CHEMICAL COMPOSITION AND QUALITY CHARACTERISTICS OF ENSILED MAIZE STOVER

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Abstract: Maize stover (MS), an abundant crop residue is a potential feed for ruminants. The nutritive value is reduced when left on the field without processing and preservation due to further lignification. The ensiling of MS without additives for preservation has not been adequately documented. Therefore, effect of non-additives on silage quality characteristics and chemical composition of ensiled maize stover was investigated. Maize stover were ensiled for 30 days using different additives (Molasses, honey and sugar) at the rate of 50gkg^{-1} to obtain the following silages: Maize stover and Molasses (MSM), Maize stover and Honey (MSH), Maize stover and Sugar (MSS) and Maize stover only (Control) which served as treatments. The pH, moisture, colour, odour and texture silage characteristics were determined using standard procedures. Dry matter (DM), Crude protein (CP), ash, Crude fibre (CF), Ether extract (EE), Nitrogen free extract (NFE), Neutral detergent fibre, Acid detergent fibre, Acid detergent lignin, Hemicellulose and Cellulose of the ensiled MS were determined using standard techniques. The greenish-brown, greenish-yellow colour, alcoholic, fruity and pleasant odour, firm texture pH (3.5 – 3.7) and moisture (64.7 – 68.7%) were similar among the silages. The DM (31.6 – 35.3%), CP(7.9 – 8.9%), CF(30.0 – 31.9%), EE (1.4 – 1.8%), NDF (68.6 – 69.9%), ADF (56.1– 63.2%) and ADL (14.0 – 16.8%) were not significantly affected by the additives. However, ash composition, NFE, and cellulose were significantly ($P < 0.05$) affected by the additives. This investigationdemonstrated that addition of additives to MS stover had no significant effect on silage quality characteristics and chemical composition compared to control silage. Consequently, maize stover can be ensiled without additive and without significant reduction in nutrient composition and silage quality characteristics.

Keywords: Additives, chemical composition, maize stover, ruminants, silage quality

Introduction

One of the challenges facing ruminant livestock farmers in the tropics especially in Nigeria is poor nutrition of their animals occasioned by the dry season. There is decline in supply and quality of herbage for livestock during the dry season (Babayemi, 2009). The concern 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). Livestock production activities among small scale farmers in the high and medium areas of Africa are integrated with crop production activities (Thairu and Tessema, 1987). The degree of integration varies, but generally intensifies with increasing human population density. Crop production benefits from animals draught power for tillage, animal manure for fertilization of crops, while crop residues constitute an important feed resource for animals especially in the dry season (Preston and Leng, 1987). With increasing human population, cropping land is expanding leading to increase 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 in the field or harvested for livestock feeding (Amuda, 2013). However, these crop residues are generally poorly utilized as animal feed each year because small-scale farmers lack the technical knowledge on how best to use them (Methu, 2003).

Farmers generally utilise these crop residues for livestock feeding without considering the use of any of the existing improvement technologies. This situation may be reversed by adapting known technologies that have been developed for local conditions, such as urea treatment, legume supplementation and ensiling process or method. In the presence of a dynamic market system, livestock production could thus be intensified and made profitable for small-scale farmers (Preston and Leng, 1987).

Field observations show that maize stover is the most abundant residue in small holder crop production systems, but poorly handled and stored (Syomiti*et al*., 2009). The most commonly observed methods of handling the maize stover are harvesting and either stacking in the field for gradual collection as required for feeding, storing under trees or in the home compound usually in the open and very rarely in roofed barns (Syomiti*et al*., 2009). This loss of considerable amounts and nutrients is due to weathering and leaf shattering. Improper management and storage methods drastically reduce the proportions of maize stover available as feed as well as the efficiency of utilisation (Promma *et al*., 1994). Silage making in the tropics is paramount if there will be all year round availability of forage for livestock. In the wet season, there is abundance of grass while it becomes scarce in the dry season.

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 national use of locally available agricultural and industrial by-products likely to be available to small scale farmers at village level.

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 (Ajayi *et al*., 2012). 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. This study therefore was undertaken to documentsilage quality characteristics and chemical composition of ensiled maize stover.

Materials and Methods

The experiment was carried out at the Teaching and Research Farm of the University of Ibadan, Nigeria in July 2010. The location was $7^{0}27$'N and $3^{0}45$'E at an altitude of 200 – 300m above sea level.The average annual rainfall was about 1250mm with a mean temperature of 25 – 29^{0}C (Babayemi *et al.*, 2003).

Harvesting and silage making

Freshly harvested maize stover was obtained from Practical Year Training Programme (PYTP) from University of Ibadan. The harvested maize stovers were weighed to determine the expected amount for the making of silage. Representative samples of known weights were taken for dry matter analysis by drying in the oven for 48hrs at 65^{0}C until a constant weight was obtained. The harvested samples were wilted under shade for 24h in order to reduce the moisture content. There were four treatments comprised mixtures of the Maize stovers (MS):

Treatment A : MS + molasses (MSM)
Treatment B : MS + Honey (MSH)
Treatment C : MS + Sugar (MSS)
Treatment D : MS only (Control)

Maize stover was chopped into 2 – 3cm lengths (for ease of compaction and consolidation for silage) according to (t'Mannetje, 1999). The chopped maize stover was then weighed, mixed and divided into equal portions (1kg) in five replicates for the different treatments were filled in a 2kg capacity plastic. The plastic was lined internally by polythene sheets. Each layer of the maize stover was compacted manually to displace the air until the containers were filled. The final compaction was made after which the polythene sheet was wrapped over the material. Sand bag of 2kg weight was later rolled on the filled material and was left for 30 days for fermentation.

