

# Intake and Growth Performance of West African Dwarf Goats Fed *Moringa oleifera*, *Gliricidia sepium* and *Leucaena leucocephala* Dried Leaves as Supplements to Cassava Peels

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## Abstract

An 84-day feeding trial was employed to investigate dried leaves of *Moringa oleifera* (MOR), *Leucaena leucocephala* (LEU) and *Gliricidia sepium* (GLI) as supplements to cassava peels by 16 growing West African Dwarf goats, with a mixed concentrate (MC) of groundnut cake and wheat offals (50:50) as the reference supplement. Feed intakes, weight gain, feed conversion (FCR) and protein efficiency ratios (PER) were monitored. Crude protein contents of the browse leaves were high and ranged from 21.64 to 28.86 % for GLI and LEU respectively. Dry matter intakes ranged from 3.55 to 4.12 % of body weights for animals on *gliricidia* leaf and mixed concentrates supplements respectively. MOR supplementation resulted in an average weight gain of 20.83 g/animal/day, comparable ( $P < 0.05$ ) to the value of 21.43 g/animal/day for the MC supplementation. Feed and protein were however more efficiently utilized by animals on the MOR supplement, with FCR and PER values of 14.94 and 1.87 which were both significantly ( $P > 0.05$ ) lower than the corresponding values of 16.54 and 2.74 for animals on the MC supplement. The high potentials of MOR for replacing expensive concentrates as supplements to a wide array of fibrous crop residues, as represented by cassava peels, were demonstrated by the results of this study.

**Keywords:** WAD goats, concentrate feeding, cassava peels, *Moringa oleifera*, *Gliricidia sepium*, *Leucaena leucocephala*

## 1. Introduction

Livestock plays a very important role as an integral part of farming and rural life in developing countries; providing food and the critical cash reserve and income for many farmers who grow crops essentially for subsistence purposes (Preston & Leng 1987). In the rural areas where most of the resource-poor farmers in Africa live, goats play an important socio-economic role (Anaeto et al., 2009), and form an integral part of the cultural life system of Nigeria's peasantry (Ajala, 2004). Goats are multipurpose animals producing meat, milk, skin and hairs (French, 1970). However, out of these products, meat is the major form in which goats are consumed in Nigeria (Alikwe et al., 2011). Goat meat is widely accepted and consumed in Nigeria because there is no taboo against it (Peacock, 1996). The demand for goat meat is very high especially in rural areas where it often commands higher market price than beef (Odeyinka, 2000). The meat from goat is preferable to those from other animal species because of its flavour, tenderness and palatability (Idiong & Orok, 2008). They are indispensable in marriage and religious rites (Gefu et al., 1994) and are an insurance against crop failure (Matthewman, 1980). In southern Nigeria, goats are a ready source of family income and a good medium to establish friendship or restore peace in a community (Idiong & Udom, 2011). The West African Dwarf (WAD) goat is a predominantly indigenous breed found in southern Nigeria (Odeyinka, 2000).

Small ruminants suffer scarcity of feed supply and pasture quality in the humid region of West Africa, especially during the dry season when the natural vegetation is of poor nutritive value (Aye, 2007). Specifically for goat production in Nigeria, Ahamefule & Elendu (2010) identified feed shortage as a major constraint. Native rangelands produce the cheapest source of nutrients for goats, and for a greater part of the year, grasslands do not supply sufficient nutrients to stock for greater productivity (Ndlovu, 1992). The goats also subsist on household wastes and crop residues (Odeyinka, 2000). Cassava peel is an important by-product available from the

