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Potentials of Ensiled *Panicum Maximum* with Different Crop Residues as Ruminant Feed During Dry Season

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ABSTRACT

The experiment was conducted to determine the nutritive value of ensiled guinea grass with different additives using in-vitro gas production method. The silage were in 5 treatments T1: 90% of guinea grass + 10% yellow maize residue, T2: 90% of guinea grass + 10% white maize residue, T3: 90% of guinea grass + 10% guinea corn residue, T4: 90% of guinea grass + 10% soy bean residue, T5: 100% of guinea grass.. The silage quality, physical properties, chemical composition, the in vitro gas production after 24hours of incubation were investigated. Methane (CH4) gas produced was measured. Metabolizable energy (ME), Organic matter digestibility (OMD) and the short chain fatty acid (SCFA) were estimated from the in vitro gas production parameters. The colour of the silage varied among the silage treatments and were closer to the colours of the fresh forage. All the silage had pleasant smell and the temperature had no significant difference among the silage treatments. The pH ranged from 4.23 – 5.60 which has significant difference among the silage treatments. The chemical composition of the silage were as follows: Dry matter (DM) 23.73 to 29.50%, Crude protein (CP), 6.93 to 11.05%; Crude fibre (CF), 27.84 to 31.20%; and ash, 15.01 to 17.50%. Hemicellulose ranges from 23.29 to 26.05%, Cellulose ranges from 21.07 to 30.50%. The mineral composition value of the ensiled ranges are as follow: CA, 0.19 to 0.23%; P, 0.17 to 0.19%; NA, 0.08 to 0.11%; k, 0.34 to 0.45%; MG, 0,10 to 0.13%. Potential gas production varied from 13.00 ml/200mg DM to 18.67 ml/200mg DM. The high ($P<0.05$) potential gas value of 18.67 ml/200mg DM was obtained for silage T4. The highest value of ME (5.41MJ/kg DM); OMD (46.10%) and SCFA (0.51µmol) were obtained in silage T3 which contain 90% guinea grass with 10%guineacorn residue. Result indicates that silage from 90% guinea grass with 10% white maize residue have the best nutritive value.

Keywords : Ruminants, In- Vitro, Gas Production, Minerals, Silage, Panicum Maximum

I. INTRODUCTION

Nutrition is one of the main causes of low ruminant production in Nigeria. The animals live on unimproved native pasture and crop residues of high fibre, low protein and deficient minerals. Tropical forages are characterized by rapid growth during wet season with preponderant yield exceeding livestock requirements which, if not harvested and fed, continue to grow and quickly become fibrous and lignified (Osakwe, 2006). Livestock farmers face their biggest challenge during the dry season when a 'staircase' growth pattern is observed in animals as a result of inadequate animal feeds. At the onset of dry season, grass becomes scarce as a result of rapid drying up and lignifications hence yield and quality of forage from perennial tropical grasses decline rapidly during the dry season, leading to shortage in supply of quality feed during this period (Odedire and Abegunde, 2014). Therefore, there is need for conservation and improvement of the nutritive values of the tropical forages.

Conservation can be achieved by sun drying (hay), artificial drying (meal), and addition of acids or fermentation (silage). Hay making is difficult in tropical regions because at the time when the forage is of good quality for conservation (early in the wet season), the weather is likely to be too unreliable for sun drying. Artificial drying is expensive and facilities are not available locally, addition of acids may be beyond the resources of small holder farms and can be dangerous.

With this reason, the last method which is the fermentation by silage making can be done using fresh or preferably wilted material. Babayemi and Igbekoyi (2008) described silage production in the tropics as a sustainable means of supplementing feed for ruminants in the dry season. Excess forages available during the wet season can be conserved as silage to tide over the period of scarcity and prevent the loss in weight of animals associated with this period. Materials to be ensiled can be grasses, legumes, fodder crops (sorghum, maize), crop residues or by-products. Only excess forage, crop residues or by-products for which there is no other economic use should be ensiled. The material to be ensiled should be easily compactable and covered to exclude air. Du Ponte *et al.* (1998) demonstrated that guinea grass can be successfully ensiled, maintaining nutritive quality and minimal spoilage under tropical climatic conditions.

Silages made from tropical grasses alone are poor in nutrient because of the low protein content, suggesting a rich protein source as additive. In this way, sufficient fermentable carbohydrate for lactic acid bacteria is provided and simultaneously, the protein content of the silage is increased (Asefa and Ledin, 2001). A sustainable way of improving the silage is by introducing additives like remains of processed maize, guinea corn and soybeans. The additives increase the water soluble carbohydrate in the silage and aid the fermentation process of lactic acid bacteria hence, the protein content of the silage is also improved.

II. MATERIALS AND METHODS

2.1 Experimental site Experimental site

The experiment was conducted at the Teaching and Research Farm, Ladoke Akintola University of Technology, Ogbomoso, Oyo state, in the south western part of Nigeria. In vitro gas production experiment was carried out at the Animal Science Laboratory of University of Ibadan.

