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Gmelina Arborea at Shika, Nigeria: Nutritive Indices, Preference and Intake of Plant Parts by Yankasa Sheep

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Abstract: *In northern Nigeria, fodder trees are an integral part of the diet of small ruminant animals and constitute the main source of proteins, minerals and vitamins during the dry season. Nutritive indices, dietary preference and intake of plant parts of Gmelina arborea (Gmelina) by Yankasa breed of sheep were investigated over a short-term period at Shika, Nigeria. For the dietary preference, Gmelina plant parts were offered in 4 states [fresh (within 60 minutes of harvest), wilted after harvest for 24 hours, wilted after harvest for 48 hours and sun-dried after harvest] to two Yankasa sheep groups (adult non-pregnant and juvenile). Ranking within post-harvest treatments taken into account preference index showed the same trend for Gmelina parts for both fresh and the 24-h wilted forms of presentation and in the order of: leaf > tender stem/twig > flower > pod > bark. Analysis of the plant parts showed that the leaf had the highest crude protein (CP) content (21.1%), followed by tender stem/twig (17.8%) while other fractions had <10.0% CP content. Both sheep groups generally preferred fresh plant parts to wilted or sun-dried ones. Bark was consistently least preferred while leaf was most preferred by both sheep groups. Feed intake was higher for leaf and tender stem/twig and lower for bark. Adult sheep consumed more of the feed on offer than young sheep.*

Keywords: *Feed value, plant parts, post-harvest treatments, sheep, Gmelina*

1. INTRODUCTION

The adequacy of feeding livestock with the right quality and quantity of forage materials during the long dry season period which could last for 5 to 7 months has always been a source of great concern to livestock farmers, researchers and extension workers in northern Nigeria. Quality of the available feed, namely to digestibility and nutrient content, decline rapidly as the rangeland grasses mature, become dry and fibrous as the dry season progresses thereby making stock to subsist on a below maintenance diet. Browse plants have great potential as source of high quality nutrient for ruminants, being high in protein, minerals and vitamins (3, 6). In trying to circumvent the constraints of lack of forage materials for livestock during the dry season, a vast array of browse plants has been examined and suitable ones identified for livestock during the critical period of food shortage in the zone (7).

In the dry season and to some extent during the raining season, livestock farmers mostly cut and carry *Gmelina arborea* (Roxb) leaf and tender stem/twig for their animals, while other fractions such as: bark, pod and flower are also relished by free roaming ruminants. Earlier studies identified *G. arborea (Gmelina)* as one of the most preferred browse species by sheep during the dry season in a part of sub-humid Nigeria (7), but detailed examination of *Gmelina* plant parts, which are readily consumed by livestock, is limited. In Nigeria, *Gmelina* is among the leading plantation tree species. Due mainly to its good pulping characteristics, large-scale pulpwood plantations were established from the mid-1960s making this forage resource available at a large scale in the area. Today, *Gmelina* plantations in Nigeria are estimated at 112,000.00 trees ha^{-1} (8). A recent study revealed that the fresh fruit pulp of *Gmelina* at all stages of growth is for use as non-conventional feeding materials for livestock (1). There is scanty information on above-ground biomass yield of whole *Gmelina* tree in northern Nigeria. In western Nigeria, the above-ground biomass production of *Gmelina* plantations (using 5–21 years old trees) was reported to varied from 83.2 t ha^{-1} for 5 years old trees to 394.9 t ha^{-1} for 21 years old trees (8). The objective of this study was to assess the nutritive value indicators, preference and short-term intake of *Gmelina* plant parts offered at different post-harvest states (or treatments) to adult and juvenile Yankasa sheep during the dry season in northern Nigeria.

2. MATERIALS AND METHODS

Two experiments were conducted at National Animal production Research Institute (NAPRI), Shika-Samaru, Zaria, Nigeria.

