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Evaluation of the Nutritive Value of Selected Browse Plant Species in the Southern Guinea Savannah of Nigeria for Feeding to Ruminant Animals

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Authors' contributions

This work was carried out in collaboration between all authors. Author DOO designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript and managed literature searches. Authors GOT and FKO assisted in the management of the analyses of the study, literature searches and reviewers comments. All authors read and approved the final manuscript.

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ABSTRACT

One of the major problems of ruminant production in the tropics is the scarcity of quality forage all the year round. *Gliricidia sepium* which remains green even during drought has been extensively used for forage during forage scarcity. However, there is need to screen more browse species to broaden the feed base to improve ruminant animal production. Ten common but less utilized browse plants (*Ficus polita*, *Ficus cogensis, Daniella oleiveri*, *Prosopis africana, Parkia biglobosa*, *Gliricidia sepium*, *Ecliptaalba*, *Albizia odoratissima*, *Polyalthia longifolia* and *Moringaoleifera*) were

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evaluated for their nutrient composition. Results showed that crude protein content was highest (29.60%) in *Moringa oleifera* and lowest (15.84%) in *Daniella oleiveri*. Crude fibre compositions ranged between 13.87% - 29.33% in *Albizia odoratissima* and *Parkia biglobosa* respectively. A range of 3.25% - 6.30% and 6.68%-9.45% values were recorded for EE and ash respectively for the ten browse plants. The values reported for mineral content showed that *M. oleifera* had the lowest value of Ca (0.68%), P (0.15%) and Mg (0.25%). *Eclipta alba* was observed to be richest in mineral elements amongst the browse species with the highest concentrations of Ca, Mg, P, K, Zn, Fe, Cu and S. The fibre contents of the forages showed a range of 42.41 to 61.31, 29.51 to 49.58, 5.71 to 9.27, and 10.98 to12.90 for NDF, ADF, ADL and hemicelluloses respectively. The non-fibrous carbohydrate (NFC) contents of the browse species were observed to vary widely ranging from 6.59 (*Pakia biglobosa*) to 22.16% (*Gliricidia sepium*). The values reported for anti-nutritive factors (tannin, saponin, phytate and oxalate) were low in all species. The results of this study showed that the browse species in general contained high levels of nutrients and hence have potential as good feedstuffs for ruminant animal feeding.

Keywords: Chemical composition; browse plants; Eclipta alba; Daniella oleiveri.

1. INTRODUCTION

Ruminant animals play a very prominent role in Nigeria most especially in the southern part of the country. Ruminant animal production is a means of sustainability to people living in rural, peri-urban and urban areas. Livestock, in a mixed farming system, serves as financial reserve for the populace to face risk and uncertainty in harsh weather [1] when crops may fail. Products such as milk, meat, manure are obtained majorly from ruminants to improve people's livelihood and provide critical nutrients to support food and health. Nonetheless, poor feeding and quality of feeds available have hindered the animal productivity. Good quality forage is of importance for high productivity of animals all the year round.

Studies have shown that feed intake [2] contributes to animal's productivity but milk yield and growth of ruminant animals are largely affected by the quality of forage [3]. However, due to high cost of conventional feedstuff, some workers [4,5,6] both in Nigeria and abroad have conducted research on the utilization of alternative feed ingredients– particularly browse plants which are not utilized as human foods thus not in direct competition with man [7]. Many of these browse species that may be relished by ruminants require further evaluation to determine their nutritive values for livestock. Bamikole et al. [8] in their evaluation of some Ficus species observed that the foliage of browse plants are the reservoir of valuable nutrients such as proteins, vitamins and minerals that are not found in grasses and other crop residues, that can be critically important most especially during the dry season.

Sheep, a ruminant specie, are usually on popular demand during the Muslim festivals in Nigeria, especially in the parts of the country where the population is predominantly Muslims. However, inadequate nutrition has been a main factor limiting its production in the tropics, mainly attributed to the unavailability of feed all year round.

