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National Animal Production Research Institute
Ahmadu Bello University
P.M.B 1096, Shika-Zaria,
Kaduna State, Nigeria.
Email: japr@napri.gov.ng
Website: http://journals.napri.gov.ng

EFFECTS OF *Gmelina arborea* AND *Moringa oleifera* LEAF MEAL INCLUSION ON INTAKE, DIGESTIBILITY AND NITROGEN BALANCE OF RED SOKOTO BUCKS FED *Digitaria smutsii* HAY BASED DIETS

[*1]Okafor, E. C., [2]Lakpini, C. A. M., [1]Abdu, S. B. and [2]Lamidi, O. S.
[1]Department of Animal Science, Ahmadu Bello University, Zaria, Nigeria, [2]National Animal Production Research Institute, Ahmadu Bello University, Zaria, Nigeria.
**Corresponding author; email echibuzor@yahoo.com, GSM +2348060431467.*

ABSTRACT

Twenty Red Sokoto bucks aged between 7 and 8 months with an average weight of 15.20±0.80 kg were used to ascertain the effect of level of inclusion (0, 10, 20, 30%) and ratio of *Gmelina arborea* and *Moringa oleifera* leaf meal (75:25) on nutrient intake, nutrient digestibility and nitrogen balance in *Digitaria smutsii* hay based diets. The bucks were randomly assigned to four treatments balanced for weight with five bucks per treatment in a completely randomized design. Nutrient intake increased with increasing level of Gmelina and Moringa leaf meal inclusion but declined in T_4 (30%). There was no significant ($p<0.05$) difference in dry matter intake and organic matter intake across the dietary treatments. Dry matter intake ranged from 310.28 g/d in T_1 to 372.61 g/d in T_3. Diet with 20% leaf meal inclusion had significantly ($p<0.05$) higher dry matter but similar crude protein intake (49.37g) to that of 10% inclusion (46.70) which was similar to other treatments. The crude fibre, Neutral detergent fibre and Acid detergent fibre intakes were significant and followed similar pattern with crude protein. Dry matter digestibility was significantly ($p<0.05$) higher in animals fed T_2 (75.86%) and T_3 (73.16%) than other treatments. Organic matter digestibility (OMD) showed significant difference ($p<0.05$) across treatments. Animals fed T_3 and T_2 showed significantly higher OMD 84.98% and 84.97% respectively than the other treatments. Crude protein digestibility was similar and ranged from 72.60% in T4 to 77.62% in T3. Crude fibre digestibility was different significantly ($p<0.05$) across the treatments with highest value at T3 (76.15%). NDF digestibility was significantly higher ($p<0.05$) with diets containing Gmelina and Moringa leaf meal than the control. ADF digestibility followed the same pattern with the NDF digestibility. The result of N intake was significantly ($p<0.05$) different in animals fed T3 (20%) with higher nitrogen intake (7.90g/d) than other treatments. Nitrogen retention was positive across the treatments with animals on T3 having significantly ($p<0.05$) higher but similar nitrogen retention (5.37g/d) to T_1 and T_2. Nitrogen retention was least in animals fed 30% inclusion of Gmelina and Moringa leaf meal. It can be concluded from the results of this study that inclusion of Gmelina and Moringa leaf meal at 20% in *Digitaria smutsii* hay based diets had no adverse effect on intake, nutrient digestibility and nitrogen balance in goats.

Keywords: Red Sokoto bucks, *Gmelina aborea, Moringa oleifera,* Intake, Nutrient digestibility, Nitrogen balance

INTRODUCTION

Small ruminants form an integral part of the livestock economy in Nigeria. The arid and semi arid areas are home to over 80% of small ruminants and their sustenance is reducing due to dependence on natural pastures (Kosgey *et al.,* 2008). They support 46-58% of pastoral

households and play a significant role in the food chain and overall livelihoods of rural households, where they are largely the property of women and their children (Lebbie, 2004).

Dry season feeding of ruminants in most tropical areas has always been a problem for farmers since little good pasture exists during this period. 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 them with crop residues and browse plants. These feed resources are not consumed by man but can be converted by ruminants into animal products desirable as human food. This therefore reduces total cost of animal production without a decrease in productivity and also maintains efficient feed utilization.