processing of cassava (*Manihot esculentus*) root for food uses and starch, and has been used in feeding various classes of livestock (Akinfala & Tewe, 2004). During the dry season, the native rangelands and crop residues available for ruminants after crop harvest are usually fibrous and devoid of most essential nutrients including proteins, energy, minerals and vitamins which are required for increased rumen microbial fermentation and improved performance of the host animal (Osuji et al; 1995) resulting in weight losses, low birth weights, lowered resistance to disease, and reduced animal performance (Onwuka et al., 1989). In response to these challenges, the usual practice has been to supplement livestock diets with protein rich ingredients such as groundnut cake (GNC), soybean meal (SBM) and cotton seed cake (CSC). Concentrate mixtures including cereal grains, cereal bran and oil seed meals have resulted in increased intake in intensive production systems, and such strategies have been the subject of several excellent reviews, including that of Bangani et al. (2002). Unfortunately, these supplements are often not fed due to their unavailability and their high costs (Nouala et al., 2006; Olomola et al., 2008). A cheaper alternative of enhancing utilization of low quality grass is by supplementation with the foliages of high nitrogen multipurpose trees (Norton 1994; Abdulrazak et al., 1997). Browse plants with high nutritive values have been successfully fed to small ruminants in alley farming systems (Fasae & Alokun, 2006). Studies have shown that multipurpose trees can be used as cheap protein supplements which can improve voluntary intake, digestibility and general performance of animals fed low quality feeds (Kakengi et al., 2001). The leaves of *Leucaena leucocephala* and *Gliricidia sepium* plants have been widely reported (Shelton & Brewbaker, 1994; Asaolu & Odeyinka, 2006; Yousuf et al., 2007) as valuable forage supplements to ruminants consuming low-protein diets. The two leguminous browse plants have been introduced to, and popular among rural goat owners and keepers in southern Nigeria (Odeyinka, 2000).

*Leucaena leucocephala* is a relatively fast-growing tree in the production of forage (Szyzka et al., 1983). Reynolds & Atta-Krah (2006) reported that the browse plant has the ability of being available all year round because of its drought resistance, persistence, vigorous growth and re-growth and palatability. *Leucaena leucocephala* is a tree legume noted for its high nutritive value for ruminant production (Babayemi & Bamikole, 2006), being high in proteins, vitamins and minerals (Odeyinka, 2001). Its amino acid pattern is comparable with that of soya bean and fish meal (Ter Meulen et al., 1979) and other animal feed sources available in developing nations (Kale, 1987). *Leucaena leucocephala* leaves have been found to play a valuable role in providing supplemental nitrogen to goats fed maize residues under the village system of management (Fasae et al., 2011). It is readily available in smallholder settlements in south west Nigeria (Fasae et al., 2011), although it has its origins in Central America and the Yucatan Peninsula of Mexico (Brewbaker et al., 1985). *Gliricidia sepium* is a tropical tree legume, which grows abundantly in the southern part of Nigeria (Amate & Bratte, 2008), although native to Central and South America (Smith & van Houtert, 1987). This leguminous tree produces a high quality fodder and is a potential substitute of other feed resources (Adejumo, 1991; Abdulrazak et al., 1997). It is a resource that can be mechanically harvested, with production levels of up to 150 metric tons of green matter/ha/yr (Adejumo, 1991). Previous records (Gohl, 1981; Asaolu & Odeyinka, 2006) have shown that the leaves contain as much as 20 – 30% CP and about 15% CF. The plant grows vigorously, is drought-resistant and persistent, has good re-growth potentials, and so can be used to provide feed all-year round (Atta-Krah & Sumberg, 1986). *Gliricidia sepium* has been described as a suitable feed for ruminants which they can consume in large quantities without deleterious effects on animal performance (Bawala et al., 2006). It presents nutrient levels which are superior to minimum critical levels required for ruminants, and is comparable to other shrubs considered as having a high fodder quality (Smith & van Houtert, 1987).

The use of *Leucaena leucocephala* is however reportedly (Baumer, 1992) hampered by its susceptibility to psyllid (*Heterospana cubana*) attack, causing considerable reduction in fodder yields, particularly during the dry season. *Gliricidia sepium* is also limited by its low acceptability and higher contents of toxic compounds and odour (Norton, 1994). Lowry (1990) observed that animals often refuse *gliricidia* leaf on the basis of smell and even reject it without tasting it. This led him to conclude that the problem lies with volatile compounds released from the leaf surface. Apart from volatile compounds, the low palatability may be related to other deleterious factors such as tannins, essential oils or other aromatic compounds which are frequently present in many tree leaves (Kumar and Vaithyanathan, 1990).

