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Potential of *Albizia lebbeck*-Cassava Peel Silage as Dry Season Feed for West African Dwarf Sheep

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ABSTRACT

The study evaluated the growth performance, digestibility, and nitrogen utilisation of West African Dwarf (WAD) sheep fed with *Albizia lebbeck* - cassava peel silage and *Panicum maximum*. Sixteen female WAD sheep (6–7 months old and average live weights of 11 kg) were randomly allotted into four dietary treatments in a complete randomized design. Dietary treatments of *A. lebbeck* - cassava peel silage are: Diet 1 (60% Cassava peel + 25% *A. lebbeck* + 15% *P. maximum*), Diet 2 (45% Cassava peel + 40% *A. lebbeck* +15% *P. maximum*), and Diet 3 (30% Cassava peel + 55 % *A. lebbeck* + 15% *P. maximum*), while Diet 4 (100% *P. maximum*) is the control. The pH values (4.27–5.39), NH_3-N (0.089–0.125%), lactic (0.72–1.08%), and butyric (7.04–10.53%) acids, contents of silages differed ($p < 0.05$). Intakes of dry matter (68.6–71.3 g/kg $W^{0.75}$/d) and crude protein (15.9–18.4 g/kg $W^{0.75}$/d) of sheep were similar ($p > 0.05$) across treatments, while total feed intake (840 g/d) and weight gain (46.07 g/d) of sheep fed diet 1 were superior ($p < 0.05$) to other treatment groups. Although, sheep fed diet 4 had the best ($p < 0.05$) feed conversion ratio, silage diet was efficiently utilized by the sheep fed diet 1. Nutrient digestibility varied ($p < 0.05$) across treatment groups. The values of apparent nitrogen digestibility (69.33%), nitrogen absorbed and retained was highest (2.08 and 1.97 g/d) in sheep fed diet 1, while nitrogen absorbed and retained was lowest (1.37 and 1.12 g/d) in sheep fed diet 3. In conclusion, WAD sheep fed diet 1 performed remarkably in terms of feed intake, weight gain, and N-utilisation. Therefore, *A. lebbeck*-cassava peel silage can be a viable option for sheep feeding in the dry season when grass quality is low.

Keywords: Albizia lebbeck foliage, cassava peel, digestibility, nitrogen utilisation, performance, silage

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INTRODUCTION

In the humid or subhumid regions of Nigeria, small ruminant (sheep and goats) production contribute to the income resource of the rural poor and supply of animal protein (milk and meat) of most households. However, the dry season (usually from December to March) is a critical period when the performance of small ruminant decreases. This is due to the rapid decline in quantity and quality of pastures and the high cost of concentrate feed, which rural smallholder farmers cannot afford to supplement the available low-quality forages. Under these conditions, the animals have to survive on highly lignified roughages (Ademosun, 1992), which are relatively deficient in the essential nutrients required for improved performance.

Cassava peel constitutes the bulk of dry season feed and the most outstanding sources of energy for small ruminant in the intensive and semi-intensive system of production (Adegbola, Smith, & Okeudo, 2010). However, when cassava peel is fed solely to a ruminant, it is not adequate to meet the energy and nitrogen requirements for improved animal performance, even when the animals scavenge household wastes or graze low-quality roughages (standing hay). In the light of the aforementioned, efficient utilisation of low-quality roughages for improved performance would be enhanced through nitrogen supplementation from multipurpose tree legumes.

Utilisation of multipurpose tree legumes as a cheap protein-rich supplement to balance nutrient deficiencies of feed during the dry season in the tropics has been documented (Bansi, Wina, Matitaputy, & Turafelli, 2014). In the same vein, optimal utilisation of low-quality roughages by ruminants through supplementation with foliages of multipurpose tree legumes has also been reported (Attaelmnan, Fadel Elseed, & Salih, 2009; Mousa, 2011) to increase dry matter intake and improve animal performance.

Meanwhile, it is worth mentioning that despite the nutritional potentials of leguminous tree fodder, smallholder ruminant farmers in the humid South Western parts of Nigeria rarely utilize foliages of some leguminous tree fodder as ruminant feed. One of the numerous under-utilized leguminous tree fodders is *Albizia lebbeck.* Objections to its utilisation might be due to lack of awareness about the inherent nutritive value and how to integrate them in feeding system, fear of losing their animals on account of likely "poisonous substances" (anti-nutritional factors) and the stress of harvesting particularly cut and carry in the intensive or semi-intensive system of ruminant production.

