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ORIGINAL RESEARCH ARTICLE

In vitro Fermentation and Acceptability by West African Dwarf Sheep of two Weeks Ensiled Maize Stover With or Without Additives.

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ABSTRACT

This study was carried out to investigate the acceptability, chemical composition and in vitro gas fermentation characteristics of ensiled maize stover with or without additives. The maize stovers were ensiled for 15 days using three energy additives (molasses, honey and sugar) at the rate of 50g kg^{-1} in four treatments to obtain the following silages: T_1 (maize stover only) control, T_2 (maize stover + molasses), T_3 (maize stover + honey) and T_4 (maize stover + sugar). The feed samples were dried and milled for gas production determination and chemical composition in a completely randomized design. Eight West African dwarf (WAD) sheep were used to assess the silage acceptability using coefficient of preference (CoP). Nutritive value of the silages was determined using in vitro fermentation technique to obtain total gas volume (TGV ml), methane (CH_4 %), and organic matter digestibility (OMD %) dry matter digestibility (DMD %) short chain fatty acid (SCFA µml) and metabolisable energy (ME Kg/DM). Data obtained were subjected to analysis of variance. The result of coefficient of preference (CoP) indicates that ensiled maize stover with molasses was highly preferred, followed by ensiled maize stover with honey and ensiled maize stover only by WAD sheep with CoP values of 1.05, 1.03 and 1.01. The fibre fractions: neutral detergent fibre, (NDF), acid detergent fibre (ADF), acid detergent lignin (ADL) and Hemicellulose were similar across the treatments. Crude protein (CP) was similar among the treatments except for silage with sugar that was significantly ($P<0.05$) different from fresh maize stover. Crude fibre (CF) and ash components of the silages were similar across the treatments. There were significant ($P<0.05$) differences in the treatments means of TGV (34-39.33), CH_4 (5.67-11.33%), DMD (40.00-66.67%), OMD (48.94-53.80%), ME (7.35-8.09KJ/DM) and SCFA (0.75-0.88µml). The findings of this study revealed that in vitro fermentation, chemical composition and acceptability of ensiled maize stover with and with additives by WAD sheep are similar. Therefore, maize stover can be preserved without additives.

Key words: *silage, organic matter digestibility, fibre fraction, crude protein*.

Introduction

Recently, one of the major challenges facing cattle farmers in Nigeria is inadequate forages to sustain their animals and this usually results to incessant clashes between farmers and herdsmen which had led to death of many farmers and animals and destruction of crops. There is decline in supply and quality of herbage for livestock during the dry season (Amuda *et al.*, 2018).

One of the major concerns of Animal Scientists is feed production and utilisation in the dry season to stem the cyclic pattern of weight gain and loss between seasons (Sowande, *et al.*, 2008). Consequently, there is need for us to source for alternative feed such as crop residues in order to complement inadequate available pasture for ruminant animals. Crop residues constitute an important feed resource for animals especially in the dry season. With increasing human population, cropping land is expanding, leading to increased production of crop residues. However, this is associated with decreasing land availability for fodder production, thus forcing crop residues to contribute significantly to the livestock feed resources pool. In Nigeria, large quantities of crop residues such as cereal straw and stover, legume crops, straw and hulls, sugar cane tops, cassava leaves and sweet potato vines are left on the field and/or harvested for livestock feeding (Amuda *et al.,* 2017). However, these crop residues are generally poorly utilised as animal feed each year because small-scale farmers lack the technical knowledge on how best to use them (Methu, 2003). The main constraint to the utilization of roughages by ruminants is voluntary feed intake, therefore prediction of feed intake, particularly of fibrous roughage, is one of the important aspects of ruminant nutrition (Amuda, 2013).

In vitro gas production has been used to predict dry matter intake. Various workers have reported significant correlation between *In vitro* gas production and dry matter intake (Amuda, 2013). Forage cell walls have considerable influence on voluntary feed intake through rumen fill mechanism (Van Soest, 1994). Gas production reflects all nutrients fermented, soluble as well as insoluble; and fractions that are not fermentable which do not contribute to gas production. Furthermore, the kinetics of fermentation can be obtained from a single incubation, allowing the rate of fermentation to be calculated. Gas measurement is a direct measure of microbial activity and can be a better index of forage ME content than an indirect *in vitro* measured based on nutrients (Makkar, 2004). The gas measuring technique has been widely used for evaluation of nutritive value of feeds. More recently, the increased interest in the efficient utilization of roughage diets has led to an increase in the use of this technique due to the advantage in studying fermentation kinetics. Gas measurement provides a useful data on digestion kinetics of both soluble and insoluble fractions of feedstuffs.

Field observations show that maize stover is the most abundant residue in smallholder crop production systems, but poorly handled and stored (Syomiti, *et al*., 2009). Ensiling has been reported to effectively conserve forages and fodder crops (Babayemi, 2009). The ensiling of crop residues and by-products is a simple and appropriate method of conservation. It is the most-effective way to improve animal feed resources through the use of locally available agricultural and industrial by-products available to small scale farmers at village level (Amuda *et al.*, 2018).