PREPARATION OF GRASS FOR SILAGE

Guinea grass (*Panicum maximum)* was obtained from an existing pasture paddock within the University Farm. The plot was rouged to remove weeds and guinea grasses from another plot were transplanted into available space in the paddock. After 8 weeks, rationed part of the pasture plot was harvested leaving the edge row uncut. The harvested grasses were weighed in order to determine the expected amount for the making of silage. Representative sample of known weight were taken for dry matter analysis by drying in the oven for 72h at 80^0C until a constant weight was obtained. The harvested samples were wilted for two hours in order to reduce the moisture content. The grasses was chopped into 2-3 lengths for easy compaction and allowed to wilt by spreading under shade to reduce the moisture content of the grass.

Silage Preparation

The grass and each additives in 3 replicates for the different treatments were filled in a small capacity plastic silo. The plastic was lined internally by polythene sheet. Each layer was compacted manually to displace the air until the containers were filled. The final compaction was made after which the polythene sheet was rapped over the material. Sand bag of over 5kg were latter placed on the filled material and was left to ferment for 160 days.

Silage additives

Four additives were used and these include yellow maize residue, white maize residue, guinea corn residue and soybean residue. All additives were obtained as by product from local vendors producing pap (made from white maize, yellow maize, and guinea corn) and soya milk in ogbomoso. The residues were air dried so as to reduce the moisture content before use.

Experimental layout

Five treatments were produced, which are 90% *Panicum maximum* and 10% additives in three replicates each. The treatments are as follows:

- Treatment 1: 90% of Guinea grass + 10% yellow maize residue.
- Treatment 2: 90% of Guinea grass + 10% white maize residue.
- Treatment 3: 90% of Guinea grass + 10% guinea corn residue.
- Treatment 4: 90% of Guinea grass + 10% soy bean residue.
- Treatment 5: 100% of Guinea grass + 0% additives

Determination of Silage Quality

The silage was opened and fermentation was terminated for silage quality assessment after 160 days. Colour, smell, texture, pH and temperature were the characteristics assessed (Babayemi and Igbekoyi, 2008). After the silage was opened, a laboratory thermometer was inserted to determine the temperature. Colour chat and visual observations were used to determine the silage colour. The pH level of the silage was determined by using the pH meter. The smell of the silage was determined as to whether fruity, pleasant, very pleasant, fairly pleasant and pungent. Sub-samples were taken from different points and depths and latter mixed together for oven drying at 65^0C until a constant weight was achieved to determine the dry matter. The dried samples were milled and stored in an air tight container until chemical analysis was ready to be done.

In-vitro gas production

Rumen fluid was obtained from three West African Dwarf goats through suction tube described by Babayemi (2007) before the morning feed. The animals were fed with 40% concentrate and 60% Guinea grass. Incubation was carried out using 120ml calibrated syringes in three batches at 39^0C (Menke and Steingass, 1988). To 200mg sample in the syringe was added 30ml inoculum that contained cheese cloth strained rumen liquor and buffer (9.8g NaHCO3 + 2.77g Na2HPO4 + 0.57g KCL + 0.47g NaCL + 0.12g MgSO4. 7H20 + 0.16g CaCI2 . 2H20 in a ratio (1:4 v/v) under continuous flushing with CO2. The gas production was measured at 3, 6, 9, 12, 15, 18, 21 and 24h. After 24 hours of incubation, 4ml of NaOH (10M) was introduced to estimate the amount of methane produced (Fievez *et al.*, 2005). The average volume of gas produced from the blanks was deducted from the volume of gas produced per sample. The volume of gas production characteristics were estimated using the equation $Y = a + b (1 – e^{ct})$ (Ørskov and McDonald (1979),, where Y = volume of gas produced at time't', a = intercept (gas produced from the soluble fraction), b = gas production from the insoluble fraction, (a+b) = final gas produced, c = gas production rate constant for the insoluble fraction (b), t = incubation time. The post incubation parameters such Metabolizable energy (ME, MJ/Kg DM) and organic matter digestibility (OMD, %) were estimated as established (Menke and Steingass, 1988) and the value of short chain volatile fatty acids (SCFA) was calculated as reported (Getachew *et al.*, 1998) : ME = 2.20 + 0.136*Gv + 0.057*CP + 0.0029*CF; OMD = 14.88+0.889Gv + 0.45CP + 0.651 XA; SCFA = 0.0239*Gv – 0.0601; where Gv, CP, CF and XA are net gas production (ml/200 mg DM), crude protein, crude fibre and ash of the incubated samples respectively.

CHEMICAL ANALYSIS

Crude protein, crude fibre, ether extract and ash contents of the grasses was carried out in triplicates as described by AOAC (2000) and the amount of CP was calculated (N x 6.25). The fibre components including neutral detergent fibre, acid detergent fibre and acid detergent lignin was determined according to Van Soest *et al.* (1991).

STATISTICAL ANALYSIS

All data collected were analyzed using analysis of variance by following the procedure of SAS (SAS, 2002).

III. RESULTS AND DISCUSSION

Results

Table 1 showed the colour, smell, texture and temperature. The colour of the silage ranges from yellowish green for T1 (ensiled 90%GG +10%YMR) to olive green for T2 (ensiled 90%GG +10%WMR), and olive green with red patches for T3 (ensiled 90%GG +10%GCR) while yellowish green colour is for T4 (90%GG +10%SBR) and yellowish green for T5 (100%GG).

