.99 % was recorded in *Ziziphus spinachristi* pods while the least value of 15.39 % was recorded in *Moringa oleifera* leaves. Ogunbosoye and Babayemi (2010) reported similar CF value of 26.41 % for *Adansonia digitata* leaves. However, Ogunbosoye *et al.* (2015) reported a similar value of 15.87 % for *Moringa oleifera* and a higher value of 24.23 % for *Ficus polita* leaves. Similarly, Njidda (2010) reported crude fibre value of 18.00 % in *Ziziphus spinachristi* and a higher value of 32.00 % in *Adansonia digitata* compared with the result obtained in the

present study. The browse leaves had moderate to high content of fibre. The high level of crude fibre in the leaves could be due to maturity. According to Wilson (1982), environmental factors, particularly temperature, significantly influenced the content and digestibility of cell wall in forage through faster tissue maturation. The highest EE value of 6.73 % was obtained in *Khaya senegalensis* leaves while the least (1.10 %) was observed in *Ziziphus spinachristi* pods. Higher values ranging from 9.19 to 14.72 % were reported by Ogunbosoye and Babayemi (2010) for some non-leguminous browse plants in Nigeria. Gidado *et al.* (2013) reported similar EE values of 6.14 % and 6.75 % for *Adansonia digitata* and *Khaya senegalensis*, respectively and a higher value of 9.83 % for *Ficus polita* leaves. The variations in nutrient content might be attributed to within species differences, plant parts, season, harvesting regime, location, soil type and age (Norton, 1998). The ash values recorded in this study ranged from 2.14 % in *Guiera senegalensis* leaves to 12.14 % in *Moringa oleifera* leaves. Liman *et al.* (2016) reported ash values of 3.71 and 17.05 % for *Prosopis Africana* and *Ficus sycomorus*, respectively and similar values of 4.97 % in *Adansonia digitata* and 10.70 % in *Khaya senegalensis*. The values observed in this study were within the range of 7.9 – 12.6 % reported for browse leaves (Sandoval-Castro *et al.*, 2005). According to Verma (2006), ash content of the feed represents its mineral level. The NFE values of browse trees/shrubs obtained in this study ranged from 41.98 - 60.77 %. The NFE value recorded for *Moringa oleifera* leaves was similar to the value (42.6 %) reported by Melesse (2012) for *Moringa oleifera* leaves. The values of 47.30 and 60.77 % NFE obtained in *Adansonia digitata* and *Khaya senegalensis*, respectively were

higher than the values 30.57 % (*Adansonia digitata*) and 41.27 % (*Khaya senegalensis*) reported by Njidda (2010). The NFE value of browse species is moderate and may serve as energy sources for ruminant animals.

Dry matter degradability

The percentage dry matter degradability (DMD) of all browse plants is presented in Table 2. The DMD significantly ($P < 0.05$) differed among the browses. The degradability of the browse plants increased with increase in incubation period. At 48 hours of incubation over 40 % of the DM in most of the browses had been degraded except for GSL and ALL. Modu-Kagu *et al.* (2018) reported a higher degradability at 48 hours of incubation for *Faidherbia albida* pods (72.02 %). Liman *et al.* (2016) recorded similarly higher values at 48 hours of incubation for leaves of *Adansonia digitata* (55.30 %) and *Khaya senegalensis* (64.20 %). Similar values of DMD at 48 h incubation for some semi-arid browses ranging from 57.65 to 41.27 % was reported by Njidda *et al.* (2012). At 96 hours of incubation, most of the browse plants were degraded above 60 % (MOL 87.90, ANL 82.00, ZSL 80.00 and ZSP 74.10 %) except for some (GSL 51.90 and ALL 43.50 %) which were below 60 %. This implied good digestibility potential for these browses when harnessed as feed resources for ruminant livestock. FAO (1986) suggested a minimum of 40 to 50 % degradation at 48 hours in the rumen. Furthermore, Nyako *et al.* (2014) reported that degradability values at 48 hours incubation forms the basis for ranking feeds for ruminants. Thus, browse plants have good potential degradability and as such can be used in formulating rations for ruminants.