Composition of feed given to animals has a very significant influence on animal performance such as fibre, milk production/quantity as well as growth performance (meat production). Various physiological stages - maintenance, growth, pregnancy, lactation, and fiber - production underlie the differing nutritional requirements of livestock.

Dry season, in Nigeria signifies a period of scarcity of quality feeds to animals most especially ruminants dependent on forages as the major component of the diet. The conventional concentrate or supplemental feed resources (grains) available during this critical period are very expensive to feed ruminants because of the direct competition with human food needs. This situation has indeed necessitated the search for cheaper and readily available feed materials that can meet the nutritional requirements of farm animals for better productivity. The multipurpose trees (MPTS) used as fodders are unique in that they may also serve other purposes such as food, fruits, fibre, timber, wood, shade, live fences etc across the agro-ecological zones in Africa and in the world. In addition, they act as carbon dioxide (CO_2) sinks from the air and create a favourable environment during harsh weather. Most of these MPTS have hitherto not been systematically exploited for strategic year round livestock

production; especially during dry the season to boost improved productivity.

Nonetheless, much research had been carried out on the use of MTPS as feed resources for livestock. Luu et al. [6] studied the introduction and evaluation of *Moringa oleifera* and observed that the plants could be harvested seven times/ year, and the annual fresh biomass yield could be from 43 to 52 tones/ha, used as a sole feed for goats. During the early growth stage of these browse plants, arable crops can be intercropped which would serve as a source of additional income to the farmer. Ogunbosoye and Babayemi [9] reported that the daily weight gain of animals fed *Albizia odoratissima* was highest when compared with other existing and well recognized browse trees. In his study, Teferedegne [10] pointed to the role being played by ruminants in the livelihood of farmers in the developing world, including milk, meat, animal traction and manure for improved crop production. He further reported that local trees (legumes) have been investigated as potential supplements for ruminants because of their beneficial effect of increasing metabolizable energy, N intake and feed efficiency and thereby improving animal production. He reported that foliage of some tree plants, however, has been shown to be selectively toxic to rumen protozoa with chemical compound acting as anti –protozoa or natural defaunating agent.

Khanal and Subba [11] also evaluated nutritional composition of some fodder trees in Nepal with result further revealing that they could be relevant to animal nutrition.

Evaluation of more feeds will provide nutritionists with the necessary information to formulate diets from both a physiological and an economical point of view in order to optimize animal performance. Therefore, the objective of this study was to measure the nutritive characteristics of selected fodder species as feeds for ruminant animals in Nigeria.

2. MATERIALS AND METHODS

2.1 Collection of Forages

The legumes (*Parkia biglobosa, Gliricidia sepium, Prosopis africana, Albizia odoratissima*) and non-legumes (*Daniella oleiveri, Eclipta alba, Ficus polita, Ficus cogensis, Moringa oleifera, Polyalthia longifolia*) browse trees and shrubs were collected at the peak of the dry season (February 2014) from Malete (Lat 8º 71ˈN and Long 4º 44ˈE), Moro Local Government, Kwara State, Nigeria. Fresh leaves were defoliated, oven dried to a constant weight at 105ºC to determine the dry matter and later ground to pass through a 1 mm sieve for subsequent analyses.

2.2 Chemical Analysis

The ground samples were analyzed for crude protein, crude fibre, ether extract and ash contents following standard procedures as outlined by AOAC [12]. Crude protein was determined by the micro-kjeldahl procedure (N × 6.25), ash by incineration at 500ºC for 2 hours in a closed furnace and acid detergent fibre (ADF), neutral detergent fibre (NDF), acid detergent lignin(ADL)were assessed using the method proposed by Van Soest et al. [13]

Analysis for mineral levels of the sampled browse plant species was determined by wet digestion using nitric-perchloric acid and mixture. The mineral elements Calcium (Ca), Magnesium (Mg), Iron (Fe), Copper (Cu), Zinc (Zn, and Manganese (Mn) were determined by atomic absorption spectrophotometer (AAS) (Model 490 Gallen Kamp London, UK while the flame photometer (FP 419 Corning) was used to estimate the Sodium (Na) and Potassium (K) elements. Phosphorous concentration was determined colorimetrically as outlined by Parkinson and Allen [14].

