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ENHANCING MAIZE STOVER SILAGE QUALITY USING MOLASSES AND UREA FOR SUSTAINABLE AGRICULTURE IN AFRICA

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ABSTRACT

This study evaluates the effectiveness of molasses and urea as additives for improving the physical properties of maize stover silage to enhance livestock feed quality. The research employs an experimental design with different ensiling periods (3, 5, and 7 weeks) and assesses pH changes in maize stover treated with molasses, urea, and a control group. A 2×3 factorial arrangement laid in a Randomized Complete Block Design (RCBD) was used for the study. The study finds that molasses treatment results made the best silage quality with the lowest pH values, making it a preferable option for livestock feed preservation. The study aims to contribute to food security and sustainable agriculture in Africa. Irrigated red variety of maize stover were collected at the Department of Agricultural Education research garden, wilted or three for two days and chopped at 2-5cm. The

Introduction

Livestock are vital to subsistence and economic development in Sub-Saharan Africa. They provide a flow of essential food products throughout the year, they are a major source of government revenue and export earnings, sustain the employment and income of millions of people in rural areas. Livestock systems occupy about 30 per cent of the planet's ice-free terrestrial surface area (Steinfeld, *et al*. 2006) and are a significant global asset.

Maize (*Zea mays*) popularly known as 'corn', is one of the crop having wider climatic adaptability. Globally, maize is

chopped materials were added with urea as T1, molasses as T2 and without additives as T3 (Control). 24 bama bottles after thorough washing and drying were used as silos. Chopped materials were tightly packed in silos, air was removed by the use of vacuum sealer and store in the laboratory lockers at 27° to 30˚c. Silages were harvested at 3, 5 and 7weeks of preservation. pH values were taking by the use of digital pH meter. Collected data were analyzed by the use of Microsoft clustered chart. Results showed that molasses treatment made the best silage with the lowest decreasing acidic pH values of 3.07, 2.70 and 2.15 at weeks 3, 5 and 7 respectively. Control treatment at 3, 5 and 7 weeks of ensiling had the following decreasing acidic pH values; 4.71, 2.87 and 2.16 respectively, while urea treatment had the decreasing acidic pH values; 3.59, 2.87 and 2.52 at weeks 3, 5and 7 of ensiling respectively. It was concluded that, maize stover silage (MSS) at three, five and seven weeks made the best silage and is hereby recommended for preservation and use to feed livestock, especially during feed scarcity for sustainable agriculture in Africa.

Key Words: Silage, Feed additives, Ruminant nutrition, Livestock feed and, Sustainable agriculture.

Also known as 'queen' of cereals crop. Maize silage (*Zea mays)* is made out of whole ensiled maize plants. It is one of the most valuable forages for ruminant livestock and it is used wherever maize can grow, from temperate regions to the tropics.

The popularity of maize silage is due to several factors. It is a consistent source of palatable and high-energy forage for all classes of ruminants, including dairy cattle, beef cattle, sheep and goats (Roth *et al.,* 2001*).* It is one of the most high-yielding forage crops, requires less labour (since it is harvested in a single operation) and is generally less costly (per 2 Dry matter) to produce than other forage crops (NASS, 2015; Arvalis, 2011;Roth & Babayemi, 2001). Maize silage is also a good way to secure the crops as it is possible to turn a maize grain crop damaged by frost, rain or drought into maize silage (Arvalis, 2011; Roth & Babayemi,*,* 2001). Though relatively easy to produce, maize silage requires good crop and harvest management as well as careful ensiling practices (Arvalis, 2011). In recent decades, both breeders and producers aimed to maximize the fresh and dry matter yield of maize silage and increasing the proportion of the ear in the total dry matter. Good silage maize hybrids are considered to have the same quality traits as grain maize hybrids. Many farmers still choose hybrids based on the grain yield, but this is not related to silage quality.

Vol. 9, No. 1
Berkeley Journal of Entomology and Agronomy Studies

Statement of the Problem:

Sustainable livestock production in Africa faces significant challenges, particularly during dry seasons when forage availability is critically low. One of the most accessible yet underutilized crop residues is maize stover, which remains abundantly available after maize harvesting. However, its direct use as livestock feed is limited by its low crude protein content (typically 3–5%), high fiber, and lignin levels, resulting in poor digestibility and low voluntary intake by ruminants (Van Soest, 2006). These limitations compromise animal productivity, especially among smallholder farmers who rely heavily on crop residues to feed their livestock.