The smell of the silage ranges from fairly pleasant for T1 (ensiled 90%GG +10%YMR) to very pleasant for T2 (ensiled 90%GG +10%WMR), and pleasant for T3 (ensiled 90%GG +10%GCR) and T4 (90%GG +10%SBR residue) and fairly pleasant for T5 (100%GG). The texture of the silages were firm except for T1 (ensiled 90GG +10YMR) and T5 (100%GG) that had soft.

Table 1 : Colour, Smell And Texture of Ensiled Guinea Grass With the Different Additives

Treatment	Colour	Smell	Texture
T1	Yellowish green	Fairly pleasant	Soft
T2	Olive green	Very pleasant	Firm
T3	Olive green with red patches	Pleasant	Firm
T4	Yellowish green	Pleasant	Firm
T5	Yellowish green	Fairly pleasant	Soft but wet

NB: T1 = 90% of guinea grass + 10% yellow maize residue; T2= 90% of guinea grass + 10% white maize residue; T3 = 90% of guinea grass + 10% guinea corn residue; T4 = 90% of guinea grass + 10% soy bean residue; T5= 100 % guinea grass.

Figure 1 shows the temperature of the silage which ranged from 26.33 to 27.5^{0}C .The temperature was not significantly affected by the experimental treatments additives. T1 had the highest temperature of 27.5^{0}C, followed by T4 with 27.33^{0}C while T5 had the least temperature of 26.33 ^{0}C. Figure 2 shows the pH of the silage which ranged from 4.23 to 5.6. Additives have significant effect ($p<0.05$) on pH of ensiled treatments. Ensiled guinea grass with no residue (T5) had the highest (5.60) pH while T3 (ensiled guinea grass with guinea corn residue) had the lowest (4.23) pH value

Table 2 shows chemical composition of the silages. There were significant differences between the different silages. Dry Matter (DM) ranged from 23.73

to 29.50% DM, lowest in T5 (the ensiled guinea grass only) and highest in T2 and T3. Crude protein (CP) content ranged from 6.93 to 11.05%, CP was highest in T2 and lowest in T5. Ash content varied from 15.01% in T2 to 17.50% in T4. Crude fibre ranged from 27.84 in T1 residue to 31.20 in T4. Ether extract ranged from 4.63 (T5) to 5.51% in T2. NDF ranged from 62.26 to 73.85%, ADF ranged from 36.22 to 51.20%, ADL ranged from 15.15 to 20.70%.

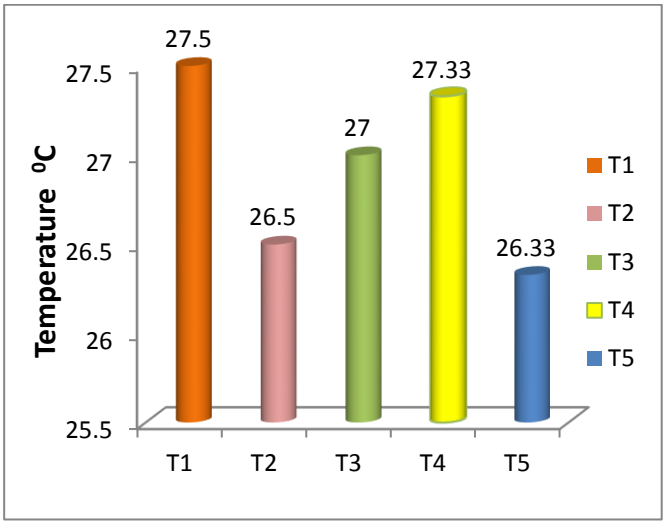

Fig 1: Effect of Temperature on Ensiled Guinea Grass And Different Additives

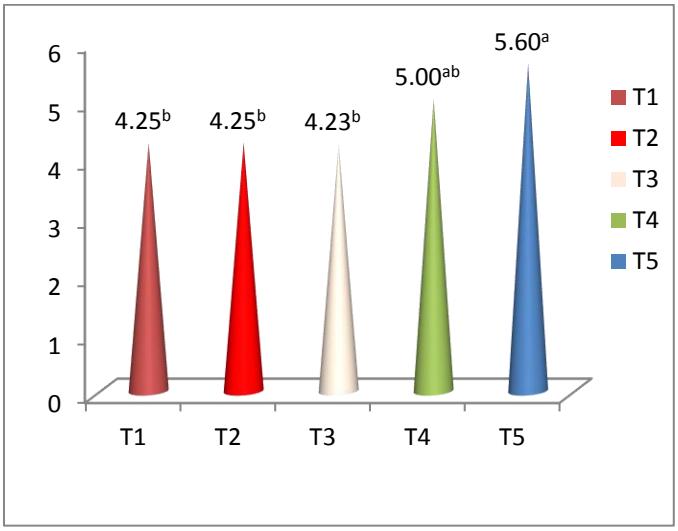

Fig 2 : pH of Ensiled Guinea Grass With Different Additives

T1= 90% of guinea grass + 10% yellow maize residue; T2= 90% of guinea grass + 10% white maize residue; T3= 90% of guinea grass + 10% guinea corn residue; T4= 90% of guinea grass + 10% soy bean residue; T5=100% of guinea grass + 0% additives.

