

Silage quality of *Panicum maximum* with varying levels of *Delonix regia* seeds for sustainable ruminant animal production in Niger Delta region of Nigeria

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ABSTRACT

Silage quality of *Panicum maximum* with varying levels of *Delonix regia* seeds for sustainable ruminant production was studied. *Panicum maximum* was ensiled with varying levels of milled *Delonix regia* seeds as T1: 100/0%; T2: 70/30% and T3: 60/40% respectively for ensiling duration of 9 months. The physical characteristics, volatile fatty acid fractions, proximate composition, fiber fractions, mineral profile, phytochemical properties and *in vitro* characteristics were examined. Results show that the colour of the silage varies from yellowish-green to brown colour. There was a significant ($P<0.05$) difference in the nutrients considered except ether extract (EE). Fiber fractions was significant differences ($P<0.05$) in all the fiber fractions. Similar ($P>0.05$) content of minerals was recorded except Zn. The value of Ca, P, K, Mg and Na ranged between 0.16 - 0.17, 0.43 - 0.44, 0.43 - 0.44, 0.20 - 0.24 and 0.22 - 0.24% respectively. There was no significant difference ($P>0.05$) in the phytochemical properties of the silage. Significant ($P<0.05$) difference was observed among all the volatile fatty acid fractions considered. There was a significant ($P<0.05$) difference in the short chain fatty acids (SCFA) and metabolizable energy (ME) contents of the silage. Similar ($P>0.05$) value of SCFA and ME was recorded for T3 and T2, also similar for T2 and T1. Ensiling *Panicum maximum* at 60 % with *Delonix regia* seeds at 40% level (T3) improved the qualities of the silage. It is therefore recommended that 40% *Delonix regia* seeds can be used for silage production for sustainable ruminant animal production in Niger Delta region Nigeria.

Keywords: *Delonix-regia*-seeds, *Panicum-maximum*, Quality, Silage, Sustainable, Ruminant

INTRODUCTION

Ruminants plays crucial role in micro and macro-economic development of a nation. Their production has been peasantry and managed on the natural pasture in Nigeria (Lamidi, 2016). Ruminant production has been affected by the inadequate availability of a sustainable feed resources during the dry season in which they are left with lignified grasses, crop residues and

industrial by-products. However, the plants become fibrous and lignified as they age and as they move towards dry season (Ojo *et al.*, 2016). The conventional feed that may be available during this period are expensive as a result of competition between man and monogastric animals like poultry, swine etc. Hence, animals are unable to meet their protein and energy needs with consequent marked weight loss and low productivity.

Babayemi and Igbekoyi (2008) described silage production in the tropics as a sustainable means of supplementing feed for ruminants in the dry season. Hence, the 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). Fortunately, apart from the conventional forage crops, materials that can be ensiled include fodder crops and crop residues or by-products ('t Mannetje, 2000).

Panicum maximum (Jacq) is a household forage grass in the tropics, its abundance in the rainy season has made it popular among the other grass, it has been researched in respect of silage production. However, low protein content of Guinea grass has been a challenge, there is need for protein sources for its fortification. Forage seeds have been reported to be high in crude protein (Babayemi *et al.*, 2004) and as such are suitable as protein concentrate and are nutritional promising for optimum performance ruminants (Babayemi and Bamikole, 2006). *Delonix regia* (Boj. Ex Hook) (Caesalpinidae) is a tree, which is about 12 m high with a slightly flat or curving crown. It is an ornamental leguminous plant, which produces tonnes of pods containing seed in the fruiting season (Keay, 1967). These seeds are left unutilized since they are neither consumed by any animal nor utilized for any other medical purposes. Its seeds contain 20.50 % crude protein, 4.18-4.23 % ether extract, 4.45-6.84 % crude fibre and secondary compounds of condensed tannins and saponins at 90-95 mg 100 g⁻¹ and 10–15 %, respectively (Alemede *et al.*, 2010; Kaga, 2011). The study investigates the silage quality of *Panicum maximum* ensiled with varying levels of *Delonix regia* seeds for sustainable ruminant animal production in Niger Delta region Nigeria.

MATERIALS AND METHODS

Location of the study

The study was carried out at the Forage Science Unit, Department of Animal Science laboratory, Faculty of Agriculture, University of 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 (Lamidi and Ogunkunle, 2016).

Sources and preparation of experimental materials and treatments

Panicum maximum was harvested at four (4) weeks regrowth from the Forage Utilization farm of Department of Animal Science, University of Port Harcourt, at 10 cm above ground level, wilted for 24 hours and chopped into 2 – 3 cm long pieces. Matured *Delonix regia* fruits was harvested from *Delonix regia* trees within the University of Port Harcourt community Port Harcourt. The collected pods were sun-cured for three days and dehulled to obtain the seeds. The seeds then sun dried for three days, milled and sieved into 2mm. The grass and the milled seeds were then mixed at different proportions as follows:

T1. 100% of *Panicum maximum*: 0% of *Delonix regia*,

T2. 70% of *Panicum maximum*: 30% of *Delonix regia*,

T3. 60% of *Panicum maximum*: 40% of *Delonix regia*.

