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RESEARCH ARTICLE

Dried Gmelina *(Gmelina arborea Roxb) L*eaves as Replacement Forage to Groundnut Haulms in the Diet of Fattening Red Sokoto Bucks

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ABSTRACT

Twenty-five Red Sokoto bucks with average weight of 10.96±2.42 kg were used to study effects of replacing groundnut haulms with dried *Gmelina* leaves (GL) at 0, 25, 50, 75, and 100 % levels on dry matter intake, live weight, nutrient digestibility, nitrogen balance and cost of feed. The bucks were randomly assigned to five treatments, with five bucks per treatment in a completely randomized design. The diets consisted of *Digitaria smutsii* hay, concentrate diet and varying levels of GL fed at 1, 2 and 3 % of body weight (BWT), respectively. A metabolism trial was conducted to investigate the effect of the varying levels of inclusion of GL on nutrient digestibility and nitrogen balance. The GL inclusion had no significant effects on all performance indices measured. The 50 % inclusion level had the best result in numerical terms with DMI of 817.92 g/d which translated into higher weight gain of 4.30 kg and ADWG of 47.78 g/d. The varied levels of GL inclusion had significant effects on apparent nutrient digestibility and nitrogen balance. The result showed significantly higher CP, CF, NDF, and ADF digestibility and nitrogen retention in bucks fed 50 % GL than bucks in other treatment levels. The studies showed that GL can be included in the diet of bucks up to 50 % for best results. Complete replacement of groundnut haulms during critical period of feed scarcity will have no adverse effects.

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INTRODUCTION

Dry season feeding of livestock especially ruminants in the tropics has always been a problem to the farmers. At this time, the performances of these animals are seriously impaired. One possible way to alleviate this problem and maintain production in the tropics is to feed the ruminants with crop residues and browses which may serve as alternative feeds in the dry period. Incorporation of browse leaves into ruminant diets reduces total cost of production without a decrease in productivity or in efficiency of feed utilization. Browse plants have great potential as source of high quality nutrient for ruminants, being high in protein, minerals and vitamins (Babayemi *et al.*, 2003; Amodu and Otaru, 2004). They are available all year round because of their drought resistance, persistence, vigorous growth, re-growth and palatability (Crowder and Chheda, 1982). For this also the browse plants are found all year round in contrast to grasses which rapidly deteriorate with increasing fibre and decreasing protein. They also have higher nutritive value than grasses (Agishi, 1984). The browse species: *Gmelina arborea, Leuceana leucocephala, and Gliricidia sepium,* have been reported to remain green to larger part of dry season and have been fed to ruminants with appreciable results (Lamidi *et al.*, 2009).

Gmelina arborea Roxb (family verbenanceae) is a fast growing deciduous tree reaching up to 40 m tall and 140 cm in diameter, but usually smaller than this (Jensen, 1995). Previous records (Osakwe and Udeogu, 2007; Ahamefule *et al*., 2006; Adu *et al*., 1996) have shown that the leaves contained as much as 10.01-38.4 % crude protein and 3.10-30.46 % crude fibre. However, availability and cost reduction alone may not be beneficial

if performance indices such as growth, feed intake, weight gains and livability are adversely affected.

This study was therefore carried out to ascertain the effect on body weight, feed intake, nutrient digestibility, feed conversion and feed costs of feeding Red Sokoto bucks using diets in which groundnut haulms were replaced at varying levels with dried *Gmelina arborea* leaves.

MATERIALS AND METHODS

Experimental Site

The study was carried out in the Experimental Unit of the Small Ruminant Research Programme of the National Animal Production Research Institute (NAPRI), Shika, Zaria, Nigeria. Shika lies between latitudes

11 and 12 °N and between longitudes 7 and 8 °E, with an altitude of 640 m above sea level and within the Northern Guinea Savannah Zone. It has an average annual rainfall and temperature of 1107 mm and 24.4 °C respectively. The seasonal distribution of Shika's annual rainfall is approximately 0.1 % (11.0 mm) in the late-dry season (January–March), 25.8 % (285.6 mm) in the early-wet season (April–June), 69.6 % (770.4 mm) in the late-wet season (July– September) and 4.5 % (49.8 mm) in the early dry season (October–December). The experiment was conducted during the late wet to early dry seasons (late September-January).