*Moringa oleifera* Lam (syns. *Moringa pterygosperm*, family Moringaceae), a non-leguminous multi-purpose tree, is one of the fastest growing trees in the world, with high crude protein in the leaves (> 20 %) (Makkar & Becker, 1996). *Moringa* is native to sub-Himalayan regions of India and is now naturalized in many countries in Africa, Arabia, Southeast Asia, Caribbean Islands and South America (Ramachandran et al., 1980). It offers a good

alternative source of protein to humans and ruminants wherever they thrive (Nouala et al., 2006). Its leaves and green fresh pods are used as vegetables by humans and are rich in carotene and ascorbic acid with a good profile of amino acids, vitamins A, B and C, Ca, Fe and P (Makkar & Becker 1996). Laboratory analysis (Makkar & Becker 1997; Asaolu, 2009) showed negligible amounts of tannins (1 to 23 g/kg) in all fractions of the *Moringa oleifera* plant and high levels of sulphur-containing amino acids. There has been an increasing interest in the use of moringa as a protein source for livestock (Makkar & Becker, 1997; Sarwatt et al., 2004; Asaolu et al., 2009; 2010). Sarwatt et al. (2004) reported that moringa foliage is a potential inexpensive protein source for livestock feeding. The advantages of using moringa as a protein resource are numerous, and include the fact that it is a perennial plant that can be harvested several times in one growing season and also has the potential to reduce feed cost. Moringa can easily be established in the field, has good coppicing ability, as well as good potential for forage production. It can reach 12 m in height at maturity, yielding up to 120 tonnes/ha/yr when planted very densely for use as forage (Makkar & Becker, 1997). Additionally, it is not affected by any serious diseases in its native or introduced ranges (Parrotta, 2005).

In an earlier nutrient utilization study with WAD goats (Asaolu et al., 2011), high and comparable nutrient digestibility, nitrogen utilization and predicted relative feed values were reported for the forages of *Moringa oleifera*, *Leucaena leucocephala* and *Gliricidia sepium*. This follow-up study was conducted to investigate the effects of supplementing a basal diet of cassava peels with dried forages of *Moringa oleifera* (MO), *Leucaena leucocephala* (LEU) and *Gliricidia sepium* (GLI) on the performance of WAD goats. Performance indices were voluntary dry matter intake, crude protein intake and growth rate.

## 2. Materials and Methods

### 2.1 Experimental Site

The experiment was carried out at the Small Ruminant Unit of the Ladoko Akintola University of Technology Teaching and Research Farm, Ogbomoso. The area is located at 8° 10' North latitude and 4° 10' East longitudes with annual rainfall of 1270 to 2030 mm, which occurs in 7-10 months with a peak between July and September of the year. The temperature of the area ranges between 28°C to 33°C, with humidity of about 74% all year round except in January when the dry wind blows from the North (Olaniyi, 2006).

### 2.2 Experimental feeds procurement and processing

MOR, LEU and GLI leaves were harvested from existing plantations at the Teaching and Research Farm after a cut-back period of 60 days in March 2010; the peak of the dry season. The leaves of each of the three browses were pooled together separately and air-dried to constant moisture levels, and thereafter bagged separately for later use and chemical analysis. Fresh cassava peels were collected from a "gaari" processing plant at Iluju, a town located within 20 km radius of Ogbomoso. The peels were dried to a constant moisture level at the Small Ruminant Unit of Teaching and Research Farm and bagged for subsequent use and chemical analysis. Wheat offals (WO) and groundnut cake (GNC) were purchased from a reputable commercial feed store in Ogbomoso, and sampled for chemical analysis.

### 2.3 Animals, experimental design and management

Sixteen (16) growing West African Dwarf goats (8 males and 8 females), weighing  $7.5 \pm 0.2$  kg, were purchased from some local small ruminant markets in Ogbomoso. The goats were quarantined for a period of three weeks prior to the commencement of the study. During this period, oxytetracycline and a multivitamin preparation were administered at the rate of 1 ml per 10 kg body weight through intramuscular route for prophylactic treatment. Ivermectin was also administered subcutaneously at the rate of 0.2 ml per 10 kg body weight against external and internal parasites. The animals were group-fed *ad lib* on cassava peels, and offered mixed supplements of *Moringa oleifera*, *Gliricidia sepium* and *Leucaena leucocephala* leaves between 08.00 and 09.30 hours daily.