Degradability parameters and effective degradability

The DM degradation characteristics of the browse plants is shown in Table 3. The result showed that the 'a' values ranged from 4.09 % in *Khaya senegalensis* to 37.01 % in *Moringa oleifera* leaves. This low value recorded in KSL was a reflection of the fact that DM component was not readily soluble. According to Njidda *et al.* (2016), the low 'a' is possibly an indication of high level lignification in most of the leaves or may have, resulted from the accumulation of insoluble carbohydrates due to later stages of maturity. Njidda *et al.* (2016) reported lower and higher values of 8.01 and 14.34 % for *Acacia nilotica* and *Ziziphus spinachristi* leaves when compared with 26.26 and 10.50 % for *Acacia nilotica* and *Ziziphus spinachristi* leaves obtained in this study. The relatively high soluble DM values in these tree leaves especially *Moringa oleifera* revealed their potential as a good source of more nutrients for microbial growth (Djouvinov and Todorov, 1994). Gomes *et al.* (1994) reported a positive relationship between DM intake and Microbial growth. According to Chumpawadee *et al.* (2005), the high soluble fractions make the feed easily attachable by ruminal microorganisms and leads to higher degradation. The rumen degradable fraction 'b' ranged between 76.71 % and 39.57 % for ZSL and ALL, respectively. Njidda *et al.* (2016) reported higher values ranging from 59.24 to 75.81 % for some browse leaves. Potential degradable fraction 'b' values at the range of 60.16 to 50.25 % were reported for some tropical feeds used for feeding ruminants (Modu-Kagu *et al.*, 2018). Feed ingredients with high potential degradable fraction implied that the structure can be attachable by rumen microorganisms leading to high degradability, and this could be due to their high crude protein content. The rate

of degradation constant 'c' ranged from 0.009/h in ALL to 0.310/h in ZSP. A higher 'c' value of 0.023/h for *Khaya senegalensis* was reported by Njidda *et al.* (2012). Lower values of 0.014/h and 0.025/h were reported for *Ziziphus spinachristi* leaves and *Acacia nilotica* leaves, respectively (Njidda *et al.*, 2016). The in situ 'c' fraction has been suggested to be a good predictor of intake (Chenost *et al.*, 2001). According to Preston (1986), the rate of degradation 'c' is an important parameter in the assessment of the fermentation of crop residues in the rumen. The low c value recorded in this study in some of the feed ingredients is a reflection of its low CP and high fibre content which reduces invasion by microorganism, leading to slow rate of degradation. The potential degradability (a + b) of the protein rich browses appeared to have an inverse relationship with the rate of degradability 'c'. The highest a + b value of 87.21 % was recorded in ZSL while ALL recorded the least value of 58.10 %. The effective degradability of the protein rich browses is shown in Table 4. The effective degradation in the rumen depends on how long the feed remains in the rumen which is also a function of the quality of the feeds fed to the animals (Reddy, 2001). The highest effective degradability (ED) value of 66.71 % was observed in MOL while ALL recorded 30.81 % at a fractional outflow rate of $k = 0.02$. Liman *et al.* (2016) reported ED value at $K = 0.02$ of 53.70 and 60.80 % for *Adansonia digitata* and *Khaya senegalensis*, respectively. The rumen outflow rate is an inverse of the mean retention time (MRT) of feeds in the rumen. It then suggest that the MRT for the protein feed is 20 – 60 h. The ED at an outflow rate (k) = 0.03, 0.05 and 0.08 follow the same trend as that of $k = 0.02$. Effective DM degradability decreased with increase in outflow rates in this study. Ikhimioya *et al.* (2005) observed

ED of DM to decrease as the outflow rates increased. The ED values calculated as a proportion of their DM contents (Table 4) using values for 5 % outflow rate showed that ZSP and MOL had over 50 % of their DM content effectively degraded, whereas similar proportions of the other feeds were barely up to 40 %. The high ED values of DM is an indication of a high microbial activity.

***In vitro* gas production of protein feed ingredients**

The result of the *in vitro* gas production of the browse plants is shown in Table 5. The result showed that cumulative gas volume at the different incubation time differed ($P < 0.05$) significantly, and increased with increasing hour of incubation. Although gas produced during rumen fermentation processes are waste products and of no nutritive value to the ruminant animal, gas production tests are used routinely in feed research because gas volumes are related to both extent and rate of degradation (Blummel *et al.*, 1997). The volume of gas production range at 24 and 48 hours (16.77 - 48.30 ml) and (22.75 – 88.40 ml), respectively in the present study were higher than the corresponding ranges of 9.83 - 30.30 ml and 11.80 – 47.89 ml reported by Sisay *et al.* (2018) for some browses in Ethiopia. Okunade *et al.* (2014) reported a range of 19.00 – 34.00 ml for 48 hours gas production for some guinea savannah browse plants in Nigeria. Getachew *et al.* (2004) reported that gas produced at 24 hours of incubation averaged 89 % of total gas produced at 48 hours. Gas production in MOL and ZSP at 24 and 48 hours were higher ($P < 0.05$) than other feeds and the lowest was obtained in FPL. Many factors such as nature and level of fibre, the presence of secondary metabolites and potency of the rumen liquor for incubation have been reported (Babayemi *et al.*, 2004) to determine the amount of gas produced during

fermentation. As seen in the current study gas production during the first hours of incubation is very small, and this might be attributed to its crude fibre or secondary metabolites which influenced its degradability at the initial stage. Higher gas production of *Moringa oleifera* leaves is of high nutritional value than the other feed ingredients. The incubation pattern of protein rich feeds is characterised by initial fast fermentation and reach maximum after 20 h of incubation, and after 46 h of incubation protein content is likely fully fermented (Blummel *et al.*, 1997).