To address these nutritional limitations, enhancing the ensiling process of maize stover with additives such as urea and molasses has been proposed. Urea, a non-protein nitrogen source, can increase the crude protein content and improve microbial degradation of lignocellulosic materials in the rumen (Kass *et al*., 2017). Molasses, on the other hand, provides readily fermentable sugars that promote lactic acid bacteria activity during ensiling, lowering silage pH and improving palatability and preservation (Tesfaye *et al*., 2020). The combined use of urea and molasses has been shown to improve silage quality significantly, resulting in enhanced feed intake, digestibility, and animal performance (Kavana & Msangi, 2005; Mlambo *et al*., 2009).

Despite the proven efficacy of these additives, their adoption across Africa remains low due to several constraints, including lack of farmer awareness, limited access to input supplies, and inadequate extension services (FAO, 2019). Furthermore, improper application of urea during silage preparation can lead to toxicity risks for livestock and environmental concerns. These factors underscore a critical need for research-driven, context-specific strategies that promote the safe, economical, and effective use of urea and molasses in maize stover silage to support sustainable livestock systems in Africa.

Aim and Objectives

The aim and objectives of the study is to evaluate the **Enhancing Maize Stover Silage Quality Using Molasses and Urea for Sustainable Agriculture in Africa**, while the specific objectives is to;

1. **To evaluate the effect of molasses and urea treatments on maize stover silage**
2. **To compare the fermentation quality and preservation characteristics of maize stover silage under different treatment levels of molasses and urea.**
3. To evaluate effect of ensiling period on ensiled maize stover treated with urea and molasses
4. **To develop practical recommendations and extension strategies for promoting the adoption of improved silage practices among African smallholder farmers.**

Literature Review

Maize (Zea mays L.) is a major cereal crop widely cultivated across Africa, serving as both a staple food for humans and a crucial feed resource for livestock. After grain harvest, the residual biomass maize stover represents a significant portion of the total crop biomass and holds substantial potential as livestock feed (Owen & Jayasuriya, 1989). However, its high lignocellulosic content and low crude protein make it nutritionally inadequate when fed untreated, leading to reduced animal productivity (Khan *et al*., 2016).

Silage making is a proven method of preserving crop residues like maize stover, but achieving high-quality silage depends on adequate fermentation and nutrient preservation. Molasses, a rich source of readily fermentable carbohydrates, has been widely used as an additive to improve lactic acid production, reduce pH quickly, and enhance silage palatability (Kung *et al*., 2018). On the other hand, urea serves as a non-protein nitrogen (NPN) source that can increase the crude protein content of silage and support rumen microbial activity (Filya, 2003).

Several studies have demonstrated that the combined use of molasses and urea can synergistically improve both the fermentative quality and nutritional value of maize stover silage. For instance, Muck & Shinners (2001) observed that molasses enhanced silage exhibited lower pH and higher lactic acid levels, while the inclusion of urea increased ammonia N content, suggesting improved protein availability. Similarly, recent research in sub-Saharan Africa shows that these additives help improve silage characteristics, animal feed intake, and weight gain in ruminants, thereby supporting sustainable livestock production systems (Abate *et al*., 2020; Aregheore, 2005).

In the context of sustainable agriculture in Africa, the use of molasses and urea as silage additives aligns with circular economy principles by valorizing agricultural by-products and reducing feed costs. Moreover, improved silage quality contributes to better livestock productivity, which is essential for food security and rural livelihoods across the continent.

Physical Properties of Silage

Quality silage can be recognized by its smell, color and consistency. Good forage has an aromatic smell without any unpleasant notes of butyric acid, vinegar or other odors. (Eweedash, 2005). Physical characteristics like smell, texture and color can be used but evaluating pH and fermentation acids gives better feedback. It is strongly recommended not to taste the silage as poorly preserved feed may have undesirable bacteria, yeast and molds. (Amuda, & Tanko, 2019). The pH is used to tell the amount of acid in silage. Silage with a pH of 3.5-4.2 indicates excellent fresh acidic /sweet silage, 4.2-4.5 is good acidic, 4.5-5.0 fair less acidic and above 5.0 poor pungent /rancid smelling silage. Better quality silage has low acetic acid (1-3%), butyric and high in lactic acid (4-7%) and sugars. Lactic acid is responsible for most of the drop in pH of the silage, which is desirable although very high levels are associated with acidosis type problems (Altaf-un-Rahman & Aneela, 2004). Silage that is excessively dry will be prone to heating, mold growth and secondary fermentation. Where bad preservation does occur, it further reduce dry matter digestibility as well as reduce intake potential of the silage (Givens & Rulquin, 2004). Micro –organisms such as clostridia, listeria, and salmonella can occur on contaminated grass (Amuda, & Tsekaa, 2019).

