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*Full Length Research Paper*

# Nutritional characteristics of four browse plants consumed by free-ranging ruminants in Western part of Nigeria

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**The current study was undertaken to evaluate the chemical composition, *in vitro* dry matter degradation and gas production of four browse species (*Azadirachta indica, Ficus exasperate, Synedrella nodiflora* and *Boerhavia diffusa*). The results showed that ash, crude protein, dry matter and neutral detergent fibre contents were significantly different (p< 0.05) among all the species. *A. indica* had the highest crude protein concentrations exceeding 30%. *In vitro* gas production was different (p< 0.05) between *B. diffusa* and *S. nodiflora* from 9 to 48 h of incubation. *S. nodiflora* however, recorded the highest (p< 0.05) values for dry matter degradability of 65.0% at 48 h; organic matter digestibility of 45.86%; the predicted dry matter intake of 4.0% body weight and the lowest (p<0.05) rate of digestion (0.01 ml/h). It was concluded that, all the browse species would provide good nutrition for browsing ruminants, but of these four plants, *S. nodiflora* appeared to be the best browse species with the lowest potential for methane emission.**

**Key words:** Browse plants, gas production, *in vitro* degradation, methane emission.

## INTRODUCTION

A number of browse plants worldwide serve as alternative feedstuffs for livestock (Ammar et al., 2004; Aregawi et al., 2008; Rinehart, 2008; Fayemi et al., 2011). As a result, animals under semi-intensive and free-range systems have been observed feeding on them (Isah et al., 1999; Isah et al. 2007; Apori et al., 2002). The location-specific studies on these groups of livestock have confirmed that their production system is based on free grazing of roadside and bush forages complimented with household wastes (Onwuka, 1992; Upton, 2003; Isah et al., 2004). Common leguminous and non-leguminous browse species that are constantly grazed by ruminants and pseudo-ruminants in different parts of Nigeria include: *Adansonia digitata, Azadirachta indica, Boerhavia diffusa, Bombax glabra, Ceiba pentandra, Ficus exasperate, Ficus thonningii, Gliricidia sepium, Kigelia africana, Leucaena leucocephala, Marantochloa leucantha, Milicia exselsa, Moringa oleifera, Newbouldia leavis, Spondias mombin, Synedrella nodiflora, Spondia mombin, Treculia africana, Tabebuia rosea, Terminalia catappa* and *Terminalia superba* (Isah et al., 1999; Babayemi and Bamikole, 2006; Ogunbosoye and Babayemi, 2010; Fayemi et al., 2011).

The availability of these feed resources has totally become an integral component of the silvopastoral systems as grazeable materials in the nutrition of range animals (Menke and Steingass, 1988; Papachristou et al., 1999; Njidda and Ikhimoya, 2010). Apart from their availability, the presence of secondary compounds in these plants has made the assessment of nutrient digestibility using *in situ* techniques more difficult (Krishnamoorthy et al., 2005). Through these procedures, the effect of dilution and

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solubilization in the rumen has often been contributing to inaccurate estimates of organic matter digestibility. The use of *in vitro* gas production technique therefore remains a better alternative for the determination of gas production kinetics and energy value of ruminant feedstuffs.

This is because the *in vitro* gas production is accurate for the prediction of the organic matter digestibility and escape of nutrients from the rumen (Makker et al., 1999; Aiple et al., 1996; Krishnamoorthy et al., 2005; Ajayi and Babayemi, 2008). The technique is however reliably useful for determining the relationship between chemical composition, incubation time and digestibility of forage feeds (Tolera et al., 1997; Larbi et al., 1998). It has also been reported to be less expensive, rapid and allows for proper control of experimental conditions as compared with *in vivo* trials. In a broad sense, *in vitro* method is preferably used to predict dry matter intake (Blummel and Qrskov, 1993), digestibility (Khazaal et al., 1993) and metabolisable energy (Babayemi and Bamikole, 2006) and for determining the rate or extent of gas degradation (Akinfemi et al., 2009).

So far in Nigeria conversely, the use of this method has not received satisfactory scrutiny for assessing *in vitro* dry matter degradation, degradation rate and gas production in browse species that are habitually grazed by ruminants. As a result, this study was designed to determine the nutritional characteristics based on their: chemical composition, *in vitro* dry matter degradation and gas production of the selected four browse species that are consumed by free-ranging ruminants in Western part of Nigeria.