Browse plants have great potential as source of high quality nutrient for ruminants, being high in protein, minerals and vitamins (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). The use of browse plants as supplement has been shown to enhance intake, improve growth rate and increase reproduction in ruminants (Lamidi *et al.,* 2009; Okafor *et al*., 2012; Abdu *et al.* 2012).

Moringa is one of the most promising plants which could contribute to increased intake of some essential nutrients and health-promoting phytochemicals. It has a high crude protein content ranging from 20-26% CP in leaves (Ben Salem *et al.,* 2004 and Asaolu *et al.,* 2011) with negligible contents of anti-nutrients (Makkar and Becker, 1996).

Gmelina arborea Roxb. (Family verbenanceae) is a fast growing deciduous tree that can grow up to 40 m tall and 140 cm in diameter (Jensen, 1995). Even though *Gmelina arborea* can shed some of its leaves when the dry season is approaching, the regrowth of new leaves could serve as animal feed during the dry season (Osakwe and Udeogu 2007).

The objective of this study was to ascertain the effect of feeding Gmelina and Moringa leaf meal inclusion levels on nutrient intake, nutrient digestibility and nitrogen balance in Red Sokoto bucks fed *Digitaria smutsii* hay based diets.

MATERIALS AND METHODS

Experimental Site

The experiments were conducted in the Experimental Unit of the Small Ruminant Research Programme of the National Animal Production Research Institute (NAPRI), Shika, Zaria, Nigeria. Shika is located between latitude 11º 10´57.43´´N and longitude 7º 36´ 16.64´´ E, with an altitude of 640m above sea level (GPS, 2015). 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), (IAR, 2015).

Feed Preparation

Fresh *Gmelina arborea* (GM) leaves were harvested within the Ahmadu Bello University Main Campus. Leaves were allowed to air-dry for three days and then removed by carefully beating the branches with sticks. Dried Moringa leaves were sourced from Sabon-Gari market, Zaria, Kaduna, Nigeria. The *Digitaria smutsii* hay was sourced from National Animal Production Research Institute (NAPRI). The dried leaves and *D. smutsii* hay were ground with hammer mill

fitted with 2cm screen for easy mixing with other feed ingredients. The ground ingredients were packed in sacks and stored in a well-ventilated store room.

Experimental Dietary treatments

Four isonitrogenous complete diets were formulated, with 40% *D. smutsii* hay base. The complete diets were compounded to contain 13% CP. *Gmelina arborea and Moringa oleifera* leaf meals were combined at ratio of 75 and 25% respectively. The combined leaf meal was included at 0, 10, 20 and 30%. Each level of inclusion served as a treatment. Other ingredients in the complete diet are maize offal, cotton seed cake, salt and bone meal (Table 1).

Table 1: The Ingredient Composition of Complete Diets (%) fed to Red Sokoto bucks

Ingredients	Level of Gmelina and Moringa leaf meal inclusion (%)			
	T_1 (0)	**T_2 (10)**	**T_3 (20)**	**T_4 (30)**
75GM:25MO leaf meal	0	10	20	30
Cottonseed Cake	23.40	20.00	16.00	12.30
Maize offal	34.60	28.00	22.20	15.80
Bone meal	1.5	1.5	1.5	1.5
Salt	0.5	0.5	0.5	0.5
D.smutsii hay	40	40	40	40
Total	100	100	100	100
Calculated analysis				
% Crude Protein	13.01	13.06	13.02	13.00
ME (Kcal/kg)	2437	2407	2375	2357
Cost/kg feed (N)	44.14	40.63	37.12	33.52

75 GM: 25 MO= 75:25% combination of Gmelina and Moringa leaf meal; ME=Metabolizable energy.

Management of animals and Experimental design

Twenty (20) Red Sokoto bucks between 7 and 8 months of age with an average weight of 15.20 ± 0.80kg were used. The animals were obtained from the Small Ruminant Research flock in NAPRI. They were given prophylactic treatment, consisting of Ivermectin ® at 200µg/kg body weight (BWT) against endo and ectoparasites and Terramycin long lasting (LA) ® at 20mg/kg BWT against bacterial diseases 7 days before the commencement of the experiment. The experimental animals were randomly allocated to four dietary treatments with five animals, each serving as a replicate in a completely randomized design.