A concrete way of addressing the problem of feeding ruminant livestock in the dry season is using silage or hay. Silage is a sustainable means of supplementing poor quality feed for ruminants in the dry season. Silage making can be considered the most effective way of preserving green forages over hay making, if all essential steps of silage making are followed. Silage making is less dependent on weather (Amuda *et al.,* 2018). This study was carried out to evaluate the nutritional composition of ensiled maize stover with different energy additives by *in vitro* gas fermentation method and acceptability by West African dwarf sheep.

MATERIALS AND METHODS

Harvesting and Silage Making

Freshly harvested green maize stovers were collected from Practical Year Training Programme Farm University of Ibadan. Harvesting was done in the month of July and the samples were collected in batches. Harvested maize stovers were chopped into 3 – 5cm pieces size (for easy compaction). Thereafter, the chopped materials were wilted under shade for 24 hours on concrete floor and then weighed, mixed and divided into equal portions (1kg) for the application of four experimental treatments. Each of the treatment was ensiled in polythene bags, each capable of holding a 30kg of wilted maize stover were used as silos. Each polythene bag was placed inside a 65 litres capacity plastic basing for reinforcement and ease of fermentation. Ensiling was done by rapid compaction of the material (to eliminate air) into the silos. Sealing of the silos was done by placing a 25kg sandbag on top of the polythene bags after tying carefully and firmly. Each additive was added at 5% level treatment. Treatment 1: Maize Stover only (MS), Treatment 2: Maize Stover + Molasses (MS+M); Treatment 3: Maize Stover + Honey (MS+M); Treatment 4: Maize stover + Sugar (MS+S). The control forage was ensiled without additive. All were replicated five times in a completely randomised design. Ensiling was done by rapid compaction of the material (to eliminate air) into the silos, sealed up and compressed with the small sand bag of 2kg. Fermentation period was 15 days. The pH, temperature, colour, smell, texture and moisture content were determined (Bababyemi *et al*., 2009 and Amuda *et al.*, 2017).

Acceptability study

A total of eight growing West African dwarf (WAD) sheep weighing between (10 – 12kg) and about 7 – 8 months old were used for the study. The animals were purchased from local market at Iwo in Osun state. Animals were subjected to free choice feeding to evaluate acceptability of the ensiled maize stover (MS) prepared with different energy additives (Diets: T_1, T_2, T_3 and T_4) in a cafeteria feed preference study (Babayemi *et al*., 2006). The animals were housed together in the group pen in the sheep unit of the University of Ibadan with adequate ventilation. The floor of the house was made of concrete covered with wood shavings to serve as bedding and also for easy cleaning. The four silages were introduced on a cafeteria basis to the animals (WAD sheep). 1kg of each silage type was served in four plastic feeding troughs and the position of each feeder was changed daily to avoid the animals sticking to particular treatment at a particular spot. The sheep were allowed to feed for 8 hours daily and for upward of 5 days. The intake was measured by deduction of remnants from the amount of feed offered. The silage preferred was determined using coefficient of preference (CoP) value; calculated from the ratio between intake of each individual silage divided by the average intake of the four silage types (Bamikole *et al.,* 2004, Babayemi *et al.*, 2009).

$$\text{Coefficient of preference (CoP)} = \frac{\text{Intake of individual silage}}{\text{Mean intake of the five silage types}}$$

If CoP is less than (< 1), the material is poorly accepted and when it is greater than (> 1), the material is well accepted (Bamikole *et al.,* 2004).

Chemical Analysis

The samples were ground in the laboratory with hammer mill fixed with 1mm sieve and subjected to chemical analysis as described by AOAC (2000). Fibre fractions NDF, ADF and ADL were assayed by the method of Van Soest *et al*., (1991). Hemicellulose was calculated as the difference between NDF and ADF and cellulose as the difference between ADL and ADF (Rinne *et al*., 1997).

In vitro gas production study

Two hundred milligrams (200mg) of dried and ground samples of four silage types (EMS only, E MS+M, EMS+S and EMS+S) and unensiled/fresh maize stover were weighed into 100ml calibrated syringes with pistons lubricated with

Vaseline. A buffered mineral solution was prepared consisting of ($NaHCO_3$ + Na_2HPO_4 + KCl + NaCl + Mg SO_4. $7H_2O$ + $CaCl_2.2H_2O$) and stirred at 39^0C. Rumen fluid was obtained from the three female WAD goats under the same feeding regime before morning feed. The method for collection was as previously described by Babayemi and Bamikole (2006), using suction tube. The animals were previously fed with (60%) *Panicum maximum* and (40%) concentrate feed at 5% body weight twice daily for 7 days. The rumen liquor was collected into a thermos flask that had been pre-warmed to a temperature of 39^0c and was later filtered through layers of cheese cloth and flushed continuously with CO_2. The post incubator parameters such as metabolisable energy (ME) organic matter digestibility (OMD) and short chain fatty acids (SCFA) were estimated from the volume of gas produced after 24 hours with CO_2. The incubation procedure was as described by (Menke and Steingass 1988) using 100ml calibrated transparent plastics syringes with fitted silicon tube. 30ml of inoculum containing strained buffered rumen fluid was introduced into the syringes containing (200mg sample) feeds. The incubation was done in triplicate at 39 $\pm 1^0$C. The gas production was measured at 3, 6, 9, 12, 15, 21 and 24hrs and after 24hours of post incubation period, 4ml of NaOH (10M) was introduced to estimate methane production as described by Fievez et al (2005). The average volume of gas produced from the blanks was deducted from volume of gas produced per sample. Rates and extent of gas production were determined for each substrate from linear equation $Y= a+b\ (1-e^{-ct})$ as described by 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 (b), t = incubation time. Metabolisable energy (ME) was calculated as ME = 2.20 + 0.136 *Gp + 0.057*CP + 0.0029CF (Menke and Steingass, 1988). Organic matter digestibility (OMD %) was assessed using the equation OMD = 14.88 + 0.889 GV + 0.45CP + 0.651 XA (Menke and Steingass, 1988). Short chain fatty acids (SCFA) as 0.0239GV - 0.0601 (Getachew *et al*., 1998) was also obtained, where GV(Gas Volume), CP (Crude Protein), CF (Crude Fibre) and XA (Ash) are total gas volume (ml/200 mg DM).The design of the experiment was a completely randomised (CRD). Data obtained were subjected to analysis of variance where significant differences occurred, the means were separated using SAS package of (2003).