In experiment 1, Yankasa sheep were observed for their preference of five *Gmelina* plant parts (leaf, tender stem/twig, flower, pod and bark). A total of 24 (12 adult ewes and 12 young ewes) were used in 3 groups of adult ewes, young ewes and a mixture of adult and young ewes. The live-weight of the 12 adult ewes averaged 25.8 kg, while those of 12 young ewes averaged 10.9 kg. Pruned plant parts (leaf, tender stem/twig, flower, pod and bark) were offered to the 3 groups of sheep following 3 post-harvest treatments: (i) fresh within 60 minutes of harvest, (ii) wilted for 24 hours under shade, (iii) wilted for 48 hours under shade, (iv) sun-dried materials (in the open) for 3-12 days, with the fruits taking longer days to dry. The plant parts were presented at once side by side in wooden feeding troughs measuring 1 m (width) x 9 m (length) x 0.3 m (height) in dimension. The troughs were partitioned into five compartments in order to house each plant part separately. Prior to the start of data collection, animals were allowed free access to each post-harvest state of offer for 1.5 h a day for 3 days each (acclimatization period). The animals were fasted overnight and the following morning (9.00-11.00 a.m.), each group of sheep was introduced to each post-harvest treatment consisting of the *Gmelina* plant parts for 40 minutes a day and this was repeated for 5 days in the following predetermined order: fresh parts - days 1, 5, 9, 13 & 17; wilted (24 h) parts - days 2, 6, 10, 14 & 18 for; wilted (for 48 h) parts - days 3, 7, 11, 15 & 19; and sun-dried parts - days 4, 8, 12, 16 & 20. A total of 20 days was used for this experiment. Each plant part in the feeding troughs was weighed before and after the test, and the difference indicated the amount eaten by each sheep group. The test parts were offered in excess to maximize animals selectively. Dietary preference index (PI) was calculated as amount of plant parts consumed divided by amount of plant parts offered. Within post-treatment ranking across the 3 groups of sheep used was done based on % DM of feed consumed. Overall ranking of all parts x 3 post-harvest treatments was also done.

In experiment 2, short-term intake of *Gmelina* plant parts by individual sheep fed daily for a short period (for 1 h a day). The most preferred post-harvest state (fresh) from dietary preference (experiment 1, above) was considered for this part of the study. To determine the short-term intake, 5 adult & 5 young sheep from experiment 1 after an overnight's fasting period were individually/separately housed and offered the test fractions for 1-hour a day for a total of 25 consecutive days, after allowing an initial 3-day adjustment period. The feeding of each fresh plant part was repeated 5 times in the following order: fresh leaf - days 1, 6, 11, 16, & 11; fresh tender stem and twig - days 2, 7, 12, 17 & 22; fresh flowers - days 3, 8, 13, 18 & 23; fresh fruit (pod with seed enclosed) - days 4, 9, 14, 19 & 24; and fresh bark - days 5, 10, 15, 20 & 25. The amount of fresh plant part materials consumed was calculated by differences between amounts on offer and consumed, and the result expressed as short-term voluntary intake per hour corrected for metabolic live-weight of the animal ($W^{0.75}$, where W is the live-weight of the animal in kilograms). After each day's study period, the animals were given concentrate diets and then released for the day's grazing on mixed pastures.

Samples of *Gmelina* plant parts used for both experiments 1 & 2 were taken every day of the trial for chemical composition analysis in the laboratory following standard wet chemistry procedures (1). The plant parts used in this study were collected from >25 years old *Gmelina* trees found within NAPRI premises.

Neutral detergent fibre (NDF), acid detergent fibre (ADF), and acid detergent lignin (ADL) contents were measured according to the procedures of Van Soest *et al.* (10). Cellulose was calculated as the differences between acid detergent fiber (ADF) & acid detergent lignin (ADL), while hemicellulose was calculated as the difference between neutral detergent fiber (NDF) & ADF (2). The following parameters were calculated (4): dry matter intake (DMI) = 120 / %NDF; relative feed value (RFV) = (DDM x DMI) / 1.29; nitrogen free extract (NFE) = 100 - (%Moisture + %Protein + %Fiber + %Ash + %Fat); TDN = 96.35 - (%ADF x 1.15); neutral detergent soluble (NDS) = 100 – NDF; TDN = 96.35 - (%ADF x 1.15); metabolized energy (ME) = 0.0362 x TDN; net energy-gain (NEG) = (1.42 ME - 0.174ME2 + 0.0122ME3 - 1.65) / 2.205; net energy-maintenance (NE_M) = (1.37ME - 0.138ME^2 + 0.0105ME^3 - 1.12) / 2.205; net energy-lactation (NE_L) = (%TDN x 0.01114) - 0.054.

The data from each experiment were subjected to analysis of variance (ANOVA) using SAS Proc GLM (9). The chemical composition (proximate analysis, macro-mineral element, and detergent & cellulose analysis) of plant parts (leaf, tender stem/twig, flower, pod and bark) of *Gmelina* shown in Table 1 are mean values of the samples from the 5 experimental days in Experiment 2. Experiment 2 (Table 3) was mainly designed to examine the variations between short-term intake of fresh plant parts, so only means across sheep group are presented and discussed, although main effects cannot be interpreted independently when the interaction is significant.