After the quarantine period, the animals were grouped into four of four goats each, and balanced for weight and sex. The animals were thereafter moved into pens measuring  $1.20 \text{ m}^2$  (1.5 by 0.8 m), and equipped with feeding and watering facilities, before being allotted to four treatments in an 84-day feed intake and growth study using a randomized complete block design. The 84-day study was preceded by a 14-day adaptation period. Animals in Group 1 were placed on the control diet, which consisted of a basal component of cassava peels offered *ad libitum*, and a mixed concentrate supplement of GNC and WO in equal proportion offered at 250 g/animal/day. Animals in Groups 2 to 4 were placed on the three experimental diets; consisting of the same basal component, but supplemented with dried leaves of *Moringa oleifera*, *Gliricidia sepium* and *Leucaena leucocephala* leaves

respectively, also offered at 250 g/animal/day. The animals were provided with free access to mineral-salt licks and clean fresh water daily throughout the duration of the experiment. Cassava peels were offered in two equal installments; in the morning (around 09.30 hours) and in the afternoon (around 15.00 hours) to ensure availability at all times. The supplements were offered between 08.00 and 09.30hrs before the basal diet. Feed offers and refusals were weighed every day before daily morning feeding. The basal component of the diet (cassava peels) was adjusted so that 10% more of the previous day's intake was offered daily. Animals were weighed at the commencement of the experiment and subsequently weekly before morning feeding.

#### 2.4 Chemical analyses

Experimental feed samples were collected weekly in the course of the study. At the end of the study, they were separately re-dried to constant weights, and subsequently analyzed for the proximate contents using the standard methods of AOAC (2000). The ADF and NDF components were determined by the methods of Van Soest *et al.* (1991). Metabolizable energy values were predicted from the equations of Abate & Meyer (1997) for tropical forages and concentrates; ME (MJ kg<sup>-1</sup> DM) = 20.27 - 0.1431CF - 0.1110NFE - 0.2200ASH; R<sup>2</sup> = 0.25, P < 0.0001 and ME (MJ kg<sup>-1</sup> DM) = 5.34 - 0.1365CF + 0.6926NFE - 0.0152NFE<sup>2</sup> + 0.0001NFE<sup>3</sup>; R<sup>2</sup> = 0.45, P < 0.0001 respectively.

#### 2.5 Statistical analyses

The data that were generated on the performance indices were subjected to Analysis of Variance using the General Linear Model procedures of SAS (SAS, 2001). Significant differences between means were compared using the Duncan New Multiple Range test (DNMRT) of the same package.

### 3. Results and Discussion

#### 3.1 Experimental diet compositions and nutrient compositions of experimental feedstuffs

The compositions of the experimental diets are as shown in Table 1 while Table 2 shows the nutrient compositions of the experimental feedstuffs. Cassava peels could be taken to represent the array of low-protein and low-energy crop residues often available in this part of the world for ruminants after crop harvest, especially during the dry season; while GNC is generally regarded as a safe feed for all classes of livestock with high CP and predicted ME values in addition to low ADF content (Table 2). Wheat offals, arguably the most important cereal offal in Nigeria, also supplies both protein and energy (Table 2). The cassava peels used in this study contained 3.28 % crude protein and 1.72 % EE, with a predicted ME of only 5.73 MJ/kg DM. The ADF value of 52.00 % was on the high side (Table 2). These values fell within earlier reported ranges (Tewe, 1987; Asaolu & Odeyinka, 2006). Norton (1994) observed that feeds containing less than 8 % CP could not provide the ammonia levels required by rumen microbes for optimum activity, while Yousuf *et al.* (2007) opined that relatively high ADF but low ether extract and crude protein contents were suggestive of low nutritional quality. The nutrient contents of all the experimental supplements (Table 2) were in agreement with earlier reported values (Asaolu & Odeyinka, 2006; Asaolu *et al.*, 2010; Eniolorunda, 2011). The CP contents were much higher than the 8 % level required for optimum rumen microbial activity (Norton, 1994). They also exceeded the range of 11.00 to 13.00 % known to be capable of supplying adequate protein for maintenance and moderate growth in goats (NRC, 1981). Ranjahan (2004) reported that if a growing animal is provided with insufficient protein, the efficiency with which it utilizes metabolizable energy would probably be altered. The ADF and NDF contents of the forages (Table 2) were low to moderate when compared with low quality roughages which ruminants effectively degrade (Okoli *et al.*, 2003). As was observed for the mixed concentrate supplement (50GNC:50WO), the predicted ME values of the three experimental fodders were also high (Table 2), and compared favourably with a reported value of 10.00 MJ/kg DM for alfalfa forage at the pre-bloom stage (Close & Menke, 1986). Eniolorunda (2011) considered forage nutrient compositions similar to those obtained in this study as suggestive of their suitability for fodder use. Browse plants have been reported to have high CP of high digestibility, and are also high in vitamins and minerals (Osakwe, 2003; Asaolu *et al.*, 2011) In a nutrient utilization study with WAD goats (Asaolu *et al.*, 2011), high and comparable nutrient digestibility, nitrogen utilization and predicted relative feed values were reported for the forages of *Moringa oleifera*, *Leucaena leucocephala* and *Gliricidia sepium*, thus making them potentially valuable supplements for goats maintained on poor-quality agro-industrial by-products and crop residues.

