Rumen Dry Matter Degradability and Preference by West African Dwarf Goats for selected Multipurpose Trees in Nigeria

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Abstract: The incorporation of trees into farming systems is a viable option to profitable and sustainable crop and livestock production. Trees help to reduce reliance on fertilizers, minimize soil erosion, maintain soil fertility, ensure plant diversity and provide a range of useful products like fodder, mulch, timber, food, medicine and crop protection. In Africa, a wide range of tree species are available but only few have been given detailed nutritive characterization taking into consideration both plant and animal factors. This study involved evaluation of seven local and four exotic multipurpose trees for proximate and mineral compositions, rumen dry matter degradability and preference by West African Dwarf goats, with *Leucaena leucocephala* and *Gliricidia sepium* as controls. Crude protein content varied from 17.5% for *Dialium guineense* to 29.9% for *L. leucocephala.* The average crude fibre content was 19.8%. There was no significant difference (P>0.05) in nutrient composition of legume and non-legume browse types. Ca content ranged from 0.02% for *Alchornea cordifolia* to 1.10% for *Grewia pubescens* while P content ranged from 0.004% for *Calliandra calothyrsus* to 0.2% for *A. cordifolia.* Potential degradation varied from 32.8% to 87.5% for *D. guineeense* and *A. cordifolia* respectively while effective degradability was highest in *G. pubescens* and least in *Xylia xylocarpa*. *G. sepium* was the most preferred species by WAD goats followed by *D. guineense* while *Milletia thonningi* and *Enterolobium cyclocarpum* were least preferred. *D. guineense, Inga edulis, A. cordifolia and G. pubescens* were recommended as potential ruminant feed resources.
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1. Introduction

The problem of ruminant production in sub-Saharan Africa is both genetic and nutritional; nutritionally, appropriate techniques for local breeds of ruminants to express their full genetic potential through enhanced feeding systems are lacking. Also, the major feed resources for ruminant animals are natural grasslands, which are becoming increasingly unavailable due to human pressure on land-use and unpredictable drought (precluding animals from herbage preference) which constrain the animals to the insufficient, low-quality available herbage. The use of straws, stovers and crop wastes and by-products such as groundnut and bean haulms, maize cobs, brewers' grains and rice husk as supplements to natural grazing is limited by high fibre contents, low metabolizable energy, crude protein, minerals, vitamins and low to moderate digestibility.

In Nigeria, the two exotic browse species, *Leucaena leucocephala* and *Gliricidia sepium* have shown appreciable forage potentials. However, they have difficulty adapting to the local environment and are susceptible to pests and diseases, such as psyllid attack on *Leucaena.* Furthermore, most native species shed their leaves during the dry season and majority of them possess physical structures and anti-nutritive chemical compounds that are said to protect them against herbivores (Coley et al. 1985), but could reduce their palatability as well as limit their nutrient availability and digestibility (Barry, 1989).

There is therefore, an urgent need to identify alternative fodder sources which are less unencumbered by morphological, biochemical or cultural limitations in livestock nutrition. This is the basis of the present study with the objective to determine the proximate and mineral compositions, rumen dry matter degradability and preference by West African Dwarf goats of eleven multipurpose tree species with *L. leucocephala* and *G. sepium* as controls.

2. Materials and Methods

The study was conducted at the Teaching and Research Farm, University of Ibadan and the International Livestock Research Institute (I.L.R.I.), Ibadan in the rain forest zone of southwestern Nigeria. The species used in the study were harvested in the early dry season (November) from the arboretum of International Institute of Tropical Agriculture (I.I.T.A.), Ibadan and consisted of the followings: *L. leucocephala* (control), *Calliandra calothyrsus, Enterolobium cyclocarpum, Inga edulis, Grewia pubescens, Pterocarpus santalinoides, G. sepium* (control), *Dialium guineense, Prosopis africana, Milletia thoningii, Alchornea cordifolia, Xylia xylocarpa* and *Albizia niopoides.* Leaves were harvested from at least 10 different trees and then pooled and oven dried at 60 °C for 48 h.

Samples for chemical analyses were ground to pass through a 1 mm sieve and then analyzed for proximate and mineral compositions (AOAC 1990). N content was determined using the Kjedahl method and crude protein (CP) calculated as N × 6.25. Dry matter (DM) was determined by drying fresh samples in the oven at 105ºC for 24 hours and ash by igniting the samples in a muffle furnace at 525 °C for 8 h. Nitrogen-free extract (N.F.E.) and organic matter (OM) were determined by difference. Calcium content was determined by flame photometry and Phosphorus by the phosphomolybdate method after digesting the samples.