Table 2 : Chemical composition (g/kg/DM) of ensiled guinea grass with the different additives

Treatment	T1	T2	T3	T4	T5	SEM
Dry Matter	27.70^{a}	29.50^{a}	29.50^{a}	26.77^{ab}	23.73^{b}	1.04
Crude Protein	8.92^{b}	11.05^{a}	7.56^{c}	7.20^{c}	6.93^{c}	0.27
Crude Fibre	27.84^{c}	30.59^{a}	27.96^{c}	31.20^{a}	28.85^{b}	0.21
Ether Extract	5.00^{a}	5.51^{a}	5.10^{a}	5.01^{a}	4.63^{a}	0.32
Ash	16.31^{b}	15.01^{c}	15.47b^{c}	17.50^{a}	15.72^{bc}	0.27
NDF	64.64^{c}	69.42^{b}	62.26^{d}	72.44^{a}	73.85^{a}	0.64
ADL	39.60^{d}	44.64^{c}	36.22^{e}	49.15^{b}	51.20^{a}	0.24
ADF	15.25^{c}	18.10^{b}	15.15^{c}	18.69^{b}	20.70^{a}	0.21
Cellulose	25.04^{ab}	24.78^{abc}	26.05^{a}	23.29^{bc}	22.65^{c}	0.67
Hemi cellulose	24.35^{c}	26.54^{b}	21.07^{d}	30.47^{a}	30.50^{a}	0.3

^{abc}mean with different superscripts along the same column differ significantly ($p<0.05$).CF: Crude fibre; CP: Crude protein; DM: Dry matter; EE: Ether extract; NDF: nitrogen detergent fibre; ADF: acid detergent fibre; ADL: acid detergent lignin; HEMI: Hemicellulose; Cellulose. T1 = 90% of guinea grass + 10% yellow maize residue; T2= 90% of guinea grass + 10% white maize residue; T3 = 90% of guinea grass + 10% guinea corn residue; T4 = 90% of guinea grass +

10% soy bean residue; T5= 100% guinea grass; SEM= standard error mean.

The selected mineral compositions of the experimental treatments were presented in Table 3. The selected minerals were Calcium (Ca), Phosphorus (P), Sodium (Na), Potassium (K) and Magnesium (Mg). There were significant variations in the amount of different minerals present in each sample. Ca content (0.19 %) was similar in T1, T3 and T5 but differed significantly from T2 (0.23%) and T4 (0.22%). P ranged from 0.17% to 0.19%. The value of Na in T1 and T3 (0.08%), T4 and T5 (0.10%) were similar but significantly different from T2 (0.11%). K ranged from 0.34 to 0.45 while Mg ranged from 0.10 to 0.13%. Silage from T2 had the highest mineral content in all the mineral contents measured.

Table 3 : Mineral content of ensiled guinea grass and the different additives

Treatment	Calcium	Phosphorus	Sodium	Potassium	Magnesium
T1	0.19^{bc}	0.17^{c}	0.08^{c}	0.45^{a}	0.11^{b}
T2	0.23^{a}	0.19^{ab}	0.11^{a}	0.41^{ab}	0.13^{a}
T3	0.19^{bc}	0.18^{bc}	0.08^{c}	0.34^{b}	0.10^{b}
T4	0.22^{ab}	0.19^{ab}	0.10^{b}	0.38^{ab}	0.11^{ab}
T5	0.19^{c}	0.17^{c}	0.10^{b}	0.37^{ab}	0.12^{ab}
SEM	0.0078	0.0025	0.0022	0.0275	0.01

^{abc}mean with different superscripts along the same column differ significantly ($p<0.05$).. T1 = 90% of guinea grass + 10% yellow maize residue; T2= 90% of guinea grass + 10% white maize residue; T3 = 90% of guinea grass + 10% guinea corn residue; T4 = 90% of guinea grass + 10% soy bean residue; T5= 100% guinea grass; SEM= standard error mean.

Table 3 shows the cumulative gas produced and it is between 13.00 and 18.67 ml/200mg DM. Gas production was significantly affected by the experimental silage additives at 3, 12, 15 and 21 hour incubation intervals. There were no significant variations in gas produced at 24 hour incubation time. The gas produced increases with increasing incubation time. Gas production of

Silage additives

Four additives were used and these include yellow maize residue, white maize residue, guinea corn residue and soybean residue. All additives were obtained as by product from local vendors producing fermented pap (made from white maize, yellow maize,

and guinea corn) and soya milk in Ogbomoso. The residues were air dried so as to reduce the moisture content before use.

Experimental layout

Five treatments were produced, which are 90% Panicum maximum and 10% additives in three replicates each. The treatments are as follows:

- Treatment 1: 90% of Guinea grass + 10% yellow maize residue.
- Treatment 2: 90% of Guinea grass + 10% white maize residue.
- Treatment 3: 90% of Guinea grass + 10% guinea corn residue.
- Treatment 4: 90% of Guinea grass + 10% soy bean residue.

Treatment 5: 100% of Guinea grass + 0% additives T5 was significantly lower than all other experimental treatments at all incubation periods except at 18 and 21hours where the gas produced was greater than that of T1. Among treatments ensiled with additives however, least gas volume of 14.00 ml/200mg DM was recorded from T3 at 24hour of incubation. Significantly highest gas volume of 18.67 ml/200mg DM at the end of the incubation was recorded from T2 followed by T4 (18.33 ml/200mg DM).