A. lebbeck, (family: Fabaceae) is an introduced leguminous fodder tree species in Nigeria (Keay, Onochie, & Standfied, 1964), widely adapted to mild and high climates of tropical and sub-tropical countries (Lowry, Prinsen, & Burrows, 1994). Being an evergreen and woody perennial plant, they are grown purposely to provide shade. It is often noticeable with its dry pods held on the tree year round. While the nutritive value and anti-nutritional contents (tannin and phenolic compounds) of the leaves have been documented (Balgees, Elmnan, Elseed, & Salih, 2011; Chitra & Balasubramanian, 2016), higher dry matter intake (286 g/d and 335.5 g/d) and digestibility (64.22 % and 72.22 %) have also been reported (Adeloye, Daramola, Yousuf, & Ogundun, 2006; Balgees et al., 2011) in West African Dwarf (WAD) and Nubian goats, fed crop residues supplemented with *A. lebbeck* leaves, respectively.

Ensilage is a complex biochemical process in which arrays of compounds are generated as a result of fermentation. However, variations in nutritional value and fermentation quality of silage may have an impact on feed intake (Krizsan & Randby, 2007), and consequently on the performance of animals. Although foliages of *A. lebbeck* mixed with grass makes good quality silage for lactating goats (Solorio-Sanchez, Sol-Jiménez, Sandoval-Castro, & Torres-Acosta, 2007), there is limited information about the optimal level of *A. lebbeck* supplementation with cassava peel and utilisation of *A. lebbeck*-cassava peel silage by WAD sheep.

Since *A. lebbek* foliage can be fed as hay or silage, alone or mixed with grasses to ruminants, there is a need to ensile *A. lebbeck* leaves, cassava peel, and *Panicum maximum* mixtures for dry season feed. The aim of this experiment was to evaluate the fermentation quality of *A. lebbeck* - cassava peel silage, performance, digestibility, and nitrogen utilisation of WAD sheep fed *A. lebbeck* - cassava peel silage.

MATERIALS AND METHODS

Study Location, Animal Management, and Experimental Design

The experiment was conducted at the sheep and goat unit of the Institute of Agricultural Research and Training, Moor Plantation, Ibadan, South West Nigeria, latitude (7°15’–7°30’N) and longitude (3°45’–4°0’E). The area has a tropical humid climate with a mean annual rainfall of 1415 mm and an average daily temperature between 28°C and 35°C. Sixteen female WAD sheep (6–7 months old, average live weight of 11 kg) were weighed and randomly allocated to individual pens, and to one of four treatments diets in a complete randomized design with four animals per replicate in a 105-day feeding trial. Experimental house and individual pens were washed and disinfected, and floors of the pens were covered with wood shaving.

Before the commencement of the experiment, animals were given prophylactic treatments once (administration of injectable oxytetracycline and a multivitamin preparation at the rate of 1 mL per 10 kg body weight via intramuscular route), treated against ecto and endoparasites (administration of ivermectin, subcutaneously at the rate of 0.2 mL per 10 kg body weight), and vaccinated against *Peste de Petit Ruminant* (PPR). The animals were adjusted to their treatments over a 2-week preliminary period, which was followed by a 105-day feeding trial.

Preparation of the Silages

Fresh foliages of *A. lebbeck* was harvested from the National Cereals Research Institute (NCRI) Moor Plantation, Ibadan. Fresh cassava peel was collected from a gari processing mill and spread on a concrete floor to wilt to about 50% DM. *P. maximum* (Guinea grass) was harvested from an established pasture of the Institute of Agricultural Research and Training, Moor Plantation, Ibadan. Foliages of *A. lebbeck* and guinea grass were harvested at 6-week re-growth interval, chopped into 3-5 cm size in length and allowed to wilt. All the materials to be ensiled were weighed in varying proportions, as indicated below and mixed to form a homogenous mixture. Each mixture was ensiled separately for 28 days as previously described (Ajayi, Omotoso, & Dauda, 2016).

Feed, Feeding, and Growth Trials

The diets consisted of concentrate feed as depicted (Table 2), guinea grass (*P. maximum)* and *A. lebbeck*-cassava peel silage mixtures in varying proportions as highlighted below:

Diet 1 = 60% Cassava peel + 25% *A. lebbeck* + 15% *P. maximum*

Diet 2 = 45% Cassava peel + 40% *A. lebbeck* + 15% *P. maximum*

Diet 3 = 30% Cassava peel + 55% *A. lebbeck* + 15% *P. maximum*

Diet 4 = 100% *P. maximum*

Sheep were randomly allotted to the four dietary treatments as indicated above in complete randomized design, with four animals per replicate in a 105-day feeding trial. *A. lebbeck* - cassava peel silage (basal diet) and guinea grass (control diet) were offered separately at 3% body weight. The control diet (*P. maximum*) was harvested at 6-week re-growth intervals, wilted and chopped to 5 cm before feeding. Concentrate feed was offered to all the sheep at 2% body weight. Experimental diets and concentrate mixtures (10 kg maize, 30 kg wheat offal, 10 kg corn bran, 25 kg palm kernel cake, 13.7 kg limestone, 10 kg Groundnut cake, 0.5 kg Fish meal, 0.5 kg Growers premix, 0.3 kg salt) were offered separately at 09:00 and 16:00 h, respectively.