Feed Preparation

Fresh *Gmelina arborea* leaves were harvested within the Ahmadu Bello University environment and NAPRI. Leaves were allowed to air-dry on the branches and then removed by carefully beating the branches with sticks. The dried leaves were bagged and kept until used. Groundnut haulms (harawa) were purchased at Dumbin-rauga along Zaria-Kaduna Road and the forage bulk was beaten to reduce the particle size and for easy handling.

The ingredients used for compounding the concentrate feed were maize offal (69.23%), cottonseed cake (29.27%), bone meal (1.00%) and common salt (0.50%). The concentrate feed was compounded to contain 16% CP. Table 1 shows the chemical compositions of the supplemental forages. The concentrate and supplemental diets were mixed fortnightly to maintain freshness and samples taken to determine chemical composition.

Animal Management, Experimental design, Feeding trial, and Data analysis

Preference Study

Twenty five (25) Red Sokoto bucks with an average body weight of 10.96±2.42 kg were used. The bucks were randomly assigned to five (5) treatments balanced for weight with 5 animals per treatment in a completely randomized design. They were individually penned and given prophylactic treatment, consisting of Ivermectin at 200µg/kg body weight (BWT) against endo and ectoparasites and Terramycin long lasting (LA) antibiotics at 20mg/kg BWT against bacterial diseases 7 days before the commencement of the experiment.

Groundnut haulms and *Gmelina* leaves were offered separately in different feeding troughs at 3 % of body weight. The forages were fed to the animals at 8.00 hrs and withdrawn at 10 hrs. The left-over of both feeds were weighed and recorded separately. The difference between quantity offered and the left-over was recorded as intake. Thereafter, the bucks were fed concentrate feed and *Digitaria smutsii* hay. Fresh clean drinking water was offered *ad libitum.* Feed intake was recorded for a period of seven days. The mean intake and relative % of intake was calculated for the two test feeds to determine preference for the forages.

Feeding Trial

After the preference study, the same 25 intact Red Sokoto bucks were used in this study. Dried *Gmelina* leaves were used to replace groundnut haulms at 0 %, 25 %, 50 %, 75 % and 100 % levels. The supplement forages were offered at 3.0 % of body weight (BWT) to all the animals while *Digitaria smutsii* hay was fed at 1.0 % and concentrate at 2.0 % of BWT across the treatments. At 8.00 am, concentrate feed was offered to the bucks, then *Digitaria smutsii* hay and the supplemental forages. Water was provided *ad libitum* to the animals. The bucks were adjusted to these feeds for 14 days before data collection. The feeding trial lasted for 90 days.

Daily feed (concentrate, hay and supplement forages) intakes were recorded before feeding in the morning throughout the study. The bucks were weighed weekly. Change in weight was recorded as the difference between weight of the previous week and the current. Weekly weights of the bucks were used to adjust the quantities of feeds offered in order to maintain the pre-determined level of feeding.

Metabolism Trial

Ten Red Sokoto bucks ranging between 17.50 and 22.10 kg (selected from the same 25 bucks used for feeding trial) with 2 bucks per treatment were used for the metabolism trial. Each buck was individually offered its appropriate corresponding ration to evaluate the digestibility of the diets. The study comprised a one-week preliminary period of adjustment and one week of sample collection. The animals were housed in individual metabolism cages with facilities for separate collection of faeces and urine. The faecal and urine samples were collected each morning just before feeding. Ten percent (10 %) of each daily faecal and urine outputs were collected and stored at – 4 °C in a deep freezer from which sub-samples were bulked for chemical analyses.

