CHEMICAL COMPOSITION AND SOME MINERAL PROPERTIES OF MAIZE COBS ENSILED WITH WOOD ASH EXTRACT FORTIFIED WITH MOLASSES

BY

Gift Kelechi KISSIWE (Miss)

AGR2000089

DEPARTMENT OF ANIMAL SCIENCE

FACULTY OF AGRICULTURE

UNIVERSITY OF BENIN

BENIN CITY

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A PROJECT WORK SUBMITTED TO THE DEPARTMENT OF ANIMAL SCIENCE, FACULTY OF AGRICULTURE, UNIVERSITY OF BENIN, IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF BACHELOR OF AGRICULTURE

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CERTIFICATION

This is to certify that the project work was carried out by Gift Kelechi KISSIWE, Department of Animal Science, Faculty of Agriculture, University of Benin, Benin City, Nigeria, under the supervision of Prof F.U. Igene.

Prof. F.U. Igene ------------------------------

Project Supervisor Signature & Date

Mrs. O.B. Abiloro ----------------------------

Co- Project Supervisor Signature & Date

Dr. N. C. Akaeze ----------------------------
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Head of Department Signature & Date

DEDICATION

This research work is dedicated to God Almighty and my Family, KISSIWE Family.

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Firstly, Praises and thanks to God Almighty for divine blessings and provision throughout my research work. I would like to express my deep and upmost gratitude to my Project supervisor, Prof. F. U. Igene for his patience, understanding and guidance throughout this research, and also I would love to express my deep and upmost gratitude to my Co- Project supervisor, Mrs. O.B. Abiloro for her continuous support, guidance and motherly love towards my project colleagues and I throughout this research. I also appreciate the Dean of Faculty of Agriculture Prof. C.O. Emokaro, Head of Department, Dr. N.C. Akaeze and to my lovely lecturers; Prof. J.M. Omoyhaki, Prof. M.A. Bamikole, Prof. S.O. Nwokoro, Prof. J.O. Oyedeji, Dr. G.I.O. Odafe, Dr. (Mrs). G.O. Egigba, Mr Paul Aduba, Dr. B.G. Onagluse, Mrs. B.O. Issac, Dr. W.O. Agbonghae, Dr. E.S. Abel, Dr Ekom Udofia, and Mrs. V.E. Ekhorurtomwen, for their relentless efforts towards impacting knowledge, advice and good morals to me.

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ABSTRACT

This study investigated the chemical composition and some mineral properties of maize cobs ensiled with wood ash extract fortified with molasses. The study aimed to determine the effect of soaking durations and additive combination on the proximate and mineral composition of maize cob silage. Six treatments were used, comprising ordinary dried ground maize cobs (control), maize soaked in only water, maize soaked in 500 ml of wood ash for three days, maize soaked in 500 ml of wood ash for seven days, maize soaked in 500 ml of wood ash and molasses for three days, and maize soaked in 500 ml of wood ash and molasses for seven days. Samples of these differently treated maize cobs were analyzed for moisture content, dry matter content, crude protein, crude fat, ash, crude fiber, carbohydrate, and selected minerals such as nitrogen, phosphorus, potassium, calcium, zinc, and sodium. The results showed that the inclusion of wood ash extract and molasses, as well as prolonged soaking duration, had significant effects ($p < 0.05$) on the chemical and mineral composition of the maize cob silage. Moisture, ash, and mineral contents increased with the addition of wood ash extract and molasses, while crude protein, fat, and carbohydrate showed slight decreases as fermentation progressed. The highest ash (6.53%), calcium (188.30 mg/100g), potassium (578.10 mg/100g), and sodium (99.91 mg/100g) contents were recorded in maize soaked in 500 ml wood ash and molasses for seven days, while the control recorded the least mineral enrichment.

The increase in mineral content indicates that wood ash extract served as a good mineral fortifier, while molasses enhanced fermentation and nutrient stability. Prolonged soaking improved nutrient diffusion and fermentation efficiency, resulting in better silage quality. The combination of wood ash extract and molasses for seven days proved to be the most effective treatment, producing silage with improved nutritional and mineral composition suitable for livestock feed. This study concludes that maize cobs can be effectively converted into nutritionally valuable and mineral-rich silage through ensiling with wood ash extract fortified with molasses, thereby providing a cost-effective and sustainable feed resource for livestock production.