RESULTS AND DISCUSSION

The result of acceptability of ensiled maize stover with and without additives fed to WAD sheep is shown in Table 1. In this study, T_2 (EMS+M) recorded the highest CoP value of 1.05 compared to other silages followed by T_3 (EMS+H) 1.03, while the remaining two silages had values of 1.01 for T_1 (EMS only) control and 0.921 for T_4 (EMS+S), which was less than unity. Coefficient of Preference (CoP) is a direct measure of acceptability and nutritional capabilities of a feedstuff. In recent times, cafeteria techniques have been used to assess the acceptability of some forages (Bamikole *et al*., 2004, Babayemi, 2007 and Amuda and Onaleye, 2018). In this study, the mean dry matter intake and coefficient of preference (CoP) by sheep placed on ensiled maize stover (MS) with and without additives are indicated. The CoP and dry matter intake (DMI) varied from 0.921 to 1.05 and 583.25 – 663.26g/DMI/day with the order of preference as; $T_2 > T_3 > T_1 > T_4$. In order words, MSM, MSH silage and MS (Control) silage with CoP ranging above unity were accepted or preferred while ensiled maize stover with sugar additives (T_4) with CoP value of 0.921 was poorly accepted or rejected. There are number of factors that may influence acceptability of feed by small ruminants. Plant physical structure and chemical composition are the most important factors that influence preference (Babayemi *et al*., 2009 and VanSoest, 1994). Generally,acceptability, seasonal variation and availability are some factors that influenced feed intake by an animal. The forage acceptability on the basis of preference revealed that ensiled maize stover with molasses additive (T_2) was consumed most among the four silage types which may be attributed to relative high level of crude protein content. Furthermore, acceptability of T_1 silage indicates that silage of good quality characteristics can be produced from maize stovers without additives by wilting under shade for 24hrs.

Table 1: Dry Matter Intake and Coefficient Preference of WAD Sheep 15days fed ensiled Maize Stover.

Silage type	Mean daily consumption of animals (g/DMI/day)	Coefficient of Preference
T_1 (Control)	636.38	1.01
T_2	663.26	1.05
T_3	650.14	1.03
T_4	583.25	0.921

T_1 = EMS, T_2 =EMS+M, T_3 = EMS+H and T_4 = EMS+S
EMS -Ensiled Maize stover only, EMS+M = Ensiled Maize stover + Molasses, EMS+H = Ensiled Maize stover + Honey, EMS+S = Ensiled Maize stover + Sugar,

