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ORIGINAL ARTICLE

IN VITRO DIGESTIBILITY AND GROWTH OF WEST AFRICAN DWARF GOATS FED GUINEA GRASS ENSILED WITH SUBSTRATES

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Abstract

The research was carried out to determine the feed quality and utilization of guinea grass ensiled with cassava and plantain peels as substrates using growth trial and in vitro gas production technique. Guinea grass were harvested from the University of Port Harcourt grassland and chopped to 2-3cm after wilting and were ensiled with cassava and plantain peels at equal proportions in three experimental treatments for 21 days ensiling duration. The treatments were: 100% ensiled guinea grass (T1), 50% ensiled guinea grass + 50% cassava peels (T2) and 50% ensiled guinea grass + 50% plantain peels (T3). All the six experimental animals were offered concentrate ration. The results revealed that crude protein content was highest in T3 (10.57±0.58%) and lowest in T1 (7.50±0.58%). Goats fed T3 diet had better (2.70±0.88) feed conversion ratio than T2 (3.82±0.88) and T1 (3.98±0.88), respectively. Cost/kg gain was lower in T2 (₦482.75±116.94) than in T3 (₦457.49±116.94) and T1 (₦524.64±116.94), respectively. There were significant differences ($P < 0.05$) in the volume of gas produced throughout the 24 hours of incubation. Therefore, ensiling guinea grass with cassava or plantain peels have potentials for effective utilization by small ruminants in the tropics during the dry season.

Keywords: guinea grass, cassava peels, plantain peels, silage, goats, in vitro

Introduction

Forages serve as the main source of feed for ruminants to meet their nutritional requirements, either for maintenance or production purposes (Iriso et al., 2024). But, a reduction in the supply of grasses during the dry season and the low nutritional value of grasses such as guinea grass affects animal performance and may increase methane emissions from enteric fermentation (Fontanilla, 2024; Okunlola et al., 2021). Hence, animal nutritionists are involved in constant search for alternative feed resources that are sustainable, would increase farm incomes and with low or zero methane emission potentials. In order to increase farm incomes from livestock in developing countries, a sustainable low-cost feeding model must be developed (Okunlola et al., 2021).

In some developing countries, the management of waste is a major difficulty faced by agrobased industries (Uzairu and Kano, 2021). Agro and industrial products/wastes such as cassava and plantain peels have attracted the attention of nutritionists due to their economical and nutritional potentials to meet the requirements of animals. Cassava and plantain processing produces large amount of these wastes (peels) that contributes to environmental nuisance, when dumped in the surrounding of processing plants or left to rot away in the field (Akinruli et al., 2022). These feed resources can serve as useful source of ruminant animal feed if processed or conserved as silage for later use in the period of scarcity.

Silage technology is one of the major ways of conserving these feed resources for feeding animals especially in an intensive animal production management system. Guinea grass, cassava peels and plantain peels are silage materials that can provide high-quality nutrients to ruminants and their combination as silage could be employed as a dry season alternative feed material for ruminants. However, there are few references on the nutritional quality of mixing this silage materials and its utilization by ruminants. Hence, while ensiling mixed cassava peels, plantain peels and guinea grass as feed materials for ruminant animals during the long dry season, it is vital to find out the best proportion of the two crop residues that works best for ruminant nutrition. Therefore, this research was conducted to improve the nutritive values of guinea grass ensiled with cassava and plantain peels as ensiled substrates fed to West African dwarf goats for sustainable ruminant production.

Materials and Methods

Experimental Location

The study was carried out at the University of Port Harcourt Teaching, Research and Demonstration farm, Choba, Obio-Akpor Local Government Area of Rivers State in Niger Delta area of Nigeria.

Silage Preparation

Guinea grass (Megathyrsus maximus) was harvested from the demonstration grassland of the University of Port Harcourt, at 10 cm above ground level, wilted for 24 hours and chopped into 2 – 3cm long pieces. Cassava and plantain peels were collected from identified cassava and plantain smallholder farmers within the University community and later chopped. Thereafter, the chopped guinea grass, cassava and plantain peels were then mixed at different proportions for the three different experimental treatments, in 25kg capacity plastics used as storage silos. The silos were compacted and sealed airtight to exclude any air penetration in the silo. Bags filled with sand were placed on each silo to prevent air penetration and were stored at room temperature of 28 to 32ºC for 21 days. The concentrate mixture displayed in Table 1 was offered to all the experimental animals.