Different *Panicum* and *Delonix* seeds were mix thoroughly and were ensiled in laboratory bottles (Bamma 960 ml) as silos. The silos were tightly tied 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 9 months (270 days).

Physical and chemical quality evaluation of the silage

Physical characteristics as well as temperature ($^{\circ}\text{C}$) and pH of the silage were determined immediately the silos were opened. Physical characteristics of silage of *Panicum maximum* with varying level of *Delonix regia* seeds were carried out according to the procedures of Oduguwa *et al.* (2007), while pH and temperature were determined using Digital pH Meter. Sub-samples of the ensiled forage materials were oven-dried, ground with a Thomas Willey Laboratory Mill-Model 4 to pass through 1 mm sieve.

Volatile fatty acids and Chemical analysis

Volatile fatty acid was determined by Samuel *et al.* (1997) procedures. 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 $\text{NFC} = 100 - (\text{CP} + \text{Ash} + \text{EE} + \text{NDF})$ (Ojo *et al.*, 2016).

Mineral composition of the samples was carried out using the Atomic absorption spectrophotometer of AOAC (1990).

Tannin and saponin contents were determined according to the methods described by Lamidi and Ogunkunle, (2015). Oxalate was according to Munro (2000) while phytate was determined as described by Prokopet and Unlenbruck (2002).

In vitro gas production procedures

Rumen fluid was collected from three (3) 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). Two hundred (200) mg of the milled samples were weighed into calibrated transparent plastic syringes with fitted silicon tube. The rumen fluid was taken to the laboratory, sieved with four layers' cheese cloth and added to the anaerobic buffer medium. Thirty (30) ml of the mixture was then added to each syringe in ratio 1:4 (v/v) respectively. The mixture was handled under continuous flushing with CO_2 and immediately dispensed using 50 ml 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 hours.

Preparation of buffer

A buffered mineral solution was prepared consisting of $\text{NaHCO}_3 + \text{Na}_2\text{HPO}_4 + \text{KCl} + \text{NaCl} + \text{MgSO}_4 \cdot 7\text{H}_2\text{O} + \text{CaCl}_2 \cdot 2\text{H}_2\text{O}$ (Makkar, 2003).

Methane Determination

The volume of methane gas produced from each sample was determined by dispensing 4 ml of 40 % NaOH (40 g of NaOH in 100g of distilled water) to the sample at the end of 24 hours of incubation. The tip of 5 ml syringe containing the 4ml NaOH was introduced into the incubated syringes through the silicon tube just above the metal clip. The clip was carefully unscrewed and the reagent introduced. The NaOH was added to absorb CO_2 produced during the

process of fermentation and the remaining gas was recorded as methane according to Fievez *et al.* (2005). The syringe was then turned upside down for the reading of CH₄ level.

Calculations

Hemicellulose was calculated as NDF – ADF, Cellulose was calculated as ADF – ADL, Non-fibre carbohydrates was calculated as (100 - (CP + EE + Ash + NDF).

In vitro organic matter digestibility (OMD) was estimated as:

$$\text{OMD} = 14.88 + 0.889 \text{ GV} + 0.45 \text{ CP} + 0.651 \text{ ash (Menke and Steingass, 1988).}$$

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

$$\text{SCFA} = 0.0239 \text{ GV} - 0.0601 \text{ (Getachew et al., 2000).}$$

Metabolizable energy (ME) was calculated as:

$$\text{ME} = 2.20 + 0.136 \text{ GV} + 0.057 \text{ CP} + 0.00029 \text{ CF (Menke and Steingass, 1988).}$$

The Fermentation Efficiency (FE) was calculated as:

$$\text{Fermentation Efficiency (FE) = Dry matter Digestibility (g/kg)/ Total Gas Volume (mL/g)}$$

Experimental design and data analysis

The experimental design was a complete randomized design (CRD), in which the experimental treatments is the only source of variability.

The model of analysis is as follows:

$$X_{ij} = \mu + T_i + \sum_{ij}$$

Where X_{ij} = value of observation; μ = population mean; T_i = treatment effect; \sum_{ij} = error term

All data obtained were subjected to the analysis of variance (ANOVA). Means were separated using Duncan's Multiple Range Test SAS (1999) package.

RESULTS

Physical characteristics of silage of *Panicum maximum* with varying level of *Delonix regia* seeds

Table 1 indicates the physical characteristics for silage of *Panicum maximum* ensiled with varying levels of *Delonix regia* seeds. The colour of the silage varies from yellowish-green to brown colour. Pleasant odour was observed in T1 and T2, while T3 had relatively chocking odour. Firm texture was observed for all the treatments. The wetness reduces as the inclusion of *Delonix regia* seeds increases. There was no mould in all the experimental treatments. Higher temperature (31.5 °C) was recorded for the T3, followed by T2 and T1 with 31.0 °C and 27.0 °C respectively, the pH followed the reversed trend T1 (3.7) > T2 (3.3) > T3 (3.1).