The crude protein and fibre fractions of ensiled maize stover are presented in Table 2. Crude protein ranged from 7.53% in (MS+S) to 9.27% (MS-fresh/unensiled). Nitrogen free extract (NFE) of the silage types varied significantly (P<0.05) among the treatments. All the fibre fractions were similar across the treatments. The NDF (total cell walls) ranged from 69.10% (MS+H) to 70.02% (MS+S) while the ADF (lignocelluloses) ranged from 56.53% (MS+H) to 59.48% (MS+M) and the ADL ranged from 14.72% (MS+S) to 16.36% (MS+M). Hemicellulose and cellulose values ranged from 10.23 -12.54% and 41.30 - 43.84% respectively. Chemical composition of ensiled maize stover showed a decrease in crude protein content of ensiled maize stover with and without additive but the difference was minimal. This is similar to a report made by Idris *et al*., (1999) that corn stover after harvest of matured cobs at 75 days of growth contained 9.60% CP and after ensiling the value decreased to 8.20%. Crude protein (CP) content (9.27%) obtained for fresh/unensiled maize stover is consistent with the 9.6% established by Idris *et* al., (1999). The crude protein in the silages ranged from 7.53% in the MSS to 8.22% in MSM. Generally, the crude protein content of ensiled maize stover with or without additives is relatively low. This is in agreement with the report of Adegbola (1998), who observed that cereal stovers and straws, which form the bulk of crop residues, are inherently low in crude protein. The reduction in crude protein in this study could also be due to dilution effect factor as all additives used are carbohydrates. However, levels of crude protein are within the critical value of 7.0% or 70g/kg recommended for small ruminants by NRC (1981) but lower than minimum protein requirement of 10 – 12% recommended by ARC (1985) and Gatenby (2002) for ruminants. The range values (50.96 – 54.04g/100g) of nitrogen free extract (NFE) obtained for ensiled maize stover with or without additives suggest that soluble carbohydrates could support volatile fatty acids in the rumen during fermentation (Blummel *et al.,* 1997). The fibre fractions (NDF, ADF, and ADL) have implication on digestibility. The neutral detergent fibre (NDF), which is a measure of the plants cell wall contents, is the chemical component of feed that determines its rate of digestion. NDF is inversely related to the plants digestibility (McDonald *et al*., 1995, Gillespie, 1998). The higher the NDF the lower the plants digestible energy. NDF is correlated with the level of dry matter intake by cows; the lower the NDF, the higher the level of intake. The NDF level (69.10 – 70.02%) obtained is relatively the same with values (68.60 – 69.20%) obtained by Amuda *et al*. (2017) but higher than 48% reported by Elkholy, *et al*., (2009). High NDF could result in low intake while high ADF may engender low digestibility (Babayemi *et al*., 2010). The acid detergent fibre (ADF) consist of mainly lignin and cellulose and is correlated with the digestibility. ADF level of 56.53 – 59.48% obtained was within the ranged values (56.1 – 63.2%) reported by Amuda *et al*. (2017) but higher than 29.0% reported by Elkholy *et al*. (2009). Acid detergent lignin (ADL) of a plant is the most indigestible component of the fibre fraction (Gillespie, 1998), and its amount will also influence the plant digestibility. Lignin is generally accepted as the primary component responsible for limiting the digestion of forages (Van Soest, 1994; Traxler et al.,1998; Agbagla-Dohnani et al .,2001). The ADL level of 14.72 – 16.36 % obtained in this study was within the values of 14.0 – 16.80 and 14 and 17 % reported for ensiled maize stover for 30 days by Amuda *et al.,* (2017) and Guinea grass/lablab mixture by Alasa *et al*., (2010). Since fibre fractions (i.e. NDF, ADF and ADL) content of the silages were relatively high, the intake and potential digestibility will be low when fed alone to ruminants without concentrate supplements. According to Van Soest (1994), forage digestibility in ruminants is constrained by the extent of cell wall (NDF) digestion. Furthermore, it is the most important factor affecting the total diet organic matter digestibility (Nousiainen *et al*., 2004) and it has influence on animal performance (Oba and Allen, 1999). The high level of fibre fractions observed in this study may be attributed to the age or maturity at harvest and leaf to stem- ratio of the ensiled maize stover. The hemicellulose and cellulose are cell wall constituents and polysaccharides. They are very indigestible in monogastrics but digestible in ruminants through fermentation by rumen microbes. Hemicellulose values obtained for silages ranged from 10.81 – 12.49% while cellulose ranged from 39.30 – 44.81%. These values are not too high for ruminants due to the nature of their stomach and the presence of cellulolytic bacteria and fibrolytic fungi in the rumen. According to McDonald et al. (1995), ruminants can be fed solely on feed that contain 40% cellulose and 20% hemicellulose.

Table 2: Chemical composition and Fibre Fractions of Fresh and Ensiled Maize Stover

Fibre Fractions	T_0	T_1 (control)	T_2	T_3	T_4	SEM
Crude protein	9.27^{a}	7.86^{ab}	8.22^{ab}	7.84^{ab}	7.53^{b}	0.78
Crude fibre	32.27	32.52	29.31	32.22	32.27	1.56
Ash	7.32^{a}	6.85^{b}	6.76^{b}	6.57^{b}	6.92^{b}	0.32
NFE	49.42^{b}	50.96^{b}	54.04^{a}	51.54^{b}	51.04^{b}	1.93
NDF	69.23	69.82	69.71	69.10	70.02	0.46
ADF	57.50	59.11	59.48	56.53	58.56	1.40
ADL	15.94	16.03	16.36	15.26	14.72	0.76
Hemicellulose	11.73	10.71	10.23	12.54	11.59	1.05
Cellulose	41.52^{ab}	43.08^{a}	43.12^{a}	41.27^{ab}	43.84^{a}	1.29

a, b = Means on the same row with different superscripts are significantly ($P < 0.05$) different
T_0 = Fresh/Unensiled Maize Stover, T_1 = Ensiled Maize Stover Only (Control), T_2 = Ensiled Maize Stover and Molasses (MSM), T_3 = Ensiled Maize Stover and Honey (MSH),
T_4 = Ensiled Maize Stover and Sugar (MSS), SEM = Standard Error of Means

