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Evaluation of nutritive value and *in vitro* digestibility of five selected browse plants as feed for ruminants in Nigeria

*[1]Adebayo, B. J., [1]Nwani, A. N. and [1]Mafimidiwo, A. N.
[1]Department of Agricultural Technology, Yaba College of Technology, Yaba, Lagos.

***Corresponding author**: babatunde.adebayo@yabatech.edu.ng: +2348030559306

Abstract

Some trees, especially browse plants are cherished by cattle, sheep and goats in the tropics. However, the browse plants have their peculiar characteristics and nutrients in them. Therefore this study was conducted to evaluate nutritive value, chemical composition and in vitro digestibility of Morinda lucida, Moringa oleifera, Ficus exasperata, Pentaclethra macrophylla and Palisota [hirsute.s] Samples were investigated for proximate composition, in vitro gas production characteristics, estimated organic matter digestibility (OMD%), metabolizable energy (ME, MJ/kgDM) and short chain fatty acid (SCFA, mol). Results showed that there were significant differences in proximate composition with crude protein (CP) ranging from 17.87 in Palisota hirsute to 27.20% in Moringa oleifera. The content of the neutral detergent fibre (NDF) differed significantly (P<0.05) with values ranging from 53.39 in Pentaclethra macrophylla to 60.39% in Morinda lucida. The estimated SCFA, OMD and ME were significantly (P<0.05) higher in Pentaclethra macrophylla (0.37 mol, 30.88 % and 4.65 MJ/kgDM) respectively. In conclusion, the selected plants evaluated in this study had high crude protein contents which would make them good protein supplement to poor quality feeds especially during feed scarcity without adverse effect.

Keywords: *In vitro*, Gas production, nutrients, Metabolizable energy, Organic matter

Évaluation de la valeur nutritive et de la digestibilité *in vitro* de cinq plantes broutées sélectionnées pour l'alimentation des ruminants au Nigéria

Résumé

Certains arbres, en particulier les plantes broutées, sont appréciés par les bovins, les moutons et les chèvres sous les tropiques. Cependant, les plantes broutantes ont en elles leurs caractéristiques et leurs nutriments particuliers. Par conséquent, cette étude a été menée pour évaluer la valeur nutritive, la composition chimique et la digestibilité in vitro de Morinda lucida, Moringa oleifera, Ficus exasperata, Pentaclethra macrophylla et Palisota hirsute. Les échantillons ont été étudiés pour la composition immédiate, les caractéristiques de production de gaz in vitro, la digestibilité estimée de la matière organique. (DMO%), énergie métabolisable (EM, MJ/kgDM) et acide gras à chaîne courte (AGCC, mol). Les résultats ont montré qu'il existait des différences significatives dans la composition immédiate des protéines brutes (PB) allant de 17,87 chez Palisota hirsute à 27,20 % chez Moringa oleifera. La teneur en fibres détergentes neutres (FDN) différait significativement (P < 0,05) avec des valeurs allant de 53,39 chez Pentaclethra macrophylla à 60,39 % chez Morinda lucida. Les AGCC, DMO et EM estimés étaient significativement (P <0,05) plus

élevés chez Pentaclethra macrophylla (0,37 mol, 30,88 % et 4,65 MJ/kgDM) respectivement. En conclusion, les plantes sélectionnées évaluées dans cette étude avaient des teneurs élevées en protéines brutes, ce qui en ferait un bon complément protéique aux aliments de mauvaise qualité, en particulier en cas de pénurie alimentaire, sans effet indésirable.