Samples for dry matter degradability were ground to pass through a 2.5 mm sieve and 3g of each sample were measured in triplicates into weighed Dacron bags. These were then tied onto rubber loops and inserted into the rumen of three matured West African Dwarf (WAD) goats fitted with permanent rumen cannulae for a period of 6, 24, 48 or 72 hours of incubation. After each incubation period, the samples were thoroughly washed under tap water until the water became colorless. Washing loss, or degradability at zero hour, was determined by soaking nylon bags containing 3g of each sample in ordinary warm water (37ºC) for one hour. The bags were then dried to constant weight at 65ºC. The DM degradability of each sample at each incubation time was calculated as the difference in the quantity of DM in the bags before and after incubation (Ørskov et al. 1980). The goats used for the experiment were kept in individual pens and were fed on a diet of fresh *Panicum maximum* (60%) and concentrate (40%). They had unrestricted access to water and mineral licks.

Relative preference for each species was determined using the cafeteria technique (Larbi et al. 1993). It was conducted over a fourteen-day period divided into seven days each of adjustment and data collection respectively. WAD goats (n = 6) averagely weighing 12.7 kg were used. On each collection day, 500g fresh leaves of each species were offered in separate feeding troughs for one hour. The troughs were randomly placed around the perimeter of an $8m^2$ floor pen. Left-over was weighed immediately after to determine consumption of each species. A daily relative preference index for each species was calculated by dividing quantity consumed of the species by the value for the species with highest consumption and multiplying the result by 100. Browse species were ranked based on mean preference index.

The DM degradation data were fitted to the exponential equation

$$P = a + b\,(1-e^{-ct})$$

where P = DM degraded in rumen at time t, a = the rapidly soluble fraction, b = the insoluble but fermentable fraction, c = the constant rate of degradation of b (% h^{-1}), a + b = potential degradability (PD) or extent of degradation and t is the rumen incubation time (Ørskov & McDonald, 1979). Effective degradability (ED) was calculated by applying the equation

$$ED = a + [bc / (c+k)]$$

where k is the rumen outflow rate of 2% per hour.

Values for a, b, c, PD, ED were analyzed by ANOVA (SAS, 1998). The statistical model adopted was

$$Y_{ij} = \mu + \alpha_i + \beta_j + e_{ij},$$

where Y_{ij} = record of the i_{th} species measured in the j_{th} goat; μ = common mean; α_i = effect of the i_{th} species; β_j = effect of the j_{th} goat; e_{ij} = uncontrolled environmental and genetic error. Means were separated by Duncan (1955) methods. Linear correlation and regression analyses were determined using a scientific calculator (Casio *fx*-7400G PLUS POWER GRAPHIC model) to show the relationship between nutrient composition, DM degradability and preference index values.

3. Results and Discussion

From Table 1, average DM content of the selected browse plants was comparable with 38.7% for selected leaves of shrubs and trees in Nigeria (Ikhimioya, 2008) and 40.8% for jackfruit leave (Ly et al. 2001). Species with DM contents >40% probably have hard and coarse leaf texture, as reported by Daovy et al. (2008) for mango leaves. Mean CP content (22.1%) is higher than 14.7% obtained by Ngodigha and Oji (2009) for tropical browse plants. This suggests that the evaluated species have the potential to supply moderate to high levels of CP and can therefore be used as protein supplements to tropical grasses and other low quality feeds in ruminant diets. Difference in CP contents of leguminous (L) and non-leguminous (NL) browse species were not significant. This contradicts the findings of Cobbina et al. (1990) and Larbi et al. (1993), probably because two NL species against eleven L species were used in the study. Mean ash content compares favourably with that reported by Topps (1992) while mean Ca and P contents were slightly lower than those reported by Kabaija and

Smith (1988), probably due to differences in species, climatic and edaphic factors. Apart from *A. niopoides,* Ca:P ratio in all the species are higher than recommended, although the mean is within the range (1:1 – 1:7) in which no harmful effect may occur to the animal, provided the level of the two minerals in the diet are adequate (Underwood, 1981).

Table 2 shows that the species differed significantly (P<0.05) in rumen DM degradability parameters. *Leucaena* had the highest soluble fraction (33.98%) while *D. guineense* had the least (8.19%). Higher level of soluble fraction is known to result in a more efficient fermentation in the rumen (Beever et al. 1978). The differences in soluble fraction could be attributed to the proportion of soluble carbohydrates to structural carbohydrates (Ngodigha and Oji, 2009). According to Van Soest (1982), the soluble carbohydrates ferment faster than structural carbohydrates and their relative proportions are determined by differences in the stage of maturity. This is probably why *Leucaena* with moderate CF content had the highest soluble fraction and *X. xylocarpa* with the highest CF content had the least soluble fractions, apart from *D. guineense*. Degradable fractions (b) in *G. pubescens* and *A. cordifolia* were comparable and significantly higher (P<0.05) than in other plants. Both species could therefore have better potential as sources of highly fermentable nutrients than the other plants especially since they have moderate to high crude protein contents.

