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Quality of ensiled Guinea grass (*Panicum maximum*) at varying proportions with sweet potato peels for ruminant production in Niger Delta, Nigeria

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Abstract

Quality of ensiled Panicum maximum with different proportion of sweet potato peels for ruminant production was studied. Panicum maximum (PAM) were harvested at 4-week regrowth, chopped to 2-3 cm, wilted and ensiled with sweet potato peel (SPP) at different proportions (%) to have seven experimental treatments: T1 (100 PAM/ 0 SPP); T2 (90 PAM/ 10 SPP); T3 (80 PAM/ 20 SPP); T4 (70PAM/ 30 SPP); T5 (60 PAM/ 40 SPP; T6 (50 PAM/ 50 SPP); T7 (40 PAM/ 60 SPP). Bamma bottles (960mL) were used as laboratory silos. Each treatment had three replicates in completely randomize design. The ensiled materials were kept for 270 days. Physical characteristics, chemical composition and fiber fractions were examined. The colour observed were yellowish-green to olive-green, while the aroma was mild sweet in all the treatments except T3 and T6 with 20% and 5% mouldiness, respectively. Firm texture was recorded for all the treatments, while the pH values ranged from 2.9 – 3.7. There was a significant (P<0.05) difference in DM, CP, CF, ash, NFE, NDF, ADF and NFC except ether extract. There was no significant (P>0.05) different in the Ca, P, Na and Mg content of the silage. The value of Fe and Zn was significantly different (P<0.05) and ranged from 165.7 – 169.2 mg/kg and 22.30 – 23.70 mg/kg, respectively. There was a significant difference (P<0.05) in the 24hrs gas production, methane production (CH4), short chain fatty acid (SCFA), organic matter digestibility and metabolizable energy (ME), while similar (P>0.05) value was recorded for dry matter digestibility(DMD) and fermentation efficiency (FE) across the experimental treatments. The qualities recorded for the experimental treatments at the end of 270 days ensiled period, showed that the silage of Panicum maximum with different proportions of sweet potato peel especially T4 (70 PAM/30 SPP) could sustain ruminant production especially during the dry season.

Keywords: In vitro, *Panicum maximum*, Ruminant, Silage, Sweet potato peel, and Sustainable production

Introduction

Nigerian ruminant industry is facing the problem of forage scarcity with high cost of feeds precipitated by inadequate supply of feed ingredients. This constraint has affected ruminant production negatively and created a wide gap between the demand and supply of animal protein in Nigeria. Silage as fermented forage stored under anaerobic condition (Amodu and Abubakar, 2004) is one of the major ways of conserving forages. Perennial forage surplus obtained when the weather is favorable is recommended for storage as silage in order to meet the animal requirements throughout the year (Bonelli *et al*., 2013). Forage conservation as silage seems to be a more adequate conservation technique under the sub-humid conditions in the tropics (Heinritz, 2011) compared to the semi-arid and arid tropics.

The preservation of forage crops as silage depends on the production of sufficient acid to inhibit activity of undesirable microorganisms under anaerobic conditions (Ogunjobi *et al*., 2012). Fortunately, apart from the conventional forage crops, materials that can be ensiled include fodder crops and crop residues or by-products ('t Mannetje, 2000).

Sweet potato peel is a waste which cannot be consumed by humans; it has been used as animal feed. Considering the abundance of sweet potato peel in the Niger Delta region of Nigeria, it can be used as silage materials by the ruminant animal farmers for sustainable ruminant animal production in the region. Chemical analysis coupled with visual examination of silage such as colour, odour and general appearance provide a good indication of the expected overall nutritive value of silage. There are different methods of assessing nutritional quality of feed resources, these include nutrients composition analysis, in-vitro digestibility and feeding trial.

The in-vitro degradability method is a laboratory estimation of assessing the potential nutritive value of the feed. It is also a method that is reproducible and parameters obtained correlate well with in-vivo trials (Fajemisin, 2002). This study intends to examine the physical characteristics, chemical composition and in-vitro digestibility of ensiled *Panicum maximum* with varying proportion of sweet potato peel in order to solve the dry season feed and feeding problem of ruminant animals.