Chemical Analysis

The Proximate Analysis was carried out on the feed and faecal samples using the procedures outlined by the Association of Official Analytical Chemists (A.O.A.C., 2000). Acid Detergent Fibre (ADF) and Neutral Detergent Fibre (NDF) were determined according to the procedures by Van Soest, *et al.* (1991). Urine N was determined using the Micro Kjeldal method (A.O.A.C, 2000). The Metabolizable Energy (ME) contents of supplemental diets were calculated using the formula: ME ($MJ \cdot kg^{-1}DM$) = 11.78 + 0.00654 CP + $(0.000665EE)^2$ – CF(0.00414EE) – 0.0118A where A=Ash, CP=crude protein, EE=Ether Extract, CF=Crude Fibre (Alderman, 1985).

Mineral content of the supplement forages, *D. smutsii* hay and concentrate were analyzed using the Flame Spectrophotometer as described by Kennedy (1984). The anti-nutritional factors including tannins were determined using Folin Ciocalteu as described by Makkar (2000),

Table 1: Chemical Composition (%) of supplemental Forages fed to Red Sokoto bucks

Parameters (%)	Treatments (Levels of *Gmelina arborea* leaves)				
	T1(0)	T2 (25)	T3 (50)	T4 (75)	T5 (100)
Dry Matter(DM)	98.15	96.13	96.51	96.75	96.76
Organic Matter(OM)	92.77	88.91	89.50	89.24	90.83
Crude Protein (CP)	13.73	13.54	13.35	13.21	13.38
Crude Fiber (CF)	24.40	27.60	27.53	24.10	19.00
Ash	5.38	7.22	7.01	7.51	5.93
Ether Extract (EE)	2.34	5.27	4.50	5.90	3.34
NDF	62.02	47.93	47.89	48.70	53.52
ADF	44.94	37.67	32.43	29.29	19.41
Hemicellulose (HC)	17.08	10.26	15.46	19.41	23.33
NFE	42.34	50.28	48.87	46.46	39.38
ME ($MJ.kg^{-1}DM$)	11.57	11.18	11.27	11.19	11.53

NDF=neutral detergent fibre; ADF=acid detergent fibre; NFE=nitrogen free extracts; ME=Metabolizable energy. The ME values of the experimental rations were calculated as per Alderman (1985) as follows: ME ($MJ{\cdot}kg^{-1}DM$) = 11.78 + 0.00654CP + $(0.000665EE)^2$ – CF(0.00414EE) – 0.0118A where A=Ash, CP=crude protein, EE=Ether Extract, CF=Crude Fibre.

while saponins and alkaloids were determined according to A.O.A.C (2000), oxalates (Oke, 1969) and phytates (Reddy *et al*., 1982).

Economic Analysis

Market prices in Zaria and its environs were used to determine the cost of bucks and feeds. The costs of harvesting and transportation of *Gmelina arborea* leaves were used as it is not sold in the markets. Feed consumption was used to multiply cost per kg of feed to obtain the cost of feeding. The information from the markets was used to work out total cost of feed consumed per treatment, value of gain, and income over feed cost.

Statistical Analysis

Data generated during preference study was analyzed using the t-test technique to compare the feed intake of the two test forages. All other data on feed intake, digestibility and live weight changes were analyzed statistically using the General Linear Model (GLM) procedure of SAS, (2005). Significant differences between treatment means were determined according to Duncan's Multiple Range Test of the same software.

RESULTS AND DISCUSSION

Chemical composition of the supplemental forages

The result of the chemical composition of the supplemental forages (Table 1) showed that the CP content of the control (groundnut haulms) was comparable to the other treatments. Forages and feedstuffs containing less than 7 % CP have been reported to be poorly digested by ruminants due to insufficient nitrogen to stimulate rumen microbial functions (Ahamefule *et al*., 2002). The supplemental forages contained more than the minimum protein requirement adequate for microbial functions.

The NDF and ADF contents in the supplemental diets decreased with increasing level of *G. arborea* leaves inclusion in the diets. The energy content of the supplements was adequate and comparable to ME of 9-12 MJ/kg DM recommended for intensive feeding of goats (Barkley, 2004; Flint, 2005).