Rate of degradation (c) varied from 0.3% h^{-1} in *A. niopoides* to 3.9% h^{-1} in *P. santalinoides*. Abdulrazak et al. (1996) found that 'c' values of foliage from *G. sepium* and *L. leucocephala* fluctuated from 5.2 to 7.6%/h and from 4.0 to 5.2%/h, respectively, while Alayón (1996) estimated a degradation rate of 10.7%/h for *G. sepium* foliage. These values are higher than those obtained for both species in this study, probably due to the difference in the basal diets fed to the experimental animals, ages of the leaves used and species of fistulated animals (Ezenwa and Kithara, 2001). The faster degradation of DM of *P. santalinoides, G. pubescens,* and *D. guineense* could be advantageous, which may probably release greater rumen metabolites, enhance rumen microbial functions and proliferations, improve the rumen ecology (i.e., N, minerals and isoacids), and they may further enhance forage intake since they move out of the rumen faster and thus reduce rumen fill (Bonsi et al. 1995).

Potential degradation increased markedly from 32.8% in *D. guineense* to 87.53% in *A. cordifolia.* This compares with 30.4 % to 80.9 % reported by Bamualim et al. (1980) for tropical browse legumes. According to Von Keyserlingk et al. (1996), the higher the CP content of forage, the higher the effective degradability. This was confirmed in this study as *G. pubescens* with the highest ED had very high crude protein content comparable with *L. leucocephala* while *X. xylocarpa* with the least ED had one of the least CP contents.

Table 3 shows the average preference index (API) values and ranking of the evaluated species. The highest preference ranking of *G. sepium* in this study is probably because it is the most familiar to the goats at the time of the study since according to Ikhimioya (2008), goats more readily accept feeds with which they have had previous experience. The result is in contrast with Larbi et al. (1993) and Odeyinka (2000) who reported low preference for *G. sepium* leaves which according to Lowry (1990) are refused by animals on the basis of smell, and is often rejected without being tasted, which suggests that the problem lies with volatile compounds released from the leaf surface. These compounds probably include coumarin which imparts a repulsive odour on leaves and barks (Lana et al. 1989) and other phytochemical compounds (Russel and McDonald, 1992).

However, the result agrees with Mejia et al. (1991) who stated that *G. sepium* was selected in preference to all other feeds and also with Brewbaker (1986) that it is highly acceptable to animals when fed in a cut and carry method. There is therefore an apparent variation in the acceptability of *G. sepium* by ruminant animals in different parts of the world. Factors responsible for this probably include climatic or edaphic effects on leaf chemical composition, differences in behaviour or in rumen flora between animals in different places (whether genetically or environmentally caused), or genetic variation in *Gliricidia* itself (Simons and Stewart, 1994).

The 2nd and 3rd ranking recorded for *Dialium* and *Inga* in this study is probably a reflection of the coarse nature of the leaves judging from their very high dry matter contents since according to Quedrago et al. (1996) goats prefer coarse feeds. Larbi et al. (1993) equally reported a high acceptability of *Dialium* by small ruminants. Species like *Calliandra, Milletia* and *Enterolobium* were least preferred probably because of lack of previous experience by the goats or presence of strong smell resulting in aversion for the species by goats (Simons and Stewart, 1994).

From Table 4, correlations between RPI and chemical components were non-significant, in contrast to the findings of Lambert *et al* (1989) that preference in sheep and goats correlate positively with CP content of forages. However it is similar to the report of Hadjigeorgiou et al. (2003) and Ikhimioya (2009). Also, non-significant correlations were obtained between RPI and DM degradation characteristics.

Table 1: Proximate and mineral compositions (%) of browse species

Species	DM	CP	CF	EE	ASH	NFE	Ca	P
G. sepium	31.60	24.38	14.23	3.14	9.63	48.62	0.74	0.09
D. guineense	45.00	17.15	21.45	4.02	8.80	48.58	0.34	0.10
I. edulis	43.80	17.33	22.01	3.17	8.42	49.07	0.70	0.04
L. leucocephala	34.30	29.87	17.41	2.40	9.65	40.67	0.74	0.12
G. pubescens	37.20	28.93	22.11	2.33	8.37	38.26	1.10	0.12
A. cordifolia	34.23	18.67	17.28	3.36	9.14	51.55	0.02	0.20
A. niopoides	32.25	23.33	19.40	3.23	9.25	44.79	0.22	0.12
X. xylocarpa	48.20	18.08	32.14	3.45	9.64	36.69	0.84	0.10
P. santalinoides	32.92	19.83	13.53	3.50	9.02	54.12	0.92	0.04
C. calothyrsus	40.52	27.65	10.40	3.02	9.80	49.13	0.72	0.04
P. africana	47.20	19.60	22.05	4.10	9.09	45.16	0.48	0.12
M .thonningi	30.70	21.35	31.13	2.22	8.61	36.69	0.76	0.08
E. cyclocarpum	39.32	20.42	17.59	3.42	9.47	49.10	0.52	0.12
Mean	38.25	22.05	20.06	3.18	9.15	45.57	0.62	1.01
SEM	5.95	4.25	6.04	0.56	0.47	5.55	0.29	3.17