The non-fibrous carbohydrate (NFC) was calculated as 100 – (%NDF + % CP + %EE + %Ash) using the equation of NRC [15] where NDF is the neutral detergent fiber, CP is the crude protein and EE is the ether extract of the tested browse plant species.

Anti-nutritional factors (tannin, saponin, phytate and oxalate) were determined as outlined in previous publication [16,17,18].

3. RESULTS

The chemical composition of the browse foliage is shown in Table 1. The browse plants were grouped in to legume (n=4) and non-legume (n=6). Although, there was no distinct different between the two groups, however, significant variations (P=0.05) were observed among the nutrients measured. Both the highest and lowest crude protein (CP) content were recorded within the non-leguminous plant species with *Moringa oleifera* highest (29.6%) and lowest *Daniella oleiveri* (15.84%). All the plant species in this

study have their CP level within the acceptable range (7-14%) for ruminant diets. Variations were observed in the crude fiber contents of the browse plants. The legume (*Parkia biglobosa)* had the highest percentage while the least value was recorded against *Daniella oleiveri* (non-legume). The highest value of ether extract was obtained in *Daniella oleiveri* which is an indication of high energy. The ash contents ranged from 6.68% to 9.48% in *Polyalthia longifolia* and *Albizia odoratissima* respectively. There was no significant difference in the NFC contents of the browse species. The fibre fraction of the foliage of browse plants also indicated that legumes had the higher contents of NDF, ADF, and ADL than the non-leguminous browse plant species.

Table 2 shows the composition of macro and micro mineral concentrations of the browse plants. The highest concentration of all the mineral components was observed in *Eclipta alba* leaves which is a non-leguminous plant. This is showing the richness in minerals of *Eclipta alba.*

Presented in Table 3 is the anti-nutritional factors of the foliage of browse plant species. The results revealed that all the browse species contain low anti-nutritional factors. Indicating that animal will be able to consume these plants to their satisfaction because none of the values was up to 1%.

4. DISCUSSION

The value of CP content in *M. oleifera* reported here is comparable to that reported by Fadiyimu et al*.* [19] for browse plants which was between 17.1 and 31.2%. All the browse species in this study have their CP level higher than the acceptable range (7-14%) for ruminants [20]. The crude protein content of all the browse in this study was however higher than the values obtained for species of Ficus and *Spondias mombin* [8,21]. A higher CP concentration of Moringa was observed when compared with what was obtainable elsewhere [6]. Also, Ogunbosoye [5] reported a lower percentage CP (15.99%) for *Albizia odoratissima.* The difference in CP content among species and between values from samples collected in different studies 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 leguminous plants. The other factors causing variation in the chemical composition of browse may be soil type (location), the plant part (leaf, stem, pod), age of leaf and season at which the plants were harvested. With regard to the location, some authors have reported that browse plants in the sahelian zone are higher in nitrogen compared to plants in the humid zone Rittner and Reed [22). This may likely be the case of the present study which was carried out in Southern guinea savannah area. The CP contents of these browses were higher than the minimum of 7- 8% necessary to provide the minimum ammonia levels required by rumen micro-organisms to support optimum rumen activity Norton [23]. In addition, high protein in the forage should be aimed at as it will favourably enhance intake and digestibility. This indicates the browse plants under this study may be well utilized as a protein supplement to low quality feed such as grasses and crop residues due to a higher level of crude protein of all the browse plant species. The highest value of ether extract obtained in *Daniella oleiveri* is an indication of high energy feed. Ether extract is the lipid component and the energy derived from it is utilized by the animal for body maintenance and production. Foidl et al. [24] reported that EE in the feed is also a source of carotene and pigment, but it is observed in this work that EE was generally low and therefore may indicate a low level of carotene and pigments. Nonetheless, the EE value was higher than the report (0.31-1.08%) of Isah et al. [21] on some browse species in Edo State, Nigeria but lower than what Luu et al. [6] Ogunbosoye and Otukoya [25] reported on Moringa and some fodders in Nigeria (5.95 - 18.58%). The result, nonetheless compared favourably to the report of Mbomi et al. [26] for Tephrosia species (3.39 - 4.26%). The ash content of any feed indicates the mineral level and the values in this present work compared very well with the observations made in another study [26] which reported ash ranges of 9.79 to 11.85%. Non-fibrous carbohydrate (NFC) level of the fodders is higher than the values obtained by Mirzael-Aghsaghali et al. [27] suggesting these fodders to be good source of energy to ruminants. The NFC serves as sources of energy in the diets of ruminant animals but the optimal dietary of NFC in dairy diets is suggested to be between 30-40%DM [28]. The values of NFC of these browse species is moderate and may serve as good diet for all classes of ruminant animals.