METHODOLOGY

Experimental Location

The Experiment was conducted in the Agricultural Laboratory at the Federal College of Technical Education Bichi Kano state, Nigeria. Bichi has an area of $12km^2$ and a population of 277,099 at the 2006 census. Its geographical coordinates are 12°14'8" North and 8°4'21" East. And $12°13^1$ - 14N in the Sudan Savannah zone of Northern Nigeria. The zone is characterized by two obstinct season namely, wet (season May-September) and dry (season October-April) mean annual rainfall range from 500-1000mm and temperature from 21-39°c. (KNARDA, 2001).

Justification for Using Molasses and Urea

The use of **molasses** and **urea** as additives in the ensiling of maize stover is well supported by research that demonstrates their synergistic roles in improving silage fermentation quality and nutritive value. Maize stover, while abundant, is limited in its utility as a ruminant feed due to low crude protein, high fiber content, and poor digestibility (Aregheore, 2005). Effective treatment strategies are essential to enhance its value in sustainable livestock production systems.

Molasses is a by-product of sugar processing and is rich in soluble carbohydrates, which are essential substrates for **lactic acid bacteria (LAB)** during the early phase of silage fermentation. The addition of molasses stimulates rapid lactic acid production, thereby lowering the pH quickly and inhibiting the growth of undesirable microorganisms such as clostridia and enterobacteria (Kung *et al*., 2018). This rapid acidification helps in preserving the silage, improving palatability, and minimizing nutrient losses (McDonald *et a*l., 1991).

Urea, on the other hand, serves as a non-protein nitrogen (NPN) source that can significantly increase the **crude protein content** of low-protein crop residues such as maize stover. Once incorporated into silage, urea undergoes hydrolysis by urease

Vol. 9, No. 1
Berkeley Journal of Entomology and Agronomy Studies

enzymes, releasing ammonia, which acts as a microbial inhibitor and a preservative while also serving as a nitrogen source for rumen microbes (Filya, 2003). Moreover, urea treatment helps to break down the lignocellulosic matrix of stover, enhancing fiber digestibility (Chenost & Kayouli, 1997).

The combined application of molasses and urea not only improves fermentation characteristics—such as reduced pH, increased lactic acid content, and better aerobic stability but also enhances the **nutritional quality** of the silage. Studies have shown that this combination leads to increased feed intake, weight gain, and overall productivity in ruminant animals (Abate *et al*., 2020; Aregheore, 2005).

Given the widespread availability and cost-effectiveness of molasses and urea in most African agro-ecological zones, their use is a practical approach that aligns with the goals of **resource-efficient and sustainable livestock production systems** on the continent.

pH Determination

The pH of silage is a critical indicator of fermentation quality. A low pH (typically between 3.8 and 4.2 for good silage) reflects successful lactic acid fermentation and preservation.

Procedure:

- Approximately **20 g** of silage sample is weighed and placed in a beaker.
- **100 mL of distilled water was** and mix thoroughly by vigorous shaking for about **5 minutes**.
- The mixture is then filtered through muslin cloth or Whatman No. 1 filter paper.
- The pH of the clear filtrate was measured using a **digital pH meter**, calibrated with standard buffer solutions (pH 4.0 and 7.0) before use (Kung & Ranjit, 2001).

Experimental Materials

Maize Stover, Molasses, Urea, Water, Bama Bottles, Shears, Beaker, Spatula, pH Meter, Thermometer, Distilled water, Masking tape, Top bond, Stainless plate were used for the Research.

Experimental Design

A 2×3 factorial arrangement laid in a randomized complete Block Design (RCBD) was used for the experiment. The factor was maize Stover which were ensiled at three different levels of 3,5 and 7weeks at 3.2kg, then molasses and urea were added on the maize stover at 5 and 10% respectively while the control was ensiled without any of the

Vol. 9, No. 1
Berkeley Journal of Entomology and Agronomy Studies

above mentioned for all treatments. The treatments were allocated to the experimental units completely at random.