Table 4 : Gas Production Volume (Ml/200g Sample) of Ensiled Guinea Grass with the Different Additives

Treatment	3hr	6hr	9hr	12hr	15hr	18hr	21hr	24hr
T1	4.33^{ab}	7.33	7.67	8.33^{ab}	8.67^{b}	9.67	10.00^{c}	14.33
T2	4.00^{ab}	9.67	10.67	13.33^{a}	14.00^{a}	14.67	16.00^{ab}	18.67
T3	3.67^{ab}	7.00	8.67	9.67^{ab}	10.33^{ab}	11.67	11.67^{bc}	14.00
T4	6.33^{a}	10.00	12.00	13.33^{a}	13.67^{a}	15.00	17.00^{a}	18.33
T5	1.00^{b}	6.00	6.67	7.67^{b}	8.33^{b}	10.33	10.33^{c}	13.00
SEM	1.16	1.31	1.62	1.59	1.45	1.68	1.59	1.69

^{abc}mean with different superscripts along the same column differ significantly ($p<0.05$). 90%GG +10%YMR = 90% of guinea grass + 10% yellow maize residue; 90%GG +10%WMR= 90% of guinea grass + 10% white maize residue; 90%GG +10%GCR = 90% of guinea grass + 10% guinea corn residue; 90%GG +10%SBR = 90% of guinea grass + 10% soy bean residue; 100%GG= 100% of guinea grass; SEM= standard error mean

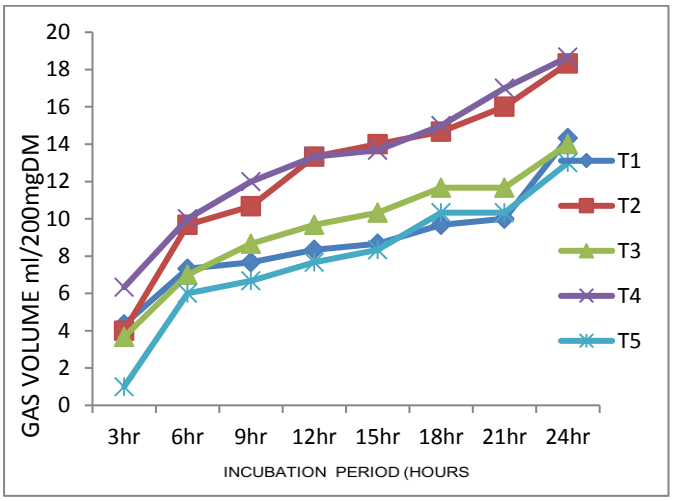

Fig 3 : *In-Vitro* Gas Production Of Ensiled Guinea Grass With The Different Additives

Fig 4 shows the methane gas produced ranged between 13.00 and 6.50 ml/200mg DM. Methane gas production was significantly affected by the experimental treatments additives. The least methane gas volume of 6.50 ml/200mg DM was recorded from T1. The highest methane gas volume of 13.00 ml/200mg DM at the end of the incubation was recorded from T4 followed.

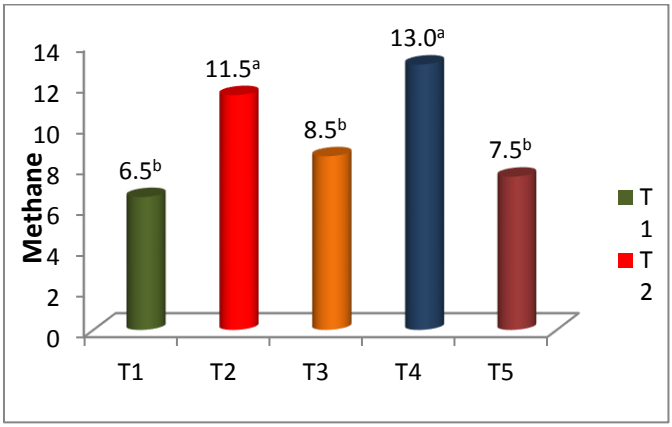

Fig 4 : Methane gas production of Ensiled Guinea Grass And Different Additives

T1= 90% of guinea grass + 10% yellow maize residue; T2= 90% of guinea grass + 10% white maize residue; T3= 90% of guinea grass + 10% guinea corn residue; T4= 90% of guinea grass + 10% soy bean residue; T5=100% of guinea grass + 0% additives

Table 5 shows the *in vitro* gas production characteristics. Gas production (a + b) (ml/200mgDM) ranged from 13.00 to 18.67 ml/200 mg DM silage. There were significant differences ($p<0.05$) in the gas production characteristics of all the silage. The highest potential gas production (a + b) value of 18.67 ml/200mg DM is recorded for T2 followed by 18.33 ml/200mg DM obtained from T4 (90%GG +10%WMR,), T1 (then ensiled 90%GG +10%YMR) T3 (ensiled 90%GG +10%GCR) and finally T5 (ensiled 100%GG) which has the lowest value of 13.00 ml/200mg DM.