There was provision for a daily feed allowance of 10% above the previous week's consumption. Fresh and clean water was served *ad libitum* to all the animals. Daily feed intake was determined by subtracting feed refused from feed offered over a 24-h period. Animals were weighed at the commencement of the experiment and subsequently live weight change was measured once each week before feeding in the morning throughout the feeding trial.

Digestibility and Nitrogen Balance Trials

After the feeding trial, sheep were transferred to metabolic cages and adapted for 7 days. The study was carried out over a period of 7 days for each treatment for measurements of intake, faeces, and urine of each sheep. Feed offered, feed refused, faeces and urine samples were sampled daily for dry matter determination and chemical analysis. Loss of nitrogen by volatilization was prevented by adding 10 mL of 10% concentrated sulfuric acid (H_2SO_4) into plastic containers for the collection of urine (Chen & Gomes, 1992). Daily collections of faeces and urine were bulked and 10% sub-sample of each was taken for analysis. Urine samples were frozen for nitrogen determination. Faecal samples were oven dried to a constant weight in a forced air oven at 60ºC, ground and analyzed for chemical analysis.

Chemical Analysis

Samples of un-ensiled feedstuffs (*A. lebbeck* foliage, guinea grass, and cassava peel), silage diets and feces were dried in an oven to a constant weight, milled to pass through a 2-mm sieve, and then analyzed for Crude protein (Micro-Kjeldahl method, N × 6.25), dry matter, ash, ether extract, calcium and phosphorus according to the standard proximate procedures (AOAC, 1995). Neutral detergent fiber (NDF), acid detergent fiber (ADF), and acid detergent lignin (ADL) were determined according to the procedure of Van Soest, Robertson and Lewis (1991).

Silage samples were extracted with distilled water and used for measuring the pH, volatile fatty acids (VFAs), ammonia nitrogen (NH_3-N), water-soluble carbohydrates (WSCs), and alcohol contents.

The pH of silages was read on a digital pH meter (model 3510; Jenway). Concentrations of the lactic, acetic, propionic, and butyric acids were measured by the titration method according to the procedure by Gilchrist Shirlaw (1967). Ammonia nitrogen (NH_3-N) content was determined by a colorimetric method using a Spectronic21-D as described by Bolsen et al. (1992). WSC was determined by the colorimetric method as described by Dubois, Giles, Hamilton, Rebes and Smith (1956), and the alcohol content was determined according to AOAC (2005).

Statistical Analysis

All data obtained were subjected to analysis of variance for a completely randomized design using the general linear model (PROC GLM) of SAS (1998), with the following statistical model: $Y_{ij} = \mu + D_i + e_{ij}$. Where Y_{ij} = observed variation, μ= population mean, D_i = fixed effect of diets (1–4), and e_{ij} = residual error. Duncan's Multiple Range Test (Duncan, 1955) was used to detect significant differences among means at $p < 0.05$.

RESULTS AND DISCUSSION

Chemical Composition of Experimental Diets and Raw materials

Chemical and nutrient compositions (g/100 g DM) of feedstuffs and experimental diets are presented in Tables 1 and 2. The dry matter contents of silage diets were relatively similar with a mean value of 85.13% (Table 2). Dry matter (DM) values were highest in diet 3 (86.83%) and lowest in diet 4 (43.62%). The crude protein (CP) contents of diet 1 to diet 3 (11.29-13.32%) were above the 10-12% recommendation for growth or maintenance of small ruminants (NRC, 1985) while control diet (6.81% CP) was below the minimum threshold level (7% CP) required for optimal rumen microbial activities (Norton, 2003). Ether extract also followed a similar trend, with highest values in diet 3 (5.17%) and lowest in diet 4 (1.84%).

The increased CP (11.29–13.32%) content of silage diets (Table 2) observed in this study corroborated the findings of Balgees et al. (2011) who supplemented baggase with varying proportions (100 g and 150 g) of *A. lebbeck* leaves. The

Table 1
Nutrient composition and fiber fractions (g/100 100 g DM) of feedstuffs for the experimental diets

Composition	*A. lebbeck* foliage	Cassava peel	*P. maximum*
Dry matter	89.43	89.9	92.93
Ash	10.72	9.15	10.11
Crude protein	15.96	6.04	8.40
Ether extract	3.25	1.92	1.13
Neutral detergent fibre	41.35	43.59	61.26
Acid detergent fibre	35.17	26.96	33.89
Acid detergent lignin	8.36	7.71	4.47
Hemicellulose	6.18	16.63	27.37
Cellulose	26.81	19.25	29.42