3. RESULT

3.1. Chemical Composition

The crude protein (CP) was highest (21.1%) for leaf and lowest (4.60%) for bark. Crude fibre (CF) varied from 12.7% for pod to 44.9% for bark. Leaves were lower and pods were higher in ether extract. The ash varied from 5.53% for pod to 8.40% for leaf. Pod significantly had the highest mean nitrogen-free extract (NFE, 53.2%) than other plant parts.

Generally, measured macro-mineral elements differed significantly ($P<0.05$) among plant parts examined. Leaf and bark contained higher P than other plant parts. Mean potassium (K) was highest (2.34%) for leaf and lowest (1.14%) for bark. Mean Calcium (Ca) was significantly ($P<0.05$) low for flower than other plant parts. The resulting mean Ca:P ratio varied widely from 1.34 to 9.23% for plant parts. Like most macro-elements under examination, mean Mg was also highest (0.25%) for leaf and least (0.08%) for pod.

Gmelina bark had the highest mean NDF (77.4%), ADF (58.0%) and cellulose (44.4%). Both mean ADL and hemicellulose respectively varied from 3.65 to 14.4% and 8.90 to 22.0%. Mean NDS was highest for pod (53.6%) and lowest for bark (22.7%). Surprisingly, mean NDS was <50% for leaf, tender stem/twig and flower. Mean silica significantly was highest for leaf (4.16%) and least for bark (1.16%).

Pods followed by flower were higher in all forms of measured energy, digestibility and intake than other plant parts (Table 1).

Table 1. *Chemical composition (% DM) of Gmelina plant parts sampled across the 5 feeding days in experiment 1(N=5)*

	Leaf	Tender stem/twig	Flower	Pod	Bark
Proximate analysis (% DM)					
Crude protein	21.1	17.8	6.25	5.05	4.60
Crude fibre	19.0	25.2	19.9	12.7	44.9
Ether extract	23.8	24.1	40.9	78.4	26.2
Ash	8.40	7.00	7.90	5.53	7.18
Nitrogen-free extract	23.7	15.7	52.2	52.2	13.7
Macro-mineral element (%DM)					
Nitrogen	3.37	2.85	0.99	0.81	0.73
Calcium (Ca)	1.32	1.20	0.20	1.00	1.32
Phosphorus (P)	0.18	0.13	0.11	0.08	0.17
Potassium (K)	2.34	1.94	1.72	1.68	1.14
Magnesium (Mg)	0.25	0.19	0.14	0.08	0.18
Ca:P ratio	7.33	9.23	1.78	1.34	7.76
Detergent fibre & cellulose analysis (%DM)					
Neutral detergent fibre (NDF)	57.9	59.1	50.9	46.4	77.4
Acid detergent fibre (ADF)	39.4	40.1	28.9	17.5	58.0
Acid detergent lignin (ADL)	14.4	12.8	9.13	3.65	13.6
Cellulose	25.0	27.3	19.7	13.8	44.5
Hemicellulose	18.5	19.0	22.0	8.90	19.4
Neutral detergent soluble (NDS)	42.2	40.9	49.1	53.6	22.7
Silica	4.16	2.89	3.11	2.33	1.16
Energy, digestibility & relative feed value					
TDN, %	51.0	50.2	63.1	76.2	29.7
Metabolisable energy (ME, Mcal/kg DM)	1.85	1.82	2.28	2.76	1.07

Net energy for gain (NE_G, Mcal/kg DM)	0.21	0.20	0.38	0.54	0.01
Net energy for maintenance (NE_M, Mcal/kg DM)	0.46	0.44	0.64	0.83	0.09
Net energy for lactation (NE_L, Mcal/kg DM)	0.51	0.51	0.65	0.80	0.28
Digestible dry matter (DDM, %)	58.2	57.7	66.4	75.3	43.7
Dry matter intake (DMI, %)	3.05	2.99	4.15	6.86	2.07

3.2. Forage Preference

Preference of *Gmelina* plant parts differed among forms of presentation and between groups of sheep (Table 2). The order of preference was fresh > wilted for 24 hrs > wilted for 48 hrs > sun-dried. Regardless of form of presentation, preference index was generally lower with young sheep group than adult or mixed group. The order of preference was adult sheep > mixed sheep > young sheep. Fresh bark consistently had the lowest preference while fresh leaf was the most preferred for all groups sheep. Even then, fresh leaf, tender stem/twig and flower were better for both adult and mixed category of sheep than did for young sheep. Fresh bark and pod were not as palatable as the other parts to any of the groups of sheep used in the study.

