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Voluntary feed intake and nutrient utilization of West African Dwarf sheep fed supplements of *Moringa oleifera* and *Gliricidia sepium* fodders

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Abstract: *Moringa oleifera* (Mo) and *Gliricidia sepium* (Gs) fodders and their mixtures were fed as protein supplements to basal diets of *Panicum maximum* (Pm) and cassava peels. Thirty two (32) yearling West African Dwarf (WAD) rams were divided into four groups of eight animals balanced for body weight and allocated to dietary treatments in a Completely Randomized Design for fifteen (15) weeks. Animals in group 1 consumed the basal diet only while animals from group 2, 3 and 4 were fed basal diets with supplements of Mo, Gs and their mixtures respectively. Voluntary feed intake (VFI), nutrient digestibility and nitrogen utilization of the animals were evaluated. Animals fed basal diet only had reduced VFI (252.36±22.0g day^{-1}) while those on Mo and Gs mixtures had significantly higher ($p<0.05$) VFI value of 344.96±22.2g day^{-1}. Voluntary feed intake of basal diet was increased significantly ($p<0.05$) for animals in group 2 and 4 (260.20±30.00 and 270.46±20.6g day^{-1} respectively). Higher but significantly different ($p<0.05$) dry matter digestibility values of 63.90±3.06, 62.72±3.02 and 68.50±4.32% were obtained for animals in group 2, 3 and 4 respectively while the animals in group 1 had the least value of 48.39±2.03%. Similar trend exist in crude protein and crude fibre digestibility with animals in group 4 having significantly higher ($p<0.05$) values of 60.62±5.24 and 68.63±3.22% respectively. The result of nitrogen utilization indicate significantly lowest ($p<0.05$) value of 3.56±0.16g day^{-1} of digested nitrogen for animals in group 1. Higher nitrogen retention value ($p<0.05$) of 65.81±4.20% was obtained in sheep on Mo and Gs fodder combinations. Those on separate Mo and Gs fodders were statistically similar (58.55±3.02% and 58.00±5.30% respectively) but higher ($p<0.05$) than those on basal diet (43.70±3.02%). Supplementation of *Panicum maximum* and cassava peels basal diet with *Moringa oleifera* or *Gliricidia sepium* fodders improved the intake of basal diet and enhanced better nutrient utilization of WAD sheep. Mixtures of the two fodders in the same ratio were superior to either supplementation.

Keywords: *Moringa oleifera,* Fodder Trees, Voluntary Feed Intake, Foliage Mixtures, Supplementation

1. Introduction

The increased importance of fodder trees as a non-conventional feed resource has been recognized as one of the most effective means of improving forage supply in small holder ruminant production (1). They provide biomass that remain green and seem to be cheap protein supplements that can improve voluntary intake, digestibility and general performance of animals fed low quality feeds which characterize the pasture and agricultural by-products in the tropics (2).

Research efforts have been intensified in Nigeria to characterize the agronomic features, management requirements and feed value of some promising tree species. Agishi identified about 40 families of trees and shrubs as foliage species in Nigerian rangelands (3). Out of these trees, *Gliricidia sepium*, an exotic leguminous tree is found in abundance in South-Western Nigeria, but well known as fencing, staking and shade tree than as a source of fodder (4). Animals often refuse gliricidia leaves on the basis of smell without even tasting it (5). On the other hand, *Moringa oleifera* is one of several trees that have not received sufficient attention for animal use in Nigeria (6, 7). Moringa is called a "Miracle tree" because of its wide range of purposes (8). Its nutritional importance, fast growth rate coupled with low anti-nutrients components merit its use as a valuable fodder for ruminants in South

Western Nigeria (6).

Depending on availability, presence of toxic substance, adaptability, voluntary intake and quality, a range of browse feeding strategies can be developed and these may prompt farmers to mix foliage given to animals. High responses of these mixtures have been reported for small ruminants. For example, Bosman *et al*. fed West African Dwarf (WAD) goats with gliricidia and leucaena as mixture (9). Weight gain with gliricidia alone was 2g/W $^{-0.75}$/day and for the mixture a weight gain of 8.2g/W $^{-0.75}$ /day was obtained. In another study, foliage from *Leucaena leucocephala, Calliandra calothyrsus* and their mixtures were used as supplements to maize husks for goats. Daily weight gain was 28, 19 and 22g while dry matter intake was 335, 315 and 317g for animals supplemented with leucaena only, calliandra only and their mixtures respectively (10).