Table 1. Physical characteristics of silage of *Panicum maximum* with varying level of *Delonix regia* seeds

Parameters	Treatments		
	T1	T2	T3
Colour	Yellowish-green	Greenish brown	Light brown
Odour	Pleasant	Pleasant	Relatively chocking
Texture	Firm	Firm	Firm
Appearance	Leafy	Leafy	Relatively leafy
Wetness	Wet	Relatively wet	Very dry
Mouldiness	No mould	No mould	No mould
Temperature (⁰ C)	27.0	31.0	31.5
pH	3.7	3.3	3.1

T1. 100% of *Panicum maximum*: 0% of *Delonix regia*; T2. 70% of *Panicum maximum*: 30% of *Delonix regia*; T3. 60% of *Panicum maximum*: 40% of *Delonix regia*.

Volatile fatty acid in silage of *Panicum maximum* ensiled with proportions of *Delonix regia* seeds

Table 2 indicates volatile fatty acid in silage of *Panicum maximum* ensiled with proportions of *Delonix regia* seeds. There was a significant ($P < 0.05$) difference in all the volatile acid fractions considered in the silage. Acetic acid was highest ($P < 0.05$) in T3 (2.11 %) followed by T2 and T1 with

2.23 % and 2.11 % respectively. Similar ($P > 0.05$) content of propionic acid was recorded in T3 and T2, while T1 had least significant ($P < 0.05$) content of propionic acid (0.67 %). Butyric acid varied from 0.30 – 0.48 %. Lactic acid was highest ($P < 0.05$) in T3 (4.53%), while T1 (4.39%) and T2 (4.33%) had similar ($P > 0.05$) content of lactic acid.

Table 2. Volatile fatty acid in silage of *Panicum maximum* ensiled with proportions of *Delonix regia* seeds

Parameters	Treatments			SEM	LOS
	T1	T2	T3		
Acetic acid (%)	2.11 ^c	2.23 ^b	2.31 ^a	0.03	*
Propionic acid (%)	0.67 ^b	0.97 ^a	0.91 ^a	0.46	*
Butyric acid (%)	0.48 ^a	0.40 ^b	0.30 ^c	0.03	*
Lactic acid (%)	4.39 ^b	4.33 ^b	4.53 ^a	0.32	*

^{a, b, c} means on the same row having different superscripts are significantly different ($P < 0.05$) T1. 100% of *Panicum maximum*: 0% of *Delonix regia*; T2. 70% of *Panicum maximum*: 30% of *Delonix regia*; T3. 60% of *Panicum maximum*: 40% of *Delonix regia*. SEM: standard error of mean; LOS: level of significant; * Significant ($P < 0.05$)

Proximate composition (%) of silage of *Panicum maximum* with varying levels of *Delonix regia* seeds

Proximate composition for the silage of *Panicum maximum* with varying levels of *Delonix regia* seeds is depicted in Table 3. There was a significant ($P < 0.05$) different in

all the parameters considered except Ether extract (EE). The dry matter range from 88.34 – 89.63 %, highest ($P<0.05$) was recorded in T3 (89.63 %), follow by T2 and T1 with 89.05 % and 88.34 % respectively. The highest CP was recorded in T3 (9.57 %) followed by T2 (9.22 %) and T1 (8.89 %).

Ether extract (EE) ranged from 2.38 – 2.56 %DM. The CF was higher in T1 (31.27 %DM) followed by T2 and T3 with 30.93 and 28.84 %DM, ash was higher ($P<0.05$) in T3 (10.98 %DM) while NFE was higher in T2(35.02 %DM).

Table 3. Proximate composition (%) of silage of *Panicum maximum* with varying level of *Delonix regia* seeds

Parameters	Treatments			SEM	LOS
	T1	T2	T3		
Dry matter	88.34 ^c	89.05 ^b	89.63 ^a	0.19	*
Crude protein	8.89 ^c	9.22 ^b	9.57 ^a	0.10	*
Ether extract	2.38	2.47	2.56	0.81	NS
Crude fibre	31.27 ^a	30.93 ^b	28.84 ^c	0.38	*
Ash	10.78 ^c	10.92 ^b	10.98 ^a	0.03	*
NFE	35.02 ^b	36.13 ^a	34.59 ^c	0.23	*

^{a, b, c} Means on the same row having different superscripts are significantly different ($P< 0.05$) T1. 100% of *Panicum maximum*: 0% of *Delonix regia*; T2. 70% of *Panicum maximum*: 30% of *Delonix regia*; T3. 60% of *Panicum maximum*: 40% of *Delonix regia*. SEM: standard error of mean; LOS: level of significant; NS: not significant; * Significant ($P< 0.05$). Non-fibre carbohydrates was calculated as $(100 - (CP + EE + Ash + NDF))$.

Fibre fractions (%) of *Panicum maximum* with varying level of *Delonix regia* seeds

Table 4 shows the fibre fractions of the silage of ensiled *Panicum maximum* with varying level of *Delonix regia* seeds. There was a significant different ($P<0.05$) in all the fiber fractions of the silage. The NDF, ADF and ADL value was higher in T1 with 68.76,

52.09 and 18.79 %DM respectively while T3 had highest value of hemicellulose (17.13 %DM) and cellulose (33.79 %DM), there was no significant different in the value of non-fiber carbohydrates in T1 and T3, the T2 had highest significant ($P<0.05$) value (9.83 %DM) of NFC.