Table 1: Ingredient Composition of Formulated Concentrate Mixture

Ingredients	Percentage (%)
Maize	30.00
Wheat bran	22.75
Palm kernel cake	25.00
Groundnut cake	18.00
Bone meal	3.00
Salt	1.00
Vitamin premix	0.25
Total	100
Calculated analysis	
Crude protein	17.39
Metabolisable energy (kcal/kg)	2475

The treatments were:
T1 = 100% ensiled guinea grass
T2 = 50% ensiled guinea grass + 50% cassava peels
T3 = 50% ensiled guinea grass + 50% plantain peels

Experimental Animals and Management

Six West African dwarf goats aged 5-6 months weighing appropriately 6-8 kg were used for the experiment. These animals were purchased from a reputable livestock farm within Port Harcourt metropolis and housed in individual pens. The pens were washed using disinfectant before the commencement of the experiment. The animals were dewormed against endoparasites and vaccinated against ectoparasites before introduction to the pens. The growth trial lasted for 8 weeks after an initial 14 days adjustment period.

Chemical Analysis

Chemical composition of the experimental diets was analyzed for dry matter content, crude fiber, crude protein, ether extract, ash and nitrogen free extract (AOAC, 2005).

In vitro gas production

The in vitro incubation was carried out using 120mL calibrated syringes containing the inoculums (Rumen liquor: buffer). 200 mg of each sample of feed was weighed into ankom bags for the incubation at 39ºC with 30mL of inoculums. The time at which the incubation commenced was noted and the syringes were monitored at three hour intervals for the next 24 hours. At the 24^{th} hour of incubation, the final readings were taken and the syringes were placed on ice to stop further gas production (Babayemi et al., 2006).

Determination of post in vitro fermentation parameters

The sealed Ankom bags containing the sample were taken out from the syringes, washed with water until the water becomes clear and oven dried at 100°C to constant weight and the dry matter determined expressed as the percentage of the original sample weight to calculate dry matter degradability, Organic matter digestibility, metabolisable energy, fermentation efficiency, methane reduction (CH_4red %), gas volume and short chain fatty acids.

Economic analysis

Market prices in Port Harcourt metropolis were used to determine the cost of concentrate mixture. The costs of transportation of guinea grass, plantain and cassava peels were used as it is not sold in the markets to determine the cost benefits of silage production. Feed consumption was used to multiply cost per kg of feed to obtain the cost of feed consumed. The information from the markets was used to work out total cost of feed consumed per treatment and feed cost per kilogram of live weight gain.

Statistical Analysis

Data collected were subjected to analysis of variance using General linear model procedure of Statistical Package for the Social Sciences (Version 16.0).

Results and Discussion

Table 2 shows the proximate composition of ensiled guinea grass with or without cassava or plantain peels mixture. Dry matter content was similar between T1 (94.75±0.4%) and T3 (94.84±0.4%), but, was significantly lower (P<0.05) in T2 (93.78±0.4%). Crude protein (CP) was lowest in T1 (7.5±0.58%), whilst, the highest CP was obtained in T2 (10.57±0.58%).

Nitrogen free extract was higher in T3 (75.62±0.68%) than in T1 (72.72±0.04%) and T2 (73.17±0.65%). The differences observed in DM content of the diets are probably due to the different substrates included in the silage. Crude protein contents for T1, T2 and T3 exceeded the minimum level of 7% necessary for the maintenance of goats (Lanyasunya, 2006). These results are in tandem with the findings of Fontanilla (2024), who reported that crude protein content would increase if substrates are added to guinea grass silages. However, the CP content of T1 was higher than the 4.37% recorded by Fontanilla (2024) and therefore, suggests the addition of other richer protein sources to the ensiled guinea grass in order to meet the maintenance requirements of goats.

Table 2: Proximate composition of ensiled guinea grass with or without cassava or plantain peels mixture

Constituents (%)	T1	T2	T3
Dry Matter	94.75±0.4[a]	93.78±0.4[b]	94.84±0.4[a]
Crude Fibre	10.96±0.19[a]	8.35±0.19[a]	7.24±0.19[ab]
Crude Protein	7.50±0.58[c]	10.57±0.58[a]	9.51±0.58[b]
Ether Extract	1.7±0.01[a]	1.5±0.01[c]	1.5±0.01[b]
Ash	7.13±0.01[a]	6.41±0.01[b]	6.13±0.01[c]
Nitrogen free extract	72.72±0.04[bc]	73.17±0.65[b]	75.62±0.68[a]

abc= Means within the same row with different superscripts are significantly different (P<0.05) T1: 100% ensiled guinea grass; T2: 50% ensiled grass + 50% ensiled cassava peels; T3: 50% ensiled guinea grass + 50% ensiled plantain peels.