Mots-clés: *In vitro*, Production de gaz, nutriments, Énergie métabolisable, Matière organique

Introduction

Poor quality feeds and fluctuating seasonal feed supplies are the main constraints facing the livestock industry. Shortage of forages during the dry season in turns affects the livestock industry in terms of weight gain, reproduction, growth rate and productivity (FAO, 1983). It also results in communal clash between livestock owners and crop farmers. This has been the basic reason for poor performance of livestock. Tropical grass fodder and crop by-products available during dry season in tropics have a low nutritive value due to their low protein and fermentable energy though they grow rapidly during the period of heavy rainfall and high temperature and this leads to grass maturing early and so contains high level of lignin. Forage quality and availability vary greatly from season to season which however, affect the output of the animals. One possible way to mitigate this challenge and maintain production in the tropics is to introduce unconventional feeds which cannot be consumed by man but can be converted by ruminants into desirable human food. This will go a long way in reducing the cost of production without a decrease in productivity (Odeyinka, 2001).

Leguminous forages and the foliage of multipurpose trees which are found in Africa are promising sources of protein if used as a supplement to ruminants receiving low-quality forages (Devendra, 1990). Likewise, the potential value of browse trees lies in the provision of protein, vitamins and also the mineral elements that are lacking in grassland pastures during the dry season (Bamikole *et al*., 2004). There are many forage plants that have the ability to produce high yields of biomass, but could not be utilized for improvement of livestock production because the information on their nutrient composition is not known.

A sustainable way of improving the feeding value of poor-quality pastures is through supplementation with browse plants. Browse plants are edible parts of trees, shrub/bushes and other woody-stemmed plants which are available for animal consumption, mainly leaves, fruits and shoots. These plants include, *Morinda lucida*, *Moringa oleifera*, *Ficus exasperata*, *Pentaclethra macrophylla* and *Palisota hirsute*. Browse plants survive long dry season as source of supplementary proteins, this is because they survive long dry season by the possession of deep rooting habit, low transpiration xerophytic foliage and often have good water-harvesting architecture. These make browse plants remain green in the dry season when other vegetation has senesced (Fajemisin, 2015).

There are different methods of assessing nutritive value of plants, these include chemical analyses, *in-vitro* digestibility and feeding trial. The *in-vitro* degradability method is a laboratory estimation of rate and extent of nutrient disappearance in livestock feed sample for the purpose of assessing the potential nutritive value of the feed. It is also a method that is reproducible and parameters obtained correlate well with *in vivo* trials (Fajemisin, 2002). *In vitro* gas degradability method has the advantage of not only being less expensive and less time consuming but it allows for more precision in experimental conditions than the *in vivo*

method (Makkar, 2002). It is convenient, fast and allows a large number of samples to be handled at a time. It is based on the quantification of substrate degraded and of gas or short chain fatty acid produced in rumen fermentation system. (McDonald *et al*., 1995). Thus, this study was designed to evaluate the nutritional composition of *Morinda lucida*, *Moringa oleifera*, *Ficus exasperata*, *Pentaclethra macrophylla* and *Palisota hirsute* using the *in vitro* gas production technique.

Materials and methods

Experimental site

The experiment was carried out in Yaba College of Technology, Epe Campus, Lagos State. It is situated at latitude 6.58°N and longitude 3.98°E. It is 42m above the sea level along Epe Ijebu-ode road on km 16. Epe lies in lowland rain forest vegetation zone within the savanna agro-ecological zone of Southwest Nigeria (Google earth, 2016).

Collection of samples

Five plants were collected around the premises of the College in the month of June with the aid of cutlass. The forage plants were: *Morinda lucida, Palisota hirsute, Moringa oleifera, Ficus exasperata,* and *Pentaclethra macrophylla.*

Preparation of samples

Harvested samples from each of the five selected forages were pooled for each individual plant species and sub-samples were taken and oven dried at 65°C to constant weight for 3 days to determine the dry matter. Dried samples were milled and sieved to 1.0mm particle size, bulked individually and stored in an air tight container till the time required for chemical analysis. Chemical composition of the selected plants was done according to AOAC, 2005. The *in vitro* digestibility was carried out at the laboratory of the Department of Animal Nutrition, Federal University of Agriculture, Abeokuta, Ogun State both in Nigeria.