## MATERIALS AND METHODS

### Study location

The leaf samples were conducted at the arboretum of the University of Agriculture, Abeokuta (UNAAB), Ogun State, Nigeria. The study location lies within the savanna agro-ecological zone of southwest Nigeria (latitude: 7° N, longitude 3.5°). Abeokuta has an average annual rainfall of 1037 mm. The town also has a bimodal rainfall pattern that characteristically peaks in July and September with a break of 2–3 weeks in August. Temperatures are fairly uniform with daytime values of 28–30°C during the rainy season and 30 to 34°C during the dry season with the lowest night temperature of approximately 24°C during the harmattan period (December and February). Relative humidity of the study site is high during the rainy season with values ranging between 63 and 96% as compared to dry season values of 55 to 84% (Anene et al., 2011).

### Sample collection and preparation

Four tropical browse plants (*A. indica, F. exasperate, S. nodiflora* and *B. diffusa)* were used for this study. Leaf samples from each of these browse plants were harvested from mature plants within the arboretum of the University of Agriculture, Abeokuta, Nigeria.

Approximately 0.2 kg of the leaves was collected from each plant species and maintained separately by species.

### Analysis of the browse samples

The foliage samples were sub-sampled, weighed fresh in the field and then oven-dried to a constant weight at 65°C. The dried foliage samples were hammer-milled through a 1 mm sieve. Crude protein (% Nitrogen*6.25), ash and ether extract were analysed according to the standard methods of Association of Official Analytical Chemists (AOAC) (1990). The neutral detergent fibre (NDF), acid detergent fibre (ADF) and lignin were determined according to van Soest et al. (1991). The difference between NDF and ADF was designated as hemicellulose, and the differential between ADF and ADL was labeled as cellulose.

### Determination of the *in vitro* gas production

The *in vitro* gas production was determined according to Menke and Steingass (1988). West African dwarf (WAD) rams fed a mixed diet of fresh *Pennisetum purpureum* (60% DM) and concentrates (40% DM) were used. The concentrate feed consisted of (as fed basis) 4% corn, 10% wheat offal, 10% palm kernel cake, 20% groundnut cake, 5% soybean meal, 10% dried brewers' grain, 1% common salt, 3.75% oyster shell and 0.25% fish meal. Feeds were offered in two equal meals at 07: 00 and 19:00 h respectively. Rumen fluid was collected prior to feeding with the use of suction tube from three rumen-fistulated West African dwarf (WAD) rams. The fluid was strained through two layers of cheese cloth into a pre-warmed, insulated bottle.

All laboratory handling of rumen fluid was carried out under a continuous flow of carbon IV oxide. Samples (200 mg) of the oven-dry and milled leaves were accurately weighed into 100-ml glass syringes fitted with plungers. *In vitro* incubation of the samples was conducted in triplicates. Syringes were filled with 30 ml of medium consisting of 10 ml of rumen fluid and 20 ml of buffer solution. Three blanks containing 30 ml of medium only were included. The syringes were placed in a rotor inside the incubator (39°C) with about one rotation per min. The gas production was recorded after 0, 3, 6, 9, 12, 18, 24, 48 and 72 h of incubation.

### Methane determination

The volume of methane gas produced by each browse sample was determined by dispensing 4 ml of 10 N sodium hydroxide into each incubated sample at the end of 24 and 48 h of incubation periods. Sodium hydroxide was added to absorb carbon-dioxide produced during the process of fermentation and the remaining volume of gas was recorded as methane according to the method of Fievez et al. (2005).

### Determination of percentage dry matter degradability (DMD)

500 mg samples were weighed into 125-ml Erlenmeyer flasks. The samples were then incubated in a buffered medium containing rumen liquor (40 ml). Dry matter degradability was estimated after 24 and 48 h incubation; contents of the flasks was then treated with neutral detergent solution according to the procedure of van Soest and Robertson (1985) to obtain NDF. The determination of dry matter degradability was calculated thus: %DMD = 100 – neutral detergent residue.