#### 3.2 Animal performance indices



All the experimental animals had adequate total DMI (g/animal/day) with values ranging from 288.48 to 354.49 for animals on GLI and MC supplementations respectively (Table 3). These values were comparable to the range (291.55 – 313.42 g/animal/day) reported for WAD goats fed cassava peels-cassava leaf meal based diets (Ukanwoko *et al.*, 2009). When expressed as percentages of body weights, the afore-mentioned values respectively represented 3.55 and 4.12 (Table 3); which fell within recommended dry matter intake levels for small ruminants (NRC, 1985). In absolute terms (g/animal/day), significant ( $P < 0.05$ ) differences were observed in DMI across all the treatments with the highest intake level recorded for animals on the MC supplement and the least intake recorded for animals on GLI supplementation. When expressed relative to metabolic body weight and as a percentage of body weight, significant ( $P < 0.05$ ) differences were still obtained. However, while the intake of animals on the MC concentrate was still significantly ( $P < 0.05$ ) higher than those of animals on the other supplements followed by that of animals on MOR, no significant ( $P > 0.05$ ) differences were found in the intake levels of animals on GLI and LEU supplements. The DMI ( $\text{gkg}^{-0.75}$ ) ranged between 59.98 and 70.59 for animals on GLI and MC supplements respectively. Mba *et al.* (1982) had reported a DMI of 54.81  $\text{gkg}^{-0.75}$  for WAD goats maintained on *Gliricidia sepium* plus concentrate on a 1:1 ratio while Asaolu *et al.* (2010) reported DMI values ranging from 54.60 to 59.60  $\text{gkg}^{-0.75}$  for WAD goats on groundnut hay basal diets, and offered moringa and bamboo foliages as supplements. The observed trends were most probably dictated by the intake pattern of the supplements by the animals as observed also in Table 3, which followed the same trend as observed for total DMI in absolute terms. The supplements were not consumed to the same extent. The MC supplement was consumed in the highest ( $P < 0.05$ ) amount, followed by MOR, LEU and GLI in that order. The intake pattern of the supplements could be a reflection of the relative acceptability and palatability of these supplements. Masafu (2006) described feed intake as a measure of diet appreciation, selection and consumption by an animal. For many tree leaves, palatability has been related the contents of volatile compounds, tannins, essential oils, or other aromatic compounds, which are frequently present in many tree leaves (Kumar & Vaithyanathan, 1990). The least DMI was observed for animals on GLI supplement (Table 3). Lowry (1990) suggested that the real constraint to *gliricidia* feed value for ruminants lies in its palatability. The DMI pattern, as was observed in this study, could also have been due to the CPI levels (Table 3). Significantly ( $P > 0.05$ ) higher CPI was observed for animals on the MC supplement while comparable levels ( $P < 0.05$ ) were observed for animals on MOR and LEU supplements. Mtenga & Shoo (1990) reported a positive correlation between crude protein intake and dry matter intake. The crude protein intakes were seemingly reflections of the CP contents of the supplements (Table 2) and their corresponding DMI levels (Table 3). The mixed concentrate supplementation resulted in the highest dietary protein availability, hence, the highest CPI. Similar observations had been earlier reported (Fasae *et al.*, 2005; Arigbede, 2007).