In vitro gas production and digestibility

In vitro degradability was carried out on the selected forages. Rumen fluid was obtained from six WAD goats using the method for collection as described by Babayemi and Bamikole (2006) using a stomach tube from these animals that were fed with 40% concentrate feed containing (40% corn, 10% wheat offal, 10% palm kernel cake, 20% groundnut cake, 5% soyabean meal, 10% brewers' grain, 1% common salt, 3.75% oyster shell and 0.25% fishmeal) and 60% *Panicum maximum* at 5% body weight. The rumen fluid was collected before morning feeding into thermos flask that was pre- warmed to a temperature of 39°C.

Incubation procedure involved 120mL calibrated transparent plastic syringes with fitted silicon tube. Samples were milled and sieved. Each milled sample weighing 200mg was carefully put into incubation bag, sealed with the aid of sealing machine and dropped into the syringe and thereafter 30mL inoculum containing cheese cloth strained rumen liquor and buffer 1g per litter of ($NaHCO_3$+$_3Na_2HPO_4$+KCl +NaCl+$MgSO_4$.$7H_20$+$CaCl_{2.2}H_20$) plastic calibrated syringe. The syringes were inverted, tapped and the content pushed upward by the piston to eliminate air in the inoculum. The silicon tube in the syringe was then tightened by a plastic and metal clip to prevent escape of gas. The syringes were carefully arranged in the incubator and maintained at a temperature of 39°C. Incubation was carried out at 39 + 1°C and the volume of gas production was measured at 3, 6, 9, 12, 15, 18, 21, 24, 27, 30, 33, 36, 39, 42, 45 and 48 hours. At post incubation period 4mL of NaOH was introduced to estimate methane production Fievez *et al;* 2005). The mean volume of gas produced

from blank syringe was deducted from the volume of gas produced from sample. After estimating methane, bags containing residue was dried in the oven at 60^0C for 24 hours, weighed and digestibility was calculated as follows:

Metabolizable energy (ME, MJ/Kg DM) and organic matter digestibility (OMD %) were estimated (Tilley and Terry 1963) and short chain fatty acids (SCFA (mL) was calculated (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.

Statistical analysis and experimental model

Data collected were subjected to one way analysis of variance and significant differences among means were compared using Duncan Multiple Range test (SAS, 2005)

$Yij = \mu + Ti + \square ij$

Where

Yij = Observed value of dependent variable

μ =Population mean

Ti = Mean effect of selected browse plants

□ij = Random residual error

Results

Proximate composition of selected plants

Proximate composition of selected plants as presented in Table 1 showed that there were significant differences in the parameters observed. The dry matter (DM) ranged from 86.83% to 89.78% in *Palisota hirsute* and *Pentaclethra macrophylla* respectively. The highest crude protein (CP) content (27.20%) in all the selected plants was observed in *Moringa oleifera* while the least value (17.87%) was obtained in *Palisota hirsute*. Crude fibre (CF) was significantly varied from 4.17% to 7.08% in *Morinda lucida* and *Moringa oleifera* respectively. Ash content in *Moringa oleifera* (10.09%) was ($P<0.05$) higher when compared to other plants. *Moringa oleifera* had the highest value (6.33%) ether extract (EE) while the least value (4.03%) was observed in *Ficus exasperata*. Organic matter (OM) (96.13%) was higher in *Pentaclethra macrophylla* when compared to other plants.

Percent fibre content of the selected plants

As shown in Table 2, *Ficus exasperata* recorded significantly higher value of 62.36% in NDF while the least value (53.39%) was observed in *Pentaclethra macrophylla*. ADF values ranged from 20.19 to 32.29% in *Ficus exasperata* and *Pentaclethra macrophylla* respectively. Cellulose was least ($P<0.05$) in *Ficus exasperata* (5.31%) and higher content was recorded in *Pentaclethra macrophylla* (21.69%). Hemicellulose ranged from 21.10 to 41.87% in *Pentaclethra macrophylla* and *Ficus exasperata* respectively.