The highest gas produced from the soluble fraction (a) with value of 6.33ml/200mg DM is recorded for T2 and lowest value of 1.00ml/200mg DM from T5. The gas produced from insoluble fraction (b) ranged 10.00 to 14.33ml/200mg DM The gas production rate for the insoluble fraction (c) ranges from 0.05 to 0.09. The time of incubation (t) ranged from 6 hours to 9hours. The total volume of gas produced (y) ranged from 6ml/200mg DM in T5 to 10ml/200mg DM in T2. The values of ME, OMD, SCF ranged from 4.34 to 5.36 MJ/Kg; 40.73 to 49.46% and 0.36 to 0.51 µmol respectively.

Table 5 : *In-Vitro* Gas Production Characteristics Of Ensiled Guinea Grass With the Different Additives

Treatment	a	a+b	b	c	t	y	ME	OMD	SCFA
T1	4.33^{ab}	14.33	10.00	0.05	9.00	8.00	4.74^{ab}	42.25^{ab}	0.40
T2	4.00^{ab}	18.67	14.67	0.06	6.00	10.00	5.41^{a}	46.10^{a}	0.50
T3	3.67^{ab}	14.00	10.33	0.08	7.00	8.00	4.62^{ab}	40.80^{ab}	0.39
T4	6.33^{a}	18.33	12.00	0.09	6.00	9.67	5.24^{ab}	45.92^{a}	0.51
T5	1.00^{b}	13.00	12.00	0.09	6.00	6.00	4.45^{b}	39.79^{b}	0.37
SEM	1.16	1.69	2.08	0.03	0.89	1.22	0.24	1.61	0.04

^{ab}mean with different superscripts along the same column differ significantly ($p<0.05$). ME= metabolisable energy, OMD=organic matter digestibility, SCFA=short chain fatty acid. Y = volume of gas produced (ml/200 mg DM) at time t , a = gas production (ml) from the soluble fraction, b = gas production (ml) from an insoluble fraction, c = gas production rate (h-1) constant from insoluble fraction b , a + b = potential gas production (ml), t = incubation time. T1 = 90% of guinea grass + 10% yellow maize residue; T2= 90% of guinea grass + 10% white maize residue; T3 = 90% of guinea grass + 10% guinea corn residue; T4 = 90% of guinea grass + 10% soy bean residue; T5= 100% guinea grass; SEM= standard error mean

3.2 Discussion

Silage colour is one of the parameters used in assessing silage quality, and when the colour is close to the colour of its original fresh forage, the silage is considered to be of good quality (Oduguwa *et al.,*

2007). Since guinea grass is the main content of the silage, its colour was used to judge the colour attribute of the silage. The different yellow colour obtained in this study was expected as this is the colour of good silage. The yellowish green was similar to the original colour of the grass before ensiling. Babayemi and Igbekoyi, 2008 and Oduguwa *et al.,* 2007 observed that good silage usually assumes the original colour of the ensiled materials.

The result of the present study shows that all the silage treatments exhibit fairly pleasant to very

pleasant aroma which is an indication of well-made silage as reported by Kung and Shaver (2002). Structure of the silages was firm and indestructible when squeezing tightly in the hand, implying that there were no viscous or slimy appearances of the material an indication that the silages were well conserved. The texture of the silage was firm which was expected to the best texture of good silage (Kung and Shaver, 2002)

The temperature of the fermented forage varied from 27-28°C which was presumed to produce excellent silage (Muck, 1996). The lower the temperature the better the silage and the less the colour change. The temperatures of silages were 26.33- 27.2°C and which is closer to the range (25-27°C) obtained by Babayemi (2009) in ensiled Guinea grass. The pH value of the silage mixtures was desirable and within the range of 4.23-5.60, this was classified to be pH for good silage by Menenses *et al*. (2007). pH is one of the easiest way of evaluating silage quality. The pH value obtained in this study is in agreement with 4.2 -5.0 reported by Babayemi (2009) and within 4.3-4.7 range by Kung and Shaver (2002).

Additives are used to improve silage preservation by ensuring that lactic acid bacteria dominate the fermentation phase. Possibly the most important benefit of additives such as maize or sorghum grain or cassava meal is to improve DM in early-cut crops when moisture content is high and where effluent is lost to the silage through seepage. Tropical grasses have been successfully ensiled with maize meal (Van Onselen and Lopez, 1988), cassava meal (Panditharane *et al*., 1986) and sorghum grain (Alberto *et al*., 1993). The decrease of pH in the silage was probably due to fermentation of WSC by lactic acid bacteria that produced organic acids leading to a decrease in pH (McDonald *et al*., 2002). The effect of the different additive was significant on the chemical composition of the silage. Silages with DM content between 25 and 35% are considered to be good (Patterson 1998). According to Akinola (1989) partial wilting increases DM content, this reduces bacterial activity in the silage. Wilting the forage before ensiling is recommended as a means of increasing dry matter content, the WSC on fresh weight basis and reducing losses from effluent and undesired fermentation (Humphreys, 1991, Nussio, 2005). The effluent observed in this study was rather negligible. The use of additives in silages of tropical forages is important because they reduce the risks of the ensiling process and improve the nutritive value of silage. According to Zanine *et al.* (2006), a good additive for ensiling tropical grasses should have high dry matter content, excellent water absorption capacity, high nutritional value, good palatability, and high content of soluble carbohydrates, and also need to be easily manipulated, available at market, and be of low cost.