Table 2
Chemical compositions (g/100 g DM) of A. lebbeck - *cassava peel silage and* P. maximum *fed to West African Dwarf sheep*

Composition	Silage Treatments				*P. maximum* Concentrate
	Diet 1	Diet 2	Diet 3	Diet4	
Dry matter	86.07	82.49	86.83	43.62	90.61
Crude protein	12.80	11.29	13.32	6.81	16.43
Ether extract	2.53	3.54	5.17	1.84	7.32
Ash	3.62	3.31	4.25	4.27	9.40
NDF	31.17	25.55	35.26	55.30	63.85
ADF	29.40	24.61	28.77	34.18	48.31
ADL	26.13	22.32	18.73	8.12	5.67
Hemicellulose	1.77	0.93	6.49	21.12	15.54
Cellulose	3.27	2.29	10.04	26.06	42.64
Calcium	0.66	0.54	0.75	0.01	0.94
Phosphorus	0.85	0.88	0.67	0.03	1.02

CPL: Cassava peel; AL: *A. lebbeck*; PM: *P. maximum*;
Diet 1: 60 % CPL + 25% AL + 15 % PM; Diet 2: 45% CPL + 40 % AL +15 % PM;
Diet 3: 30 % CPL + 55 % AL + 15 % PM; Diet 4: 100% PM; NDF: neutral detergent fiber; ADF: acid detergent fiber; ADL: acid detergent lignin

higher percentage of CP obtained in silage diets compared to the control diet was probably due to the release of CP from *A. lebbeck* leaves into the ingredient mixtures. Meanwhile, the values of NDF, ADF, and ADL obtained among silage diets (diet 1 to diet 3) were not above the range (55–60 g/100 g DM) that could limit feed intake and degradation of tropical forages by ruminant (Meissner & Paulsmeier, 1995). The NDF (55.30%) and ADF (34.18%) values were highest in the control (diet 4) compared to silage diets. Among silage diets, ADL content varied from 18.73-26.13%, while NDF (35.26%) and ADF (29.40%) values were highest in diet 3 and diet 1, respectively. The values of hemicellulose (0.93–6.49%) and cellulose (2.29–10.04%) contents of silage diets in this study fell below the range of hemicellulose (8.00–22.00%) and cellulose (13.00–22.00%) contents reported (Inyang, Babayemi, Adeniji, & Ifut, 2013) for cassava wastes - *A. saman* pod silage.

The low levels of NDF and ADF in silage diets could be attributed to the breakdown of hemicellulose in the ingredient mixtures through hydrolysis by organic acids produced during the ensiling process (McDonald, Henderson, & Heron, 1991). Increased ADL content could also be a consequence of the synthesis of Maillard polymers during the fermentation process, which have properties similar to lignin (Van Soest, 1994). The wide variations observed in the hemicellulose and cellulose contents between diet 1 (1.77% and 3.27%) and diet 3 (6.49% and 10.04%) could have arisen from the ensiling conditions (silage pH, and temperature, bacterial species and the population of bacteria) within each diet during the ensiling process and the proportion of cell wall fractions exposed to hydrolysis by organic acid (McDonald et al., 1991).

However, the levels of fiber fractions in this study could be categorized as moderate and might favor the proliferation of fiber digesting microorganisms in the rumen. The DM, CP, and fibre contents of silage diets (diets 1-3) are also suggestive of inherent nutritive value that could impact positively on animal performance. The observed differences in values of chemical compositions could be due to the proportions of young and matured leaves of *A. lebbeck* and varying proportions of ingredient mixtures. Others include cassava cultivar, the age of harvest of cassava tuber and the extent of removal of tuber from the skin during processing.

Fermentation Characteristics of Silage Diets

The fermentation characteristics of silage diets fed to WAD sheep differed ($p < 0.05$) significantly across the treatments (Table 3). Evaluation of silage quality is a subjective process in which, silage pH reflects the rate of fermentation and to a limited extent, the quality of ensiled forages. The pH range (4.27–5.39) obtained in this study, being highest in diet 3 and lowest in diet 1 is contrary to the pH range (3.38–4.61) reported (Inyang et al., 2013) for cassava wastes – *A. saman* pod silage. However, it falls within the pH range (4.4–5.5) for good silage (Menenses et al.*,* 2007). The differences in values of silage pH from this study compared to that reported by Inyang et al. (2013) might be due to the buffering capacity and amount of WSCs of the leguminous fodder (*A. lebbeck* foliage). In addition, the quantity of fermentable starchy mesocarp or endocarp layer of cassava tuber attached to the peel and the extent of utilisation of the limited WSC of ingredients mixtures by lactic acid producing bacteria to drop the pH.