Metabolism Study

Five animals per treatment were separately housed in metabolism crates with facilities for separate collection of faeces and urine as described by (Osuji *et al.*, 1993). Each buck was individually offered its appropriate ration at 4% of body weight to evaluate the digestibility of the diets. The study comprised of 7 days preliminary period of adjustment to the crate and 7 days of sample collection.

The faecal and urine samples were collected each morning just before feeding. Urine samples were collected into plastic containers acidified with 25ml of 10% H_2SO_4 acid. Ten percent (10%) of total daily urine collected was sub-sampled and kept for each animal at -4°C in freezer. Daily total faecal samples were also recorded from each animal, weighed, sub-sampled and stored in polythene bags. At the end of the collection period, the faecal and urine samples were bulked, mixed thoroughly and sub-sampled for each animal. The samples were kept at -4°C in freezer until required for chemical analysis.

Nutrient digestibility was calculated as the portion of nutrient intake not recovered in faeces. Nitrogen retention (NR) was calculated as the amount of average daily nitrogen intake (NI) not excreted in faeces (FN) and urine (UN).

NR = NI (g/d) – (FN + UN) (g/d).

Chemical analysis

The feeds and faecal samples were analyzed for Dry Matter (DM), Crude Protein (CP), Ether Extract (EE), Crude Fibre (CF), and Ash using the procedures outlined by the Association of Official Analytical Chemists (A. O. A. C., 2005). Acid Detergent Fibre (ADF) and Neutral Detergent Fibre (NDF) were determined according to Van Soest *et al.,* (1991) procedures. Urine N was determined using Micro Kjeldal method (A. O. A. C., 2005).

Statistical Analysis

Data generated on nutrient intake, apparent digestibility and nitrogen retention 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 SAS, (2005). The model below was used:

$Y_{ij}= \mu+t_j + e_{ij}$,

Y_{ij} is the response of animal i in treatment j

μ is the overall mean, t_j is the fixed effect of jth treatment (j=1, 2, 3, 4)

e_{ij} is the random error.

RESULTS

The result of the chemical composition of the feed ingredients and experimental diets are presented in Table 2. Results showed that the dry matter of Gmelina, Moringa, Gmelina and Moringa mixture and *D.smutsii* hay were 96.23, 94.85, 96.17 and 97.36% respectively. The crude protein contents of Gmelina, Moringa, the mixtures and *D.smutsii* hay were 14.50, 26.47, 17.94 and 5.50% respectively. The crude fibre contents of the feed ingredients were low to moderate with *D.smutsii* hay having the highest value (30.00%). The ash contents of the feed ingredients in this study were high ranging from 7.68% in Moringa leaf meal to 9.33% in Gmelina leaf meal.

The chemical composition of the experimental diets with varied inclusion levels of *Gmelina and Moringa* leaf meal showed that the CP contents of all the diets were iso-nitrogenous containing 13%. The DM, CF, OM and Ash contents of the experimental diets were comparable in this study. The NDF and ADF values were low to moderate.

Table 2: Chemical composition (%) of feed ingredients and experimental diets fed to Red Sokoto bucks

Parameters	Gmelina leaves	Moringa leaf meal	75GM:25 MO	*D. smutsii* hay	T_1	T_2	T_3	T_4
Dry matter	96.23	94.85	96.17	97.36	94.44	94.10	93.90	94.08
OM	86.90	87.17	87.49	88.21	87.59	87.63	87.19	87.23
Crude protein	14.50	26.47	17.94	5.50	13.09	13.00	13.15	13.25
Crude fibre	17.00	11.51	14.89	30.80	27.43	25.26	23.27	28.23
Ash	9.33	7.68	8.68	9.15	6.85	6.47	6.71	6.85
Ether Extract	3.78	4.03	3.80	2.99	7.91	5.66	5.08	5.88
NDF	49.31	22.79	46.45	67.06	41.59	46.22	45.71	43.51
ADF	27.99	11.09	21.50	46.39	22.56	26.94	26.41	24.51