Determination of silage quality

After 30 days, the fermentation was terminated and the silage was opened for quality assessment. The assessed quality characteristics were colour, odour, moisture (%) texture, pH and temperature according to Babayemi and Igbekoyi (2008). Immediately the silage was opened, a laboratory thermometer was inserted to determine the temperature. Sub-samples from different points and depths were later taken and mixed together for dry matter determination by oven-drying at 65^{0}C until a constant weight was achieved. The samples were later milled and stored in an air-tight container until ready for chemical analysis. The pH of sub-sampled silage was done by heating 100g in beaker containing 100ml of distilled water for 5 min at 60^{0}C.The supernatant liquid was decanted, cooled at room temperature and pH meter was used to determine the level of pH. Colour chart was used to ascertain the silage colour.The odour or smell of the silage was relatively assessed as to whether nice or pleasant or fruity.Structure of the silage was also determined whether it is separable or visible or collapsible.

Chemical and statistical analysis

Crude protein, crude fibre, ether extract, ash contents and nitrogen free extract of the silage were carried out in triplicates as described by AOAC (1995) 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 were determined according to Van Soest *et al*. (1991). Data were analysed using analysis of variance by following the procedure of SAS (SAS, 2003). The model for the analysis was:

$Y_{ij} = \mu + ai + eij$

Where: Y_{ij} is the studied parameters, ai is the effect of additives on silage production and ei is the residual error. The significant means were separated by the use of New Duncan Multiple Range Test (Duncan, 1955).

Results and Discussion

The quality of the ensiled maize stover with or without additives as reflected in terms of colour, texture, moisture, and odour are shown in Table 1.Presented in Fig. 1 is the temperature of the silages while Fig. 2 showed the pH of the silages. Colour of the silages ranged from greenish-brown in MS only (Control) to greengage in MSM, MSH and MSS. Differences were observed in the odour of the silage as all the silages were characterized by pleasant fruity and alcoholic odour. Fruity and pleasant odour exhibited by control and MSM silage indicates that maize stover can be ensiled without additives. Kung and shaver (2002) reported that pleasant odour is accepted for a good or well made silage. Good silage usually preserves the original colour of the forage used to produce it (t'Mannetje, 1999). The greenish brown and greenish-yellow colour close to the original colour of the maize stover which was an indication of good quality silage that was well preserved (Oduguwa *et al*., 2007; Babayemi, 2009). Generally, temperature is one of the essential factors affecting silage colour. The lower the temperature during ensilage, probably the less will be the colour change(Adesogan and Newman, 2010).

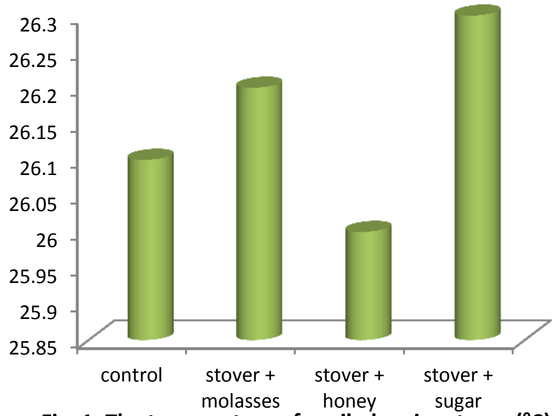

Fig. 1: The temperature of ensiled maize stover (^{0}C)

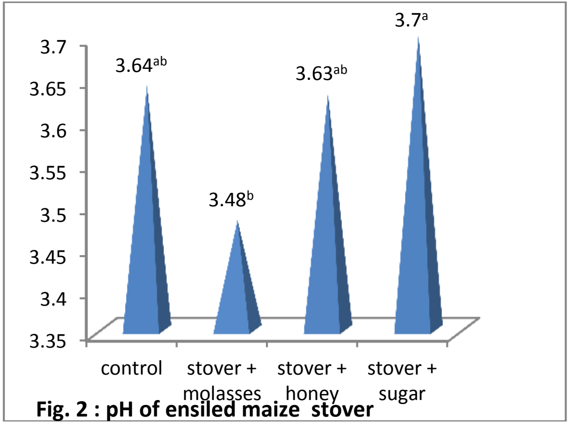

Fig. 2 : pH of ensiled maize stover

The temperature range of 26.0 to 26.3^{0}C of all the silages was below 27^{0}C and indicated well preserved silage. This temperature range would appear to be the operating temperature for normal silage fermentation. As observed by Bolsen *et al*. (1996), any excessive heat production can result in Mailard or browning reactions which can reduce the digestibility of both protein and fibre constituents. The pH value of the silage is shown in Fig. 2. The pH value in the present result was within the range of 3.2 – 3.8 and 3.1 – 3.6 reported by Oduguwa *et al*.(2007) and Fasina (2012), respectively an indication of well preserved and good quality silage. The texture of the silage was firm, which was expected to be the best texture of good silage (Kung and Shaver, 2002).