Ranking within post-harvest treatments taken into account preference index showed the same trend for both fresh and the 24-h wilted form of presentation: leaf > tender stem/twig > flower > pod > bark. But for the sun-dried form, flower ranked 1 and bark ranked 5. However, considering all the post-harvest treatments together, overall ranking of preference index of the top four was in the order of: fresh leaf > wilted leaf (24h) > fresh tender stem/twig > fresh flower > wilted tender stem/twig (24h) dried leaf dried flower wilted pod (24h) fresh pod wilted pod (48h) (Table 2).

Table 2. *Preference index and rankings of Gmelina plant parts offered to three groups of sheep (N=3)*

				Within	Overall
	Preference index (PI) of Sheep Group			Post-treat	Post-treat
	Young	Adult	Mixed	Ranking[1]	Ranking[2]
Fresh					
Leaf	0.51	0.89	0.83	1	1
Tender stem/twig	0.25	0.87	0.7	2	3
Flower	0.45	0.73	0.79	3	4
Pod	0.16	0.49	0.29	4	9
Bark	0.08	0.21	0.12	5	14
Wilted for 24 hrs					
Leaf	0.41	0.86	0.73	1	2
Tender stem/twig	0.15	0.84	0.71	2	5
Flower	0.29	0.63	0.7	3	6
Pod	0.02	0.09	0.17	4	15
Bark	-	-	-	5	18
Wilted for 48 hrs					
Leaf	-	0.74	0.6	1	7
Tender stem/twig	-	0.42	0.49	3	10
Flower	-	0.93	0.23	2	8
Pod	-	-	-	4	17
Bark	-	-	-	5	18
Sun-dried					
Leaf	-	0.31	0.39	2	12
Tender stem/twig	-	0.24	0.32	3	13
Flower	-	0.31	0.46	1	11
Pod	-	-	0.26	4	16
Bark	-	-	-	5	18

[1], *Within post-treatment ranking, calculation based on % DM of feed consumed across the post-harvest treatments.*

[2], *Overall post-harvest treatment ranking.*

3.3. Short-Term Intake of Gmelina Plant Parts by Individual Sheep

Table 3 shows short-term intake rate of *Gmelina* parts fed to two sheep age groups. There was significant *Gmelina* parts x age of the animals (see Table 3). The significant interaction showed that, intake rate significantly varied from 0.8 g DM/KgLW$^{0.75}$h^{-1} for fresh bark fed to young sheep to 50.9g DM/KgLW$^{0.75}$h^{-1} for fresh flower when fed to adult sheep.

Table 3. *Short-term intake (g DM/kgLW$^{0.75}$h^{-1}) of Gmelina plant parts fed as fresh to sheep*

Fractions	Young sheep	Adult sheep
Leaf	37.5	50.9
Tender stem/twig	29	48.6
Flower	34.6	44.6
Pod	10.7	24.9
Bark	0.8	15.3

P = 0.011 for plant parts
P = 0.014 for categories of sheep
P = 0.001 for plant parts x sheep age interaction

4. DISCUSSION

The present study shows that both leaf and tender leaf/twigs were favoured by higher CP than other parts. Both leaf and tender leaf/twigs met and in some cases far exceeded the CP requirements of a non-lactating and lactating ewe, as well as the CP needed for early weaned lambs, lamb finishing and replacement rams and ewes (5). Generally, protein contents of the flower, pod and bark fell appreciably below the suggested nutritional requirements for various classes of sheep (9.1-15.0% protein), and goats (11-14% protein) (5).

Considering the suggested Ca levels for all categories of sheep (5), only flower fell short of meeting the Ca requirements of sheep (0.21-0.41% Ca) in the present study. Except for leaf, none of the parts had sufficient amounts of P suggested by NRC (5) for all categories of sheep (0.16-0.31% P). Only leaf had sufficient amount of P needed by a replacement ram lamb (0.16% P). Since P requirements generally fell appreciably below the critical levels suggested, P supply to animals during the dry season (when provided with *Gmelina* plant parts) would need to be supplemented with diets with this element. Wide Ca:P ratios found in this study are attributable to high Ca content of the plant parts.

The values of all detergent fibre, cellulose and hemicellulose analysis in the present study (Table 1) shows that pod appeared to be of better nutritive value going by its lower levels for these parameters compared to other plant parts. Similarly, in terms of all forms of energy (TDN, ME, NEG, NEL, NEM), DDM and DMI, pod also showed better quality judging by its higher value for each of these parameters compared to other plants parts. Next to pod in terms of better energy, DDM and DMI was flower. Bark consistently showed poor quality. Although DMD was calculated from an equation, we believe that, this approach may ignore the likely effects of plant characteristics such as taste, odour and fell, which are characteristics of *Gmelina* plant parts. Generally, leaf, stem and bark fell short of TDN requirements for sheep and goats, but flower and pods were within the suggested ranges of 58-77% TDN for sheep and 55-68% TDN for goats (5).