Table 4. Fibre fractions (%) of *Panicum maximum* with varying level of *Delonix regia* seeds

Parameters	Treatments			SEM	LOS
	T1	T2	T3		
Neutral detergent fiber (NDF)	68.76 ^a	67.09 ^c	67.87 ^b	0.25	*
Acid detergent fiber (ADF)	52.09 ^a	50.57 ^b	50.74 ^b	0.25	*
Acid detergent lignin (ADL)	18.79 ^a	16.49 ^c	16.95 ^b	0.35	*
Hemicellulose	16.67 ^b	16.51 ^b	17.13 ^a	0.10	*
Cellulose	33.30 ^b	34.08 ^a	33.79 ^a	0.12	*
Non-fibre carbohydrates	9.19 ^b	9.83 ^a	9.02 ^b	0.13	*

^{a, b, c} Means on the same row having different superscripts are significantly different ($P< 0.05$) T1. 100% of *Panicum maximum*: 0% of *Delonix regia*; T2. 70% of *Panicum maximum*: 30% of *Delonix regia*; T3. 60% of *Panicum maximum*: 40% of *Delonix regia*. SEM: standard error of mean; LOS: level of significant; NS: not significant; * Significant ($P< 0.05$)

Mineral profile in silage of *Panicum maximum* ensiled with varying proportion of *Delonix regia* seeds

The mineral profile in silage of *Panicum maximum* ensiled with varying proportion of *Delonix regia* seeds shown in Table 5. There was a similarity ($P < 0.05$) in the content of minerals recorded for the silage except Zn.

The value of Ca, P, K, Mg and Na ranged between 0.16 - 0.17 %, 0.43 – 0.44 %, 0.43 - .044 %, 0.20 – 0.24 % and 0.22 – 0.24 % respectively. The highest ($P < 0.05$) content of Zn was recorded in T3 (24.20 %) followed by T2 (23.10 %) and T1 had the least content of Zn (22.50 %).

Table 5. Mineral profile in silage of *Panicum maximum* ensiled with varying proportion of *Delonix regia* seeds

Parameters	Treatments			SEM	LOS
	T1	T2	T3		
Calcium (%)	0.16	0.17	0.17	0.01	NS
Phosphorus (%)	0.43	0.43	0.44	0.01	NS
Potassium (%)	0.43	0.43	0.44	0.01	NS
Magnesium (%)	0.20	0.24	0.26	0.01	NS
Sodium (%)	0.22	0.22	0.24	0.01	NS
Zinc (mg/kg)	22.50 ^c	23.10 ^b	24.20 ^a	0.25	*

^{a, b, c} Means on the same row having different superscripts are significantly different ($P < 0.05$) T1. 100% of *Panicum maximum*: 0% of *Delonix regia*; T2. 70% of *Panicum maximum*: 30% of *Delonix regia*; T3. 60% of *Panicum maximum*: 40% of *Delonix regia*. SEM: standard error of mean; LOS: level of significant; NS: not significant; * Significant ($P < 0.05$)

Phytochemical properties in silage of *Panicum maximum* ensiled with varying level of *Delonix regia* seeds

Table 6 indicated the phytochemical properties in silage of *Panicum maximum* ensiled with varying level of *Delonix regia* seeds. There was no significant value

($P > 0.05$) in the phytochemical properties of the silage. The value obtained for tannin varied from 0.13 – 0.15 %, while saponins ranged from 0.31 – 0.33%, phytate and oxalate contents of the silage ranged from 0.25 – 0.28% and 0.15 – 0.18% respectively.

Table 6. Phytochemical properties in silage of *Panicum maximum* ensiled with varying level of *Delonix regia* seeds

Parameters	Treatments			SEM	LOS
	T1	T2	T3		
Tannin (%)	0.13	0.13	0.15	0.01	NS
Saponins (%)	0.33	0.31	0.33	0.01	NS
Phytate (%)	0.28	0.25	0.28	0.01	NS
Oxalate (%)	0.17	0.15	0.18	0.01	NS

a, b, c Means on the same row having similar superscripts are not significantly different ($P < 0.05$) T1. 100% of *Panicum maximum*: 0% of *Delonix regia*; T2. 70% of *Panicum maximum*:

30% of *Delonix regia*; T3. 60% of *Panicum maximum*: 40% of *Delonix regia*. SEM: standard error of mean; LOS: level of significant; NS: not significant; * Significant (P< 0.05)

***In vitro* characteristics in silage of *Panicum maximum* ensiled with different proportions of *Delonix regia* seeds**

Post *in vitro* characteristics in silage of *Panicum maximum* ensiled with different proportions of *Delonix regia* seeds after 24 hours of incubation was depicted in Table 7. There was no significant (P>0.05) difference in the methane (CH₄) production, organic matter digestibility (OMD) and fermentation

efficiency. The value of CH₄ produced ranged from 7.33 – 16.00ml, OMD and fermentation efficiency were varied from 16.33 – 24.37 % and 0.58 – 1.20 respectively. There was a significant (P<0.05) difference in the short chain fatty acids (SCFA) and metabolizable energy (ME). Similar (P>0.05) value of SCFA and ME was recorded for T3 and T2, also similar for T2 and T1.