The disappearance of feed particles from the reticulo-rumen depends primarily on the rate of digestion. High fibre rations such as tropical pastures and crop by-products result in longer retention and lower intake (11). Voluntary intake is inversely related to the fibre content and directly proportional to chemical composition of herbages consumed which affect the survivability and productivity of animals (12).

This study was designed to evaluate the effects of fodders of *Gliricidia sepium* and *Moringa oleifera* and their mixtures as supplements to basal diet of *Panicum maximum* and cassava peels on voluntary feed intake, and nutrient utilization of West African Dwarf (WAD) rams in South-Western Nigeria.

2. Materials and Methods

2.1. Experimental Site and Animals' Management

The study was conducted at the Teaching and Research Farm, Ekiti State University, Ado-Ekiti, South Western Nigeria between April 2010 and April 2011. Ado-Ekiti lies between latitude 07^{o} 37$^{'}$ 15$^{''}$ N and longitude 05^{o} 13$^{'}$ 17$^{''}$ E with an average relative humidity of 72%. It experiences a tropical climate with a temperature range of 20-28^{o}C and a bimodal rainfall distribution between April and October with peaks in June and September and a break in August. Dry season is between November and March. The average precipitation in this area is 1367mm.

Thirty two (32) yearling West African Dwarf (WAD) rams weighing 13.0±0.6kg were purchased from Otun-Ekiti, Ekiti State, Nigeria and quarantined for 30 days using the routine treatment developed at NAPRI (13).

2.2. Basal Diets

2.2.1. Cassava Peels

Cassava peels were obtained from the Garri Processing Unit of the Teaching and Research Farm, Ekiti State University, Ado-Ekiti. The fresh cassava peels were sun dried for about 2-4 days depending on the weather condition.

2.2.2. Panicum maximum (Guinea Grass)

Guinea grass was harvested from the University Campus premises with a sickle when the stems and leaves of the grass were still succulent. It was hereafter chopped into small pieces with a cutlass to prevent wastage by the animals. The grasses were harvested and wilted for a day before feeding to prevent scouring in the animals.

2.3. Supplemental Diets

Gliricidia sepium and Moringa oleifera fodders were harvested from gliricidia and moringa plantations at the Teaching and Research Farm, Ekiti State University. These fodders (leaves and twigs) were harvested daily and were left to wilt overnight before feeding to the animals.

2.4. Feeding Trial

The experiment lasted for fifteen weeks that comprise of one week for acclimatization to the feeding regime, twelve weeks for voluntary feed intake studies and two weeks for balance studies. The animals were weighed before the commencement of the feeding regime and divided into four groups of eight animals balanced for body weight and randomly allocated to dietary treatments in a Completely Randomized Design (CRD). The experimental diets were fed daily in two installments (morning and evening) at 08:00h and 17:00h. The basal diet of *Panicum maximum* plus cassava peels were supplemented with fodders of gliricidia, moringa or their mixture based on daily feed allowance of 4% of body weight. Equal fodder combinations of *Moringa oleifera and Gliricidia sepium* were thoroughly mixed manually to minimize animal preference/selection in Treatment 4. The rams had free access to fresh water daily. The dietary treatments were as follows

Treatment 1: *Panicum maximum* + Cassava peels

Treatment 2: *Panicum maximum* + Cassava peels + *Moringa oleifera*

Treatment 3: *Panicum maximum* + Cassava peels + *Gliricidia sepium*

Treatment 4: *Panicum maximum* + Cassava peels + *Moringa oleifera* + *Gliricidia sepium*

2.5. Digestibility Study

This was carried out immediately after the performance trial by transferring sixteen (16) WAD rams into wooden metabolic cages fitted with facilities for collection of faeces and urines. The quantity of feed offered, feed refusal, faeces and urine were determined for 7 days, after 7 days of adjustment to cages. Ten percent of the faeces and urine collected daily over the 7-day collection period were bulked. Nitrogen loss from urine and bacteria growth infestation were prevented by introducing 20cm^{3} of 10% H_2SO_4 into urine collection bottles and kept in freezing cabinet. Ten percent (10%) of faeces were weighed and used for moisture determination and the remaining oven-dried at 70^{0}C for 36 hours and milled.

2.6. Chemical Analysis

Samples of experimental diets and faecal materials were collected for dry matter (DM) determination and proximate analysis. The samples were weighed and oven-dried at 105^{o}C for 24 hours, weighed and ground to pass through a 2mm sieve. The milled experimental diets and faecal samples were analyzed for proximate analysis using the procedures described in AOAC (14). Gross energy (GE) contents of the experimental diets were determined against thermo-chemical grade benzoic acid standard using Gallenkamp ballistic bomb calorimeter (Cam Metric Ltd, Cambridge, UK). The nitrogen content of the urine was determined by the micro-Kjeldahl method as described by Pearson (15).