Presented in Table 3 is the *in vitro* gas production characteristics of ensiled maize stover with or without additives. The *in vitro* gas production characteristics were similar across the treatments except for 'b' and 'a+b' which were significantly ($P<0.05$) different. The intercept value 'a' for all the silages including the unensiled/fresh maize stover (T_1) ranged from 10.00 to 12.67 at 24hrs. The extent of gas production 'b' values were similar across the treatments except T_3 which was significantly ($P < 0.05$) different from other treatments such that, it was the lowest among the treatments. Potential gas production (a+ b) was significantly ($P < 0.05$) different. T_1 was significantly higher than treatments T_3 and T_4 but similar to T_2 and T_5. The rate ('c') of gas production of incubated samples ranged from 0.03 to 0.05 for all the treatments while the volume of gas ('y') produced at time 't' ranged from 16.00 to 26.67. The time of rapid gas production ranged from 12.00 to 16.00. The soluble fraction makes the microbial attachment in the rumen to be done easily and this translated into much gas production. Gas production is a nutritional wasteful product (Mauricio *et al.,* 1999), however it provides a useful basis for the prediction of metabolisable energy (ME), organic matter digestibility (OMD) and short chain fatty acids (SCFA). Furthermore, gas production helps to measure digestion rate of soluble and insoluble fraction of feedstuff (Menke and Staingass, 1988, Pell and Schofield, 1993). There were significant differences in the extent of gas production 'a+b' which ranged from 34.00 – 47.33. The potential degradability 'a+ b' of a diet depicts the level at which the diets could be degraded if it were in actual rumen of the animal (*in vivo*). However, this largely depends on how much of the fibre fraction (NDF and ADF) have been broken down for easy access of the microbes to the nutrients available in the diets. A linear relationship has been established between high crude protein in forages and in vitro degradability (Njidda *et al*., 2010). The values of 'b' obtained in this study (24.00 – 32.00) were consistent with those reported for dry matter (DM) degradation of some tropical legumes and grasses (Ajayi *et al*., 2007 and the values of 9.5 – 32.0ml/200mg DM) reported for some crop residues (Babayemi *et al*., 2009). Blummel and Orskov (1993) also reported that 'b' value could account for 88% of voluntary feed intake. The volume of gas ‘y’ at time” t”is the peak of gas production for each sample at 24hrs incubation period. Since rate ‘’c” of gas production at time’ ‘t” and volume of gas “y” of the incubated samples were similar across the treatments, it means that additives had no effect on MS silage regarding the “c” t and “y “ characteristics of the gas. However, there are many factors that may determine the amount of gas production during fermentation, depending on the nature and level of fibre, the presence of secondary metabolites (Babayemi *et al*., 2004) and potency of the rumen liquor for incubation. Orskov and Ryle, (1990) also found that the rate ‘c’ determines digestion time and consequently how long a potentially digestible material would occupy space in the rumen. It is possible to attain potential gas production of a feedstuff if the donor animal from which rumen liquor for incubation was collected got the nutrient requirement met.

Table 3*: In vitro* fermentation characteristics of ensiled maize stover with or without additives at 24hrs incubation period.

Fermentation characteristics	Treatments					
	T_0	T_1	T_2	T_3	T_4	SEM
a(ml^3)	12.67	10.00	11.33	12.00	10.00	1.43
b (ml^3)	32.00^a	29.33^a	30.67^{ab}	27.33^{ab}	24.00^b	2.13
a+b(ml^3)	47.33^a	39.33^b	34.00^b	39.33^b	34.00^b	2.19
c(mlh^{-1})	0.04	0.05	0.04	0.04	0.03	0.01
t (hrs)	14.00	16.00	16.00	12.00	12.00	2.19
y (ml^3)	26.67	24.67	21.33	22.00	16.00	3.65

a,b, c = Means on the same row with different superscripts differ significantly ($P < 0.05$)
a = zero time which idealy reflects the fermentation of soluble fraction
b = extent of gas production from insoluble but degradable fraction
a+b = potential extent of gas production, c = rate of gas production at time (t)
l = lag time (h)
Y = volume of gas produced at time (t), T_0 = Unensiled/Fresh Maize Stover, T_1 = Maize Stover Only (Control), T_2 = Maize Stover and Molasses (MSM), T_3 = Maize Stover and Honey (MSH), T_4 = Maize Stover and Sugar (MSS), SEM = Standard Error of Means