Experimental Layout for Maize Stover

Treatments	3Weeks	5Weeks	7Weeks
Urea	3U	5U	7U
Molasses	3M	5M	7M
Control	3C	5C	7C

Notes: Each of the treatment was replicated by 3 = 27. (Kuttu, *et al* 2020)

Preparation of the Experimental Sample

Experimental samples used were ensiled maize stover with or without Additives and are indicated as follows:

Treatments 1 = Urea: 3.2kg of maize stover were mixed with 1.8ml of dissolved urea

Treatments 2 = Molasses: 3.2kg of maize stover were mixed with 0.28ml of dissolved molasses

Treatments 3 = Control: 3.2kg of maize stover without Additives were ensiled

Determination of Physical Quality of Ensiled Maize Stover Silages with Additives

At the end of the ensiling period, the silage was opened at 3, 5 and 7weeks. Samples were taken using forceps from each ensiled bottle for physical observations. The attributes scored were color, odor, pH and Temperature by four independent score on a subjective value of 1-4 Muhammad *et al* (2009); Kuttu, et al 2020 as shown on the table 1. The pH of the ensiled materials was taken using a digital scale, temperature was taken using a wet and dry thermometer, colors was observed by the use of eyes while odor was felt by the use of the nose.

Table 1: Determination of Color, Aroma/Odor, pH and Temperature as indices of silage quality.

Rating	Color	Odor	pH	Temperature ˚C
1.	Brown	Sour		
2	Dark Brown	Sweat		
3	Yellow Green	Rancid		
4	Green	Putrid		

Source: Mohammed *et al.*, (2009) and Kuttu, *et al* (2020)

Vol. 9, No. 1
Berkeley Journal of Entomology and Agronomy Studies

Statistical Analysis

The data generated were subjected to Microsoft Excel Office Software and analyzed using bar charts.

RESULTS AND DISCUSSIONS

Results

Average pH values at week three is shown on Figure1. Molasses treatment had the lowest pH value of 3.07, while control treatment had the highest pH value of 4.71. Although all treatment fell under acidic conditions, molasses treatment seems better than urea and control treatments.

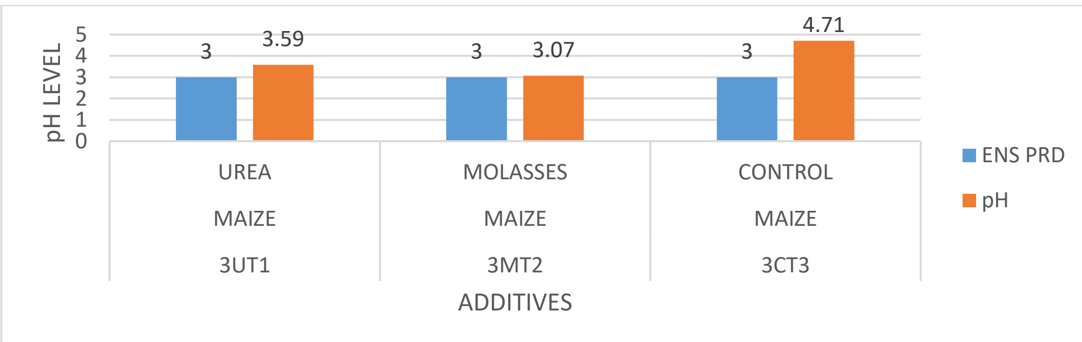
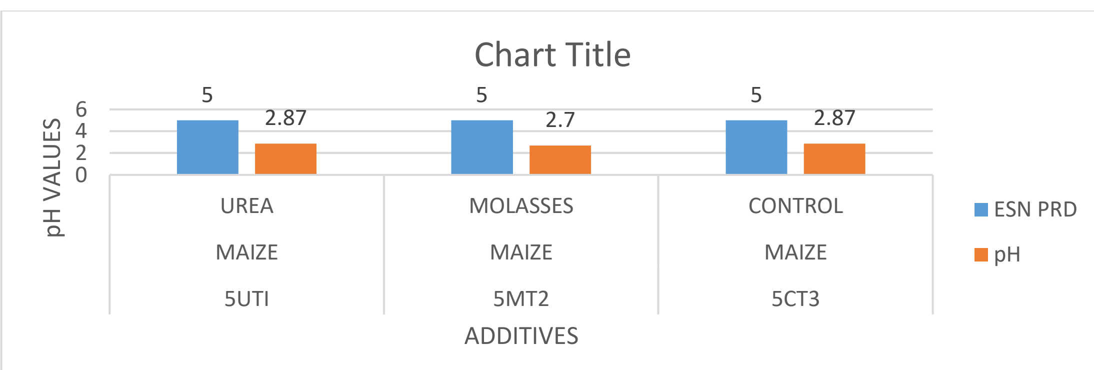


Figure1: Average pH Values at Week Three

Figure2. Shows the average pH values of ensiled maize stover at week five. Treatments 1, 2 and 3 all fall under acidic conditions by pH values. Treatment 2 which is molasses had the lowest pH value of 2.7, while treatments 1 and 3 which are urea and control had equal pH values of 2.8 each.