***In vitro* gas characteristics and estimated parameters**

The result of the *in vitro* gas production characteristics is shown in Table 6. The ‘b’ fraction describes the insoluble but fermentable part of the feed. The ‘b’ values ranged from 26.35 – 165.73 ml. *Moringa oleifera* leaves (165.73 ml) had the highest value while *Ficus polita* leaves (26.35 ml) had the lowest. The ‘b’ value of 57.84 ml obtained in *Adansonia digitata* leaves was higher than 22.33 ml reported by Ogunbosoye and Babayemi (2010) for *Adansonia digitata* browse species. Sisay *et al.* (2018) reported ‘b’ value range of 11.20 ml – 55.40 ml for some browses in Ethiopia. The fractional rate of gas production ‘c’ differed ($P < 0.05$) significantly among the browse plants. The rate of gas production ranged from 0.014 – 0.120 h⁻¹. The values of ‘c’ obtained in the present study showed that they are highly digestible as the rate at which a feed or its constituents are digested in the rumen is as important as the extent of digestion (Anele *et al.*, 2008). Sisay *et al.* (2018) reported range of 0.03 – 0.14 h⁻¹ for some Ethiopian browses. The ‘c’ value of 0.079 h⁻¹ obtained in *Adansonia digitata* leaves was similar to 0.07 h⁻¹ reported by Ogunbosoye and Babayemi (2010) for

Adansonia digitata browse species. According to Ndlovu and Nherera (1997) gas production rate 'c' is negatively correlated with NDF and ADF. The faster rate of gas production 'c' suggest that rumen microbes were able to utilize the feed better probably due to a higher content of fermentable nutrients (Sisay *et al.*, 2018), and a higher potential gas production can contribute significantly to energy supply via short chain fatty acid production (Maheri-Sis *et al.*, 2008). However, Ogunbosoye and Babayemi (2010) reported that low gas production values connote low digestibility of the feed ingredients. The low digestibility observed in some of the feed ingredients in this study may be due to presence of condensed tannins found in most browse plants (Barry and McNabb, 1999) and high level of fibre fractions most especially NDF content. Gas volume are related to both extent and rate of substrate degradation (Blummel *et al.*, 1997). The result of the estimated gas parameters of the protein feed ingredients is shown in Table 6. There is significant ($P < 0.05$) differences in these parameters among the feed ingredients. The highest organic matter digestibility (OMD) was recorded in *Moringa oleifera* leaves (76.90 %), while the least OMD value (43.56 %) was recorded in *Ficus polita* leaves. The OMD range value 38.43 – 48.67% reported by Ogunbosoye and Babayemi (2010) for some non- leguminous browse plants falls within the range of 43.56 – 76.90 % reported in this current study. Okunade *et al.* (2014) reported lower range of 32.11 – 49.06 % for some Guinea Savannah browse plants in Nigeria. The OMD value of 54.28 % recorded in this study was higher than 42.60% reported by Ogunbosoye and Babayemi (2010) for *Adansonia digitata* leaves. Sisay *et al.* (2018) reported OMD range of 40.3 – 56.86 % which fell within the range reported in this study. The short chain

fatty acid (SCFA) of the browse plants ranged from 0.298 – 1.331 mmol. The highest value (1.331 mmol) was obtained in soybean waste, while the least value (0.298 mmol) was obtained in pineapple peels. Ogunbosoye and Babayemi (2010) reported lower value of 0.39 mmol for *Adansonia digitata* plant compared with 0.705 mmol obtained in the present study. The SCFA range (0.341 – 1.094 mmol) obtained in the present study was higher than the range of 0.15 – 0.43 mmol reported by Okunade *et al.* (2014). Similarly, Sisay *et al.* (2018) reported lower value range of 0.17 – 0.66 mmol for some browses. Lower value range of - 0.012 – 0.569 mmol was reported by Njidda *et al.* (2011) for selected leguminous browse plants. The metabolisable energy (ME) and net energy for lactation (NE_L) ranged from 5.23 – 11.66 MJ/KgDM and 2.42 – 8.14 MJ/KgDM, respectively. The ME value range obtained in this study was lower than that (5.39 – 62.59 MJ/KgDM) reported by Njidda *et al.* (2011) for some leguminous browse plants. Ogunbosoye and Babayemi (2010) reported a lower ME value of 5.61 MJ/KgDM for *Adansonia digitata* plant compared with 7.57 MJ/KgDM obtained in this present study. However, the ME ranges (4.53 – 6.48 MJ/KgDM) and (4.59 – 7.20 MJ/KgDM) reported by Okunade *et al.* (2014) and Sisay *et al.* (2018), respectively are within the range obtained in the present study. The higher value of OMD and ME for MOL, ZSP, ADL and ANL in the present study could be attributed to the high crude protein content of the feed ingredients. This result is in agreement with the findings of Karabulut *et al.* (2007) and Parissi *et al.* (2005) who found positive correlation between crude protein with ME and OMD for tropical browses with high CP content. The estimation of ME values is valuable for purposes of ration formulation and to set