The crude protein value of 6.45% to 10.60 of the silage is higher than the critical value of 7.7% or 70g/kg recommended for small ruminants (NRC, 1981) but lower than minimum protein requirement of 10-12% recommended by ARC (1984) for ruminants except for T2 .The high crude protein of silage with additives in this study shows that the silage was supplemented with rich protein source. Igbekoyi (2008) ensiled guinea grass with *Albizia saman* pod to obtain 14-18% CP of the silage. The high CP content of the silage with additives may also be due to the fact that the dry matter of the silage was sufficiently high to avoid seepage loss of silage protein since protein losses in the ensiling procedure have been reported to be dependent on the run off of the proteolytic end products with the effluent (Odedire and Abegunde, 2014). The crude protein content in the diet silage mixture should be desired as it largely determines the intake and digestibility (Babayemi *et al.,* 2003) while high crude fibre (CF) content of silage will reduce its nutrient digestibility. The high crude fibre recorded for T4 residue will reduce the digestibility as it was described by Babayemi *et al.,* (2003). The crude fibre content of the various silages is above the range of 15-20% CF recommended for improved intake and

production in finishing ruminants (Buxton, 1996). Neutral detergent fibre (NDF) content of the silages ranged from 62.26% to 73.85%. This was observed to be above the range of 55- 60% threshold level in tropical grasses beyond which DM intake is affected (Meissner *et al.*, 1991) but within the acceptable levels of 60% to 65% recommended for optimum ruminant animals' performance (Messiner *et al.,* 1991 and Mahanna, 1994).

Slater (1991) reported that acid detergent fibre (ADF) of forages and silages should be within 22-50 %. The ADF contents of silages (36.22-51.20%) in this study were within the range, indicating that the diets have potentials to supply needed energy to animals during dry season. According to Van Soest (1994), ADF is negatively correlated with forage digestibility, which favors silages; feeds that contained high proportion of ADF have low availability. The NDF and ADF values of the experimental silages were within the range 30 – 75% reported by to Van Soest *et al.* (1991) for roughages. The difference between NDF and ADF is hemicellulose, which is degradable by rumen microbes. The higher the hemicellulose fraction, the higher is the feed value (Humphreys, 1991). Ibrahim and Olaloku (2000) reported that higher cellulose content is undesirable because rumen micro-organisms are unable to degrade it. The values of cellulose in this study for various silages are around the values of 30 to 40 % that are adequate for the maintenance requirement of ruminant livestock. The variation may be due differences in geographical location, stage of maturity and soil type. The values of fibre fraction in this study also agrees with McDonald *et al.* (1995) who stated that a fibre fraction of 30 – 75% is safe for feeding ruminants. The NDF and ADF contents of all the experimental silages for this study were indicative of the potentials of ensiled guinea grass to supply rumen microbial fibre requirements.

The mineral analysis of silage provides information on whether it could be used for feeding trial. The values of calcium (%) of the *silage* would meet the theoretical Calcium requirement of 0.30% needed in the diet for all forms of production in ruminants [ARC 1980]. Calcium helps in the regulation of muscle contraction required by kid, weaner and fetuses for bone and teeth development [Margaret and Vickery 1997]. Magnesium (Mg) content of silages ranged from 0.10-0.13% was found to be within the value 0.12-0.20% for the requirement of ruminant's diet suggested by (NRC, 1985). Magnesium is an important mineral element in connection with its role in circulatory diseases such as ischemic heart disease and calcium metabolism in above [Ishida *et. al.*, 2000; Hassan *et. al.*, 2006].

Phosphorus content of the silage is slightly higher than the 0.15% required ruminants (NRC, 1985). Phosphorus plays an important role in carbohydrate, lipid and amino acid metabolism. It plays a key role in muscle contraction. Phosphorus is also required for blood coagulation (thromboplastin) satisfactory bone calcification optimum growth rate and optimum utilization of birth calcium and phosphorus (Underwood, 1981).

The value of Potassium (K) (%) in the silage treatments was greater than the 0.18% recommended for grazing animals (McDowell, 1985). However, it has been suggested that ruminants with high level of productivity may require K level above (1.0%) under stress particularly heat stress (Khan *et al.*, 2005; and Afolabi *et. al.*, 1995). Potassium helps to maintain body weight and it regulates water and electrolyte balance in the blood and tissues (NRC, 1985).

Minerals derived from feedstuffs are sometimes insufficient to meet animal requirements, thus later exhibiting subclinical symptoms (Serra *et al.*, 1996). Minerals in forages are dependent upon the interaction of a number of factors including soil; plant species; stage of maturity; yield; pasture management and climate. In the absence of mineral supplements, forages should then contain sufficient macro- and micro-elements to cover the requirements of

ruminant. According to McDowell (2003) and Haenlein and Ramirez (2007), these differences in the mineral content of diets may be attributed to the interaction of a number of factors including soil, plant species, yield, pasture management, climate (temperature and rainfall) and stages of maturity.