OM= Organic matter; NDF=neutral detergent fibre; ADF=acid detergent fibre; 75 GM: 25 MO= 75:25% combination of Gmelina and Moringa leaf meals

The results of the nutrients intake are presented in Table 3. Nutrient intake (Dry matter, organic matter, crude protein, crude fibre, ether extract, NDF and ADF) followed similar pattern. They increased with increasing level of Gmelina and Moringa leaf meal inclusion but declined in T_4 (30%). There was no significant ($p<0.05$) difference in dry matter intake and organic matter intake across the dietary treatment.

The crude protein intake was highest ($p<0.05$) in 20% inclusion (49.37g) and least in 0% inclusion (40.62g). The highest ($p<0.05$) crude fibre intake was in 20% inclusion (105.15g) and the least in 30% inclusion (72.49g). Neutral Detergent Fibre (NDF) and Acid Detergent Fibre (ADF) intakes showed significant ($p<0.05$) difference in this study. NDF intake was higher in animals fed 20% (166.03) and 30% (162.12g) than in 0% inclusion (61.41g). Acid detergent fibre intake was least ($p<0.05$) in 0% inclusion (70.00g) compared with others except the 30% inclusion level.

The results in Table 4 shows that apparent nutrient digestibility was high across the dietary treatments. Digestibility increased with increasing leaf meal inclusion in animals fed 20% and then declined. Dry matter and organic matter digestibility were significantly ($p<0.05$) higher in animals fed in animals fed 10% and 20% inclusions than for other treatments. There was no significant ($p<0.05$) difference in crude protein digestibility ranging from 72.60% to 77.62%. Crude fibre digestibility was higher at 20% inclusion (76.15%) than other treatments. NDF and ADF digestibilities were significantly higher ($p<0.05$) in diets containing Gmelina and Moringa leaf meal than in the control.

Table 3: Nutrient intake of Red Sokoto Bucks fed varying levels of Gmelina and Moringa leaf meal in *Digitaria smutsii* hay based diets

Parameters (g/d)	Levels of Gmelina and Moringa leaf inclusion				SEM
	T_1	T_2	T_3	T_4	
Dry matter	310.28	359.22	372.61	311.51	31.59
Organic matter	271.77	314.78	325.03	271.60	27.62
Crude protein	40.62^{b}	46.70^{ab}	49.37^{a}	40.96^{b}	4.14
Crude fibre	78.38^{b}	98.53^{a}	105.19^{a}	72.49^{b}	8.45
Ether extract	24.54	23.96	25.64	22.05	2.21
NDF	129.04^{b}	166.03^{a}	162.12^{a}	142.39^{ab}	14.11
ADF	70.00^{b}	96.77^{a}	91.33^{a}	82.27^{ab}	8.06

a,b, Mean values with different superscripts within a row differ significantly ($p<0.05$) SEM standard error of mean; NDF=Neutral Detergent Fibre; ADF=Acid Detergent Fibre

Table 4: Nutrient Digestibility of Red Sokoto bucks fed varying inclusion levels of *Gmelina and Moringa* leaf meal in *Digitaria smutsii* hay based diets

Parameters (%)	Levels of Gmelina and Moringa leaf meal inclusion				SEM
	T_1	T_2	T_3	T_4	
Dry matter	66.54^{b}	75.86^{a}	73.16^{a}	65.28^{b}	2.55
Organic matter	79.79^{b}	84.97^{a}	84.98^{a}	78.82^{b}	1.59
Ether extract	76.00	70.31	75.55	72.21	3.70
Crude Protein	77.38	76.75	77.62	72.60	2.84
Crude Fibre	64.82^{b}	69.14^{b}	76.15^{a}	66.37^{b}	3.02
NDF	61.41^{b}	70.25^{a}	69.93^{a}	68.13^{a}	2.92
ADF	49.42^{b}	62.67^{a}	62.32^{a}	60.89^{a}	3.67

a,b, Mean values with different superscripts within a row differ significantly ($p<0.05$) SEM standard error of mean; NDF=Neutral Detergent Fibre; ADF=Acid Detergent Fibre