Table 7. *In vitro* characteristics in silage of *Panicum maximum* ensiled with different proportions of *Delonix regia* seeds

Parameters	Treatments				
	T1	T2	T3	SEM	LOS
Methane (ml)	7.33	9.33	16.00	1.86	NS
Organic matter digestibility (%)	16.33	24.37	19.45	2.42	NS
Fermentation efficiency	1.03	1.20	0.58	0.16	NS
Short chain fatty acids (mol)	0.35 ^b	0.45 ^{ab}	0.77 ^a	0.13	*
Metabolizable energy (MJ/Kg DM)	5.07 ^b	5.64 ^{ab}	7.46 ^a	0.48	*

^{a, b} Means on the same row having different superscripts are significantly different (P< 0.05)

T1. 100% of *Panicum maximum*: 0% of *Delonix regia*; T2. 70% of *Panicum maximum*: 30% of *Delonix regia*; T3. 60% of *Panicum maximum*: 40% of *Delonix regia*. SEM: standard error of mean; LOS: level of significant; NS: not significant; * Significant (P< 0.05)

DISCUSSION

The colour of silage (*Panicum maximum* with *Delonix regia* seeds) was close to the original colour of the grass, which was an indication of good quality silage that was well preserved according to Oduguwa *et al.* (2007). The yellowish green colouration in sole *Panicum* silage was in accordance with the report of Kung and Shaver (2002) that when a green plant material that is ensiled produces yellow colour. The brownish colour recorded for 60% of *Panicum maximum*: 40% of *Delonix regia* silage (T3) in this study was due to the colour of *Delonix regia* seeds contrary to the general believe that brownish colour of silage might be due to deterioration of the silage.

The odour was pleasant and texture of the silage in this study was firm, which was expected to be the best texture of good silage as reported (Kung and Shaver, 2002). The 40% inclusion of *Delonix regia* seeds for T3 might be responsible for the appearance, dryness and the temperature of the silage because *Delonix regia* seeds milled was in dried form with low moisture content. The temperature range (31.0 – 31.50°C) observed in all *Delonix regia* seeds milled treated silages (T2 and T3) was above the range (25 – 27.50°C) catalogued by Babayemi (2009) for silage from Guinea grass. Excessive heat production had been reported to results in mallard or browning

reaction which can reduce digestibility of protein and fibre components (Bolsen *et al* 1996). Under this reaction, the useful protein form complexes with carbohydrate and thereby making them less digestible (Akinbode *et al.*, 2017).

The pH of the silage decreases as the level of inclusion of *Delonix regia* seeds increases. The range of pH value (3.1 – 3.7) recorded for the *Panicum maximum* with *Delonix regia* seeds in this study shows that the silage is very good; though the value is lower than the report of Akinbode *et al.* (2017) (3.81- 4.90) when sugarcane top was ensiled with broiler litter. However, pH may be influenced by the moisture content and the buffering capacity of the original materials. Silage that has been properly fermented will have a much lower pH (be more acidic) than the original forage. This is an indication that ensiling *Delonix regia* seeds will aid the lower pH which will improve the quality of the silage by producing more acid which aid the preservation of the silage i.e. discourage mould or activities of fungi. The seeds included was responsible for the high level of acidity which resulted in a drop in pH values in the ensiled samples. Meeske and Basson (1998) found similar results when lactic acid bacteria inoculants were added to *Eragrostis curvula*. Reduction in pH is as a result of increased breakdown of carbohydrate in the process of fermentation that characterizes the process of ensilage which helps to make sugar available to produce more lactic acid (Akintokun, *et al.*, 2007)

Volatile fatty acid is a reflection of energy availability in a feedstuff. Propionic and butyric acid concentrations of all silages produced were within the normal range (less than 0.1% for propionic acid and 0.5 – 1.0%

for butyric acid) reported for grass silage (Kung and Shaver, 2002).

The lactic acid concentration recorded for all silages was close to 6% which indicated completion of desirable fermentation in these silages as stated by Kung and Shaver (2002). The finding of this study in respect of inclusion of *Delonix regia* seeds at different varying level supported the assertion of Assefa and Ledin (2001) that addition of additives into silage will also make available sufficient fermentable carbohydrate for lactic acid bacteria and simultaneously the protein content of the silage will be increased.