2.7. Statistical Analysis

The data collected were subjected to analysis of variance (ANOVA) using the general linear model (GLM) procedure of SAS. Significant differences among means were separated using the Duncan's Multiple Range Test (DMRT).

3. Results and Discussion

3.1. Results

3.1.1. Chemical Composition of the Experimental Fodders

The nutrient constituents of the basal diets; *Panicum maximum* and cassava peels, and their supplements; *Moringa oleifera, Gliricidia sepium* or combinations of *Moringa oleifera* and *Gliricidia sepium* are shown in Table 1. Crude protein (CP) of the fodders ranged from 3.96 g 100g^{-1} in cassava peels to 24.59 g 100g^{-1} in *G. sepium* fodder. Ash varied from 6.55 g 100g^{-1} in *G. sepium* fodder to 9.26 g 100g^{-1} in *P. maximum*. As for the fibre components, *M. oleifera*, *G. sepium* and their combinations were low in crude fibre with an average value of 7.52 g 100g^{-1} with *P. maximum* having the highest value of 41.16 g 100g^{-1}. Similar trend exist with the Neutral Detergent Fibre (NDF) and Acid Detergent Fibre (ADF) values. NDF varied between 25.50 g 100g^{-1} in *M. oleifera* to 59.56 g 100g^{-1} in *P. maximum* while ADF ranged from 23.58 g 100g^{-1} in cassava peels to 78.56 g 100g^{-1} in *P. maximum*. All the fodders were high in organic matter with values ranging from 85.60g 100 g^{-1} in *P. maximum* to 91.56 g 100g^{-1} in *G. sepium*. The gross energy (GE) values of the experimental fodders ranged from 14.79 MJ kg^{-1} in *M. oleifera* to 22.06 MJ kg^{-1} in *P. maximum*.

Table 1. *Chemical composition of experimental fodders/fodder combinations fed to West African Dwarf (WAD) sheep (g 100g^{-1})*

	Experimental Diets				
Parameters	***Panicum maximum***	**Cassava peels**	***Moringa oleifera***	***Gliricidia sepium***	***Moringa oleifera+ Gliricidia sepium****
DM	82.52	80.32	92.22	92.17	92.20
Ash	9.26	8.40	7.48	6.55	7.02
CP	7.56	3.96	22.69	24.59	23.64
CF	41.16	19.60	6.49	8.55	7.52
EE	1.26	0.98	16.45	12.29	14.37
NFE	48.68	66.62	40.28	40.21	40.25
NDF	59.56	34.06	25.50	28.50	27.00
ADF	78.56	23.58	40.60	29.41	35.01
OM	85.60	89.56	90.06	91.56	90.81
GE (MJ kg^{-1})	22.06	17.83	14.79	16.19	15.49

* Nutrient contents of mixed fodder were calculated.
DM – Dry matter, CP – Crude protein, CF – Crude fibre, EE – Ether extract, NFE – Nitrogen Free extract, NDF – Neutral detergent fibre, ADF – Acid detergent fibre, OM – Organic matter, GE – Gross energy.

3.1.2. Voluntary Feed Intake and Nutrient Utilization of WAD Rams Fed Supplements of Moringa oleifera, Gliricidia sepium and their Combination

Table 2 shows the effect of dietary supplementation on voluntary feed intake and nutrient digestibility of WAD rams.

There were significant differences ($p<0.05$) in voluntary feed intake (VFI) of the diet in all the treatments. The VFI ranged from 252.36 g day^{-1} in animals fed the control diet to 344.96 g day^{-1} in the *M. oleifera* and *G. sepium* combination. Supplement intake ranged from 48.60 g day^{-1} in animals on *G. sepium* fodder to 74.50 g day^{-1} in animals fed mixture of *M. oleifera* and *G. sepium* fodder combination.

The apparent nutrient digestibility of dry matter (DM) were significantly different ($p<0.05$) in all the diets. Higher but not significantly difference ($p<0.05$) values of 63.90, 62.72 and 68.50% were obtained for *M. oleifera*, *G. sepium* and *M. oleifera* and *G. sepium* combination respectively while the control diet had the least DM digestibility of 48.39%. Similar trend exist in the CP and CF digestibility with the supplement with *M. oleifera* and *G. sepium* combination having the highest values of 60.62 and 68.63% for CP and CF digestibility respectively. The coefficients of digestibility of *M. oleifera* and *G. sepium* fodders fed separately as supplements to basal diets for CP (55.40 and 53.63%) and CF (60.32 and 62.46%) were not significantly different ($p<0.05$) but were significantly higher ($p<0.05$) than the coefficient of digestibility of CP (45.03%) and CF (52.00%) in the control diet.