The results of mineral analyses in this study showed that the calcium and phosphorus increased with increasing level of *G. arborea* leaves inclusion in the supplemental forages (Table 2). The mineral content of *Gmelina* obtained in this study was similar to earlier work by Ahamefule *et al.* (2006), but higher than 0.45 % Ca and 0.32 % P by Sevilla and Meriales (1999) for *Gmelina* leaves. The mineral contents of the feeds were within the optimum requirement for maintenance and production (NRC, 1981; Okoli *et al.*, 2003). Ibeawuchi *et al.* (2002) reported that the calcium content of browse plants is usually higher than that of phosphorus, and may not require supplementation.

Table 2: Anti-nutrients and mineral contents of the supplemental forages

Anti-nutrients (mg/100g)	T1	T2	T3	T4	T5
Tannins	0.42	0.80	1.10	1.26	1.44
Phytate	0.84	1.02	1.04	1.07	1.14
Oxalates	_	_	_	_	0.80
Saponins	_	_	_	_	1.22
Alkaloids	_	_	_	_	1.26
Mineral contents (%)					
Phosphorus	0.38	0.41	0.42	0..55	0.37
Calcium	0.31	0.46	0.49	0.76	0.83
Sulphur	0.59	0.61	0.62	0.63	0.64

_ means not analyzed, mg=milligrams.

Anti-nutritional factors in supplement diets fed to Red Sokoto bucks.

Data on some anti-nutritional factors in *Gmelina* leaves and other treatment feeds presented in Table 4 showed that *G. arborea* leaves contained lower levels of tannin and phytate than the groundnut haulms and the mixtures. The tannins, phytates and saponins content levels in *G. arborea* leaves obtained in this study agreed with Yusuf (2011) who reported similar levels in his work with *Gmelina* leaves. Aderiuboye and Onwuka (2010) reported lower tannin of 0.29 g/100g and saponin of 0.08 mg/100g but similar oxalate content of 0.66 mg/100g in *Gmelina* leaves. The levels of anti-nutritional factors were within tolerable ranges and did not have any detrimental effects on the bucks.

Preference study

The result of preference study showed significant difference ($P<0.05$) in average intake/day and relative percentage (%) of the intakes (Table 3). The intake of groundnut haulms was significantly higher (99.36 g/day) than that of *Gmelina arborea* leaves (66.32 g/day). The

higher preference by bucks for groundnut haulms might be associated with nutritive value of the forage and palatability. This finding is in agreement with the earlier studies by Ngwa *et al.* (2000), Burns *et al.* (2001) and Kongmanila *et al.* (2007) who reported that goats have the ability to select and consume the most nutritious feed available.

Table 3: The feed intake of the supplemental forages fed to the bucks during preference study.

Parameters	*Gmelina arborea* leaves	Groundnut haulms	LOS
Total intakes (g)	464.25^{b} ±32.50	695.53^{a} ±49.70	**
Mean forage intake (g/d)	66.32^{b} ±4.65	99.36^{a} ±7.10	**
Relative % of intakes	40.62^{b} ±1.87	59.38^{a} ±1.87	**

[a, b,] Means in a row differ significantly (P>0.05). LOS=Level of significance. **= highly significant (p<0.01).

Performance Indices

The result of the performance of Red Sokoto bucks fed varied levels of *G. arborea* leaves showed no significant (p>0.05) difference in body weight across the treatments (Table 4). Average daily weight gain of bucks fed with 50% level of inclusion (T3) was higher in numerical terms. This might be as a result of higher DMI, lower ADF, and NDF content of the treatment diet. The DMI obtained in this study was similar to 673-840 g/d reported by Osakwe and Udeogu (2007) who fed *Pennisetum purpurum* supplemented with *G. arborea* leaves to West African Dwarf (WAD) goats. The inclusion of *G. arborea* leaves showed no significant difference on DMI. This is in agreement with the findings of Goska *et al*. (2008), who reported that forage DMI did not differ due to CP source in supplements when Red Sokoto bucks were fed CSC, blood meal or their mixtures.