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Maize (*Zea mays L.*) is one of the most widely cultivated cereal crops in the world and serves as a staple food for millions of people while also contributing significantly to livestock diets. Globally, more than one billion tonnes of maize are produced annually, with Africa contributing a significant proportion (FAO, 2022). Beyond grain harvest, large quantities of maize residues such as stover, husks, and cobs are generated, most of which are underutilized or discarded. Maize cobs constitute approximately 20–30% of the maize residue biomass and are often left in the field or used as fuel for cooking. Despite their abundance, maize cobs have low nutritive value, characterized by high crude fiber, low crude protein, and high lignin content, making them poorly digestible for livestock (Okoye *et al.,* 2022*)*. Without treatment, maize cobs cannot adequately support animal growth, lactation, or reproduction.

Ensiling has emerged as a viable method to preserve and improve the nutritional value of crop residues. It involves fermenting plant materials under anaerobic conditions to encourage lactic acid bacteria (LAB) proliferation, which lowers the pH and stabilizes the feed against spoilage organisms (Nkosi *et al.,* 2020). However, successful ensiling requires adequate fermentable carbohydrates and proper moisture content. Since maize cobs are deficient in readily available sugars, additives such as molasses are necessary to improve fermentation quality *(Liang et al.,* 2020). In addition, alkaline treatments have been shown to enhance fiber digestibility by breaking down lignin-cellulose complexes. Among these, wood ash extract a byproduct of biomass burning is increasingly gaining attention as a low-cost additive rich in minerals such as potassium, calcium, and magnesium, which may improve both fermentation and the nutritional profile of ensiled materials (Mussoline *et al.*, 2021).

Combining both wood ash extract and molasses could synergistically address both the fermentable sugar deficit (through molasses) and the buffering/mineral supplementation (through wood ash), potentially producing silage from maize cobs of significantly improved chemical composition. Investigating this combination is critical in identifying cost-effective strategies for upgrading maize cobs into useful livestock feed that addresses feed scarcity while reducing environmental waste.

1.2 Justification of the Study

Feed scarcity remains a critical constraint in livestock production, especially in developing countries where production systems are largely dependent on natural pastures. During the dry season, animals often experience drastic reductions in nutrient intake, leading to weight loss, reduced milk yield, suppressed reproductive performance, and increased susceptibility to diseases (*Yami et al., 2022*). Agro-industrial byproducts such as maize cobs offer a readily available alternative feed source. However, their low nutritive quality necessitates appropriate processing methods to improve digestibility and palatability.

The use of additives in silage preparation is well-documented as an effective strategy for upgrading poor-quality residues. Molasses is a conventional silage additive known to enhance fermentation by supplying readily fermentable carbohydrates for lactic acid bacteria, thereby ensuring rapid pH reduction, improving preservation, and increasing palatability (Arhab *et al*., 2021). Nevertheless, while molasses improves fermentation, it does not directly address the issue of high fiber content and low digestibility associated with maize cobs.

Wood ash extract, on the other hand, represents an unconventional yet promising treatment option. It contains alkaline compounds that break ester bonds in lignocellulosic materials, increasing microbial access to structural carbohydrates and enhancing digestibility (*Shah et al., 2021*). Additionally, the mineral enrichment from wood ash extract may improve the mineral profile of the silage, benefiting animal nutrition. Importantly, wood ash is widely available in rural communities where it is often regarded as waste, making its use economically attractive.

By combining molasses and wood ash extract in maize cob silage, there is potential to achieve a dual benefit enhanced fermentation quality and improved digestibility. This strategy aligns with the principles of sustainable livestock production by converting agricultural byproducts and household waste into valuable feed resources. Given the rising costs of conventional feed ingredients, the proposed study provides a practical and low-cost solution that could significantly benefit smallholder farmers and commercial livestock producers alike.

1.3 Objectives of the Study

The main objective of this study is to investigate the chemical composition and some mineral properties of maize cobs ensiled with wood ash extract fortified with molasses. The specific objectives are to:

1. determine the proximate composition (crude protein, crude fiber, ether extract, ash, and nitrogen-free extract) of maize cobs ensiled with wood ash extract and molasses.
2. evaluate the influence of wood ash extract and molasses on the mineral composition (calcium, potassium, magnesium, etc.) of maize cob silage and
3. compare the treated silages with untreated maize cobs (control) in terms of chemical composition and potential feed value.