economic value of feeds for other purposes (Getachew *et al.*, 2002). The highest ME of MOL, ADL and ANL coupled with their higher CP content suggests that such feed ingredients may enhance microbial protein synthesis as it might promote better synchronization of fermentable energy and degradable N in the rumen (Olafadehen *et al.*, 2014). The highest OMD, SCFA and ME for MOL, ZSP and ADL in the current study could be due to their highest gas production after 24 hours of incubation. A higher gas production can contribute significantly to energy via SCFA production (Maheri-Sis *et al.*, 2008). Many factors such as the nature and level of fibre, the presence of secondary metabolites and potency of the rumen liquor for incubation have been reported (Babayemi *et al.*, 2004) to determine the amount of gas to be produced during fermentation.

Conclusions

The combination of chemical analysis, *in sacco* and *in vitro* degradability technique can be used to provide enough information on feeds nutritive value within a short period of time. The selected browse plants showed appreciable amount of crude protein and can be used to supplement low quality forages during the dry season for effective rumen microbial activity and for increased livestock production.

References

- A. O. A .C. (2002). *Official Methods of Analysis of the Official Analytical Chemists*, 17th Ed. (Horwitz. W., Ed.). Association of Official Analytical Chemists, Washington, DC.
- Aganga, A. A. and Tshwenyane, S. O. (2003). Feeding values and Anti-nutritive factors of forage tree legumes. *Pakistan Journal of Nutrition*, 2 (3): 170 - 177.
- Anele, U.Y., Arigbede, O.M., Olanite, J.A., Adekunle, I.O., Jolaosho, A.O., Onifade, O.S. and Oni, A.O. (2008). Early growth and seasonal chemical composition of three indigenous multipurpose tree species (MPTS) in Abeokuta, Nigeria. *Agroforest System*, 73: 89 - 98.
- Babayemi, O.J., Demeyer, D. and Fievez, V. (2004). *In vitro* fermentation of tropical browse seeds in relation to their secondary metabolites. *Journal of Animal Science Technology*, 13 Suppl 1: 31 - 34.
- Barry, T.N. and McNabb, W.C. (1999). The implication of condensed tannins in the nutritive value of temperate forages fed to ruminants. *British Journal of Nutrition*. 81: 263 - 271.
- Blummel, M., Makkar, H.P.S. and Becker, K. (1997). *In vitro* gas production: a technique revisited. *Journal of Animal Physiology and Animal Nutrition*, 77: 24 - 34.
- Chenost, M., Aufrere, J. and Macheboeuf, D. (2001). The gas test technique as a tool for predicting the energetic value of forage plants. *Animal Research*, 50: 349 - 364.
- Chumpawadee, S., Sommart, K., Vongpralub, T. and Pattarajinda, V. (2005). *In-sacco* degradation characteristics of energy feeds sources in Brahman-Thai native crossbred steers. *Journal of Agricultural Technology*, 1 (2): 196 - 206.
- Djouvinov, D.S. and Todorov, N.A. (1994). Influence of dry matter intake and passage rate on microbial protein synthesis in the rumen of sheep and its estimation by cannulation and a non-invasive method. *Animal Feed Science and Technology*, 48: 289 - 304.