The CP values obtained in this study showed an increasing trend as the *Delonix regia* seeds increased in *P. maximum* grass in the silage mixtures, this finding was in line with the reports of Babayemi and Igbekoyi (2008) who reported a similar trend where CP increased in silage with the increase in the inclusion of *Albizia saman* (Jacq.) Merr. pods in ensiled guinea grass mixture, Ojo *et al.* (2017) also reported an increase in the CP of *Pennisetum purpureum* with processed *Enterolobium cyclocarpum* seeds. The CP contents of the silage were above the critical limit (7% CP) which forage intake by ruminants and rumen microbial activity could be negatively affected (Van Soest, 1994 and Norton, 2003). MacDonald *et al.* (1995) suggested a threshold of about 7 to 8% CP to guarantee sufficient utilization of feed. 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 (Lamidi and Ogunkunle, 2016) which in turn facilitate microbial protein synthesis (Lamidi and Aina, 2013).

The NFE is an indicator of carbohydrate content of feedstuff or ingredient that is soluble or easily digested and available for animal. It implies that the soluble carbohydrate could support the production of volatile fatty acids in the rumen during fermentation (Blummel *et al.*, 1997).

The range of 600-650 g/kg (60.0 – 65.0%) suggested as the critical limit above which efficiency of utilization of tropical forages by ruminants would be impaired (Muia, 2000). The NDF (67.09 – 68.76%) values recorded in this study fell within the range of 25 -71 % reported for some valuable multipurpose trees that are fed to sheep and goat in Nigeria (Larb *et al.*, 1993). The NDF content reported in this study was higher than the NDF range of 58.67 - 68.33 % reported by Okukenu *et al.* (2015) for *Panicum maximum* ensiled with *Centrosema molle*. The higher NDF value obtained in this study is an indication that it will be a useful feeding stuff as good energy source in ruminant animal production as NDF is preferred measure for ruminant feeds and dietary balancing programs (Van Soest, *et al.*, 1991).

The Ca contents in the silage was lower than the recommended range (0.20-0.26g/100g) for maintenance of growing and lactating sheep (Reuter and Robinson, 1997) while P content was within the recommended range (0.15-0.48g/100g) required by ruminants (McDowell, 1992; 1997). The Mg content of the silage was in line with the recommended range (0.20 - 0.26g/100g) for ruminant animals (McDowell, 1992; 1997). The Na content of the was within the recommended range of 0.1-0.4 g/100g as minimum Na for ruminants (Littledike and Goff, 1987).

Feedstuff containing saponin has been shown to be defaunating agent (Fajemisin, 2015) and capable of reducing methane

production (Babayemi *et al.*, 2004). The tannin level in silage is below 6.00 % toxic level for small ruminants and it could be an added advantage as a natural additive in the diet of ruminants, since forage or feeds containing tannin have potential of forming complexes with protein as bypass protein in the rumen (Barry *et al.*, 1999) by diminishing rumen protein digestibility, thus improving on the availability of protein to ruminants at the lower gut.

Methane production has been reported to be an energy loss to ruminants and also contributes to global warming (Babayemi and Bamikole, 2006). Although gas production is a nutritionally wasteful product (Mauricio *et al.*, 1999) but it provides useful basis from which metabolizable energy, organic matter digestibility and short chain fatty acid may be predicted. In this study the higher preponderance of short chain fatty acid in the T3 probably shows an increased proportion of acetic and butyric acid but may mean a decrease in propionic acid production (Babayemi *et al.*, 2006). The propionic acid in T3 was high which contradicts this assertion. However, the metabolizable energy values in the silage especially T2 and T3 suggests a potential to make energy available to the ruminants.

CONCLUSION AND RECOMMENDATION

Ensiling *Delonix regia* seed with *Panicum maximum* improved the quality of the silage (T2 and T3), though *Delonix regia* seeds at 40% level with *Panicum maximum* at 60% (T3) improved the quality of the silage better. It is therefore recommended that 40% *Delonix regia* seeds can be ensiled with 60% *Panicum maximum* for silage production for sustainable ruminant animal production in Niger Delta region Nigeria.