The chemical composition of ensiled maize stover with or without additives is presented in Table 2. The results showed that CP, CF, EE content of the four kinds of silages were nearly the same without significant difference ($p > 0.05$) while significant difference ($p < 0.05$) occurred in DM, Ash and NFE of the silages. Silage effect was not evident in CP and CF contents as the composition was not different from the fresh/unensiled stover. The decrease in protein content of ensiled stover compared with fresh stover though not significant, but it could be attributed to degradation of protein to non protein nitrogen (NPN) and amino acids by plant enzymes and microbes in well preserved silage (Udeybir *et al.*, 2008; McDonald *et al.*, 2010). It could also be due to dilution effects as all additives are carbohydrates. The crude protein value (7.9 – 8.6g/100g) for the present study was slightly 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 (1985) for ruminants. The low amount of protein in the present study suggests a supplementation with richer protein sources. Maize stover silage in Nigeria can be fortified with energy or protein sources by ensiling with cassava leaf browse pods and industrial by-products. Dry matter (DM) of control silage compares well with fresh/ unensiled maize stover (MS) and MS with additives except for MS and sugar which was significantly ($p < 0.05$) higher and this may be attributed to effect of sugar additives used. None significant effect of MS silage without additive (Control silage) compare to DM of fresh/unensiled MS indicate that Maize stover can be ensiled and preserved without loss of DM which confirmed the report of Soliman *et al*. (1975 and 1977) that corn stover can be successfully ensiled without any significant change in its nutritive value.

Table 1: Moisture, colour, texture and odour characteristics of ensiled maize stover

Silage treatments	Quality indicators			
	Moisture	Colour	Texture	Odour/smell
MS only (Control)	68.2	Greenish brown	Firm	Fruity
MS + Molasses	68.7	Greenish-yellow	Firm	Pleasant
MS + Honey	67.3	Greenish-yellow	Firm	Alcoholic
MS + Sugar	64.7	Greenish-yellow	Firm	Alcoholic

MS – Maize Stover

Table 2: The proximate composition of ensiled maize stover

Nutrient	Unensiled	Control	MSM	MSH	MSS	SEM
Dry matter	31.1^{b}	31.6^{b}	31.3^{b}	32.7^{ab}	35.3^{a}	0.50
Crude protein	9.3	8.4	8.3	7.9	8.6	0.46
Crude fibre	32.3	31.9	30.0	30.0	31.4	0.55
Ash	7.4^{a}	7.1^{a}	7.2^{a}	6.3^{b}	6.9^{a}	0.11
Ether extract	1.8	1.4	1.7	1.5	1.8	0.69
Nitrogen free extract	49.4^{b}	51.2^{ab}	52.9^{a}	53.7^{a}	51.5^{ab}	0.58

a,b = Means on the same row with different superscripts are significantly (P<0.05) different; MS – Maize Stover; MSM = Maize stover + Molasses; MSH = Maize stover + Honey; MSS = Maize stover + Sugar; SEM = Standard Error of Mean

Table 3: Fibre fractions (%) of ensiled maize stover

Nutrient	Unensiled MS	MS only (control)	MSM	MSH	MSS	SEM
NDF	69.2	69.3	69.9	69.6	68.6	0.63
ADF	57.5	58.5	59.5	63.2	56.1	1.66
ADL	16.5	15.6	14.0	14.8	16.8	0.11
Hemicellulose	11.73	10.81	10.92	11.39	12.49	0.58
Cellulose	41.56^{ab}	42.97^{ab}	44.81^{a}	43.44^{ab}	39.30^{b}	0.92

a, b = Means on the same row with different superscripts are significantly (P<0.05) different; MS – Maize Stover; MSM = Maize stover + Molasses; MSH = Maize stover +Honey; MSS = Maize stover + Sugar; SEM = Standard Error of Means

Table 3 showed the fibre fractions of ensiled maize stover. The results showed that no significant ($p > 0.05$) differences occurred among the fibre fractions except for cellulose where significant difference occurred such that it was lowest in MS with sugar additives and highest in MS with molasses. The values for NDF, ADF and ADL obtained in this study were higher than values reported by Elkholy *et al.* (2009). High NDF could result in low intake while high ADF may engender low digestibility (Babayemi *et al*., 2010). 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. Since fibre fractions contents of the silages were relatively high, the intake and potential digestibility will be low when fed alone to ruminant without concentrate supplements.

Conclusion

Maize stover was able to preserve well with good quality characteristics and chemical composition remained relatively stable when ensiled without additives. It is recommended that maize stover can be preserved by ensiling process during production period (raining season) for dry season feeding of ruminants when there is scarcity of forages by the farmer.

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