The intake rate of *Gmelina* parts appeared to be in favour of leaf than other plant parts, with adult sheep consuming more Gmelina than young sheep, when fed as fresh in a short-term feeding trial (Table 3). Longer study period is needed for a true picture of what Gmelina plant parts intake and animal performance will look like particularly during the dry season when quality and quantity of forage materials are a source of great concern to livestock farmers, researchers and extension workers in the study area.

The results indicate that both young and adult tend to select leaf in preference to flower and pod irrespective of post-harvest treatments imposed. Consequently, when the post-harvest treatments were compared, sheep selected fresh and dried leaves in preference to other post-harvest treated plant parts. The part (leaf) most preferred which has been found to be highly palatable to adult sheep generally contains proportionally more CP, P, K Ca and Mg. The lack of any preference index and preference class values for young sheep in the forage preference part of the present study may be related to lack of experience of young sheep on forage with significant moisture content reduction. For the integration of Gmelina plants as feed source into the small ruminant (particularly sheep and goats) production systems, further research must look for ways of utilising the abundant Gmelina tree, particularly during the dry season taking into account the various aboveground utilizable parts of

Gmelina. Anti-nutritional factors of Gmelina plant parts used were not examined in the present study, but future studies would need to investigate further any possible anti-nutritive factors of Gmelina plant parts and their possible effects on ruminants.

5. CONCLUSION

This study shows that leaf was most preferred plant part and thus must probably palatable. Leaf of Gmelina also contained higher nutrients particularly in the form of CP, P, K Ca and Mg than other plant parts examined. The results show that sheep would prefer leaf and flower in fresh or wilted (for 24 h.) form to other plant parts in other postharvest treatment forms. The short-term intake studies indicate a consistent trend with preference.

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REFERENCES

[1] I.A. Amata, Comparative evaluation of the amino acid and mineral contents of the fruits of gmelina arborea tree during growth and development. *Intern. J. Plant, Ani. & Env. Sci*., 2 (2), 264-269.

[2] Association of Official Analytical Chemists (AOAC), 1990, Official Methods of Analysis, 15th Edition. Association of Official Analytical Chemists, Washington, DC, USA, pp. 69–88.

[3] Babayemi O.J., Bamikole, M.A., Daniel, I.O., Ogungbesan, A. & Babatunde, A., 2003, Growth, nutritive value and dry matter degradability of three *Tephrosia* species. *Nig. J. Anim. Prod.*, 30 (1 and 2), 62-70.

[4] Montana State University Agricultural Experiment Station, 2012, Analytical Laboratory, MT, US http://agr.mt.gov/agr/Programs/Commodities/AnalyticalLaboratory/pdf/NutritionalCalculations.pdf

[5] National Research Council, 2007, Nutrient Requirements of Small Ruminants: Sheep, Goats, Cervids, and New World Camelids (6th ed.) National Academy Press, Washington, DC (2007) 384 pp.

[6] Okagbare, G.O., Akpodiete, O.J., Esiekpe, O. & Onagbesan, O.M., 2004, Evaluation of *Gmelina arborea* Leaves Supplemented with Grasses (*Panicum Maximum* and *Pennisetum purpureum*) as Feed for West African Dwarf Goats. Trop. Ani. Health & Prod., 36 (6), 593-598.

[7] Omokanye, A.T., Balogun, R.O., Onifade, O.S., Afolayan, R.A. & Olayemi, M.E., 2001, Assessment of preference and intake rate of browse species by Yankasa sheep. Small Ruminant Research, 42, 201-208.

[8] Onyekwelu J.C., 2001, Growth characteristics and management scenarios for plantation-grown *Gmelina arborea* and *Nauclea diderrichii* in south-western Nigeria. Munich: Hieronymus Verlag, 2001. 196pp.

[9] Statistical Analysis Systems institute Inc. (SAS), 1988, SAS User’s Guide: Statistics, version 6 Edition. Statistical Analysis Systems Institute Inc., Cary, NC, USA.

[10] Van Soest, P. J., Robertson, J.B. & Lewis, B. A., 1991. Methods for dietary fibre, neutral detergent fibre, and nonstarch polysaccharides in relation to animal nutrition. J Dairy Sci 74: 3583–3597.

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