REFERENCES

- Akinbode, R. M., Isah, O. A., Oni, A. O., Arigbede, O. M., and Ojo, V. O. A., 2017. Nutritional evaluation of sugarcane top ensiled with varying proportion of broiler litter. *Livestock Research for Rural Development* 29 (1) 2017.
- Akintokun, A., Jolaosho, A. O., and Afolabi, R. 2007. Effect of *L. plantarum* and carbohydrase on microbes and composition of *Tridax procumbens* silage. *Archivos de Zootecnia* 56(214): 145-156.
- Alemede, I. C., Adama, J. Y., Ogunbajo, S. A., Abdullahi, J., 2010. Hematological parameters of Savanna Brown does fed varying dietary levels of flamboyant tree seed meal. *Pakistan Journal Nutrition*. 9, 167-170.
- AOAC., 1990. Official methods of Analyses. 15th ed. Association of Official Analytical Chemists. Arlington, VA.
- Assefa, G. and Ledin, I., 2001. Effect of variety, soil type and fertilizer on the establishment, growth, forage yield, quality and voluntary intake by cattle of oats and vetches cultivated in pure stands and mixtures. *Animal Feed Science and Technology* 92:95-111.
- Babayemi, O. J., Demneyer, D. and Fievez, V., 2004. Nutritive value and qualitative assessment of secondary compounds in seeds or eight tropical browse, shrub and pulse legumes. *Comm. Appl. Biol. Sci.* 69: 103- 110.
- Babayemi, O. J and Bamikole, M. A., 2006. Effects of *Tephrosia candida* DC Leaf and its mixtures with Guinea grass on the *In vitro* fermentation changes as feed for ruminants in Nigeria. *Pakistan Journal of Nutrition* 5 (1): 14-18.
- Babayemi, O. J., Hamzat, R. A., Bamikole, M. A., Anurudu, N. F. and Olomola, O. O., 2006. Preliminary studies on spent tea leaf: *in vitro* gas production as affected by chemical composition and secondary metabolic. *Pakistan Journal of Nutrition* 5(5):497-500.
- Babayemi, O. J. and Igbekoyi, A. J., 2008. Ensiling pasture grass with pod of browse plant is potential to solving dry season feed for ruminant in rural settlement of Nigeria. In Eric Tielkes (ed). Competition for resources in a changing world: New drive for rural development. Conference of International Research on food security, Natural resource management and Rural development, Tropentag, 7th-9th October 2008.
- Babayemi, O. J. 2009. Silage quality, dry matter intake and digestibility by African Dwarf Sheep of Guinea grass (*Panicum maximum* cv nchisi) harvested at 4 and 12 week re-growths. *African Journal of Biotechnology*. 8 (16): 3983-3988
- Blummel, M., Makkar, H. P. S., Changa, G., Mtimuni, J. and Becker, K., 1997. The prediction of dry matter intake of temperate and tropical forages from In-vitro digestibility/gas production data and dry matter intake and In-vitro digestibility of African roughages in relation to ruminant live weight gain. *Animal feed Science and Technology* 69: 131 – 141.
- Bolsen, K. K., Ashbell, G. and Weinberg, Z. G. 1996. Silage fermentation and silage additives. Review. *Asian-Australian Journal of Animal Science*. 9: 483-493.
- Bonelli, E. A., Zanies, A. M., Alexandre, L. S., Daniela, J. F. and Gulihorme, R. A., 2013. Ruminal degradability of Guinea grass silage inoculated with

- Streptococcus bovis* isolated from bovine rumen combined or not with corn wheat bran. *Agricultural Science* Vol. 4 No. 12(2013) 412084.
- Fajemisin, A. N. 2015. Evaluation of nutritional composition of *Panicum maximum* *Moringa oleifera* diets by in vitro gas production technique. *Nigerian Journal Animal Science*, 17(2): 214 – 224.
- Fievez, V., Babayemi, O.J. and Demeyer, D., 2005. Estimation of direct and indirect gas production in syringes: A tool to estimate short chain fatty acid production requiring minimal laboratory facilities. *Animal Feed Science Technology* (123-124):197-210.
- Getachew, G., Depeters, E. J., and Robinson, P. H., 2004. In-vitro gas production provides effective method for accessing ruminant feeds. *California agriculture*. 58(1);54-58.
- Kaga B.I., 2011. Performance of Rabbits Fed *Delonix Regia* Seed Diet. Ph.D. Thesis. Department of Biological Science, Ahmadu Bello University, Zaria (Nigeria).
- Keay, P. W., Onochie, C. P. and Stanfield, D. P., 1964. Nigeria trees, Federal Dept. of Forestry Research Ibadan, Nigeria. 1964;1.
- Kung, L. Jr. and Shaver, R., 2002. Interpretation and use of silage fermentation analyses reports. Dept. of Animal and Food Science, University of Delaware Newark, DE 19717.
- Lamidi, A.A., and A.B.J. Aina., 2013. Presowing treatment, agronomic parameters and nutritive potential of *Tephrosia bracteolata* (Guill. Et Perr.) at four different stages of growth. *African Journal of Livestock Extension* 11:31-36.
- Lamidi, A.A. and Ogunkunle, T., 2015. Chemical composition, Mineral profile and phytochemical properties of common feed resources used for small ruminant animal production in South-West, Nigeria. *International Journal of Science and Nature* 6(1) pp.92-96.
- Lamidi, A.A., and Ogunkunle, T. 2016. Nutritional potential of poultry dropping meal as feed resources for ruminant production in Niger Delta.” Nigeria. *Global Agricultural Science & Technology*. 1:1-11.
- Lamidi, A.A., 2016. Agronomic Feature Occurrence, Forage Utilization and Grazing Pattern of University of Port Harcourt Grazing Lawn in Niger Delta, Nigeria. *Journal Agric. Tech-Environment*. Volume 5 No.1, (2016). Pp. 54-61.
- Larb, A., Thomas, D. and Hanson, J., 1993. Forage potential of *Erythrina abyssinia* intake, digestibility and growth rates for a stalled sheep and goats in Southern Ethiopia. *Agroforestry system*. 21: 263 – 270.
- Littledike, E.T. and Goff, J., 1987. Interactions of Ca, P, Mg, and Vitamin D, that influences their status in domestic meat animals. *Journal of Animal Science* 65: 1727-1743.
- MacDonald, P., R.A. Edwards, J.F.D. Greenhalgh and C.A. Mergan., 1995. *Animal Nutrition*. EIBS Longman, London and New York. Pp. 155-159, 524.
- Makkar, H. P. S., 2003. Effects and fate of tannins in ruminant animals, adaptation to tannins, and strategies to overcome detrimental effects of feeding tannin-rich feeds. *Small Ruminant Research* 49: 241–256.
- Mauricio, R. M., Mould, F. L., Abdalla, A. I. and Owen, E. (1999). The potential nutritive value for ruminants of some tropical feedstuffs as indicated by in vitro gas production and chemical