Table 2. *Voluntary feed intake and nutrient digestibility of WAD sheep fed supplements of Moringa oleifera and Gliricidia sepium fodder*

	Experimental Diets			
Parameters	**Control**	***Moringa oleifera***	***Gliricidia sepium***	***Moringa oleifera + Gliricidia sepium***
Intake				
Basal diet (g day^{-1})	252.36±22.0^{c}	260.20±30.0^{b}	254.62±16.4^{c}	270.46±20.6^{a}
Supplement diet(g day^{-1})	–	54.46±3.20^{b}	48.60±5.60^{c}	74.50±4.80^{a}
Total (g day^{-1})	252.36±22.0^{d}	314.66±88.6^{b}	303.22±20.5^{c}	344.96±22.2^{a}
DM Digestilibility (%)	48.39±2.03^{b}	63.90±3.06^{a}	62.72±3.02^{a}	68.50±4.32^{a}
CP Digestilibility (%)	45.03±4.62^{c}	55.40±3.04^{b}	53.63±1.02^{b}	60.62±5.24^{a}
CF Digestilibility (%)	52.00±2.80^{c}	60.32±4.06^{b}	62.46±2.82^{b}	68.63±3.22^{a}

a,b,c Means with the same superscript(s) in the same row are not significantly different (p > 0.05).

3.1.3. Nitrogen Utilization of WAD Sheep Fed Moringa oleifera and Gliricidia sepium Fodders as Supplements to Basal Diet of Panicum maximum and cassava peels

The result of nitrogen utilization in Table 3 shows that nitrogen intake values of supplemental fodders ranged from 6.08±0.34 g day^{-1} in *M. oleifera* to 6.20±0.42 g day^{-1} in *G. sepium* and *M. oleifera* mixture which were significantly higher (p<0.05) than the nitrogen intake of sheep on control diet (4.79±0.62 g day^{-1}). Significant difference (p<0.05) exists among means of digested nitrogen (N). Sheep on fodder combination of *M. oleifera* and *G. sepium* had higher digested nitrogen (5.64±0.42 g day^{-1}) than those on separate *M. oleifera* and *G. sepium* fodders (5.39±0.40 g day^{-1} and 5.30±0.12 g day^{-1}) respectively. Sheep on control diet had significantly lower (p<0.05) value of 3.56±0.16 g day^{-1} of digested nitrogen.

Nitrogen balance showed significant differences (p<0.05) in animals in the different treatment groups. Sheep on fodder combination of *M. oleifera* and *G. sepium* had the highest nitrogen balance (4.08±0.20 g day^{-1}) while those on control diet had significantly lowest value (1.70±0.28 g day^{-1}). Nitrogen retention shows considerable variation (p<0.05). The highest N retention value of 65.81±4.20% was obtained in sheep on *M. oleifera* and *G. sepium* combination fodder supplement while the least value (43.70±3.02%) was obtained in sheep fed the control diet.

Table 3. *Mean Nitrogen Utilization by WAD sheep fed Moringa oleifera and Gliricidia sepium fodders as supplements to basal diets of Panicum maximum and Cassava peels*

	Experimental Diets			
Parameters	**Control**	***Moringa oleifera***	***Gliricidia sepium***	***Moringa oleifera + Gliricidia sepium***
Nitrogen intake (g day^{-1})	4.79±0.62^{c}	6.08±0.34^{a}	6.12±0.20^{a}	6.20±0.42^{a}
Faecal nitrogen (g day^{-1})	1.23±0.06^{a}	0.79±0.02^{c}	0.82±0.02^{b}	0.56±0.03^{d}
Digested nitrogen (g day^{-1})	3.56±0.16^{c}	5.39±0.40^{b}	5.30±0.12^{b}	5.64±0.42^{a}
Urinary nitrogen (g day^{-1})	1.86±0.32^{a}	1.83±0.28^{a}	1.75±0.52^{a}	1.56±0.32^{b}
Nitrogen balance (g day^{-1})	1.70±0.28^{c}	3.56±0.46^{b}	3.32±.22^{b}	4.08±0.20^{a}
Nitrogen retention (%)	43.70±3.02^{c}	58.55±3.60^{b}	58.00±5.30^{b}	65.81±4.20^{a}

a,b,c Means with the same superscript(s) in the same row are not significantly different (p > 0.05).