Table 3 shows the growth performance of West African dwarf goats fed ensiled guinea grass with or without cassava or plantain peels mixture. Silage intake differed significantly (P<0.05) between the dietary treatments; the values were higher in goats fed T1 (12.44±2.11 kg) and T2 (12.87±2.11 kg) diets, than in T3 (10.52±2.11 kg). Total feed intake was significantly lower (P<0.05) in T3 (18.72±3.03 kg) compared to T1 (20.68±3.03 kg) and T2 (20.89±3.03 kg). Final weight, total weight gain, average daily weight gain and feed conversion ratio were significantly different (P<0.05) across dietary treatments. The observed differences in total feed intake and total weight gain in this study might be due to plantain or cassava peels and concentrate inclusion in the diets which might have influenced feed palatability and acceptability by the animals. Abegunde et al. (2021) reported a similar effect by West African Dwarf goats fed guinea-grass ensiled with or without additive. The lower feed conversion ratio values observed for animals fed T3 silage in this study implies the superiority of that diet over the others.

Table 3: Growth performance of West African dwarf goats fed ensiled guinea grass with or without cassava and plantain peels

Parameter	**T1**	**T2**	**T3**
Concentrate Intake (kg)	8.25±1.02	8.02±1.02	8.21±1.02
Silage Intake (kg)	12.44±2.11[a]	12.87±2.11[a]	10.52±2.11[b]

Total Feed Intake (kg)	20.68±3.03^{a}	20.89±3.03^{a}	18.72±3.03^{b}
Daily feed intake (g/day)	369.28±54.06^{b}	373.03±54.06^{a}	334.28±54.06^{c}
Initial weight (kg)	7.50±1.19	7.65±1.19	7.60±1.19
Final weight (kg)	12.75±0.78^{b}	13.50±0.78^{a}	13.50±0.78^{a}
Total Weight Gain (kg)	5.25±0.79^{b}	5.85±0.79^{ab}	5.90±0.79^{a}
Average daily weight gain (kg/day)	0.09±0.01^{b}	0.10±0.01^{ab}	0.11±0.01^{a}
Feed conversion ratio	3.98±0.88^{a}	3.82±0.88 ^{ab}	2.70±0.88^{b}

abc= Means within the same rows with different superscripts were significantly different (P < 0.05); T1: 100% Ensiled Guinea grass; T2: 50% Ensiled Guinea grass + 50% Cassava peels; T3: 50% Ensiled Guinea grass + 50% Plantain peels

Table 4 shows the volume of gas production at different hours of incubation for ensiled guinea grass with or without cassava peels or plantain peels mixture. The gas produced increased and differed significantly (P<0.05) from the 3rd hour to the 24th hour of incubation. T3 (14.67±2.18 ml 200mg/DM) produced the highest gas volume at the 24th hour of incubation, while T2 (10.00±2.18 ml 200mg/DM) recorded the least gas volume at the 24th hour of incubation. The variation in the volume of methane gas production is an indication of energy loss at different hourly intervals as a result of the interactive effect of fermentation between the peels and guinea grass during the ensiling period.

Table 4: Volume of gas production (ml 200mg/DM) at different hours of incubation of ensiling guinea grass with different substrates

Incubation Hours	T1	T2	T3
3 HOURS	2.00±0.39^{b}	2.00±0.39^{ab}	2.67±0.39^{a}
6 HOURS	6.00±1.02^{b}	6.67±1.02^{a}	6.00±1.02^{b}
9 HOURS	8.00±1.02^{a}	7.33±1.02^{b}	8.00±1.02^{a}
12 HOURS	9.33±0.67^{b}	7.33±0.67^{c}	11.33±0.67^{a}
15 HOURS	10.00±0.77^{b}	8.00±0.77^{c}	12.67±0.77^{a}
18 HOURS	12.67±1.76^{b}	9.33±1.76^{c}	13.33±1.76^{a}
21 HOURS	12.67±1.76^{b}	9.33±1.76^{c}	13.33±1.76^{a}
24 HOURS	12.67±2.17^{b}	10.00±2.18^{c}	14.67±2.18^{a}

abc= Means within same row with different superscripts are significantly different (P<0.05). T1=100% Guinea Grass, T2=50% guinea grass + 50% Cassava peels, T3=50% guinea grass + 50% Plantain peels