In vitro gas production parameters of mixture of ensiled maize stover with or without additives are presented in Table 4. All the parameters observed at 24hrs were varied significantly ($P < 0.05$) across the treatments. The values for TGV, CH4, DMD, OMD, ME and SCFA ranged from 34.00 - 39.33, 5.67 – 11.33, 40.00 – 66.67, 48.94 -- 59.33, 7.35 – 8.59 and 0.75 – 0.88 respectively. Gas production is an indication of microbial degradability of samples (Babayemi *et al*., 2004b, Fievez *et al*., 2005). All the parameters, observed in this study indicating that the treatments had significant effects on the nutritive value of maize stover silage with or without additives. The lowest and highest gas production (TGV) and CH_4 production was obtained in maize stover silage (T_1) control and unensiled/fresh MS (T_0). However, the total gas volume (TGV) of control (T_1) silage compared well with fresh MS. In most cases, feedstuffs that showed high capacity for gas production were also observed to be synonymous for high methane production. Methane (CH_4) production in the rumen is an energetically wasteful process, since the portion of the animal's feed, which is converted to CH_4, is eructed as gas. The low value (5.67%) of methane obtained for control silage (T_1) indicates that there was minimal loss of energy. Generally, gas production is a function and a mirror of degradable carbohydrate and therefore, the amounts depends on the nature of the carbohydrates (Blummel and Becker, 1997). When feedstuffs are incubated with buffered rumen fluid (inoculums), gas production is basically the result of microbial degradation of carbohydrates under anaerobic condition to acetic, propionic and butyric acids (Steingass and Menke 1988, Getachew *et al*. 1998). The gas produced is directly proportional to the rate at which substrate are degraded (Doano *et al*., 1997). Somart *et al*. (2000) reported that gas volume is a good parameter to predict digestibility, fermentation and its product and microbial protein synthesis of the substrate by microbes in the *in vitro* system. Gas volumes also have shown a close relationship with feed intake (Blummel and Becker, 1997) and growth rate in cattle (Blummel and Ørskov, 1993). Gas production from protein fermentation is relatively small compared to carbohydrate fermentation. The contribution of fat to gas production is negligible. Beuvink and Spoelstra (1992) further stated that gas is produced mainly when feedstuff carbohydrates are fermented to acetate and butyrate with fermentation to propionate yielding gas only from buffering of the acid, therefore forage which produce high amount of propionate should produce low gas volume. The result obtained showed that gas production was directly proportional to SCFA (Beuvink and Spoelstra, 1992), the higher the gas produced, the higher the short chain fatty acids. Short chain fatty level indicates that the energy is available to the animal and it contributes up to 80% of animal daily energy requirement (Fellner, 2004). Also, the report of this study revealed that short chain fatty acid (SCFA) is directly proportional to metabolisable energy (ME) as reported by Menke *et al*., (1979). Dry matter degradability (DMD), value of 66.67% obtained for T_2 (MSM) was the highest while the least value of 40.00% was recorded for T_3 (MSH) silages. The DMD value is a good measure of the amount of dry matter in the feed that can be degraded by microbes in the rumen of ruminants. The result obtained indicates that control silage (T_2) will do better compared to other silages with additives. The organic matter digestibility (OMD) which could be said to be a measure of degradability (potentials) of the microbes on the substrates especially in the presence of sufficient ammonia nitrogen (NH_3-N) which has influence on bacterial fermentation was highest in treatment T_0, followed by T_3 and T_1 while T_4 was the least among the silages.

Table 4: *In vitro* fermentation parameters of maize stover at 24hrs incubation period

	Treatments					
Parameters	T_0	T_1	T_2	T_3	T_4	SEM
TGV (ml)	44.67^a	39.33^{ab}	34.00^b	39.33^{ab}	34.00^b	2.63
CH_4 (%)	12.67^a	5.67^c	11.33^{ab}	9.33^{ab}	8.00^{bc}	1.37
DMD (%)	44.67^a	46.67^{ab}	66.67^a	40.00^b	60.00^{ab}	6.35
OMD (%)	59.33^a	53.73^{ab}	49.25^b	53.80^{ab}	48.94^b	2.28
ME(MJ/Kg DM)	8.90^a	8.08^{ab}	7.38^b	8.09^{ab}	7.35^b	0.35
SCFA(µml)	1.01^a	0.88^{ab}	0.75^b	0.88^{ab}	0.75^b	0.06

a,b c Means along the same row with different superscripts are significantly ($P < 0.05$) different
TGV = Total Gas Volume, CH_4 = Methane, DMD = Dry Matter Degradability, OMD = Organic Matter Digestibility, ME = Metabolisable Energy, SCFA = Short Chain Fatty Acid, T_0 = Fresh/Unensiled Maize Stover, T_1 = Ensiled Maize Stover Only (Control), T_2 = Ensiled Maize Stover and Molasses (MSM), T_3 = Ensiled Maize Stover and Honey (MSH), T_4 = Ensiled Maize Stover and Sugar (MSS), SEM = Standard Error of Means

CONCLUSION

The result of this study revealed that in *vitro gas* fermentation, chemical composition and acceptability of ensiled maize stover with or without additives by WAD sheep are similar. *In vitro* gas fermentation parameter revealed that CH_4 production of ensiled maize stover without additives was very low compared to other silage types. Therefore, it was concluded from this study that, maize stover can be preserved without additives provided all the steps of silage making processes are followed and this will reduce the cost of production. Consequently, this will alleviate the menace of dry season feeding and curtail vicious cycle of lost weight-gain. Since maize stover is available throughout the entire regions in Nigeria and some part of the World, it is expected to have a great potential towards the alleviation of feeding problem usually encountered during the dry season and therefore maize stover silage could bridge the gap between forage availability in the rainy season and unavailability during the dry season.

CONFLICT OF INTEREST

The authors declare that there is no known conflict of interest as regards the conduct of this study and the data reported in this work.

REFERENCES

Adegbola, T. A. 1998. Sustainable ruminant production for human nutrition and national development .Inaugural Lecture Series No. 7. Abubakar Tafawa Balewa University, Bauchi. Pp. 1– 44

Agbagla-Dohnani, A., N oziere, P., Clement, G. and Doreau, M. 2001. In: *In sacco* degradibility, chemical and morphological composition of 15 varieties of European rice straw. *Animal Feed Science Technology*. 94: 15 – 27

Ajayi, F. T., Babayemi, O .J. and Taiwo, A .A. 2007. Effect of *Stylosanthes guianensis* and *Aeschynomene histrix* on the yield, proximate composition and in sites dry matter and crude protein degradation of *Panicum maximum* (Ntchisi). *Livestock Research for Rural Development* 19 (32).