Goats on the reference supplement (MC) and MOR gained similarly ( $P < 0.05$ ) in body weights, but each at a faster ( $P > 0.05$ ) rate than LEU and GLI supplements. The goats on the GLI supplement had the least rate of growth. These observations did not however translate to significant differences in the final live-weights of the animals (Table 3), probably as a result of the duration (84 days) of the study. It is most likely that the differences would be brought to statistical levels in a longer term study. The average daily weight gains (ADGs) ranged from 14.88 to 21.43 g/animal/day for animals on GLI and MC supplements respectively. The growth rates were lower than the range (23.33 – 28.57 g/animal/day) that was reported by Odeyinka (2001) for WAD goats fed leucaena and *gliricidia* leaves. They were also lower than the range (46.00 – 56.00 g/animal/day) that was reported by Babayemi *et al.* (2006) for WAD fed *Panicum maximum*-based diets supplemented with lablab, leucaena and *gliricidia* foliages. The growth rates were however higher than the range of 6.8 – 17.0 g/animal/day (yet to be published data from one of our studies) obtained for intestinal nematode-infested WAD goats maintained on a basal diet of groundnut hay with moringa and bamboo (*Oxytenanthera abyssinica*) leaves as supplements. The observed differences in growth rates with earlier studies could have been due to differences in the basal components of the diets, voluntary dry matter intake, efficiency of feed utilization and the physiological state of the animals. The higher growth rates of the animals on the MC and MOR supplements in this study could be ascribed to their more efficient utilization by the animals as indicated by their lower feed conversion ratios (FCRs; Table 3). Animals on the MOR supplement were even more efficient in converting feed to weight gain than those on the MC supplement. Earlier similar observations (Tripathi *et al.*, 2006) between growth and feed conversion efficiencies of growing lambs fed varying levels of tree leaves and concentrates were attributed to the influence of better nutrient density and quality of nutrients available for utilization. The relative advantage of MOR over the MC supplement could furthermore be detected in the protein efficiency ratios (PERs; Table 3), probably attributable to the better quality of MOR protein for ruminant nutrition. The crude protein of MOR (*Moringa oleifera*) has been reported (Becker, 1995) to be of better quality for ruminants because of its high content of by-pass protein (47% versus 30% and

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41% for *Gliricidia sepium* (GLI) and *Leucaena leucocephala* (LEU) respectively). Higher proportions of by-pass protein have been reported to result in faster weight gains in livestock (McNeill *et al.*, 1998).

#### **4. Conclusions**

The dried leaves of *Moringa oleifera*, *Gliricidia sepium* and *Leucaena leucocephala* resulted in adequate dry matter intakes when used as supplements to a basal diet of cassava peels for growing WAD goats. The crude protein and predicted metabolizable energy contents of the browse leaves were adequate to compensate for the corresponding acknowledged deficiencies in cassava peels as animal feeds. Average animal weight gain on the moringa supplement was comparable to that on the mixed concentrate supplement, with the gliricidia supplement producing the least weight gain. The obtained feed conversion and protein efficiency ratios however showed that the moringa supplement was even better utilized than the mixed concentrate by growing WAD goats. The high potentials of moringa leaf for replacing expensive concentrates as supplements to basal diets of a wide array of low-protein and low-energy crop residues, as represented by cassava peels, have been demonstrated by the results of this study.

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Table 1: Compositions of the experimental diets fed to WAD goats (as fed, and on daily basis)

Ration components	Experimental diets			
	1	2	3	4
<b>Basal component</b>				
Cassava peels	..... <i>Ad libitum</i> .....			
<b>Supplements</b>				
Mixed concentrate mixture (50GNC:50WO)	250g			
Dried <i>Moringa oleifera</i> leaves		250g		
Dried <i>Gliricidia sepium</i> leaves			250g	
Dried <i>Leucaena leucocephala</i> leaves				250g

Table 2: Nutrient and mineral compositions of experimental fodders, cassava peels, concentrate ingredients and mixture fed to West African Dwarf goats.