- analysis. *Animal Feed Science and Technology* 79: 321 – 330.
- McDowell, L.R., 1992. Minerals for grazing ruminants in tropical regions. 3rd Edn. University of Florida, USA.
- McDowell, L.R., 1997. Minerals for grazing ruminants in tropical regions. 3rd Edn. University of Florida, Gainesville, Florida, USA.
- Meeske, R. and Basson, H.M. 1998. The effects of a lactic acid bacterial inoculant on the fermentation dynamics of *Eragrostis curvula* during ensiling. *Afric. J. Range Forage Sci.*, 14: 88-91.
- Menke, K. H. and Steingass, H., 1988. Estimation of the energetic feed value from chemical analysis and in vitro gas production using rumen fluid. *Anim. Res. Devt.* 28: 7–55.
- Muia, J. M. K. 2000. Use of Napier grass to improve smallholder milk production in Kenya. Ph. D. Thesis. Wageningen Agricultural University. The Netherlands.
- Munro, A. B., 2000. Oxalate in Nigerian Vegetables. *West African Journal of Biological Applied Chemistry*, 12(1): 14-18.
- Norton, B. W., 2003. The nutritive value of trees legumes as dietary supplement for ruminants. In: Forage tree legumes in tropical agriculture. Gutteridge, R. C, and Shetton, H.M (EDS). Pp.171-191.
- Odugwua, B.O., Jolaosho, A.O. and Ayankoso. M.T., 2007. Effect of ensiling on the physical properties, chemical composition and mineral content of Guinea grass and cassava tops silage. *Nigerian Journal of Animal Production* 34: 100-106.
- Ojo, V.O.A. Jolaosho, O.S. Onifade, J.T. Amodu, J.A. Olanite, O.M. Arigbede, U.Y. Anele, S. A. Adeoye, P.A. Dele and T.A. Amole., 2016. Dry matter yield, botanical and chemical composition of natural forage of the south western Nigeria as influenced by topography, land use and season. *Journal of Animal Production Research*, 28(1):138-150.
- Oladepo, O., Jimoh, S. O., Adeyemi, T. A., Amao, O. A., Adams, T. O. and Ajibola, M. O., 2016. Performance of West African dwarf goats fed concentrates supplemented with varying levels of bamboo and mucuna leaves. In: O. O. Oluwatosin, O. S. Sowande, O. Olowofeso, L.T. Egbeyale, O. O. Adeleye, C. P. Njoku, A. O. Osofowora, and A. J. Sanda (Eds). *New Technologies for Enhanced Animal Production in Nigeria*. Proceedings of the 41st Annual conference of Nigerian Society for Animal Production (NSAP); Federal University of Agriculture, Abeokuta, Ogun State, Nigeria; March 20th – 24th, 2016. 962-964.
- Okukenu, O.A., Ogunrombi, O.A. and Onifade, O.S., 2015. Effect of forage proportion on the proximate and fibre composition of *Panicum maximum* and *Centrosema molle* silage. *Society for Grassland Research and Dev.in Nigeria*. 1: 23-25.
- Prokopet, G., and Unlenbruck, K. W., 2002. Protectine eine nen kalsse anti-kwoperahlich verbindungen dish. *Ges. Heit.* 23:318.
- Reuter, D. J. and Robinson, J. B., 1997. *Plant Analysis. An Interpretation Manual*. 2nd edition. CSIRO Publishing: Melbourne.
- Samuel, M. S., Sagathewan, J. Thomas and G. Mathen. 1997. An HPLC method for estimation of volatile fatty acids of

- ruminal fluid. *Indian Journal of Animal Sciences* 69:805–07.
- SAS, 1999. Statistical Analysis System, Computer Software, SAS/STAT User's Guide Version 9, Statistical Analysis Systems Institute, Cary, North Carolina, 0013402001, USA.
- t'Mannetje, L., 1999. "Introduction to the Conference on Silage Making in the Tropics." In Proc. FAO e-Conf. on Trop. Silage, FAO Plant Prod. and Protect. Paper 161. 1 Sept. - 15 Dec. 1999, edited by L.'t Mannetje. Paper 1.0: 1-3.
- Van Soest, P.J., J.B. Robertson, and B.A. Lewis., 1991. "Methods for dietary fibre, neutral detergent fibre and non-starch polysaccharides in relation to animal nutrition." *Journal of Dairy Science* 74(10): 3583-3597.
- Van Soest, P.J., 1994. *Nutritional ecology of the ruminants*. 2nd ed. Ithaca, NY USA: Comstock Publishing Associates/Cornell University Press. 476 pp.