The acid profile of silage is the best indicator of silage quality (Bethard, 2006), particularly, lactic acid. In a good quality silage, lactic acid is the primary acid and it is stronger than other acids (acetic, propionic, and butyric). The concentration of acetic acid increased ($p < 0.05$) marginally with increasing levels of *A. lebbeck*, but similar ($p > 0.05$) in diets 1 and 2. The lactic, propionic, and butyric acids differed ($p < 0.05$) significantly with values ranging from 0.72-1.08%, 5.92-8.88%, and 7.04-10.53%, respectively. Hence, lactic (0.72–1.08 %) and acetic (0.74–1.07%) acids concentrations in this study falls within the category of acceptable silage that may increase intake as recommended (Ward & Ondara, 2008). Inadequate fermentable carbohydrates from the ingredient mixtures (especially from the leguminous fodder) for usage by lactic acid bacteria and other epiphytic aerobic microorganisms (Pahlow, Muck, Driehuis, Oude Elferink, & Spoelestra, 2003), could be a reason for the lower lactic acid concentration compared to other volatile fatty acids (propionic and butyric acids).

On the contrary, the amount of propionic and butyric acids in this study were not comparable with the contents recommended (Allen et al., 1995) for well-preserved silage. Less than 0.5% (propionic acid) and 0.1-0.2% (butyric acid) were recommended as a critical concentration for an adequate

Table 3
Fermentation characteristics of A. lebbeck - *cassava peel silage fed to West African Dwarf sheep*

Composition	Diet 1	Diet 2	Diet 3	SEM	P-value
P^{H}	4.27^{c}	5.25^{b}	5.39^{a}	0.39	<.000
Lactic acid (%)	1.08^{a}	0.81^{b}	0.72^{c}	0.12	<.000
Acetic acid (%)	0.74^{b}	0.75^{b}	1.07^{a}	0.05	<.000
Propionic acid (%)	6.65^{b}	5.92^{c}	8.88^{a}	0.44	<.000
Butyric acid (%)	7.04^{c}	7.80^{b}	10.53^{a}	0.53	<.000
NH_3N (%)	0.089^{c}	0.095^{b}	0.125^{a}	0.01	<.000
Water-soluble carbohydrates (%)	65.67^{a}	65.42^{a}	57.88^{b}	1.49	0.020
Alcohol content (%)	3.68^{a}	3.25^{a}	2.35^{b}	0.23	0.023

^{abc} =Means with the same superscripts along the same row are significantly different ($p < 0.05$).NH_3N: Ammonia nitrogen; SEM: Standard error of mean; P-value: Probability value; CPL: Cassava peel; AL: *A. lebbeck*; PM: *P. maximum*; Diet 1: 60 % CPL + 25% AL + 15 % PM; Diet 2: 45% CPL + 40 % AL +15 % PM; Diet 3: 30 % CPL + 55 % AL + 15 % PM fermentation process in well-preserved silage (Ward & Ondara, 2008). The higher values of butyric and propionic acids in this study compared to the recommended concentration could have been caused by the low lactic acid content obtained in this study. It is an indication of degradation of protein content and large amount of dry matter loss as reported (Seglar, 2003).

Although propionic acid has a sharp sweet smell and taste, it is an acceptable silage acid to inhibit the development of undesirable microorganisms in silages exposed to aerobic conditions (Selwet et al., 2008). Ammonia nitrogen (NH_3-N) concentrations were highest ($p < 0.05$) in diet 3 (0.125%) and lowest in diet 1 (0.089%). The NH_3-N per total nitrogen values in all the silage mixtures were below 7-10% maximum value that could depict extensive proteolysis during ensiling (McDonald et al., 1991). Therefore, the silage in this study could be considered as excellent because the NH_3-N/N content was below 7 g/100 g of the total N as reported (Lima, Lourenço, Díaz, Castro, & Fievez, 2010).

Expectedly, WSCs and alcohol concentrations from this study increased with increasing amount of cassava peel in the silage. Hence, WSC and alcohol contents were similar ($p > 0.05$) in diets 1 and 2, but differed ($p < 0.05$) from diet 3. The percentages of WSC of *A. lebbeck*-cassava peel silage in this study suggest that it could be "residual WSC" that was not efficiently utilized by lactic acid bacteria during ensiling. This might be a reason for the high values (2.35–3.68%) of alcohol contents observed in this study contrary to <0.5% alcohol recommended (Seglar, 2003) during the fermentation process. Even though, higher residual WSC in silage supplies energy to ruminants (Weinberg, Ashbell, Hen, & Azreli, 1993), alcohol, a fermentation end-product, when it is above acceptable levels may reduce silage intake. Generally, the variations in fermentation characteristics in this study could be attributed to the varying proportion of *A. lebbeck* foliage and cassava peel in the feed mixtures, individual crop characteristics and other factors influencing silage quality.