***In vitro* gas production (ml/200mgDM) of selected browse plants at twenty-four hour**

Steady increment in *in vitro* gas production of the selected plants was observed as incubation period progressed from 3 hour to 24 hour of incubation as shown in Table 3. At 3 hour of incubation there was no significant (P>0.05) variation in the volume of gas produced in all of the plants recorded. Gas production by *Pentaclethra macrophylla* was consistently high (P<0.05) throughout the incubation period from 9 – 24 hour. At 24 hour of incubation *Pentaclethra macrophylla* recorded higher volume of gas production (18.00mL/200mg) while *Morinda lucida* recorded the lowest (9.00ml/200mg) volume of gas produced.

Methane gas (CH_4) production (ML/200mgDM) estimated short chain fatty acid (SCFA, mmol), organic matter digestibility (OMD,%) and metabolizable energy (ME, MJ/kgDM) of the selected plants

The metabolizable energy, organic matter digestibility, short chain fatty acids and methane production of the selected plants are presented in Table 4. There were significant (P<0.05) variations in all the parameters measured. *Pentaclethra macrophylla* had significant highest ME value (4.65MJ/kgDM) while the least value (3.42MJ/kgDM) was observed in *Morinda lucida*. The least organic matter digestibility value (22.88%) was obtained in *Moinda lucida* while significant higher value (30.88%) was observed in *Pentaclethra macrophylla*. The SCFA ranged from 0.16 mmol to 0.37 mmol in *Morinda lucida* and *Pentaclethra macrophylla* respectively. *Morinda lucida* and *Moringa oleifera* recorded similar lower gas production volume (1.33 ML/200mgDM) while the higher significant (P<0.05) volume of gas production (3.67 ML/200mgDM) was observed in *Pentaclethra macrophylla*.

Table 1: Proximate composition of selected browse plants

Plants	Dry matter	Crude protein	Ether extract	Ash	Crude fibre	Organic matter
Morinda lucida	87.27^{c}	18.08^{d}	4.39^{d}	8.73^{b}	4.17^{d}	91.44^{d}
Palisota hirsute	86.83^{e}	17.87^{e}	4.53^{c}	7.62^{c}	5.48^{b}	92.38^{c}
Moringa oleifera	88.20^{b}	27.20^{a}	6.33^{a}	10.09^{a}	7.08^{a}	89.91^{e}
Ficus exasperata	87.08^{d}	22.25^{c}	4.03^{e}	5.40^{d}	4.30^{c}	94.60^{b}
Pentaclethra macrophylla	89.78^{a}	23.02^{b}	6.01^{b}	3.87^{e}	5.60^{b}	96.13^{a}
SEM	0.29	0.93	0.25	0.60	0.29	0.60

^{abcde} Means along the same column with different superscript are significantly different (P<0.05) SEM= Standard error of mean

Table 2: Fibre fraction of selected browse plants

Crude fibre fractions					
Plants	NDF	ADF	ADL	Cellulose	Hemicellulose
Morinda lucida	60.39^{b}	30.27^{c}	10.76^{d}	19.51^{b}	30.13^{b}
Palisota hirsute	60.20^{b}	30.17^{c}	14.21^{b}	15.96^{c}	30.04^{b}
Moringa oleifera	60.15^{b}	31.65^{b}	11.80^{c}	19.85^{b}	28.51^{c}
Ficus exasperata	62.36^{a}	20.19^{d}	15.18^{a}	5.31^{d}	41.87^{a}
Pentaclethra macrophylla	53.39^{c}	32.29^{a}	10.60^{d}	21.69^{a}	21.10^{d}
SEM	0.82	1.15	0.50	1.57	1.78

^{abcd} Means along the same column with different superscript are significantly different (P<0.05) SEM= Standard error of mean, NDF= Neutral detergent fibre, ADF= Acid detergent fibre ADL=Acid detergent lignin

Table 3: *In vitro* gas production (mL/200mgDM) of selected browse plants at twenty-four hour