ENSPRD: Ensiling Period

Figure 2: Average pH Values for Maize Stover at Week Five

Vol. 9, No. 1
Berkeley Journal of Entomology and Agronomy Studies

Average pH Values for Maize Stover at Week Seven

Figure 3. Shows the average pH values of maize stover silage at week seven. Urea treatment had the highest pH value of 2.52, while molasses treatment had the lowest pH value of 2.15. Urea, molasses and control treatments all fall under acidic pH conditions making ensiling period at week seven an excellent silage. Although all treatments fall under acidic pH conditions, molasses treatment gave best results.

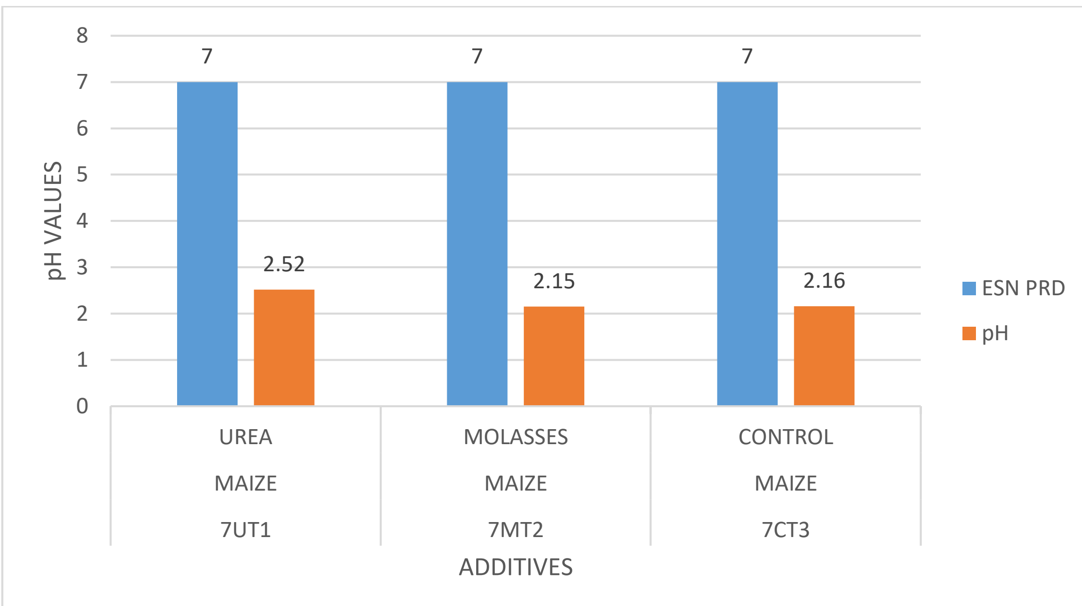
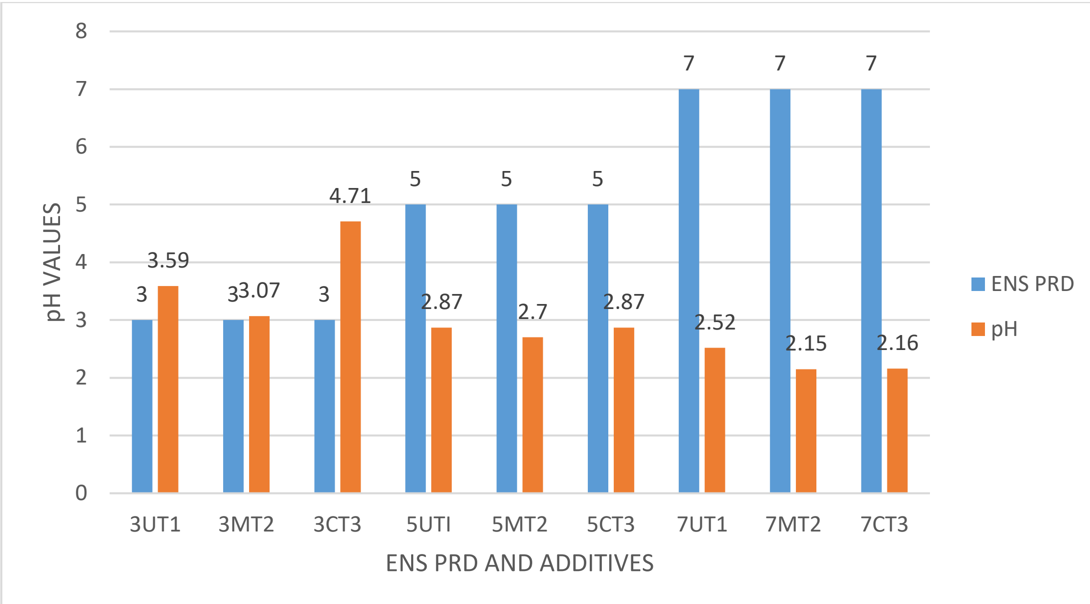