Table 1. Chemical composition (%DM) of legume and non- legume browse plant foliage

Browse species	CP	CF	EE	Ash	NFC	NDF	ADF	ADL	HC
Parkia biglobosa	19.90cd	29.36a	3.98bc	8.25abc	6.59e	61.32a	49.58a	9.14a	11.73
Gliricidia sepium	20.61cd	16.20de	3.25c	9.14a	22.15a	44.84cd	31.25d	6.96d	13.59
Albizia odoratissima	24.43b	13.87e	3.51bc	9.48a	20.18a	42.41d	29.51d	5.71e	12.90
Prosopis africana	16.20e	17.54d	4.02bc	7.15c	20.14a	52.07abc	41.71bc	7.68bcd	10.36
Non-legumes									
Daniella oleiveri	15.34e	21.64c	6.30a	7.23c	13.41bc	57.72a	45.26ab	8.80ab	12.48
Eclipta alba	15.80e	22.05c	6.23a	7.36c	10.44d	59.87a	48.81ab	9.27a	11.06
Ficus polita	20.74d	24.23bc	3.86bc	7.84bc	11.74cd	54.82ab	43.84ab	8.24abc	10.98
Ficus cogensis	18.22de	25.56b	3.68bc	6.77c	12.39bcd	58.94a	47.38ab	8.96a	11.64
Polyalthia longifolia	17.33e	26.74ab	4.05bc	6.68c	14.04b	57.90a	45.95ab	8.77ab	11.95
Moringa oleifera	29.60a	15.87c	4.62b	7.91bc	20.06a	46.81cde	35.83cd	7.51cd	10.94
SEM	0.82	0.97	0.22	0.21	0.93	2.88	2.14	0.36	0.21

abcde= means on the same column with different letters are significantly different (P < 0.05), NDF- Neutral detergent fibre, ADF- Acid detergent fibre, ADL- Acid detergent lignin, NFC= Non fibrous carbohydrate, HC= Hemicellulose

Table 2. Macro and micro mineral composition (DM basis) of browse plants leaves collected in Nigeria during the dry season

Browse specie	Ca, %	Mg, %	P, %	Na, %	K, %	Zn, mg/kg	Fe, mg/kg	Mn, mg/kg	Cu, mg/kg	S, %
Parkia biglobosa	1.05abc	0.54d	0.35b	0.45abc	2.78abcd	34.10a	295.8a	61.70ab	6.10bcd	1.79
Gliricidia sepium	0.73def	0.41abc	0.34b	0.25de	1.93f	29.10bc	273.6a	47.10c	5.40cde	1.54
Albizia odoratissima	0.83f	0.34bc	0.25c	0.30bcde	2.45bcdef	29.10bc	271.3a	52.40bc	6.20bcd	1.69
Prosopis africana	0.88cde	0.25cd	0.30bc	0.47ab	2.24ef	27.50c	270.4a	46.80c	5.05bcd	1.69
Non-legume										
Danilla oleiveri	1.22a	0.63a	0.45a	0.53a	2.96ab	35.10a	301.5a	64.40a	7.10ab	1.89
Eclipta alba	1.25a	0.63a	0.49a	0.56a	3.02a	35.50a	304.5a	65.55a	7.45a	1.92
Ficus polita	0.93bcd	0.47abc	0.27c	0.40bcde	2.55abcde	31.45ab	287.5a	56.70ab	5.45cde	1.57
Ficus cogensis	1.14ab	0.58ab	0.38b	0.49ab	2.85abc	34.80a	196.4b	62.40ab	6.40abc	1.69
Polyalthia longifolia	0.78de	0.31ab	0.18d	0.27c	2.36cdef	27.70bc	269..6a	67.50a	4.80e	1.52
Moringa oleifera	0.68ef	0.35bc	0.15d	0.19e	2.26def	28.40bc	271.4a	46.40c	5.20de	1.55
SEM	0.05	0.04	0.05	0.03	0.08	0.74	6.12	2.22	0.17	0.05