4. Discussion

The crude protein (CP) contents of cassava peels and *P. maximum* fall within the range reported in the literatures, 2.8 – 6.5 g 100g^{-1} for cassava peels (17) and 5.9 – 12.4 g 100g^{-1} for *P. maximum* (18, 19). The CP values were below the requirement of 14 g 100g^{-1} for growing small ruminants (20). The nitrogen free extract (NFE) value of cassava peels is high and within the range of 62.5-72.9 g 100g^{-1} as reported by Adegbola and Asaolu (16). This means that cassava peel is an energy source suitable for ruminants but with a characteristically low protein content. *Panicum maximum* used in this study contained high NDF and ADF. Feeds with higher NDF (more than 35%) have lower digestibilities because NDF generally ferments and passes from the reticulo-rumen more slowly than other dietary constituents leading to greater filling effect over time than non-fibrous feed components (12).

The CP value of 24.59g 100g^{-1} reported in this study for *G. sepium* is above 14.70 g 100g^{-1} and 21.64 g 100g^{-1}DM documented by Devendra and Asaolu *et al*. respectively (4, 17). These may be due to natural variations as a result of genetic background, environment, cultivation method, variations due to sample preparations and analysis as noted by Brisibe *et al*. (18). The CP of *M. oleifera* and *G. sepium* were above 20.0 g 100g^{-1}. This agrees with the observation of Waldroup and Smith that multipurpose trees contain 20% CP and above in their leaves (19). The value of CP in *M. oleifera* and *G. sepium* were above the minimum requirement recommended for small ruminants (20). The fibre components of ADF and NDF of *M. oleifera* and *G. sepium* are generally low and similar. This is consistent with the findings of Okoli *et al*. that browses contain low to moderate ADF and NDF values which make them more available for degradation by rumen microbes (21).

The observed lower voluntary feed intake (VFI) in the

sheep fed the control diet could be traced to the level of CP and NDF. Minson observed that most of the tropical forage species and crop by-products have low intake due to the lower level of protein in their leaves (20). The increase in the VFI of animals fed supplemental diets conforms to the findings of other authors which reported that supplementation increased consumption of basal diets of low nutritional value (22, 23). This is because browsing of multipurpose trees provides rumen microbes with a source of nitrogen thereby boosting the rate of passage and digestibility of grasses with a corresponding increase in intake even at relatively small levels of supplementation (24). The significantly lower intake in the *G. sepium* supplementation compared to that of *M. oleifera* could be due to palatability problem encountered by small ruminants when fed with *G. sepium* (25).

The higher VFI in *M. oleifera* and *G. sepium* fodder combination supplement than the single supplement of *M. oleifera* and *G. sepium* is in line with the reports of other authors who asserted that there were better production outcomes in browse mixtures than single browses (9, 26). This could be as a result of improved palatability due to the combination of the two fodders.

The apparent lowest dry matter (DM) digestibility in the control diet could be due to the higher fibre content of the control diet than others. Dry matter digestibility is dependent on the cell wall constituents of diets with feedstuffs having higher fibre being less digestible than those with lower fibre (27). Crude protein and CF digestibility followed the same trend with the DM digestibility. However, the CP and CF digestibility in this study (58.00-60.62% CP; 60.22-68.65% CF) were lower than the values of CP (75.56%) and CF (89.35%) obtained by Asaolu *et al*, when sole *M. oleifera* and its mixtures with equal proportions of *L. leucocephala* and *G. sepium* were fed to WAD goats (28). The difference could be due to higher nutrient concentration in the browses than grasses which revealed higher digestibility for multipurpose tree fodders than grasses (29).

Nitrogen intake, nitrogen balance and nitrogen retention increased with supplementation of the basal diet in this study. This is in consonant with the observation by McDonald *et al*. which reported that dietary nitrogen intake in animal is directly related to the proportion of nitrogen in the diet (30). The higher nitrogen retention values obtained for the supplemented diets indicate a higher efficiency of protein utilization as a result of the supplementation.

5. Conclusion

Supplementation of *Panicum maximum* and cassava peels-based diet with *Moringa oleifera* or *Gliricidia sepium* fodders improved the intake of basal diet and enhanced better nutrient utilization of WAD sheep. Mixtures of the two fodders in the same ratio were superior to either of the supplement fed alone.

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