Performance Indices of Sheep

The feed intake and growth performance of the sheep fed experimental diets are shown in Table 4. The DM and CP intakes (g/kg $W^{0.75}$) of the sheep fed the control (diet 4) and the silage diets (diets 1–3) were not significantly ($p > 0.05$) different. Meanwhile, sheep fed diet 4 had the highest (71.3 g/kg $W^{0.75}$) values of DM intake, but lowest (15.9 g/kg $W^{0.75}$) for CP intake. Among the sheep fed silage diets, DM and CP intakes (g/kg $W^{0.75}$) were highest in sheep fed diet 1 (68.6 and 18.4 g/kg $W^{0.75}$) but lowest (64.5 and 17.5 g/kg $W^{0.75}$) in sheep fed diet 3, respectively. ADL intake of the sheep on diets 1 to 3 differed ($p < 0.05$) significantly from the sheep fed control diet. However, NDF and ADL intakes were similar ($p > 0.05$) for sheep on silage diets. Meanwhile, NDF intake was significantly higher ($p < 0.05$) for the sheep fed diet 2 (60.6 g/kg $W^{0.75}$) compared to the sheep on diet 4 (55.6 g/kg $W^{0.75}$). Furthermore, the

ADF intake of sheep fed diet 3 differed ($p < 0.05$) from the animals fed diets 1 and 4, respectively, but similar ($p > 0.05$) with the sheep fed diet 2.

Nutrient intake is a function of the concentration of the DM intake. However, highest DM intake of the sheep fed control diet in this study did not translate into increased total feed intake and weight gain. This could be a reflection of the <7.0% CP content of the diet that is required for optimal rumen microbial activities (Minson, 1990). The highest DM intake of sheep fed diet 4, amongst other factors, could be due to the palatability of guinea grass. Guinea grass is highly relished by small ruminants (Babayemi, 2009).

The total feed intake (g/d) and the weight gain (g/d) differed ($p < 0.05$) significantly across the treatments. Total feed intake and weight gain of sheep fed silage diets were highest in sheep fed diet 1 (840 g/d and 46.07 g/d) and lowest in sheep fed diet 3 (768 g/d and 34.40 g/d). The significantly ($p < 0.05$) highest total feed intake and weight gain of sheep fed diet 1 (*A. lebbeck,* cassava peel and *P. maximum* silage mixtures) compared to the control in this study is

Table 4
Nutrient intake (g/KgW$^{0.75}$/d) and performance indices of West African Dwarf sheep fed A. lebbeck - *cassava peel silage and* P. maximum

Parameters	Diet 1	Diet 2	Diet 3	Diet 4	SEM	P-value
Nutrient intake						
Dry matter	68.6	68.2	64.5	71.3	1.30	0.361
Crude protein	18.4	17.8	17.5	15.9	0.49	0.337
NDF	58.2^{ab}	60.6^{a}	59.4^{ab}	55.6^{b}	0.84	0.180
ADF	28.3^{c}	31.4^{ab}	31.5^{a}	29.4^{bc}	0.49	0.015
ADL	8.6^{a}	8.4^{a}	8.0^{a}	6.7^{b}	0.26	0.009
Feed intake (%)						
Silage intake	61.20	63.16	55.37	____		
Concentrate	38.80	36.84	44.63	39.34		
P. maximum	____	____	____	60.66		
Total feed intake (g/day)	840^{a}	810^{b}	768^{c}	566^{d}		<.000
Initial live weight (kg)	10.21	10.44	11.37	10.82		
Final live weight (kg)	14.08	13.71	14.26	13.84		
Weight gain (g/day)	46.07^{a}	38.93^{b}	34.40^{c}	35.95^{c}	1.67	<.000
FCR	18.23^{c}	20.80^{b}	22.33^{a}	15.74^{d}	1.31	<.000

^{abcd}= Means with the same superscripts along the same row are significantly different ($p < 0.05$). NDF: beutral detergent fiber; ADF: acid detergent fiber; ADL: acid detergent lignin; SEM: Standard error of mean; *p*-value: Probability value; FCR: Feed conversion ratio; CPL: Cassava peel; AL: *A. lebbeck*; PM: *P. maximum*; Diet 1: 60 % CPL + 25% AL + 15 % PM; Diet 2: 45% CPL + 40 % AL +15 % PM; Diet 3: 30 % CPL + 55 % AL + 15 % PM; Diet 4: 100% PM an indication of effective degradability of the silage, which resulted to the higher nutrient intakes and good performance. The relatively good performance of sheep fed diet 1 is also indicative of optimal levels of ingredient mixtures to enhance synchronization of energy and nitrogen to the rumen for improved growth performance of animals (Cole et al., 2008; Seo et al., 2010). Findings from this study further corroborated the reports of several authors (Attaelmnan et al., 2009; Solorio-Sanchez et al., 2007), who observed increased feed intake and weight gain of small ruminants by supplementation of low-quality forages with foliages of protein-rich fodder.