### Calculations and statistical analysis

The data obtained from *in vitro* gas production was fitted to the non-linear equation (Larbi et al., 1996):

$$V \text{ (ml/0.2 g DM)} = GV(1-e^{-ct})$$

**Table 1.** Proximate and fibre composition of the selected browse species.

| Browse | *Azadirachta indica* | *Ficus exasperata* | *Synedrella nodiflora* | *Boerhavia diffusa* | SEM |
|---|---|---|---|---|---|
| DM | 32.04[a] | 19.39[b] | 16.38[b] | 15.88[b] | 0.94 |
| CP | 31.52[a] | 23.20[b] | 25.61[b] | 24.74[b] | 0.82 |
| Ash | 8.25[c] | 19.18[a] | 7.65[c] | 13.29[b] | 0.98 |
| EE | 6.25 | 6.67 | 5.88 | 5.00 | 0.99 |
| NDF | 40.00[a] | 36.00[b] | 30.00[c] | 40.00[a] | 0.99 |
| ADF | 20.00 | 40.00 | 18.00 | 19.60 | 0.75 |
| Lignin | 6.20 | 7.80 | 5.20 | 5.50 | 0.89 |
| Hemicellulose | 20.00 | 20.00 | 22.00 | 20.40 | 0.23 |

[a,b,c] Means along the same row with different superscripts are significantly different ($p<0.05$). DM: Dry matter; CP: crude protein; EE: ether extract; NDF: neutral detergent fibre; ADF: acid detergent fibre and SEM: standard error of means.

where V is the potential gas production, GV is the volume of gas and c is the fractional rate of gas production.

Other post incubation parameters determined were:

i) Organic matter digestibility (OMD) was estimated as:

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

Total gas volume (GV) is expressed as ml/0.2 g DM, CP and ash as g/kg DM.

ii) Prediction of dry matter intake

The percent NDF was used to predict dry matter intake expressed as a percentage of body weight according to Schroeder (1994). The formula used for calculation was:

PDMI (as % of body weight) = 120 ÷ % NDF

where, PDMI is the predicted dry matter intake, and %NDF is the percentage content of neutral detergent fibre in forage.

Data collected from the chemical composition, gas production kinetics, percentage dry matter degradability, organic dry matter degradability, and predicted dry matter intake were subjected to one-way analysis of variance (ANOVA) procedure using SAS (1990). Significant differences between individual means were determined using the Duncan's multiple range test (Duncan, 1955).

## RESULTS

All the browse species used for this study had excellent nutritional qualities, but *A. indica* had relatively higher ($p< 0.05$) dry matter (32.04%) and crude protein (31.52%) values more than other species (Table 1). The ether extract (EE), neutral detergent fibre (NDF), acid detergent fibre (ADF), lignin and hemicellulose contents were not significantly ($p > 0.05$) different among all the species. *S. nodiflora* recorded the least volume of methane production of 1.5 to 7.0 ml/200 mgDM at 24 h and 2 to 8 ml/200 mgDM at 48 h respectively (Figure 1).

Moreover, *B. diffusa* and *S. nodiflora* consistently showed relatively higher ($p<0.05$) gas production values from 9th- to 24th-h of incubation (Table 2). There was a difference ($p<0.05$) in the percentage degradation of dry matter which ranged between 30 and 50% at 24 h, and 40 to 65% at 48 h. For both incubation periods, *S. nodiflora* had the highest ($p<0.05$) OMD and DMD values. The organic matter degradability of the forages was different ($p<0.05$) ranging between 37.89 and 45.86% (Table 3).

## DISCUSSION

The dry matter (DM) value obtained from *A. indica was* about one-third of the value reported by Esonu et al. (2006) and Ogbuewu et al. (2010) from the leaf meal of the same plant. Ambient temperature, seasonal or climatic factors may be responsible for the disparity in the values obtained in this study as corroborated by Kumagai (2006) and Agriculture (2011). Generally, the CP values from the examined browse species (*A. indica, F. exasperata, S. nodiflora, B. diffusa)* were substantially above the critical range of 8 to 10%. Specifically, the 31.52%CP obtained from *A. indica* leaves, was higher than the range of 17.4 to 20.68% reported by FACT Sheet (1997), Babayemi and Bamikole (2006) and Esonu et al. (2006). On the contrary, the value was closer to 35%CP from its leaves (Obaroh and Achiony-Nzeh, 2011) and fall within the range of 31.40 to 40%CP recorded by Musalia et al. (2000) and Saxena et al. (2010) for its seed cake. High concentrations of CP as noted in this study gave an indication that the forage in question is very rich in CP content.