- Encarta, (2009). Encarta Microsoft @ student 2009 (DVD), Redmond, W.A: Microsoft Corporation.
- FAO (1986). Food and Agriculture Organization, FAO Production Year Book, 40: 95 and 247.
- Getachew, G., Blummel, M., Makkar, H. P. S. and Becker, K. (1997). *In vitro* gas measuring techniques for assessment of nutritional quality of feeds: a review. *Animal Feed Science and Technology*, 72: 261 - 281.
- Getachew, G., Crovetto, G.M., Fondevila, M., Krishnamoorthy, U., Singh, B., Spanghero, M., Steingass, H., Robinson, P.H. and Kailas, M.M. (2002). Laboratory variation of 24h *in vitro* production and estimated metabolisable energy values of ruminant feeds. *Animal Feed Science and Technology*, 102: 169 - 180.
- Getachew, G., DePeters, E.J. and Robinson, P.H. (2004). *In vitro* gas production provides effective method for assessing ruminant feeds. *California Agriculture*, 58 (1).
- Gidado, O.G., Kibon, A., Gworgwor, Z.A., Mbaya, P. and Baba, M.J. (2013). Assessment of antinutritive factors and nutrient composition of some selected browse plants use as livestock feeds in Taraba State. *International Journal of Applied Sciences and Engineering*, 1 (1): 5 - 9. www.ijapscengr.com
- Gomes, M.J., DeB. Hovell, F.D. and Chen, X.B. (1994). The effect of starch supplementation of straw on microbial protein supply in sheep. *Animal Feed Science and Technology*, 49: 277 - 286.
- Ikhimiya, I., Isah, O.A., Ikhatua U.J. and Bamikole, M.A. (2005). Rumen degradability of dry matter and crude protein in tree leaves and crop residues of humid Nigeria. *Pakistan Journal of Nutrition*, 4 (5): 313 - 320.
- Karabulut, A., Onder, C., Hatice, K., Fatmagul, G., Ekin, S. and Ismail, F. (2007). Comparison of *in vitro* gas production, metabolisable energy, organic matter digestibility and microbial protein production of some legume hays. *Asian Australasian Journal of Animal Science*, 20: 517 - 522.
- Liman, A.A., Malgwi, I.H., Nyako, H.D., Ardo, B.A., Mohammed I.D., Yahya, A.A., Antiev, M., Zarah, A.I., Yahya M.M. and Abdullahi, S. (2016). Nutrient evaluation and degradation characteristics of some browse plants in Taraba state – Nigeria. *International Journal of Information Research and Review*, 3 (1): 1612 - 1617.
- Maheri-Sis, N., Chamani, M., Sadeghi, A.A., MirzaAghazadeh and Aghajanzadeh-Golshani, A. (2008). Nutritional evaluation of kabuli and desi type chickpeas (*Cicer arietinum* L.) for ruminants using *in vitro* gas production technique. *African Journal of Biotechnology*, 7: 2946 - 2951.
- McDonald, I. (1981). A revised model for the estimation of protein degradability in the rumen. *Journal Agric. Science* (Cambridge), 96: 251 - 252.
- McDonald, P., Edwards, R. A., Greenhalgh, J. F. D., Morgan, C. A., Sinclair, L. A. and Wilkinson, R. G. (1995). *Animal Nutrition*. 7th Ed. Longman. London, pp. 483 - 485: 538 - 540.
- Melesse, A. (2012). *In vitro* evaluation of utilizable crude protein using ruminal fluid in leaves, whole and seeds-removed pods of *Moringa stenopetala* and *Moringa oleifera* grown in the rift valley of

- Ethiopia. *Ethiopian Journal of Agricultural Science*, 22: 62 - 72.
- Menke, K. H. and Steingass, H. (1988). Estimation of the energetic feed value obtained from chemical analyses and gas production using rumen fluid. *Animal Research and Development*, 28: 7 – 55.
- Modu-Kagu, H.A., Zarah, A.I., Abba-Aja, H.K. and Mohammed. I.D. (2018). Assessing the nutritive value of some common Tropical feeds for feeding ruminants in a Semi-arid environment of Nigeria. *Nigerian Journal of Animal Science and Technology*, 1 (1): 31 - 37.
- Moran, J. (2005). *Tropical dairy farming: feeding management for small holder dairy farmers in the humid tropics*. Landlinks Press, pp. 51 - 59.
- Ndlovu, L.R. and Nherera, F.V. (1997). Chemical composition and relationship to *in vitro* gas production of Zimbabwean browsable indigenous tree species. *Animal Feed Science and Technology*, 69: 121 - 129.
- Njidda, A.A. (2010). Determining dry matter degradability of some Semi-Arid browse species of North-Eastern Nigeria using the *in vitro* technique. *Nigerian Journal of Basic and Applied Science*, 18 (2): 160 - 167.
- Njidda, A.A., Olafadehan, O.A. and Alkali, H.A. (2016). *In sacco* dry matter and protein degradability of some browse plants' leaves used as ruminant feeds. In: Proceedings of 21st Annual Conference of Animal Science Association of Nigeria 18 - 22, 2016, Port Harcourt, pp. 905 - 909.
- Njidda, A.A., Olatunji, E.A. and Okoruwa, M.I. (2012). *In situ* degradability of dry matter of browse forages consumed by ruminants in the semi-arid region of northern Nigeria. *Journal of Biology, Agriculture and Healthcare*, 2 (9): 39-44.
- Norton, B.W. (1998). The nutritive value of tree legumes In: *Forage tree legumes in Tropical Agriculture*, R.C. Gutteridge, and H.M. Shelton, (Eds.) CAB International. Wallingford, United Kingdom, pp. 177 - 191.
- Nyako, H.D., Kibon, A., Magaji, M.Y. and Abdullahi, S. (2014). Chemical composition and rumen degradability of forages browses, crop residues and agricultural by-products in Adamawa State. 39th Conference, *Nigerian Society for Animal Production*. 16 - 19 March 2014. Babcock Univ. Ilesha-Remo, Ogun State, Nigeria.
- Ogunbosoye, D.O. and 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., Tona, G.O. and Otukoya, F.K. (2015). Evaluation of the nutritive value of selected browse plant species in the Southern Guinea Savannah of Nigeria for feeding to ruminant animals. *British Journal of Applied Science and Technology*, 7 (4): 386 - 395.
- Okunade, S.A., Isah, O.A., Aderinboye, R.Y. and Olafadehen, O.A. (2014). Assessment of chemical composition and *in vitro* degradation profile of some guinea savannah browse plants of Nigeria. *Tropical and Subtropical Agroecosystems*, 17: 529 - 538.
- Olafadehan, O.A., Okunade, S.A. and Njidda, A.A. (2014). Evaluation of bovine rumen content as a feed ingredients for lambs. *Tropical Animal Health and Production*. DOI 10.1007/s11250-014-0590-9 (In press).