In-vitro estimations of feed degradation are important tools for ruminant nutritionists. These methods measure either substrate disappearance or fermentation products (Blümmel *et al.*, 1997). In the present study, the silage with high CP produced higher gas volume. Digestibility has been reported to be synonymous to *in -vitro* gas production (Fievez *et al.*, 2005) that is, forages with high gas production will exhibit better digestibility, and thus the higher the gas produced, the higher the digestibility. Guinea grass is high in crude fibre and this may reduce its digestibility.

Fievez *et al.* (2005) reported that digestibility is synonymous to *in-vitro* gas production which is in line with the result of the 24 hour incubation period of T2 having the highest gas produced and can be traced to the high fibre content of the silage treatment. The amount of gas released when feeds are incubated *in vitro* has been reported to be closely related to digestibility of feed for ruminants (Mebrahtu and Tenaye, 1997). Thus, the gas volume can be considered a good reflection of substrate fermentation to VFAs and an estimate of potential digestibility in the rumen. The highest potential gas production (a+b) value of 18.67 ml/200mg DM is recorded for T2, and this might be attributed to its high content of degradable carbohydrates. These probably reflect the proportions of the degradable carbohydrate sources in these diets (Blummel and Becker, 1997). The potential gas production (a + b) value for T5 was the lowest (13.00 ml) and this probably is due to its high crude fibre content of 28.85 %. Babayemi and Bankole (2006) explained that sole *Panicum maximum* (100% guinea grass) is high in crude fibre and this may reduce its digestibility. The low gas production in ensiled guinea grass only in this study does not however reduce its importance in ruminant feeding. This is because it is one of the commonest grasses around and is relished by ruminants in the tropics (Bamikole and Babayemi, 2004).

The intake of a feed is mostly explained by the rate of gas production (*c*) which affects the passage rate of feed through the rumen, whereas the potential gas production (*a+b*), is associated with degradability of feed (Khazaal *et al.*, 1995). Therefore the higher values obtained for the potential gas production in T2 and *T5* might indicate a better nutrient availability for rumen microorganisms. Nature and fibre levels, presence of anti-nutritional factors had been reported to influence the amount of gas produced during fermentation (Babayemi, 2004). High level of crude fibre reduce digestibility which is synonymous to *in-vitro* gas production. *In-vitro* technique is a more reliable tool for evaluating ruminant forages. Though the two methods are independent of each other, they are interrelated (Babayemi *et al.,* 2004 and Fievez *et al., 2*005). This result nonetheless, could be a reflection of a higher proportion of carbohydrate available for fermentation (Getachew *et al.*, 1999). Since the utilization of silages is largely dependent on microbial degradation, the extent of degradation, GV, suggested that T2 and T5 possessed more degradable and fermentable carbohydrates than T1, T3and T4.

Gas production is associated with volatile fatty acid production following fermentation of substrate (Blummel and Ørskov 1993). In addition, the application of models permits the fermentation kinetics of the soluble and readily degradable fraction of the feeds, and more slowly, the degradable fraction to be described (Gatechew *et al.*, 1998). Silages that showed high capacity for gas production are also observed to be synonymous for high methane gas production in this present study. High methane gas production has a negative effect on ruminant as it implies an energy loss and when it accumulates in the

rumen of the animal, it could lead to bloat as described by Yusuf *et al.,* (2013). Methane production represent a significant energy loss to ruminants; it also contributes to global warming which is a worrisome phenomenon in the recent time and many tropical feedstuff have been indicated to increase methanogenesis (Babayemi *et al.,* 2004; Babayemi and Bamikole, 2006).

The values observed in this study for Metabolisable energy (ME) 4.45 to 5.41 MJ/kg DM, organic matter degradability (OMD) of 39.79 to 46.10% and short chain fatty acid (SCFA) of 0.37 to 0.51µmol are higher than the ranges of 2.99 to 4.75 MJ/kg DM (ME) and 21.46 to 33.80 % (OMD) cited by Babayemi and Bamikole (2006) for P. maximum (grass) and Tephrosia candida (browse plant) mixtures. The values obtained in this study are however lower than the ranges of 7.25 to 10.10 MJ/kg DM (ME), 51.87 to 80.19 % (OMD) and 0.74 to 1.22 µmol (SCFA) observed in another study on browse plants (Yusuf *et al.*, 2013). The low ME and OMD observed in the grasses could be as a result of the higher NDF they contained. Short chain fatty acid which is an indication of energy made available to the host animal ranged from 0.27-0.60 µmol. Short chain fatty acids are volatile fatty acids (VFA) and their presence denote energy available in a feedstuff (Tona, 2014). These observations imply that all the silage treatments have potential to make energy available to ruminants.

IV. CONCLUSION

According to the result, production of silage is a good way of conserving forages during the wet season when it is abundant as it makes forage available to feed animals with almost the same nutrient value during the off seasons. The addition of additives to the silage has shown to improve silage quality. The utilization of ensiled guinea grass in animal feeding should be encouraged as this will help to reduce the effect of feed shortage and cyclic animal weight changes most especially during the off season. Furthermore, inclusion of processed maize residues as additives to ensiled *Panicum maximum* (guinea grass) should be encouraged in order to prevent wastage and spoilage of processed maize residues and also to improve the silage quality.

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