The amount of gas released when feeds are incubated *in vitro* has been reported to be closely related to digestibility of feed for ruminants (Mebrahtu and Tenaye, 1997). Thus, the gas volume can be considered a good reflection of substrate fermentation to VFAs and an estimate of potential digestibility in the rumen. It can also be said that when the amount of substrate is increased, a slight depression in the amount of gas will be produced by the browse plants. Therefore, the higher gas production observed for *S. nodiflora* and *B. diffusa* suggested a higher nutrient digestibility of these browses

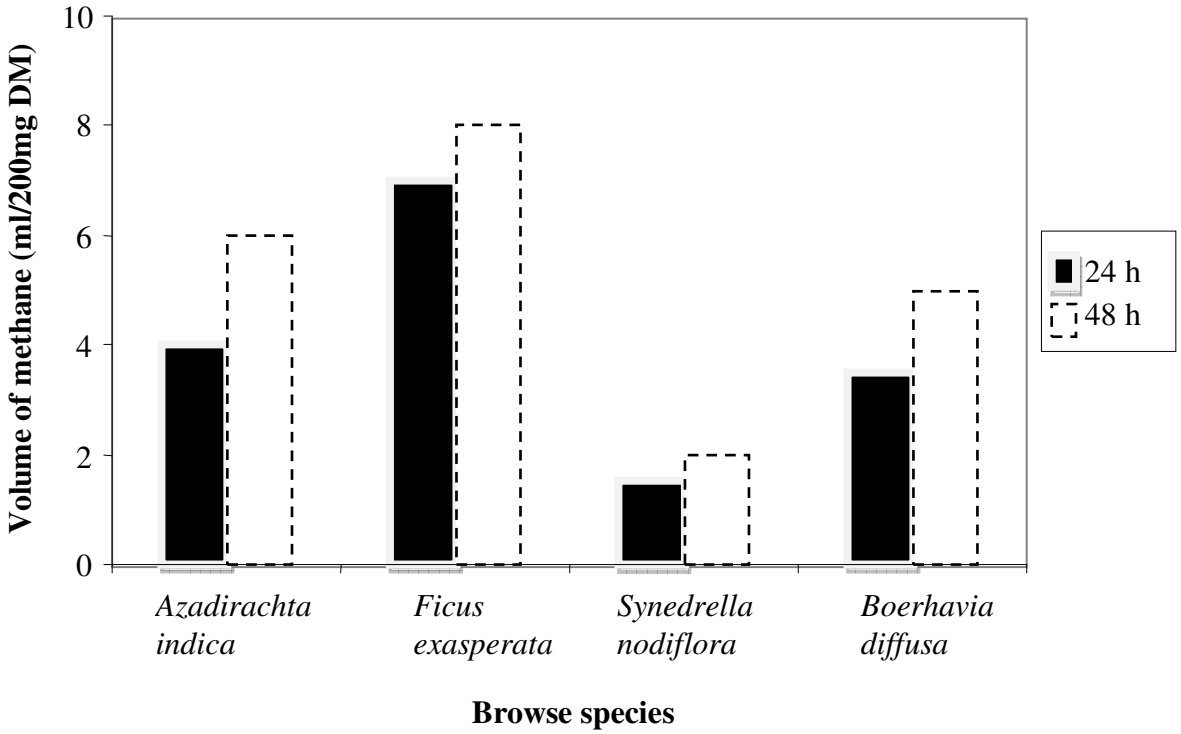


**Figure 1.** Methane production of selected browse species at 24 and 48 h incubation.

**Table 2.** *In vitro* gas production (ml/200 mgDM) of selected browse species at varying incubation periods.

| Incubation time (h) | *Azadirachta indica* | *Ficus exasperata* | *Synedrella nodiflora* | *Boerhavia diffusa* | SEM |
|---|---|---|---|---|---|
| 3 | 3.00 | 2.00 | 2.67 | 2.67 | 0.13 |
| 6 | 4.69 | 3.00 | 4.00 | 4.33 | 0.20 |
| 9 | 5.00$^{b}$ | 3.33$^{b}$ | 8.33$^{a}$ | 9.33$^{a}$ | 0.37 |
| 12 | 5.67$^{b}$ | 5.33$^{b}$ | 12.00$^{a}$ | 11.33$^{a}$ | 0.52 |
| 18 | 7.67$^{b}$ | 10.00$^{b}$ | 15.00$^{a}$ | 15.00$^{a}$ | 0.66 |
| 24 | 9.33$^{b}$ | 16.33$^{b}$ | 21.33$^{a}$ | 19.00$^{a}$ | 0.92 |
| 48 | 15.00$^{b}$ | 17.00$^{a}$ | 23.67$^{a}$ | 24.00$^{a}$ | 0.93 |
| 72 | 18.33$^{b}$ | 18.67$^{b}$ | 26.00$^{a}$ | 26.00$^{a}$ | 0.89 |
| **Gas production characteristic** | | | | | |
| b (ml) | 4.64$^{c}$ | 4.64$^{c}$ | 28.85$^{a}$ | 12.54$^{b}$ | 0.85 |
| c (ml/h) | 0.95$^{a}$ | 0.95$^{a}$ | 0.01$^{b}$ | 0.34$^{b}$ | 0.55 |

$^{a,b,c}$ Means along the same row with different superscript are significantly different ($p<0.05$).