Feed conversion ratio was significantly ($p < 0.05$) lower for sheep fed diet 4 compared to the other treatment groups. The lower feed conversion ratio obtained for sheep fed diet 4 compared to other animals on silage treatments could be linked to the intake of concentrate diet to overcome the nitrogen deficiency and enhanced proliferation of rumen microbes to promote degradability of nutrients. Incorporation of concentrate diet rich in protein in animal diets enhanced more intakes of energy and protein (Suarez, Van Reenen, Stockhofe, Dijkstra, & Gerrits, 2007), the supply of microbial nitrogen to stimulate rumen microbial activities and optimal efficiency of feed utilisation (McDonald et al., 2010) for growth, gestation, or lactation.

However, silage diet was efficiently utilized by sheep fed diet 1 (60% cassava peel, 25% *A. lebbeck*, and 15% *P. maximum* mixtures) compared to other silage treatments. Variations in efficiency of feed utilisation could be a reflection of the proportion of *A. lebbeck* foliage in silage mixtures and intake of concentrates, individual animal differences caused by development of a series of biochemical reactions in the rumen, and ability of protein-binding capacity of tannins on the ingredient mixtures to bind the fermentable carbohydrates and proteins to by-pass the rumen into the abomasum and intestines (Diaz-Hernandez, Nixon, Ball, Leng, & Rowe, 1997).

Apparent Nutrient Digestibility of Experimental Diets

The digestibility of DM, CP, ADF, and ADL differed significantly ($p < 0.05$) across the sheep fed silage diets (Table 5). Except for DM digestibility, CP, and ADF, digestibility values decreased with increasing levels of *A. lebbeck* foliage, while ADL digestibility values increased marginally with decreasing levels of *A. lebbeck* foliage The values of CP digestibility were significantly highest (88.1%) in the sheep on diet 1 and lowest (74.5%) in sheep fed diet 4, respectively. Digestibility of ether extract did not differ ($p > 0.05$) across the treatments. Digestibility of DM and NDF was similar ($p > 0.05$) in sheep on diets 1 and 2, likewise for sheep fed diets 3 and 4, respectively. However, DM digestibility values was highest ($p < 0.05$) in sheep fed diet 2 (69.5%) and lowest in sheep fed diet 3 (59.3%), but digestibility of ADF values was highest (89.1%) in sheep fed diet 1 and least (81.4%) in sheep fed diet 4. Digestibility of ADL was similar (p

> 0.05) across silage treatment groups but significantly different ($p < 0.05$) from the sheep on the control diet.

Increased nutrient digestibility of roughage-based diet has been reported with increasing levels of legume supplementation (Tolera & Sundstol, 2000). However, in this study, a numerical decrease of CP, EE, and ADF digestibility values (silage diets) was observed across the treatments with increasing levels of *A. lebbeck* foliage in silage mixtures. Irrespective of the proportions of ingredient mixtures, all the nutrients were adequately digested and digestibility values of silage diets were impressive, being >50% compared with the control.

This implied that dry matter digestibility increased when highly degradable roughages are synchronized with a readily fermentable protein required for optimal activities of rumen microbial flora (Baah, Tait, & Tuah, 1999). The observed marginal decrease in values of apparent nutrient digestibility particularly in sheep fed diet 3 despite increasing levels of *A. lebbeck* foliage across the treatments (sheep fed silage diets) could be due to the accumulation of lignin fraction that resulted from the varying proportions of cassava peel and *A. lebbeck* foliage in the feed mixtures. Lignin has been implicated to interfere with microbial degradation of fiber polysaccharides by acting as a physical barrier (Buxton & Redfearn, 1997).

Table 5
Apparent nutrient digestibility (%) of West Africa Dwarf sheep fed A. lebbeck - *cassava peel silage and* P. maximum

Parameters (%)	Diet 1	Diet 2	Diet 3	Diet 4	SEM	P-value
Dry Matter	67.4^{a}	69.5^{a}	59.3^{b}	60.9^{b}	1.38	0.001
Crude Protein	88.1^{a}	83.2^{b}	77.5^{c}	74.5^{c}	1.68	0.001
Ether extract	76.5	75.3	75.4	79.2	1.87	0.404
Neutral detergent fiber	85.7^{a}	86.4^{a}	81.8^{b}	82.4^{b}	0.73	0.025
Acid detergent fiber	89.1^{a}	88.8^{a}	84.5^{b}	81.4^{c}	1.04	0.001
Acid detergent lignin	78.3^{a}	80.1^{a}	80.6^{a}	71.4^{b}	1.28	0.009