- Orskov, E. R. and McDonald, I. (1979). The estimation of protein degradability in the rumen from incubation measurements weighted according to rate of passage. *Journal of Agricultural Science*. (Cambridge). 92: 499 - 503.
- Ørskov, E.R., DeB. Hovell, F. D. and Mould, F. L. (1980). The use of the nylon bag technique for evaluation of feedstuffs. *Tropical Animal Production*, 5: 195 - 213.
- Parissi, Z.M., Papachristov, T.G. and Nastis, A.S. (2005). Effect of drying methods on estimated nutritive value of browse species using an in vitro gas production technique. *Animal Feed Science and Technology*, 30: 119 - 128.
- Preston, T.R. (1986). *Better utilization of crop residues and by-products in animal feeding: Research guidelines 2. A practical manual for research workers*. FAO: Animal production and Health paper 50/2F, Rome, Italy. <http://www.fao.org/DOCREP/003/X6554E/X6554E00.htm>
- Reddy, D.V. (2001). *Applied Nutrition*. Oxford and IHB Publishing Co. Pvt. Ltd New Delhi, pp. 87 - 89.
- Sandoval-Castro, C.A., Lizarraga-Sanchez, H.L. and Solorio-Sanchez, F.J. (2005). Assessment of tree fodder preference by cattle using chemical composition, *in vitro* gas production and *in situ* degradability. *Animal Feed Science and Technology*, 123 - 124 (1): 277 - 289.
- Sisay, A., Negesse, T. and Nurfeta, A. (2018). Short chain fatty acid production, organic matter digestibility and metabolisable energy content of indigenous browses from Ethiopian rift valley. *Journal of Agriculture and Veterinary Science*, 11 (1): 61 - 68.
- SPSS, (2006). *Statistical Program for Social Sciences P.C. Version*. Inc.444, Michigan Avenue, Chicago. USA.
- Topps, J. H. (1992). Potential, composition and use of legume shrubs and trees as fodder for livestock in the tropics (a review). *Journal of Agricultural Sciences* (Cambridge), 118(1): 1 – 8. <http://doi.org/10.1017/S0021859600067940> Last accessed 16.01.2021.
- Uguru, C. (2014). Nutritional potential of Acacia (*Acacia nilotica* (L.) Del.) Pods for growing red Sokoto goats. Ph.D. Dissertation, Ahmadu Bello University, Zaria, Nigeria.
- Verma, D.N. (2006). *A Textbook of Animal Nutrition*. Kalyani Publishers, New Delhi-110 002: 126 - 132.
- Wilson, T. (1982). Husbandary, nutrition and productivity of goats and sheep in tropical Africa. Proceedings of a Seminar held at the International livestock Centre for Africa, Addis Ababa, Ethiopia, pp. 61 - 67.



Table 1: Proximate composition (%) of browse plants

Feeds	DM	CP	CF	EE	Ash	NFE
ANL	82.36 ^h	18.40 ^b	16.87 ^{de}	4.87 ^b	7.00 ^d	52.86 ^{bc}
ADL	89.30 ^f	16.54 ^c	24.67 ^b	6.10 ^a	5.39 ^e	47.30 ^{cde}
KSL	92.51 ^c	16.11 ^c	21.74 ^c	6.73 ^a	10.54 ^b	44.88 ^{de}
FPL	90.54 ^e	16.93 ^c	21.09 ^c	3.21 ^c	9.45 ^b	49.32 ^{bcd}
MOL	87.10 ^g	24.85 ^a	15.39 ^f	5.64 ^{ab}	12.14 ^a	41.98 ^e
ZSL	91.73 ^d	8.89 ^f	17.90 ^d	3.23 ^c	9.21 ^{bc}	60.77 ^a
ZSP	94.60 ^b	9.68 ^f	32.99 ^a	1.10 ^d	2.88 ^f	53.35 ^b
GSL	95.40 ^a	13.90 ^d	21.70 ^c	2.70 ^c	2.15 ^f	59.55 ^a
ALL	91.50 ^d	12.00 ^e	15.96 ^{ef}	3.50 ^c	8.00 ^{cd}	60.54 ^a
SEM	0.177*	0.440*	0.479*	0.390*	0.479*	1.912*

Key: - DM = dry matter, CP = crude protein, CF = crude fibre, EE = ether extract, NFE = nitrogen free extract, ANL= *Acacia nilotica* leaves, ADL= *Adansonia digitata* leaves, KSL= *Khaya senegalensis* leaves, FPL= *Ficus polita* leaves, MOL= *Moringa oleifera* leaves, ZSL= *Ziziphus spinochristi* leaves, ZSP= *Ziziphus spinochristi* pods, GSL= *Guiera senegalensis* leaves, ALL= *Anogeissus leiocarpus* leaves, SEM = standard error of means, ^{a, b, c, d, ...} means in the same column bearing different superscripts are significantly (p<0.05) different.