Materials and methods

The experiment was conducted at Forage Utilization Unit, Department of Animal Science, Faculty of Agriculture, University of Port Harcourt, Port Harcourt, Rivers State, Nigeria. Port Harcourt is a coastal city located in the Niger Delta region of Nigeria within latitudes 6° 58' – 7° 60'E and longitudes 4° 40' – 4°55'N. The monthly rainfall in Port Harcourt follows a sequence of increase from March to October before decreasing in the dry season months of November to February (Uko and Tamunobereton Ari, 2013 and Lamidi and Ogunkunle, 2016).

Preparation of experimental materials

Panicum maximum (PAM) was harvested at four (4) weeks regrowth from the University of Port Harcourt Demonstration Grassland, at 10 cm above ground level, wilted for 24 hours and chopped into 2 – 3 cm long pieces. Sweet potato peels (SPP) were collected from identified sweet potato selling points within University community and chopped. The grass and the sweet potato peel were then mixed at different proportions to have seven (7) experimental treatments as follows (%): T1 (100 PAM/ 0 SPP); T2 (90 PAM/ 10 SPP); T3 (80 PAM/ 20 SPP); T4 (70PAM/ 30 SPP); T5 (60 PAM/ 40 SPP; T6 (50 PAM/ 50 SPP); T7 (40 PAM/ 60 SPP). **Bamma b**ottles (960ml) were used as laboratory silos after the materials were mix thoroughly; the bottles were tightly corked and covered to avoid air penetration. Each treatment had three replicates and the ensiled materials were kept at room temperature of 28 to 32°C for 9months (270 days) (1st October 2016 – 1st July 2017).

Physical and chemical quality evaluation of the silage

Physical characteristics such as temperature, colour, aroma and pH were determined immediately the Bamma bottles were opened. The colour was determined by comparing the colour of the silage samples to a colour chart. Aroma was perceived and the pH was determined using digital pH meter. The texture was assessed by pressing with fingers, wetness was assessed by pressing the silage with hands. Sub-samples of the ensiled forage materials were oven-dried. Dried samples were ground with a Thomas Willey Laboratory Mill-Model 4 and passed through 1-mm sieve. The proximate composition of the silage was determined according to AOAC (2000) while neutral detergent fibre (NDF) was determined according to Van Soest *et* *al.* (1991). Non-fibre carbohydrate was calculated as NFC = 100 – (CP + Ash + EE +NDF). Mineral composition of the samples was carried out using the Atomic Absorption Spectrophotometer of AOAC (1990).

In-vitro Digestibility trial

The in-vitro trial was carried out at the laboratory of Department of Animal Science, University of Benin, Benin City, Edo State, Nigeria. Rumen fluid was collected from three West African Dwarf goats by using suction tube prior to morning feeding. The method of collection was as described by Babayemi *et al*. (2006). The goats were previously fed with 40% concentrate (growers mash) and 60% *Pennisetum purpureum*. The rumen liquor was collected into thermo flask that had been pre-warmed to a temperature of 39°C. Incubation procedure was as reported by Menke and Steingass (1988) using 100ml calibrated transparent plastic syringes with fitted silicon tube. The samples each weighing 200mg were carefully dropped into the syringes and thereafter, filled with 30mL inoculums containing cheese-cloth strained rumen liquor and buffer. The rumen liquor and buffer solution were mixed in ratio 1:4 (v/v), respectively. The mixture was handled under continuous flushing with CO_2 and immediately dispensed using 50ml plastic calibrated syringes. The syringe was tapped and pushed upward by the piston in order to eliminate air completely in the inoculums. The silicon tube in the syringe was then tightened by a metal clip so as to prevent escape of gas. Incubation was carried out at 39°C and the volume of gas production was measured at 3, 6, 9, 12, 15, 18, 21, and 24.

Preparation of buffer

A buffered mineral solution was prepared consisting of $NaHCO_3$ + $Na2HPO_4$ + KCl + NaCl + $MgSO_4$. $7H_2O$ + CaCl2. $2H_2O$ (Makkar, 2003).

Methane determination

The volume of methane gas produced from each sample was determined by dispensing 4mL of 40% NaOH (40g of NaOH in 100g of distilled water) to the sample at the end of 24 of incubation. The tip of 5ml syringe capacity that contained the 4mL NaOH was introduced into the incubated syringe through the silicon tube just above the metal clip. The clip was carefully unscrewed and the reagent introduced. NaOH was added to absorb CO_2 produced during the process of fermentation and the remaining gas was recorded as methane according to Babayemi *et al*. (2015) The syringe was then turned upside down for the reading of CH_4 level.