	Fodders/cassava peels/concentrate ingredients/mixed concentrate						
	CPL	GNC	WO	*MC (50GNC:50WO)	MOR	GLI	LEU
<b>Nutrients (g/100g)</b>							
DM	85.70	93.50	90.00	91.75	95.57	95.86	94.38
<b>% of DM</b>							
CP	3.28	48.04	17.38	32.71	26.74	21.64	28.86
EE	1.72	8.32	4.28	6.30	8.06	4.55	5.67
CF	17.18	7.51	9.37	8.44	11.03	10.70	12.16
NDF	28.47	37.10	39.99	38.55	26.35	29.60	29.21
ADF	52.00	16.41	14.16	15.51	32.40	34.50	34.80
OM	80.81	86.67	83.77	85.22	89.83	91.54	92.54
NFE	70.78	23.32	59.40	41.36	39.57	49.49	59.67
<b>Predicted parameter</b>							
ME (MJ/kg DM)	5.73	13.47	12.53	13.00	12.10	11.38	10.27

MOR = *Moringa oleifera*, LEU = *Leucaena leucocephala*, GLI = *Gliricidia sepium*, CPL = Cassava peels, MC = Mixed concentrate, GNC = Groundnut cake, WO = Wheat offals

\*Values were computed for the mixed concentrate

Table 3: Intake and growth indices of WAD goats offered supplements of dried *Moringa oleifera*, *Leucaena leucocephala* and *Gliricidia sepium* forages to a basal diet of cassava peels.

Item	Experimental diets				P-value	SEM
	1(MC)	2 (MOR)	3(GLI)	4(LEU)		
<i>Dry matter intake (DMI)</i>						
Cassava peels	194.56 <sup>a</sup>	188.30 <sup>b</sup>	187.85 <sup>b</sup>	182.61 <sup>c</sup>	6.02E-06	1.16
Supplements	159.93 <sup>a</sup>	122.95 <sup>b</sup>	100.63 <sup>d</sup>	117.03 <sup>c</sup>	1.39E-12	5.62
Total DMI; g/animal/day	354.49 <sup>a</sup>	311.25 <sup>b</sup>	288.48 <sup>d</sup>	299.64 <sup>c</sup>	2.1E-12	6.49
Total DMI; gkg <sup>-0.75</sup>	70.59 <sup>a</sup>	63.13 <sup>b</sup>	59.98 <sup>c</sup>	61.03 <sup>c</sup>	5.6E-08	1.10
Total DMI (% of BW)	4.12 <sup>a</sup>	3.72 <sup>b</sup>	3.55 <sup>c</sup>	3.59 <sup>c</sup>	3.62E-09	0.06
<i>*Crude protein intake (CPI); g/animal/day</i>						
Cassava peels	6.38 <sup>a</sup>	6.18 <sup>b</sup>	6.16 <sup>b</sup>	5.99 <sup>c</sup>	6.52E-08	0.04
Supplements	52.31 <sup>a</sup>	32.88 <sup>b</sup>	21.78 <sup>c</sup>	33.77 <sup>b</sup>	1.02E-08	2.89
Total CPI; g/animal/day	58.69 <sup>a</sup>	39.05 <sup>b</sup>	27.94 <sup>c</sup>	39.76 <sup>b</sup>	1.35E-09	2.89
<i>Growth performance</i>						
Initial live-weight (kg)	7.70	7.50	7.50	7.70	0.309552	0.05
Final live-weight (kg)	9.50	9.25	8.75	9.00	0.482952	0.17
ADG (g/animal/day)	21.43 <sup>a</sup>	20.83 <sup>a</sup>	14.88 <sup>c</sup>	15.48 <sup>b</sup>	6.42E-12	0.78
FCR	16.54 <sup>b</sup>	14.94 <sup>c</sup>	19.39 <sup>a</sup>	19.36 <sup>a</sup>	1.17E-05	0.53
PER	2.74 <sup>a</sup>	1.87 <sup>b</sup>	1.88 <sup>b</sup>	2.57 <sup>a</sup>	1.05E-13	0.10

<sup>abc</sup> Means in the same row with different superscripts differ significantly (P<0.05), ADG = Average Daily Gain, FCR = Feed Conversion Ratio = Weight of feed/goat net-weight gain , PER = Protein Efficiency Ratio = Goat net-weight gain/crude protein intake.

\*Values computed from DMI figures (Table 3) and the corresponding crude protein values (Table 2)