There was also no significant (P>0.05) difference in the feed conversion ratio (FCR) across the treatments (Table 4). The best feed FCR was obtained at 100 % inclusion level of *G. arborea* dried leaves. This could be attributed to better nutrient utilization of feeds at moderate level of tannins and crude fibre. The total DM intakes as expressed in % BWT obtained in this study were similar statistically and ranged 4.24 to 4.62 %. This was similar to 4.14 % of body weight reported by Abiodun, (1994) in a preliminary investigation of *Parkia fillicoidea* and *Teprosia braceolata* leaf meals in goat diets. The DM intake is an index of the acceptability of the forages to the bucks. Thus, the *Gmelina* leaves fed at 4.24 % of body weight per goat were well accepted and comparable to the control.

Digestibility of nutrients and Nitrogen balance

The result showed significant (P< 0.05) difference in nutrient digestibility across the treatments (Table 5). The DM digestibility of T1 was significantly (P<0.05) higher than other treatments, followed by T3, T4, T2 and the least DM digestibility in T5. This is similar to DM digestibility reported by Nwagu (2004) who obtained DMD ranged from 80 % to 83.49 % when GL and *Panicum maximum* was fed to West African Dwarf rams. Bucks on treatment 3 diet (50 % GL) had the best CP digestibility and those on T5 diet had the least. The digestibility of nutrients was high at 50 % GL inclusion and declined at 100 % level of inclusion. This agreed with the findings of Abdu *et al*. (2012) who reported decrease in CP digestibility with increasing *Gmelina* leaf meal in the diets of Red Sokoto bucks. This reduced nutrient digestibility might be as a result of increased passage rates at higher levels of tree leaves supplementation. This high digestibility at 50 % inclusion may be as a result of lower NDF and ADF content of the treatment diet. This agreed with the findings of Norton, (1994) who reported that the fibre fraction of food has the greatest influence on digestibility. The N-intake obtained in this study is similar to 128.93-138.55 g/d reported by Maigandi and Abubakar, (2004) who fed varying levels of *Faidherbia albida* pods to Red Sokoto bucks. Nitrogen retention was highest at 50 % GL inclusion and followed a similar pattern with digestibility of nutrient. The values obtained were close to N-retained reported by Maigandi and Abubakar, (2004). The improved protein utilization and retention in this study is in agreement with the report of Osakwe, (2004) that forages with low concentration of condensed tannins could improve the efficiency of N digestion. The values of N-retained indicate that all the bucks were in positive nitrogen balance.

Economic evaluation

Feed, whether purchased or produced on the farm, makes up a large part of the expenses (60-65 %) incurred in sheep and goat production (Schoeminon, 2003). The simple cost analysis of the feeds fed the Red Sokoto bucks was not significant except when the cost of supplements which were the test feeds was considered (Table 6). This was because the inclusion of *Gmelina* leaves which is

Table 4: Feed intake, live weight changes and feed utilization of Red Sokoto Bucks fed varying levels of dried *G. arborea* leaves.

Parameter (%)	levels of inclusion of *G. arborea* leaves					
	0	25	50	75	100	SEM
Intake (g/d) DM basis						
Concentrate	260.32	277.01	296.15	270.89	269.40	27.809
Supplement forage	370.05	366.57	401.19	329.98	316.02	41.675
D. smutsii hay	101.33	97.06	120.58	104.71	103.33	12.156
Total DMI	731.68	740.64	817.92	705.58	688.75	72.008
% BWT	4.49	4.41	4.62	4.30	4.24	0.143
Live weight changes						
Initial body weight	10.96	12.90	13.38	12.44	12.40	1.640
Final body weight	16.26	16.83	17.68	16.72	16.30	1.680
Weight gain (kg)	3.70	3.93	4.30	4.28	3.90	0.695
ADWG (g)	44.03	43.61	47.78	47.56	43.33	7.323
FCR	17.87	17.30	17.47	18.10	16.41	2.440

DMI=Dry Matter Intake, BWT=Body weight, ADWG=Average Daily Weight Gain, FCR=Feed Conversion Ratio.