abcdef= means on the same column with different letters are significantly different (P < 0.05), Ca-Calcium, Mg-Magnesium, P-Phosph Ca-Calcium, Mg-Magnesium, P-Phosphorus, Na-Sodium, K-Potassium, Zn-Zinc, Mn-Manganese, Cu-Copper, S-Sulphur,

Table 3. Anti-nutritional factor (%DM basis) of browse plants leaves collected in Nigeria during the dry season

Browse specie	Tannin	Saponin	Phytate	Oxalate
Parkia biglobosa	0.49a	0.57a	0.30a	0.19a
Gliricidia sepium	0.28b	0.33c	0.20b	0.10b
Albizia odoratissima	0.29b	0.31c	0.21b	0.11b
Prosopis africana	0.28b	0.33c	0.20b	0.10b
Non-legume				
Daniella oleiveri	0.49a	0.58a	0.31a	0.20a
Eclipta alba	0.50a	0.59a	0.31a	0.20a
Ficus polita	0.48a	0.57a	0.29a	0.21a
Ficus cogenesis	0.33b	0.45b	0.28a	0.21a
Polyalthia longifolia	0.33b	0.45b	0.28a	0.21a
Moringa oleifera	0.27b	0.31c	0.19a	0.09b
SEM	0.04	0.033	0.01	0.01

abc= means on the same column with different letters are significantly different (P < 0.05)

The fiber concentration of the tested fodders falls within the range reported by [29] but NDF and ADF contents were higher compared to the values reported by Njidda [30]. Meissner et al. [31] observed that NDF level of forage above 65% can limit feed intake. However, it is interesting to note that there is no browse species of the present study that is up to that threshold level. In general, the NDF and ADF are within the range (24 - 61% and 17-61% respectively) documented for forages used in ruminant feeding [32,33]. This is suggesting that the intake of the tested browses will not be hindered. The lignin contents of browse species in question is moderate as it is known that lignin is a component of the cell wall and deposited as part of the cell wall-thickening process [34].

All the browse forages had lower Ca than the recommended requirement (g/kg^{-1}DM diet) for growing cattle (2.6-10.8), pregnant cows, (2.1 - 3.5) and lactating cows (2.9 – 5.3) [35]. Router and Robinson [36] suggested Ca requirement for maintenance of growing and lactating sheep to be 1.2-2.6 g/kg. *Eclipta alba, Daniella oleiveri* and some of the browse species could meet these requirements.

The browse forages had lower levels of P compared to values obtained from other parts of the world. Aganga and Mesho [37] reported lower values of P for browse forages of [35] for browses of Sudan. The observation in the P contents of these browse species suggests that supplementation with phosphorus rich feed is highly necessary. The variation in the content of observed P could be due to the available soil P and soil pH, browse growth stage and proportions of leaf and stem fractions harvested for mineral analyses and sampling season. These are factors that could influence the concentration of phosphorous of any plant species.