^{abc}=Means along the same row with different superscripts are significantly different (P<0.05). SEM: Standard error of mean; *p*-value: Probability value; CPL: Cassava peel; AL: *A. lebbeck*; PM: *P. maximum*; Diet 1: 60 % CPL + 25% AL + 15 % PM; Diet 2: 45% CPL + 40 % AL +15 % PM; Diet 3: 30 % CPL + 55 % AL + 15 % PM; Diet 4: 100% PM

Nitrogen Utilisation of Experimental Diets by Sheep

The nitrogen utilisation of WAD sheep fed experimental diets is shown in Table 6. Nitrogen intake was significant ($p < 0.05$) across the treatments, but N-intake values were similar ($p > 0.05$) in sheep fed diets 1, 2, and 4, respectively. While nitrogen intake of the sheep fed diet 3 differed ($p < 0.05$) from sheep on diets 1 and 2 respectively, fecal nitrogen were similar ($p > 0.05$) across the treatment groups. Conversely, urinary nitrogen differed ($p < 0.05$) across the treatments, but values were relatively similar ($p > 0.05$) in sheep fed diets 3 and 4, respectively. Since nitrogen absorbed and retained is dependent on N-digestibility, apparent N-digestibility and N-absorbed were similar ($p > 0.05$) in sheep fed diets 1 and 2, likewise in sheep fed diets 3 and diet 4, respectively. Apparent N-digestibility values were highest in sheep fed diet 1 (69.33%) and lowest in the sheep fed control diet (57.06%). However, values of nitrogen absorbed and retained were highest ($p < 0.05$) in sheep fed diet 1 (2.08 and 1.97 g/d) and lowest in sheep fed diet 3 (1.37 and 1.12 g/d).

The positive nitrogen balance observed across the treatment groups in this study implied that the experimental diets were adequate in nutrients, well digested and utilized by the animals. The remarkable N-absorption and N-retention by the sheep fed diets 1 and 2, respectively, compared to animals on diet 3 could be attributed to higher N-intake and lower N-excretion, which suggests a better protein metabolism and efficient nitrogen utilisation. However, the lower values of N-absorption and N-retention in sheep fed diet 3 compared to other animals on silage diets could likely have arisen from reduced rate and extent of ruminal nitrogen degradability (Souza et al., 2009), orchestrated by tannin–nitrogen complexes of leguminous tree fodder.

Similarly, the variations in N-absorption and N-retention in sheep fed silage diets compared to animals fed control (diet 4) also suggest that the protein in the diet resists microbial degradation due to tannin–protein complexes on leaves of leguminous tree fodder. Tannin-rich fodders have pronounced effect on nitrogen utilisation of goats (Olafadehan, Adewumi, & Okunade, 2014). Interestingly, the remarkable nitrogen utilisation of the sheep fed diet 1 and nutrient utilisation of all the sheep fed silage diets in this study resulted in significant growth performance (weight gain) compared to the sheep fed control diet.

Table 6
Nitrogen (N) utilisation (%) of West Africa Dwarf sheep fed A. lebbeck - *cassava peel silage and* P. maximum

Parameters	Diet 1	Diet 2	Diet 3	Diet 4	SEM	P-value
N-intake (g/d)	3.0^{a}	3.0^{a}	2.38^{b}	2.41^{ab}	0.12	0.073
Fecal-N (g/d)	0.92	0.96	1.01	1.03	0.02	0.386
Urinary-N (g/d)	0.11^{c}	0.44^{b}	1.01^{a}	1.03^{a}	0.14	0.000
N-retained (g/d)	1.97^{a}	1.60^{b}	1.12^{c}	1.20^{c}	0.13	0.003
N-absorbed (g/d)	2.08^{a}	2.04^{a}	1.37^{b}	1.38^{b}	0.13	0.000
Apparent N digestibility (%)	69.33^{a}	68.00^{a}	57.56^{b}	57.06^{b}	2.19	0.003

^{abc}=Means along the same row with different superscripts are significantly different (P<0.05).
SEM: Standard error of mean; *p*-value: Probability value; CPL: Cassava peel; AL: *A. lebbeck*; PM: *P. maximum*; Diet 1: 60 % CPL + 25% AL + 15 % PM; Diet 2: 45% CPL + 40 % AL +15 % PM; Diet 3: 30 % CPL + 55 % AL + 15 % PM; Diet 4: 100% PM

CONCLUSION

From this study, silage quality and nutritive value of cassava peel improved when ensiled with *A.-lebbeck* foliage. Hence, *A. lebbeck*-cassava peel silage was acceptable and efficiently utilized by the sheep. The higher feed and nutrient intake of sheep fed diet 1 (60% cassava peel, 25% *A. lebbeck* and 15% *P. maximum* mixtures) resulted in higher weight gain compared to sheep on the control diet. Therefore, *A. lebbeck*-cassava peel silage can be a viable option for sheep feeding in the dry season when grass quality is low.

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