Calculation for post incubation parameters

Organic matter digestibility (OMD) was estimated as:

OMD = 14.88 + 0.889 GV + 0.45 CP + 0.651 ash (Menke and Steingass, 1988).

Short-chain fatty acids (SCFA) were estimated as:

SCFA = 0.0239 GV - 0.0601 (Getachew *et al*., 1999).

Metabolizable energy (ME) was calculated as:

ME = 2.20 + 0.136 GV + 0.057 CP + 0.00029 CF (Menke and Steingass, 1988).

The Fermentation Efficiency (FE) was calculated as:

Fermentation Efficiency (FE) = Dry matter Digestibility (g/kg)/ Total Gas Volume (mL/g)

Statistical analysis

The study was conducted using completely randomize design (CRD). All data obtained were subjected to the analysis of variance (ANOVA). Means were separated using Duncan's Multiple Range Test SAS (1999) package.

Results and discussion

The effect of ensiling *Panicum maximum* with sweet potato peel on the physical characteristics of silage at different proportion is shown in Table 1. The colour of the silage ranged from yellowish-green, brown-green, green and olive-green, while mild sweet aroma was noticed in all the experimental treatments except T3 and T6 that had unpleasant aroma with 20% and 5% mouldiness, respectively. Other treatments were free from mould. Firm texture was recorded for all the treatments. The silage was relatively dry, while the pH values ranged from 2.9 – 3.7. Generally, the mild sweet aroma was perceived in all the silage which is an indication of normal physical characteristics of good silage. Though T3 and T6 had unpleasant aroma, this might be attributed to mould formation recorded in these silage which might not be traced to the level of SPP inclusion. The colour of the silage was close to the original colour of the grass, which was an indication of good quality silage that was well preserved (Oduguwa *et al*., 2007). The range of pH value (2.9 – 3.7) recorded in this study shows that the silage is very good; though the value is lower than that reported (3.81-4.90) by Akinbode *et al.* (2017) when sugarcane top was ensiled with broiler litter.

Table 1: Effect of ensiling *Panicum maximum* with different proportion of sweet potato peel on the physical characteristics of the silage

	Silage quality					
Treatments	Colour	Aroma	Texture	Wetness	Mouldiness	pH
T1	Yellowish-green	Mild sweet	Firm	Relatively-dry	No mould	3.7
T2	Yellowish-green	Mild sweet	Firm	Relatively-dry	No mould	2.9
T3	Brown-green	Unpleasant	Firm	Damp	20% mould	3.6
T4	Green_	Mild sweet	Firm	Dry	No mould	3.1
T5	Olive-green	Mild sweet	Firm	Dry	No mould	3.1
T6	Brown-green	Unpleasant	Firm	Wet	5% mould	3.3
T7	Yellowish-green	Mild sweet	Firm	Dry	No mould	3.4

PAM (*Panicum maximum*); SPP (sweet potato peel); T1=100 (PAM/ 0 SPP); T2 (90 PAM/ 10 SPP); T3 (80 PAM/ 20 SPP); T4 (70PAM/ 30 SPP); T5 (60 PAM/ 40 SPP; T6 (50 PAM/ 50 SPP); T7 (40 PAM/ 60 SPP).

Table 2: Proximate composition and fiber fractions (%DM) of silage of ensiling *Panicum maximum* with different proportion of sweet potato peel