Alasa, M.C., Akinsola, S.O. and Babayemi, O.J. (2010). Chemical composition and *in vitro* gas production of *Panicum maximum* intercropped with two cultivars of *Lablab purpureus*. Babayemi, O.J., Abu, O. and Ewuola, E.O. (Eds). Proceedings of the 35th Nigerian society for Animal production, 14 – 17th March 2010 pp. 587 – 590.

Amuda A.J; D.O,Okunlola and Babayemi,O.J; 2018. Quality Characteristics and Chemical Composition of Ensiled Maize Stover with or without Additives. I.C Okoli,I.P. Ogbuewu,O.O. Emenaldom and B.O.Esonu (Eds) Proceedings of the 43rd Nigerian Society for Animal Production. 18th – 22nd March, 2010 pp.1243 – 1246.

Amuda A.J; Falola, O.O; Babayemi,O.J; 2017. Chemical composition of quality Characteristics of ensiled maize stovers. *Federal University Wukari Trends in Science and Technology JournalVol 2.*(1a) pp 195-198.

Amuda A.J. 2013. Utilisation of Ensiled Maize Stover with Concentrate Supplements by West African Dwarf Sheep. Ph.D. Thesis. Submitted to Department of Animal Science. University of Ibadan. pp. 1- 195.

A.R.C 1985 Agricultural Research Council. The Nutrient Requirements of Farm Animals. No. 2, Ruminants: Technology Review and Summaries. ARC, London.

AOAC, (2000). The official methods of analysis. Association of official analytical chemist, 16th Edn., Washington D.C., pp: 69-88.

Babayemi, O. J. Ifut, O. J. Inyang, U. A. Isaac, and Isaac, I. J. 2010. Quality and chemical composition of cassava waste ensiled with *Albizia saman* pods. *Journal of Agricultural Production*. Volume 6: (3) pp. 225– 228.

Babayemi, O. J., Ekokotu, O. A and Iyang, A. U. 2009. Evaluation of ensiled cassava peels togeher with *Albiza saman* pods. Umoh,B.I, Udedibe, A.B.I, Solomon, I.R., Obasi,O.L., Okon, B.I. and Udoh.E.J., (Eds). Proceedings of the 34th Nigerian Society for Animal Conference, pp. 547-550.

Babayemi, O. J., Demeyer, K. D. and Fievez, V. 2004b. Nutritive value and qualitative assessment of secondary compounds in seeds of eight tropical browse shrubs and pulse legumes, *Applied Biological Science,* Ghent University.6911:103-110.

Babayemi, O.J. and Bamikole, M. A. 2004. Feeding goat with Guinea grass-Verano – stylo and Nitrogen fertilizer grass with energy concentrate *Arch Zootec* 53:12-23.

Babayemi, O. J. Ifut, O. J. Inyang, U. A. Isaac, and Isaac, I. J. 2010. Quality and chemical composition of cassava waste ensiled with *Albizia saman* pods. Journal of Agricultural Production. Volume 6: (3) pp. 225– 228.

Babayemi, O. J. and Bamikole, M. A. 2006. Effect of *Tephrosia candida* DC leaf and its mixtures with guinea grass on the *in vitro* fermentation changes in feed for ruminants in Nigeria. *Pakistan Journal of Nutrition* 5: (1): 14 – 18.

Babayemi, O. J. 2007. In vitro fermentation Characteristics and acceptability by West African dwarf goats of some dry season forages. *African Journal of biotechnology* Vol. 6(10) *Panicum maximum* pp. 1260 – 1265.

Bamikole, M.A., U.J. Ikhatua, M.T. Ajulo and A.C. Osuji, 2004. Feed utillisation potential of West African dwarf goats fed different proportions of *Ficus thonningii* and. Proceedings of the 29th Annual conference of Nigeria society of animal production, pp: 336 -340.

Beuvink, J. M. W. and Spoelstra, S .F. 1992. Interaction between treatment, fermentation end-products buffering systems and gas production upon fermentation of different carbohydrates by mixed rumen micro-organisms *in vitro. Appl. Microbial Biotechnol.* 37: 505 – 509.

Blummel, M. and Ørskov, E.R. 1993. Comparison of *in vitro* gas production and nylon bag degradability of roughage in predicting feed intake in cattle. Animal Feed Science and Technology, 40: 109 – 119.

Blummel, M. and Becker, K. 1997. The degradability characteristics of 54 roughage and roughage neutral detergent fibre as described by *in vitro* gas production and their relationship to voluntary feed intake. *British Journal of Nutrition*; 77: 757 – 760.

Fievez, V., Babayemi, O. J. and Demeyer, D.I. 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* 123:197 – 210.

Demeyer, D. I. and Van Nevel, C. I. 1975. Methanogenesis, an integrated part of carbohydrate fermentation and its control. In digestion and metabolism in the ruminant (L.W. McDonald and A.C.I. Warner (eds) pp. 366 – 382. The University of New England Publishing Unit, Armidale, N.S.W., Australia.

Doano, P. H., Schofield, P. and Pell, A.N. 1997. Neutral detergent fibre disappearance and gas and volatile fatty acid production during in vitro fermentation of six forage, Department of animal Science, Cornell University, Theca, N414853.