The result of N intake was significantly ($p<0.05$) different as presented in Table 5. The result showed that animals fed 20% inclusion diet had significantly ($p<0.05$) higher nitrogen intake than other treatments except for 10% inclusion. Nitrogen excreted in urine did not differ ($p<0.05$) significantly. However, result of faecal N loss differed significantly ($p<0.05$) in this study. Faecal N loss was significantly ($p<0.05$) higher in animals fed 20% and 30% (2.02g/d and 2.08g/d respectively) than for other treatments. Nitrogen retention was positive across the treatments. Animals on all treatments were significantly similar except for those on 30% inclusion that had the least ($p<0.05$).

Table 5: Nitrogen Balance of Red Sokoto bucks fed varying inclusion levels of *Gmelina and Moringa* leaf meal in *Digitaria smutsii* hay based diets

Parameters (g/d)	Levels of Gmelina and Moringa leaf meal inclusion				SEM
	T_1	T_2	T_3	T_4	
Nitrogen intake	6.50^{b}	7.47^{ab}	7.90^{a}	6.55^{b}	0.67
Urinary nitrogen	0.52	0.45	0.51	0.61	0.10
Faecal nitrogen	1.76^{b}	1.98^{b}	2.02^{a}	2.08^{a}	0.10
Nitrogen retention	4.22^{ab}	5.05^{ab}	5.37^{a}	3.86^{b}	0.75
N retention (as % of intake)	64.06	66.11	66.32	58.02	4.80

a,b, Mean values with different superscripts within a row differ significantly ($p<0.05$) SEM standard error of mean

DISCUSSION

Dry matter content of Gmelina leaf meal (96.23%) in this study is similar to 91.60% and 92.74% reported by Adeyele and Fasae (2008) and Abdu *et al*. (2012) respectively. The dry matter content is higher than 88.68% reported by Taiwo *et al*. (2009). The CP value of 14.50% reported in this study for Gmelina leaf meal is higher than 13.38 and 10.25% recorded by Okafor *et al*. (2012) and Abdu *et al.* (2012) respectively but similar to that reported by Amata and Labari (2011). However, CP value was lower than 26.70 and 20.30% reported by Omokanye *et al*. (2001) and Taiwo *et al.* (2009) respectively.

NDF and ADF of Gmelina leaf meal in this study were lower than values reported by Taiwo *et al*. (2009). Gmelina had high ash content of 9.33% which is lower than 11.30% reported by Abdu *et al*. (2012) but higher than 7.85% obtained by Okafor *et al*. (2012) for Gmelina leaves. This is in agreement with reports of Babayemi *et al.* (2003) and Amodu and Otaru (2004) who reported that browse plants are high in mineral content.

Crude fibre (CF) content obtained for Gmelina was similar to values reported by Okafor *et al*. (2012), but lower than 30.46% reported by Osakwe and Udeogu (2007). This agreed with Anbarasu *et al*. (2004) who reported that most browse leave have high crude fiber (CF) content and attributed it to high cell-wall constituents usually present in browse leaves.

Result showed high dry matter content of Moringa leaf meal (MLM) in this study and was similar to values obtained by Adegun (2014) who reported 92.22% DM. Crude protein content of MLM in this work was similar to the report of Sultana *et al.* (2014) who obtained 25.70 to 26.10%. Makkar and Becker (1996) and Kakenji *et al*. (2005) reported that CP of Moringa leaves can vary from 15 to even more than 30% depending on the maturity and respective proportions of leaves to stems.

Crude fibre value of 11.51% observed in this study for MLM is higher than 7.10 and 6.49% reported by Aderinola *et al*. (2013) and Adegun (2014) respectively. It is in agreement with the work of Sultana *et al*. (2014) who stated that crude fibre content of Moringa ranges from 8 to 30% on dry matter basis. NDF and ADF values obtained in this study were similar to findings of Sultana *et al.* (2014). The differences in chemical composition of feed ingredients may be due to

natural variations as a result of genetic background, environment, cultivation method, variations due to sample preparations and analysis (Brisibe *et al*., 2009; Njidda, 2010).