SEM = Standard error of the mean

Table 2: Dry matter degradation characteristics of browse species (%)

Species	a	b	c	a + b	ED
G. sepium	29.99^{a}	36.89^{bc}	1.42^{b}	66.87^{bc}	45.31^{b}
D. guineense	8.19^{c}	24.61^{c}	2.88^{ab}	32.80^{d}	22.71^{d}
I. edulis	17.02^{b}	42.85^{b}	1.10^{bc}	59.87^{c}	32.22^{c}
L. leucocephala	33.98^{a}	48.97^{b}	1.49^{b}	82.94^{a}	54.89^{ab}
G. pubescens	25.42^{ab}	61.30^{a}	3.46^{a}	86.72^{a}	64.27^{a}
A. cordifolia	26.52^{ab}	61.01^{a}	0.75^{c}	87.53^{a}	43.16^{bc}
A. niopoides	25.05^{ab}	53.49^{ab}	0.37^{d}	78.54^{a}	33.40^{c}
X. xylocarpa	11.90^{c}	21.34^{c}	0.52^{c}	33.23^{d}	16.30^{d}
P. santalinoides	17.14^{b}	24.68^{c}	3.93^{a}	41.82^{d}	33.50^{c}
C. calothyrsus	25.00^{ab}	51.05^{ab}	2.22^{ab}	75.88^{ab}	51.86^{b}
P. africana	31.74^{a}	46.44^{b}	0.46^{cd}	81.64^{a}	40.42^{bc}
M .thonningi	24.53^{ab}	46.07^{b}	0.50^{cd}	69.27^{b}	33.74^{c}
E. cyclocarpum	32.56^{a}	19.71^{c}	1.21^{bc}	52.29^{c}	39.99^{bc}
Mean	23.77	41.42	1.56	65.34	39.37
SEM	7.70	14.09	1.15	18.96	12.50

a=soluble fraction; b=slowly degradable fraction; c=rate of degradation (%/hour); a+b=potential degradability; ED=effective degradability; $^{a, b, c, d}$ Means within the same column with different superscripts are significantly different ($P<0.05$); SEM = Standard error of the mean

Table 3: Average preference index (API) values and ranking of MPT species

Species	API	Rank
G. sepium	0.99	1
D. guineense	0.93	2
I. edulis	0.56	3
L. leucocephala	0.53	4
A. cordifolia	0.39	5
G. pubescens	0.27	6
X. xylocarpa	0.09	7
A. niopoides	0.03	8
P. santalinoides	0.02	9
P. africana	0.01	10
C. calothyrsus	0.005	11
M .thonningi	0.004	12
E. cyclocarpum	0.004	13
Mean	0.29	
S.E.M	0.34	

Table 4: Linear correlation and regression coefficients of some proximate and degradability components *(X)* with API *(Y)*

Nutritive Parameter	Correlation	Regression Equation
DM	-0.02	Y=0.33-0.001X
CP	-0.03	Y=0.35-2.39X
CF	-0.16	Y=0.48-9.22X
EE	+0.08	Y=0.14+0.05X
Ash	-0.07	Y=0.76-0.05X
NFE	+0.19	Y=0.25-0.01X
Ca	-0.11	Y=0.37-0.13X
P	+0.07	Y=0.24+0.59X
a	-0.18	Y=0.49-0.008X
b	-0.06	Y=0.36-0.002X
c	+0.17	Y=0.21+0.05X
a + b	-0.13	Y=0.45-0.002X
ED	+0.01	Y=0.29-0.0002X

4. Conclusion

All the species investigated in this study seem to have good nutrient composition characteristics. The general performance is however outstanding in the control species: *Leucaena* and *Gliricidia*, indicating that the two species will continue to play vital roles in ruminant feed supplementation strategies. The study also revealed that the performance of four species, *Grewia pubescens, Inga edulis, Alchhornea cordifolia* and *Dialium guineense* compared favourably with the controls and these are therefore recommended for further investigations with a view to incorporating them into ruminant feeding systems.

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