Table 5 shows significant differences (P< 0.05) in methane percentage production, methane gas volume, methane reduction, short chain fatty acids production, metabolizable energy and organic matter digestibility. T1 (7.33±0.67%) was the highest producer of methane gas, while T2 (6.67±0.67%) and T3 (5.62±0.67%) had low production of methane gas. Reduction in methane was higher in T2 (33.33±6.67%) and T3 (33.33±6.67%) than in T1 (26.67±6.67%). T3 (0.40±0.05 ml/200mgDM) produced the highest short chain fatty acids. Organic matter digestibility was higher in T3 (45.02±1.76%), than in T2 (39.45±1.76%) and T1 (37.96±1.76%) respectively. T3 (6.04±0.28) had higher metabolisable energy (MJ/kg DM) than T2 (5.00±0.28) and T1 (4.85±0.28) respectively. Methane gas production is an indication of microbial degradation of the samples (Fievez et al., 2005; Babayemi et al., 2004).The observed difference in methane reduction implies that ensiling guinea grass with or without cassava peels or plantain peels has the potential to mitigate methane emission in a way acceptable for the environment and animals. Happi Emaga et al. (2011) reported that changes in the carbohydrate composition of the peels also reflect in the short chain fatty acid profiles of the silages after fermentation. SCFA are known to contribute extensively to the energy supply of the animal (Ukanwoko et al., 2019).

Table 5: Post in vitro parameters of ensiling guinea grass with different substrates

Parameters	TI	T2	T3
Methane percentage production (%)	7.33±0.67^{a}	6.67±0.67^{b}	5.62±0.67^{c}
Methane gas volume (ml)	0.61±0.04^{a}	0.52±0.04^{b}	0.36±0.04^{c}
Methane reduction percentage (%)	26.67±6.67^{b}	33.33±6.67^{ab}	34.31±6.67^{a}
Fermentation efficiency (µml)	1.35±0.28^{a}	0.63±0.28^{c}	0.94±0.28^{b}
Short chain fatty acid (µml)	0.27±0.05^{b}	0.27±0.05^{c}	0.40±0.05^{a}
Organic matter digestibility (%)	37.96±1.76^{c}	39.45±1.76^{b}	45.02±1.76^{a}
Metabolisable energy (MJ/kg DM)	4.85±0.28^{c}	5.00±0.28^{b}	6.04±0.28^{a}

abc= Means within same row with different superscripts are significantly different (P<0.05). T1=100% Guinea Grass, T2=50% guinea grass + 50% Cassava peels, T3=50% guinea grass + 50% Plantain peels

Table 6 shows the economic evaluation of feeding ensiled guinea grass with or without cassava peels or plantain peels mixture to West African dwarf goats. Cost of silage was significantly (P< 0.05) higher in T3 (₦32.00±0.00) than in T2 (₦25.00±0.00) and T1 (₦21.00±0.00). Total cost of feed/kg was significantly higher (P<0.05) in goats fed T3 (₦144.19±0.00) than in T2 (₦135.19±0.00) and T1 (₦133.19±0.00) ration respectively. The total cost of feed consumed was significantly different (P<0.05) between treatment means. The values were higher for goats fed T3 ration compared to those fed T1 and T2 rations respectively. Goats fed guinea grass silages with or without cassava or plantain peels had lower cost/kg gain which indicates its profitability to achieve sustainable small ruminant production.

Table 6: Economic evaluation of feeds fed to West African Dwarf goats

Parameter	T1	T2	T3
Concentrate Intake (kg)	8.25±1.02	8.22±1.02	8.21±1.02
Silage Intake (kg)	12.44±2.11^{a}	12.87±2.11^{a}	10.52±2.11^{b}
Total Feed Intake (kg)	20.68±3.03^{a}	20.89±3.03^{a}	18.72±3.03^{b}

Total Weight Gain (kg)	5.25±0.79[b]	5.85±0.79[ab]	5.90±0.79[a]
Cost of Concentrates (Naira)	112.19±0.00	112.19±0.00	112.19±0.00
Cost of silage (Naira)	21.00±0.00[c]	25.00±0.00[b]	32.00±0.00[a]
Total Cost of Feed/Kg	133.19±0.00[b]	135.19±0.00[b]	144.19±0.00[a]
Total Cost of Feed Consumed	2754.36±414.75[b]	2824.12±414.75[a]	2699.24±414.75[c]
Cost/Kg Gain	524.64±116.94[a]	482.75±116.94[b]	457.49±116.94[c]

abc= Means within same row with different superscripts are significantly different (P<0.05). T1=100% Guinea Grass, T2=50% guinea grass + 50% Cassava peels, T3=50% guinea grass + 50% Plantain peels

Conclusion

The ensiled guinea grass with plantain and cassava peels were seemingly suitable as feedstuffs for ruminants because they have crude protein contents that were higher than the recommended 7% for ruminants. Goats fed ensiled guinea grass with plantain or cassava peels had better feed conversion ratio and cost/kg gain. Thus, ensiling of guinea grass with plantain and cassava peels ruminants may reduce the environmental pollution caused by the indiscriminate dumping of plantain and cassava peels.

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