Figure 3: Average pH Values of Maize Stover at Week Seven

pH Values Main effect to Maize Stover Silage at Three, Five and Seven Weeks

The pH values of Maize Stover ensiled with additives; urea, molasses and control for 3, 5 and 7 weeks was showed on Figure 4. There was a steady decrease on pH values of treatments 1, 2 and 3 on the levels of ensiling at 3, 5 and 7 weeks of Maize Stover Silage (MSS). For urea treatment there was a steady decline of pH values of 3.59, 2.87 and 2.52 at 3, 5 and 7 weeks respectively. There was equally a steady decline on pH values for molasses treatment of 3.07, 2.70 and 2.15 at 3, 5 and 7 weeks respectively. For control, there was again a steady decline on pH values of 4.71, 2.87 and 2.16 at 3, 5 and 7 weeks respectively. At week 3 of ensiling, control had the highest pH value of 4.17, while molasses had the lowest pH value of 3.07. At week 5 of ensiling, control and urea treatments had an equal highest pH values of 2.87 each, while molasses had the lowest pH value of 2.7. At week 7, urea had the highest pH value of 2.52, followed by control with 2.16 and molasses with the lowest pH value of 2.15.



ENSPRD: Ensiling Period

Figure 4: pH Values of Maize Stover Silage at Three, Five and Seven Weeks

Discussion

pH Values of Maize Stover Silage (MSS) at Three, Five and Seven Weeks

The pH values of Maize Stover Silage at Three, Five and Seven Weeks of treatments 1, 2 and 3 (urea, molasses and control) fall under acidic conditions and there was steady decrease on pH level at weeks 3, 5 and 7 of treatments 1, 2 and 3. Urea treatment at weeks 5 and 7 have the highest pH values of 2.87, and 2.52 at 5 and 7 weeks respectively though under acidic condition as compared to control and molasses, which confirms the statement of Bolsen, *et al*., (1995) and Kuttu *et al* (2020), which says, addition of ammonia increases the pH level of silage to 6 or 9.With this high pH and ammonia effects on silage, the growth of mold and yeast population is inhibited and consequently increases aerobic stability of the silage materials. According to Hill & Leaver, (2002) and Kuttu, *et al.,* (2021), the presence of ammonia nitrogen (NH3-N), in high concentrations in conserved feeds, inhibits microbial activities during ensiling and subsequent aerobic deterioration. This result also shows that, ensiling without additives did not affect the quality of silage which is in agreement with the result of Kayauli & Lee (1998) and Kuttu *et al* (2022), who connfirm that a mixture of waste bananas, cassava roots and sweet potato vines could be ensiled effectively without the need for additive.

The study is limited to evaluating the use of molasses and urea treatments enhancing physical and nutritional qualities of maize stover silage.

CONCLUSION

It was concluded that, maize stover silage (MSS) at three, five and seven weeks make a good silage when treated with molasses and urea, consequently, is hereby recommended for preservation and use to feed livestock, especially during feed for sustainable agriculture, livestock production and food security in Africa.

RECOMMENDATIONS

Based on the above conclusion, the following recommendations were made

1. Maize Stover (MS) can be used for silage making.
2. Molasses and urea can be used as additives for treating maize stover in silage making.
3. Maize Stover (MS) can be preserved and use to feed livestock, especially during feed scarcity (dry season) when treated with molasses and urea

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