Elkholy, M.E.H., Hassanein, EI. I., Soliman, M. H., Eleraky, W. E., Elgamel, M.F.A. and Ibraheim, D. 2009. Efficacy of Feeding Ensiled Corn Crop Residues to Sheep. *Pakistan Journal of Nutrition* 8 (12): 1856 – 1867.

Fellner, V. 2004. *In vitro* versus *in vivo* estimates of ruminal fermentation. Department of Animal Science. North Carolina State University.

Gatenby, R. M. 2002. Sheep Revised Edition. Tropical Agricultural Series. Macmillan Publishers Ltd. Malaysia. Pp.1 – 178.

Getachew, G., Blummel, M., Marker, H. P. S. and Becker, K. 1998. *In vitro* gas measuring techniques for assessment of nutritional quality of feeds. A review. *Animal Feed Science Technology*, 72: 261 – 281

Gillespie, J. R. 1998. Animal Science. Delmar Publishers, International ,Thompson Publishing Company. pp. 1204

Idris, A.B., Yusuff, S. M. and Sharrif, A. 1999. Sweet corn stover silage production. Proc. FAO e-Conf. on Trop. Silage. FAO Plant Production and Protection paper 161. Rome 107 – 108.

Makkar, H. P. S. 2004. Recent advances *in vitro* gas method for evaluation of nutritional quality of feed resources. Animal Production and Health Section, Joint FAO/IAEA Division,International Atomic EnergyAgency Publications. pp. 1. -10

Mauricio, R.M., Mould, F. L., Abdalla, A.L. 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 evaluation Science Technology* 79: 321-330

McDonald, P., Edward, R.A. Greenhalgh, J. F. D. and Morgan, C. A. 1995. Animal Nutrition. 5th Ed. Longman Scientific and Technical, England.

Menke, K. H., Fritz, D. and Schneider, W. 1979. The estimation of the digestibility and metabolisable energy content of ruminant production when they are incubated with rumen liquor *in vitro Journal of Agricultural Science.* (Cambridge) 92: 217 – 222.

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. Dev*. 28: 7 – 55.

Methu, J. N. 2003. Testing and Promoting silage making technologies in the smallholder dairy farmers in Kenya, Quarterly report, Land 'O' Lakes Inc. pp. 6 – 10.

NRC 1981. Nutrient Requirements for goats. Angora dairy and meat goat in temperate and tropical countries. National Research Council, National Academy of Science Press. Washington, DC., U.S.A.

Nousiainen, J. Ahvenjarvi, S. Rinne, M., Hellamak, M. and Huhtanen, P. 2004. Prediction of indigestible cell wall fraction of grass silage by near infrared reflectance spectroscopy. *Animal Feed Science Technology*. 115: 295 – 311

Oba, M. and Allen, M. S. 1999. Evaluation of the importance of the digestibility of neutral detergent fibre from forage: Effects on dry matter intake and milk yield of dairy cows. *Journal of Dairy Science,* 82: 529 – 596.

Ørskov, E. R. and McDonald, L. 1979. The estimation of Protein degradation ability in the rumen from incubation measurement weighed according to rate of passage. *Journal of Agricultural Science. Cambridge*. 92:499 – 503

Ørskov , E. R. and Ryle, M. 1990. Energy Nutrition in Ruminants. Elsevier, London. Pp. 149.

Van Soest, P. J. 1994. Nutritional Ecology of Ruminants. 2nd Edition. Cornell Universiity Press, USA. Pp. 476.

Rinne, M. Jaakkola, S., and Huhtanem, P. 1997. Grass maturity effects on cattle fed silage based diets.1 Organic matter digestion, rumen fermentation and nitrogen utilisation. *Animal Feed Science Technology*. 67: 1– 17

SAS. 2003 . Statistical Analysis Systems, User'Guide,Version 8 ed., SAS Institute Inc.SAS Campus Drive Cary, North Carolina, USA.

Sowande, O. S., Aina, A. B. J., Oguntona, E.B., Fanimo, A.O., Unaka, V.U., Hassan, T.A. and Oseni, M.O. 2008. Performance, blood constituents and mineral balance of West African dwarf Sheep fed preserved elephant grass, layers droppings and cassava peel diets during dry season. *Nig. J. of Animal Prod.* 35: 90 – 102.

Somart, K. Parker,D.S.Poulison, P. and Wanapat, M, 2000. Fermentation characteristic and microbial protein synthesis in an *in vitro* system using cassava, rice straw and dried ruzi grass as substrates. *Asia – Aust. Journal of Animal Science*. 13:1084 –1094

Syomiti, M., Wanyoike, M., Wahome, R.G. and Kuria, J.K.N. 2009. The status of maize stover utilisation as feed for livestock in Kiambu and Thika districts of Kenya: Constraints and opportunities pp. 8 – 13.

Traxler, M.J., Fox, D.G., Van Soest, P.J., Pell, A.N., Lascano, C. E., Lanna, D. P. D.,Moore, J. E., Lana, R. P.,Velez, M and Flores, A. 1998. Predicting forage indigestible NDF from lignin concentration. *Journal of Animal Science*. 76: 1469 – 1480

Van Soest, P.J., Robertson, J.B. and Lewis, B.A. 1991. Methods for dietary fiber-neutral detergent fiber, and non-starch polysaccharides in relation to animal nutrition. *Journal of Dairy Science.* 74, 3583 – 3597.