Plants	3hrs	6hrs	9hrs	12hrs	15hrs	18hrs	21hrs	24hrs
Morinda lucida	1.00	1.70^{ab}	4.00^{b}	5.33^{c}	6.67^{c}	7.67^{d}	9.00^{d}	9.00^{d}
Palisota hirsute	1.00	2.00^{ab}	4.00^{b}	5.33^{c}	7.33^{c}	9.00^{cd}	10.33^{cd}	11.33^{c}
Moringa oleifera	1.00	1.00^{b}	5.67^{b}	7.67^{b}	9.67^{b}	11.00^{bc}	12.00^{bc}	13.33^{b}
Ficus exasperata	1.00	3.00^{a}	5.00^{b}	7.67^{b}	8.33^{bc}	13.33^{ab}	14.00^{b}	14.00^{b}
Pentaclethra macrophylla	1.00	2.30^{ab}	9.30^{a}	10.67^{a}	13.00^{a}	14.00^{a}	16.67^{a}	18.00^{a}
SEM	0.00	0.24	0.56	0.58	0.65	0.72	0.77	0.83

^{abcd} Means along the same column with different superscript are significantly different (P<0.05) SEM= Standard error of mean

Table 4: Methane gas (CH_4) production estimated short chain fatty acid (SCFA), organic matter digestibility (OMD) and metabolizable energy (ME) of the selected plants

Post incubation parameters

Plants	CH4	SCFA	OMD	ME
Morinda lucida	1.33^{c}	0.16^{d}	22.88^{d}	3.42^{d}
Palisota hirsute	2.33^{bc}	0.21^{c}	24.96^{c}	3.74^{c}
Moringa oleifera	1.33^{c}	0.26^{b}	27.73^{b}	4.01^{b}
Ficus exasperata	3.00^{ab}	0.27^{b}	27.33^{b}	4.01^{b}
Pentaclethra macrophylla	3.67^{a}	0.37^{a}	30.88^{a}	4.65^{a}
SEM	0.29	0.02	0.74	0.11

^{abcd} Means along the same column with different superscript are significantly different ($P<0.05$) SEM= Standard error of mean, CH_4 = Methane, SCFA = Short chain fatty acid OMD = Organic matter digestibility, ME = Metabolizable energy

Discussion

Okoli *et al* (2003) stated that proximate analysis is specifically useful in screening the array of tropical browse plants utilized by indigenous farmers for ruminant feeding. The CP contents of the present study (17.87 – 27.20%) compared favourably and in some cases exceeded those reported in some literature for some browse plants in southeastern part of Nigeria (Ahamefule *et al*., 2006). The CP values recorded for all the plants were above 8% required to satisfy the maintenance requirement for ruminants (Norton, 2003) and above the minimum level necessary to provide sufficient nitrogen required by rumen microorganisms to support optimum rumen activity (Mc Donald *et al*., 2002) and for adequate intake of forages.

The CP recorded for *Ficus exasperata* (22.25%) was lower than the reported CP of 23.20% by Isah *et al*., (2012) for the same plant. The CP observed in sun-dried *Moringa oleifera* (27.20%) was higher than the CP recommended (26.20%) by NRC (1985) for early weaned lambs-moderate and rapid growth potential and was also higher than the CP range 13.57 – 16.63% reported by Adebayo *et al*., 2019 in some selected forages consumed by small ruminants. High CP recorded in *Pentachethra macrophylla* (23.02%) compared favourably with the report of Isah *et al*., (2012) who reported 25.61 and 24.74% for *Syndrella nodiflora* and *Boerhavia diffusa* respectively. The variation in crude protein values recorded in this study when compared to other literatures could be attributed to the influence of the sun on the protein which perhaps might have been denatured.