All the browse samples analyzed had sufficient Mg level in agreement with the report of Khan et al. [38]. Based on Minson's [3] recommendation of (2.0 g/kg DM Mg) in the diet of ruminants, the browse plants examined had higher levels of Mg. Shamat et al. [35] reported that Mg in tropical forage was not considered to be limiting, although Jumba et al. [39] reported exceptionally low concentrations in Kenyan forages. Na level in this study is observed adequate compared to normal levels (0.36 to 0.57% DM) reported by [35] for other browse forages with exception of *Polyalthia longifolia, Grilicidia sepium* and Moringa. There is general agreement that Na is deficient in most tropical grasses [40]. Sodium deficiency can be corrected by providing salt lick *ad libitum* which can satisfy the requirement for chloride. It has been suggested that high producing ruminants may require dietary potassium levels above 10 g/kg under stress particularly heat stress [41]. Nevertheless, the browse species had higher level of K compared to the report of Isah et al. [21]. Greene et al. [42] and Grings et al. [43] that K concentration appeared to vary as a function of absolute age of the leaf as well as the environmental conditions. The level of K is in consonance with the 70 mg/kg DM recommended daily to meet requirements for a goat weighing 50.0 kg [44,45]. The concentrations of S in the study were consistence with the wide range of data reported [33].

Regarding micro minerals, these species had higher levels of Fe than tabulated requirements of Fe for dairy and beef cattle (50 mg/kg DM)

[46]. Although, its availability could vary due to the fact that Fe is absorbed according to the need and thus its absorption would depend on dietary factors, age of the animal and body Fe status. It has been suggested that 30 mg/kg Zn is a critical dietary level. Tiffany et al. [47] in north Florida reported similar values. High forage concentration of Mn in the dry season was detected and attributed to low rates of Mn translocation and accumulation of Mn in older tissue [46]. All plant species had higher levels of Mn than the normal dietary requirements of 20-40 mg/kg^{-1}DM [15]. Spears [48] observed that there may be decreased forage concentration of Cu with advancing maturity, climate and seasonal changes). It is believed that Cu functions as an essential component of a number of enzymes in plants. The result of this study therefore indicate that all the browse species evaluated were deficient in Cu to meet the daily requirements (18 mg/kg) of range goats [45].

The percentage components of anti-nutritional factors in this present study were in general, very low but comparable with the reports of Bamikole et al. [8]; Mbomi et al. [27]. Among the anti-nutritional factors, the tannin content of the browse species in the present study were considerably lower than the value of 2.05% reported for *Gliricidia sepium* [49]. Values obtained in *F. polita, P. africana, and D. oleiveri* was higher compared to value reported previously (0.13 to 6.31%) by Gidado et al. [50]. A threshold concentration of 5% tannin had been reported above which there is rejection of browse plants [51]. Min and Hart [52] also reported that the action of condensed tannins in forages markedly reduced rumen proteolytics bacterial growth and some bacteolytic populations measured *in vivo*. However, goats are known to tolerate a threshold level of about 9% dietary tannin [20]. The saponin content too was also low as in other leguminous browse species. Oduguwa et al. [53] reported values of 3.24% and 3.47% for *Parkia biglobosa* and *Afzelia africana* respectively. Saponins have been found to be detrimental to protozoa and have been identified as defaunating agents in the rumen [54]. The concentration of saponin in this study is still within tolerable level of 1.5 - 2% [55]. The oxalate content of the browse species was not consistent with the reported values (1.49 to 5.79%) of some browse plants relished by ruminants in Nigeria [19]. It was observed that ruminants can consumed certain quantity of feeds with a high level of oxalate without any deleterious effect [56]. Hence, the concentration of the anti-nutritional factors inherent in these browse species should not pose any negative effect on the animals that may consume them.

5. CONCLUSION

In conclusion, it is generally believed that legumes are reservoirs of higher protein and other nutrients than non-legumuminous browse plants, but the results obtained in this study do not support this statement. Nonetheless, the nutritional composition of these browse plants showed that they can be utilized as sole feed or supplements to balance low quality forages for ruminants due to the high CP level, moderate levels of both macro and micro mineral elements and low anti-nutrients composition. It is suggested that *Eclipta alba* utilization could be encouraged due to its exceptional higher mineral concentrations. The availability of these browse species during off season periods could be an additional advantage to be used as a dry season feed.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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