Table 2: Dry matter degradability of browse plants

Feed	Incubation Time (h)						
	3	6	12	24	48	72	96
ANL	28.91 ^d	38.01 ^c	42.90 ^d	61.50 ^c	71.00 ^a	79.51 ^a	82.00 ^b
ADL	20.19 ^e	30.30 ^e	36.09 ^e	47.78 ^f	57.20 ^d	67.68 ^d	79.00 ^d
KSL	18.15 ^f	28.13 ^f	44.18 ^c	53.51 ^e	56.43 ^e	60.97 ^f	62.50 ^g
FPL	29.98 ^c	36.77 ^d	42.80 ^d	57.03 ^d	66.13 ^c	70.95 ^c	71.67 ^f
MOL	39.25 ^b	44.15 ^b	59.03 ^b	62.80 ^b	71.60 ^a	76.15 ^b	87.90 ^a
ZSL	15.13 ^h	20.71 ⁱ	28.96 ^f	43.77 ^g	54.57 ^f	66.05 ^e	80.00 ^c
GSL	15.30 ^h	21.59 ^h	25.00 ^g	29.20 ^h	38.10 ^g	47.11 ^g	51.90 ^h
ALL	17.33 ^g	23.00 ^g	24.45 ^g	28.45 ^h	31.00 ^h	36.01 ^h	43.50 ⁱ
ZSP	43.75 ^a	60.10 ^a	64.60 ^a	66.44 ^a	68.19 ^b	70.80 ^c	74.10 ^c
SEM	1.91*	2.41*	2.87*	2.72*	2.84*	2.69*	2.77*

Key: - ANL= *Acacia nilotica* leaves, ADL= *Adansonia digitata* leaves, KSL= *Khaya senegalensis* leaves, FPL= *Ficus polita* leaves, MOL= *Moringa oleifera* leaves, ZSL= *Ziziphus spinachristi* leaves, GSL= *Guiera senegalensis* leaves, ALL= *Anogeissus liocarpus* leaves, ZSP= *Ziziphus spinachristi* pods, SEM = standard error of means, ^{a, b, c, d, ...} means in the same column bearing different superscripts are significantly (p<0.05) different.

Table 3: Dry matter degradation characteristics of browse plants

Feed	Degradation characteristics			
	a%	b%	c ^{-h}	a+b%
ANL	26.26 ^b	58.10 ^d	0.033 ^d	84.36 ^d
ADL	20.15 ^d	66.13 ^b	0.020 ^e	86.28 ^b
KSL	4.09 ^h	56.58 ^e	0.097 ^b	60.13 ^h
FPL	20.94 ^c	50.58 ^f	0.052 ^c	71.52 ^e
MOL	37.01 ^a	48.27 ^h	0.032 ^d	85.28 ^c
ZSL	10.50 ^g	76.71 ^a	0.020 ^e	87.21 ^a
GSL	15.65 ^f	49.11 ^g	0.014 ^e	64.76 ^g
ALL	18.53 ^e	39.57 ⁱ	0.009 ^e	58.10 ⁱ
ZSP	4.10 ^h	65.24 ^c	0.310 ^a	69.34 ^f
SEM	1.95*	2.09*	0.018*	2.19*

Key: - ANL= *Acacia nilotica* leaves, ADL= *Adansonia digitata* leaves, KSL= *Khaya senegalensis* leaves, FPL= *Ficus polita* leaves, MOL= *Moringa oleifera* leaves, ZSL= *Ziziphus spinachristi* leaves, GSL= *Guiera senegalensis* leaves, ALL= *Anogeissus liocarpus* leaves, ZSP= *Ziziphus spinachristi* pods, a = soluble fraction, b = insoluble but degradable fraction, c = rate of degradation of b, a+b = potential degradability, SEM = standard error of means, ^{a, b, c, d, ...} means in the same column bearing different superscripts are significantly (p<0.05) different.