The range of DM values (86.83 - 89.78%) in the present study was higher than the reported values of 32.04, 19.39, 16.38 and 15.88% in *Azadirachta indica, Ficus exasperata, Syndrella nodiflora* and *Boerhavia diffusa* respectively by Isah *et al*., (2012). However, Ikhimioye (2008) reported a DM content (38.70%) for selected leaves of shrubs and trees in Nigeria. The differences observed in the

DM values obtained in this study and those of other researchers could be as a result of the seasonal or climatic factors, stage of growth, maturity, soil type, species or variety as well as the ambient temperature and growth environment as supported by Agriculture (2011).

The crude fibre (CF) content of the various plants in the present study fell below the recommended values of 15 – 20% for improved intake and production in finishing ruminants (Buxton, 1996).

The values reported for ether extracts of the sun-dried plants (4.03 – 6.33%) fall within the range of 4 - 10% EE recommendation (Preston, 1995 and Campbel *et al*., 2006). The higher EE in some of the tested samples is an indication of higher energy level for the animals (Babayemi and Bamikole, 2006; Odedire and Babayemi, 2008) and this major form of energy storage in plants which is being utilized by the animals for body maintenance and production. The values of organic matter content which ranged from 89.91 – 96.13% compared favourably with OM values (83.3, 83.6, 88.9, 92.5 and 94.0%) reported by Fadiyimu *et al*., (2011) for *Ficus exasperata. Ficus thonningii, A. africana, Moringa oleifera* and *Spondia mombin* respectively. These discrepancies could be attributed to anatomical differences between plant species which according to Phuc (2006) depend on effect of plant development and on leaf: stem ratio.

The values of NDF reported in the current research were higher compared to the reported values of NDF for *Leuceana leucocephala* (29.21g/100g), *Moringa oleifera* (26.31g/100g) and *Gliricidia sepium* (29.61g/100g) by Asaolu *et al* (2011). Abegunde *et al* (2011) reported higher values of 67.0 and 88% for *Ficus polita* in the dry and wet seasons respectively. The range of the NDF values in the present study was higher than the safe upper limit of 60% (Meissner *et al*., 1991) for forage intake by sheep.

Results of *in vitro* gas production characteristics (ME, OMD and SCFA) of the forages estimated from gas production revealed that metabolizable energy (ME) values obtained in this study (3.42 – 4.65MJ/kgDM) was higher than the reported values by Babayemi (2007) for *Leuceana leucocephala* (8.31 MJ/kgDM), *Gliricidia sepium* (11.88 MJ/kgDM) and *Centrosema pubescens* (9.95 MJ/kgDM). Adebayo *et al*. (2019) reported 7.57, 7.67, 6.47 and 9.22 MJ/kgDM for sun-dried *Gmelina arborea*, *Leuceana leucocephala, Mangifera indica* and *Moringa olifeira* respectively. Akinfemi *et al*., 2020 reported 17.02 – 33.09 MJ/kgDM, ME in rice straw treated with urea-molasses. Lower ME reported when compared with other reports mentioned could be ascribed to some certain secondary metabolites in the selected plants as corroborated by Aregheore and Abdulrazak (2005).

Short chain fatty acid (SCFA) recorded in this study ranged from (0.16 – 0.37 Mmol). Babayemi (2007) reported higher value of SCFA in *Gliricidia sepium, Leuceana leucocephala* and *puerraria phaseoloides* (1.35, 0.90 and 1.23 Mmol) respectively.

The amount of gas released when feeds are incubated in *in vitro* has been reported to be closely related to digestibility of feed for ruminants (Mebrahtu and Tenaye, 1997). *Pentaclethra macrophylla* produced the highest gas at 48 hour of incubation when compared with other plants, this is in line with the report of Isah *et al*., (2012) which could be as a result of higher crude protein content of the plants. However, the result contradicts the observation made by Sallam *et al*., (2007) that fibre components negatively affect gas production. High crude protein in feed enhances microbial multiplication in the rumen, which in turn determines the extent of fermentation.

Conclusion

Selected plants evaluated in this study had high crude protein contents which would

make them good protein supplement to poor quality feeds for ruminants especially during feed scarcity without detrimental effect on the animals.

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