	Treatments							
Parameters	T1	T2	T3	T4	T5	T6	T7	SEM
DM	88.34^{c}	88.42^{ab}	88.08^{d}	87.92^{e}	87.87^{e}	88.39^{bc}	88.48^{a}	0.01
CP	8.89^{c}	9.07^{bc}	9.48^{a}	9.17^{abc}	8.97^{c}	9.31^{ab}	9.04^{c}	0.01
EE	2.38	2.35	2.46	2.39	2.28	2.51	2.25	0.01
CF	31.68^{a}	30.36^{c}	28.65^{g}	30.48^{a}	30.76^{c}	29.96^{f}	31.68^{a}	0.01
Ash	10.86^{a}	10.72^{de}	10.86^{b}	10.69^{e}	10.76^{cd}	10.95^{a}	10.45^{f}	0.01
NFE	35.02^{d}	35.92^{b}	36.63^{a}	35.32^{c}	35.09^{d}	35.24^{c}	35.08^{d}	0.12
NDF	68.76^{ab}	68.71^{b}	67.34^{f}	68.59^{d}	67.48^{e}	68.65^{c}	68.79^{a}	0.13
ADF	52.09^{c}	52.40^{b}	50.78^{f}	51.49^{e}	50.83^{f}	51.56^{d}	52.37^{a}	0.13
NFC	9.19^{d}	9.15^{d}	9.86^{b}	9.16^{d}	10.51^{a}	8.51^{e}	9.49^{c}	0.13

a, b, c, d, e, f Means on the same row with different superscripts differ significantly (P<0.05).
PAM (*Panicum maximum*); SPP (sweet potato peel); T1=100 (PAM/ 0 SPP); T2 (90 PAM/ 10 SPP); T3 (80 PAM/ 20 SPP); T4 (70PAM/ 30 SPP); T5 (60 PAM/ 40 SPP; T6 (50 PAM/ 50 SPP); T7 (40 PAM/ 60 SPP). DM (Dry Matter); CP (Crude Protein); EE (Ether Extract); CF (Crude Fibre); NFE (Nitrogen Free Extract); NDF (Neutral Detergent Fibre) ADF (Acid Detergent Fibre); NFC (Non-Fibre Carbohydrate); SEM (Standard error of mean)

Table 2 indicated the proximate composition and fiber fractions of ensiled *Panicum maximum* and potato peel silage. There was a significant difference (P<0.05) in all the parameters except EE. The DM, CP, CF, Ash, NFE, NDF, ADF and NFC content ranged from 87.87 – 88.48%, 9.04 – 9.48%, 28.65 – 31.68%, 10.45 - 10.95%, 35.08 – 36.63%, 67.34 – 68.79%, 50.78 – 52.37% and 8.51 – 10.51% respectively. The CP contents of the experimental treatments (8.89 - 9.48%) were a little bit above the critical lower limit (7% CP) which forage intake by ruminants and rumen microbial activity could be negatively affected (Van Soest, 1994 and Norton, 2003). The CP content recorded for this study was also within the 7 to 8 % CP suggested as threshold for sufficient utilization of feed by MacDonald *et al*. (1995). Therefore, the silage would provide the adequate nitrogen requirement for the rumen microorganisms to maximally digest the main components of dietary fibre leading to the production of volatile fatty acids (Trevaskis *et al*. 2001; Lamidi and Ogunkunle, 2016) which in turn facilitate microbial protein synthesis (Lamidi and Aina, 2013).

Table 3: Mineral profile of ensiled *Panicum maximum* with different proportion of sweet potato peel

	Treatments							
Parameters	T1	T2	T3	T4	T5	T6	T7	SEM
Ca (%)	0.16	0.16	0.18	0.17	0.18	0.17	0.18	0.01
P (%)	0.42	0.43	0.42	0.43	0.43	0.44	0.45	0.01
Na (%)	0.22	0.23	0.22	0.23	0.23	0.22	0.23	0.01
Mg (%)	0.25	0.26	0.26	0.26	0.26	0.25	0.24	0.01
Fe (mg/kg)	167.6^{cd}	166.8^{d}	168.3^{bc}	165.7^{e}	168.8^{ab}	165.7^{e}	169.2^{a}	0.31
Zn(mg/kg)	22.50^{e}	23.10^{c}	22.80^{d}	23.40^{b}	22.50^{e}	23.70^{a}	22.30^{f}	0.11

a, b, c, d, e, f Means on the same row with different superscripts differ significantly (P<0.05).
PAM (*Panicum maximum*); SPP (sweet potato peel); T1=100 (PAM/ 0 SPP); T2 (90 PAM/ 10 SPP); T3 (80 PAM/ 20 SPP); T4 (70PAM/ 30 SPP); T5 (60 PAM/ 40 SPP; T6 (50 PAM/ 50 SPP); T7 (40 PAM/ 60 SPP)

There was no significant different (P>0.05) in the Ca, P, Na and Mg content of the silage. The Fe and Zn was significantly different (P<0.05) in the treatments, the value of Fe ranged between 165.7 – 169.2 mg/kg, while Zn content varied from 22.30 – 23.70 mg/kg. The mineral profile of the silage recorded in the study were within the dietary requirements of goat as recommended by NRC (1985) for Ca, K and Na 0.18 – 1.04, 0.50 – 0.80 and 0.04 – 0.10 %, respectively.