Table 5: Effect of *Gmelina arborea* dried leaves inclusion on nutrient digestibility by Red Sokoto Bucks fed *D. smutsii* hay.

Parameters (%)	(Levels of *G. arborea* dried leaves)					
	T1(0)	T2(25)	T3(50)	T4(75)	T5(100)	SEM
DM	77.32[a]	69.05[d]	74.93[b]	74.65[c]	66.55[e]	0.059
CP	72.34[b]	70.90[c]	75.46[a]	68.39[d]	54.56[e]	0.085
Ash	60.37[a]	57.70[a]	63.90[a]	61.94[a]	42.54[b]	2.281
EE	71.47[b]	72.08[b]	83.96[a]	80.85[a]	54.59[c]	1.368
CF	60.48[c]	58.77[d]	68.17[a]	67.56[b]	52.97[e]	0.165
NDF	69.35[c]	60.17[e]	70.06[b]	72.54[a]	64.62[d]	0.019
ADF	64.57[a]	52.92[e]	62.85[b]	60.46[c]	57.69[d]	0.430
Nitrogen balance(g/day)						
N-intake	145.07[c]	131.57[e]	145.35[b]	147.35[a]	133.00[d]	0.056
Faecal N	40.12[c]	38.31[d]	35.66[e]	46.58[b]	60.44[a]	0.118
Urinary N	5.53[ab]	3.13[c]	6.43[a]	2.78[c]	4.60[b]	0.340
N-retained	100.09[b]	90.20[d]	103.26[a]	97.99[c]	67.96[e]	0.499

[a, b, c, d, e,] Means in a row with common letter(s) superscript do not differ significantly (P>0.05).

Table 6: Economic Evaluation of Feeds Fed to Red Sokoto Bucks during the Feeding Trial.

Parameters (Naira)	% inclusion of *Gmelina arborea* leaves					
	0	25	50	75	100	SEM
Cost of concentrate	9.47	10.08	10.78	9.86	9.80	1.131
Cost of supplement	1.85[a]	1.51[a]	1.36[a]	0.77[b]	0.46[b]	0.187
Cost of hay	2.03	1.94	2.41	2.14	2.07	0.271
Cost of feed/d	13.35	13.53	14.54	12.77	12.33	1.483
Weight gain	3.70	3.93	4.30	4.28	3.90	0.695
Cost/kg gain	377.07	297.92	306.03	290.30	280.18	41.417
Value of gain	1850.00	1962.50	2150.00	2140.00	1950.00	347.593
Income over cost	614.50	815.30	860.20	1032.30	891.00	268.120

[a, b,] means in a row with common letter(s) superscript do not differ (P>0.05) * Naira = Nigerian currency (100 kobo make 1 naira and current exchange rate is 1 US$ = 155 naira).

cheaper when compared with groundnut haulms reduced the cost linearly as the level increased. The cost of total feed consumed by the bucks during this study was similar across the treatments. Although the cost of total feed consumed by the bucks during this study was similar across the treatments, the cost of producing 1kg of gain (meat) was reduced with increasing GL inclusion in the diets. The cost per kg gain ranged from N280.18 in T5 to N377.07 in T1 (0 % GL). Incorporating GL in the diets of fattening goat saved cost which is incurred using only groundnut haulms. This is an indication that the other treatments compared favorably with the control. Availability of the feedstuff is important when considering its use in farm enterprises. *Gmelina* leaves are readily available when compared groundnut haulms whose availability is seasonal. Income over cost obtained increases with increasing level of GL inclusion in the diets.

Conclusion

The inclusion of *Gmelina arborea* dried leaves as protein replacement to groundnut haulms had a positive effect on performance indices. Bucks fed supplemental forages containing 50 % *Gmelina* inclusion recorded the highest DMI, live weight gain, highest protein digestibility and nitrogen retention. Therefore the inclusion of GL in goats' diet had positive impact on the economics of production.

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