Table 4: Effective degradability of browse plants

Feeds	Effective degradability (%)			
	0.02	0.03	0.05	0.08
ANL	62.44 ^c	56.69 ^c	49.36 ^d	43.23 ^c
ADL	53.22 ^e	46.60 ^f	39.04 ^f	33.38 ^f
KSL	51.00 ^f	47.30 ^e	41.43 ^e	35.10 ^e
FPL	57.47 ^d	53.02 ^d	46.73 ^d	40.87 ^d
MOL	66.71 ^a	61.92 ^b	55.85 ^b	50.80 ^b
ZSL	48.86 ^g	41.18 ^g	32.42 ^g	25.84 ^g
GSL	35.87 ^h	31.28 ^h	26.39 ^h	22.96 ^h
ALL	30.81 ⁱ	27.66 ⁱ	24.57 ⁱ	22.53 ^h
ZSP	65.39 ^b	63.58 ^a	60.28 ^a	55.96 ^a
SEM	2.32*	2.34*	2.31*	2.22*

Key: - ANL= *Acacia nilotica* leaves, ADL= *Adansonia digitata* leaves, KSL= *Khaya senegalensis* leaves, FPL= *Ficus polita* leaves, MOL= *Moringa oleifera* leaves, ZSL= *Ziziphus spinachristi* leaves, GSL= *Guiera senegalensis* leaves, ALL= *Anogeissus liocarpus* leaves, ZSP= *Ziziphus spinachristi* pods, Effective degradability of the components expressed by $a+b*c/(c+k)$. (k= 0.02, 0.03, 0.05, 0.08). SEM = standard error of means, ^{a, b, c, d, ...} means in the same column bearing different superscripts are significantly (p<0.05) different.

Table 5: *In vitro* gas volume of browse plants

Feeds	Incubation Time (h)				
	3	6	12	24	48
ANL	3.22 ^g	11.33 ^e	18.27 ^e	29.17 ^d	30.40 ^f
ADL	8.90 ^c	13.50 ^d	25.60 ^a	32.00 ^c	38.13 ^c
KSL	2.00 ^h	3.05 ⁱ	4.10 ^h	22.15 ^g	24.00 ^h
FPL	4.11 ^f	5.67 ^h	10.53 ^g	16.77 ^h	22.75 ⁱ
MOL	3.00 ^g	9.30 ^g	19.00 ^e	48.30 ^a	88.40 ^a
ZSL	5.85 ^e	10.45 ^f	16.93 ^f	26.56 ^f	34.08 ^e
GSL	10.40 ^b	20.20 ^b	23.70 ^b	28.00 ^e	36.10 ^d
ALL	12.10 ^a	21.70 ^a	22.40 ^c	27.10 ^{ef}	29.00 ^g
ZSP	7.00 ^d	14.50 ^c	20.20 ^d	47.00 ^b	65.10 ^b
SEM	0.663*	1.133*	1.252*	1.946*	4.022*

Key : - ANL= *Acacia nilotica* leaves, ADL= *Adansonia digitata* leaves, KSL= *Khaya senegalensis* leaves, FPL= *Ficus polita* leaves, MOL= *Moringa oleifera* leaves, ZSL= *Ziziphus spinachristi* leaves, GSL= *Guiera senegalensis* leaves, ALL= *Anogeissus liocarpus* leaves, ZSP= *Ziziphus spinachristi* pods, SEM = standard error of means, ^{a, b, c, d} ... means in the same column bearing different superscripts are significantly different (p<0.05), * = Significant (p<0.05).

Table 6: *In vitro* gas characteristics and estimated parameters of browse plants

FEEDS	b (ml)	C (h ⁻¹)	OMD (%)	SCFA (mmol)	ME (MJ/Kg DM)
ANL	31.48 ^g	0.076 ^b	53.65 ^c	0.637 ^c	7.26 ^c
ADL	57.84 ^b	0.079 ^b	54.28 ^c	0.705 ^b	7.57 ^c
KSL	27.01 ^h	0.039 ^c	48.68 ^e	0.469 ^d	6.19 ^f
FPL	26.35 ^h	0.042 ^c	43.56 ^g	0.341 ^e	5.51 ^g
MOL	165.73 ^a	0.014 ^d	76.90 ^a	1.094 ^a	10.23 ^a
ZSL	44.85 ^c	0.037 ^c	48.49 ^e	0.575 ^c	6.37 ^{ef}
GSL	42.17 ^d	0.067 ^b	47.43 ^f	0.609 ^c	6.86 ^d
ALL	33.75 ^f	0.12 ^a	49.58 ^d	0.588 ^c	6.62 ^{de}
ZSP	39.14 ^e	0.016 ^d	62.89 ^b	1.063 ^a	9.24 ^b
SEM	8.09*	0.01 *	1.89*	0.047*	0.282*

Key : - ANL= *Acacia nilotica* leaves, ADL= *Adansonia digitata* leaves, KSL= *Khaya senegalensis* leaves, FPL= *Ficus polita* leaves, MOL= *Moringa oleifera* leaves, ZSL= *Ziziphus spinachristi* leaves, GSL= *Guiera senegalensis* leaves, ALL= *Anogeissus liocarpus* leaves, ZSP= *Ziziphus spinachristi* pods, b = insoluble but fermentable fraction, C = rate of gas production, SCFA = short chain fatty acid, ME = metabolisable energy, NE_L = net energy for lactation, OMD = organic matter digestibility, SEM = standard error of means, ^{a, b, c, d} ... means in the same column bearing different superscripts are significantly different (P<0.05).