Table 4: Post in -vitro gas production of ensiled *Panicum maximum* with different proportion sweet potato peel

	Treatments							
Parameters	T1	T2	T3	T4	T5	T6	T7	SEM
24hrs gas production	17.33^{b}	19.33^{b}	31.33^{ab}	32.00^{ab}	26.00^{ab}	41.00^{a}	30.00^{ab}	2.30
CH_4 (mL)	7.33^{c}	8.67^{c}	18.66^{ab}	14.00^{abc}	12.66^{bc}	19.00^{ab}	25.33^{a}	1.39
DMD (g/100g)	16.33	17.61	12.67	18.89	20.60	23.54	16.80	1.32
FE (%)	1.03	0.98	0.44	0.61	0.88	0.66	0.60	0.08
SCFA (mL/200mgDM)	0.35^{b}	0.40^{b}	0.69^{ab}	0.71^{ab}	0.51^{ab}	0.92^{a}	0.66^{ab}	0.55
OMD (%)	41.15^{b}	42.95^{b}	53.78^{ab}	54.12^{ab}	48.80^{ab}	62.30^{a}	52.13^{ab}	3.52
ME (MJ/kg DM)	5.07^{b}	5.36^{b}	7.01^{ab}	7.08^{ab}	6.26^{ab}	8.32^{ab}	6.80^{a}	0.31

a, b, c, Means on the same row with different superscripts differ significantly (P<0.05).
T1 (100 PAM/ 0 SPP); T2 (90 PAM/ 10 SPP); T3 (80 PAM/ 20 SPP); T4 (70PAM/ 30 SPP); T5 (60 PAM/ 40 SPP; T6 (50 PAM/ 50 SPP); T7 (40 PAM/ 60 SPP); CH_4(methane production); DMD (dry matter digestibility); FE (fermentation efficiency); SCFA (short chain fatty acid); OMD (organic matter digestibility); ME (metabolizable energy)

Table 4 indicated the post in-vitro gas production of ensiled *Panicum maximum* with different proportion of sweet potato peel. There was a significant difference (P<0.05) in the 24hrs gas production, methane production (CH4), short chain fatty acid (SCFA), organic matter digestibility and metabolizable energy (ME), range of between 17.33 – 41.00, 7.33 – 25.33 ml, 0.35 – 0.92 mL/200mgDM, 41.15 – 62.30%, 5.07 –6.80MJ/kg DM respectively. There was no significant difference (P>0.05) in the dry matter digestibility (DMD) and fermentation efficiency across the experimental treatments. The gas production is a nutritionally wasteful product (Mauricio *et al*., 1999) but provides a useful basis from which ME, OMD and SCFA may be predicted (Fajemisin *et al*., 2015). Meanwhile, the higher preponderance of SCFA in the experimental treatments T3, T4, T5, T6 and T7 probably showed an increased proportion of acetate and butyrate but may mean a decrease in propionate production (Babayemi *et al*., 2006).

Conclusion and recommendations

There was no particular trend in respect of inclusion of SPP, the physical characteristics, nutrient profile, fiber fractions and mineral contents of the silage at the end of 270 days ensiled period it shows that the silage can stand the test of time to solve the problem of dry season feeds and feeding for ruminant animal production. Ensiled Panicum maximum with sweet potato peels shows an appreciable nutritional quality of the silage especially for T3, T4, T5, T6 and T7 compared to T1(control 100 *Panicum maximum* /0 SPP) and T2 (90 PAM/ 10 SPP). However, environmental nuisance caused by sweet potato peel can be mitigated by ensiling sweet potato peel with *Panicum maximum* for dry season feed. Inclusion of protein materials such as legume will increase the protein content of the silage. T4 (70PAM/ 30 SPP) shows appreciable nutritional quality than other experimental treatments and can be recommended for the ruminant animal farmers.

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