**Table 3.** Dry matter degradability, organic matter degradability and predicted dry matter intake of the selected browse species.

| Parameter (%) | *Azadirachta indica* | *Ficus exasperata* | *Synedrella nodiflora* | *Boerhavia diffusa* | SEM |
|---|---|---|---|---|---|
| DMD (24 h) | 30.0$^{b}$ | 35.0$^{b}$ | 50.0$^{a}$ | 35.0$^{b}$ | 2.55 |
| DMD (48 h) | 40.0$^{c}$ | 50.0$^{b}$ | 65.0$^{a}$ | 50.0$^{b}$ | 3.01 |
| OMD | 37.89$^{c}$ | 41.68$^{b}$ | 45.86$^{a}$ | 43.77$^{b}$ | 2.88 |
| PDMI (%BW) | 3.0 | 2.0 | 4.0 | 3.0 | |

$^{a,b,c}$ Means along the same row with different superscript are significantly different ($p<0.05$). DMD: Dry matter digestibility; OMD: organic matter digestibility; PDMI: predicted dry matter intake (PDMI); h: hour and %BW: percentage body weight.

compared to *A. indica* and *F. exasperate*. This result nonetheless, could be a reflection of a higher proportion of carbohydrate available for fermentation (Getachew et al., 1999). Since the utilization of forages is largely dependent on microbial degradation, the extent of degradation, GV, suggested that *S. nodiflora* and *B. diffusa* possessed more degradable and fermentable carbohydrates than *A. indica* and *F. exasperate.* The existence of the negative correlation between methane production and energy utilization implies that browse species having a lower methane production would possibly indicate a better utilization of dietary energy from the species when fed to ruminants.

The 40%NDF recorded from this study confirmed an inverse relationship between NDF and dry matter intake for *A. indica,* and *B. diffusa* (Meissner et al., 1991; Bamikole et al., 2004). The highest DMD% observed for *S. nodiflora* was attributed to the lower NDF content of the browse. As asserted by Ehargara and Orskov (1987), degradability of forages at 48 h could be considered to be equivalent to digestibility. Therefore, from the degrade-ability values at 48 h, it implied that the digestibility of the forages was between 40 and 65%. This was nevertheless appreciable since a digestibility value of 40 to 50% was recommended for high performance of ruminants on pastures (McDowell, 1972). This variation could be attributed to the differences in nutrient composition of the browse species particularly in terms of fibre. As the PDMI value increases, the NDF for browses declines so, as the percentage of NDF increases in forage, animals consume more (Schroeder, 1994). Nevertheless, supplementation at 2 to 3% of body weight has been reported sufficient for optimum weight in small ruminants (Osuhor et al., 1991).

The rates of gas production and the dry matter degradability (DMD) observed in this study was consistent with the findings of Salem (2006). It also concurred with the discovery of Lila et al. (2003) where sarsaponin reduced *in vitro* dry matter digestibility (IVDMD) of hay plus concentrate after 24 h of incubation. A depression in feed degradability or reduction in IVDMD of *A. indica's* leaves may be due to astringent factor which significantly could reduce the protozoa numbers (Patra et al., 2006). In another study as well, Ferri et al. (2004) postulated that higher levels of NDF and lignin could be responsible for the lower rate of degradation and effective degradability. Although *A. indica* had lower *in vitro* DMD between 24 and 48 h, yet it can still be considered as nutritious forage for ruminant animals.

## Conclusion

The study reveals the examined browse species had competitive nutrient levels. Low NDF values in *A. indica,* and *B. diffusa* suggest that both will enhance dry matter intake by free-grazing ruminants. *S. nodiflora,* with the highest values for dry matter degradability (DMD), organic matter digestibility (OMD), and the predicted dry matter intake (PDMI), showed an inherent potential that can improve the performance characteristics of small ruminants on free range in Western part of Nigeria. Since *A. indica* had a suppressed DMD value, the browse can still be manipulated so as to get maximum inhibition in methane emission without adversely affecting feed degradability.

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