High DM value was recorded for mixture of Gmelina and Moringa leaf meal. This is because both browse forages were in dry form. The chemical composition of the mixture is similar to that of the individual forages. The CP content of all the diets were above the level suggested as adequate to meet the requirements for moderate weight gain in goats (NRC 2007). Norton (1994) recommended a diet with 8% CP for moderate live-weight gains in goats and according to this criteria all the diets had sufficient CP content. The chemical composition of experimental diets showed that the diets contained adequate dry matter and crude protein to support normal rumen functions (Ahamefule *et al.*, 2002). The similar (P>0.05) dry matter intake observed in this study improved with Gmelina and Moringa leaf meal inclusion.

Dry matter intake was comparable with 324-355g reported by Murro *et al*. (2003), when Moringa leaves replaced cottonseed cake in the diet of growing lambs. Similarly, feeding of growing goats with Moringa leaves as sole forage or combined with legume tree leaves in the diet had no significant effect on DMI ranging from 278 to 289 g/d (Asaolu *et al*., 2011). Dry matter intake is inversely related to the fibre content and directly proportional to chemical composition of diet consumed which affect the survivability and productivity of animals (Van Soest 1994).

The inclusion of the leaf meal improved crude protein, crude fibre, ADF and NDF intake in this study. Lower nutrient intake observed in control and 30% inclusion was as a result of the higher fibre contents of the diets. This is consonant with the results of **(**Abidi *et al.*, 2009 and Riaz *et al*., 2014) who reported that the CP concentration of diets had a positive effect on DMI and digestibility while fibre fractions depressed DMI of the animals. Dry matter digestibility observed in this study is similar to the values (73.30-81.69%) obtained by Sultana *et al.* (2015) whereas findings of Abdu *et al*. (2012) reported higher DM digestibility of 93.96-95.84%.

The crude protein digestibility recorded in this study is higher than values reported by Abdu *et al*. (2012) who fed complete diets to Red Sokoto goats but higher (89.35%) value by Asaolu *et al.* (2011) was reported. Reduction in digestibility at 30% Gmelina and Moringa leaf meal inclusion agreed with Melaku *et al.* (2004) who reported that increasing supplementation with tree fodder levels reduced nutrient digestibility due to increased passage rate. The digestibility recorded in this study can be attributed to the diet, as authors asserted that there were better production outcomes in browse mixtures than single browses as a result of improved palatability due to the combination of two fodders (Asaolu *et al*., 2012; Adegun, 2014).

Nitrogen intake observed in this work followed similar trend with nutrient intake and digestibility of nutrients. The values were similar to findings of Adegun (2014) who reported nitrogen intake ranging from 6.08±0.34 g/day in *M. oleifera* to 6.20±0.42 g/day in *G. sepium* and *M. oleifera* mixture and 4.79±0.62 g/day for animals on control diet. It has been reported that dietary nitrogen intake influenced nitrogen losses through urine and faeces (Badamana and Sutton, 1992). Also reduced nitrogen excretion in the urine was reported to be an indication that the diets were well balanced in energy and protein which were attributed to better nitrogen retention (Noblet and Van Milgen, 2004). Also according to McDonald *et al*. (2011), digestibility is much reduced when a ration contains little protein in proportion to the amount of readily digestible carbohydrate. Positive nitrogen balance by the bucks is an indication that the nitrogen in the diets was adequate and well utilized.

CONCLUSION

The inclusion of *Gmelina* and Moringa leaf meal as partial replacement to cotton seed cake had positive effect on nutrient intake, nutrient digestibility and nitrogen balance. Bucks fed 20% *Gmelina and Moringa leaf meal* recorded the higher nutrient intake, nutrient digestibility, nitrogen balance and nitrogen retention. However, all the animals had positive nitrogen balance an indication that nitrogen was well utilized. Gmelina and Moringa leaf meal can be included at 20% in *Digitaria smutsii* hay based diet without adverse effect on nutrient intake and digestibility in Red Sokoto goat.

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