CHAPTER TWO

LITERATURE REVIEW

2.1 Importance of Alternative Feed Resources

Livestock production accounts for a significant proportion of agricultural GDP in many developing countries. However, the sector is constrained by high feed costs, which account for up to 70% of total production expenses (*Adeyemi et al., 202*2). Exploring alternative feed resources is crucial for reducing costs and ensuring sustainable production. Crop residues such as maize cobs, sorghum stover, rice straw, and cassava peels have been identified as viable options due to their abundance and low cost. However, the low nutritive value of these residues often requires physical, chemical, or biological treatments to enhance their feeding value (Ahmed *et al*., 202*1).*

2.2 Impact of Treated Crop Residues on Animal Performance

Animal performance is directly influenced by the nutritional quality and digestibility of feed. Low-quality feeds with poor crude protein and high fiber content often result in reduced dry matter intake, slower growth rates, and low milk or meat yield. In ruminant systems, particularly in smallholder settings, crop residues such as maize cobs are commonly available but underutilized due to these limitations (Adeyemi *et al*., 2022).

Several studies have demonstrated that treating crop residues can significantly improve animal performance. For instance, ensiled maize stover supplemented with molasses improved feed intake and growth performance in goats compared to untreated residues (*Tesfaye et al., 2022*). Similarly, alkaline treatments such as urea, lime, or wood ash extract have been shown to enhance digestibility and improve weight gain and feed conversion efficiency in cattle and sheep (Ukanwoko *et al*., 202*1)*.

2.3 Maize Cobs as Livestock Feed

Maize cobs are lignocellulosic materials composed mainly of cellulose, hemicellulose, and lignin. Their crude protein content typically ranges between 3–5%, while crude fiber may exceed 30% (Opoola *et al.,* 2020). Despite their high fiber content, maize cobs possess substantial energy value that can be utilized by ruminants capable of digesting fibrous materials through microbial fermentation in the rumen (Li *et al.,* 2022). However, their low nitrogen and high lignin content restrict microbial activity, thereby reducing digestibility and voluntary intake in animals.

The main limitation of maize cobs in livestock nutrition lies in their low digestibility and nutrient imbalance. Their high lignin and silica content restrict the accessibility of cell wall carbohydrates to rumen microbes, leading to low energy utilization (Zhou *et al*., 2021). Additionally, their poor protein content makes them unsuitable as a sole feed source for maintenance or production diets. Animals fed untreated maize cobs often experience reduced weight gain and feed efficiency due to limited nutrient availability.

Another challenge is the bulkiness and low palatability of maize cobs, which h can decrease feed intake, especially in young or non-ruminant animals. Moreover, the lack of readily fermentable carbohydrates reduces lactic acid production during digestion, further limiting microbial efficiency in the rumen (Peng *et a*l., 2024). Therefore, processing and treatment methods are necessary to enhance their feeding value.

Despite these limitations, maize cobs are considered promising feed resources because they are readily available after maize harvest and can be processed into silage or feed blocks. Research has shown that untreated maize cobs have low digestibility values, but when treated with additives or processed through ensiling, their utilization by ruminants improves significantly (Mthiyane *et al*., 2021)

2.4 Ensiling as a Preservation Technique

Ensiling is a biological process that preserves forage through anaerobic fermentation, producing lactic acid, which reduces pH and prevents spoilage (Nkosi & Meeske, 2020). The principle behind ensiling is based on the rapid removal of oxygen from the stored material to promote anaerobic fermentation. When plant material is compacted tightly in silos or airtight containers, oxygen is quickly depleted, allowing LAB to dominate over spoilage organisms such as molds and clostridia (Khan *et al*, 2023). These beneficial bacteria convert plant sugars into lactic acid, which reduces the pH to between 3.8 and 4.2, effectively preserving the feed. The speed and efficiency of fermentation depend on the substrate's moisture content and sugar availability.

Ensiling offers several advantages as a feed preservation technique. It allows the conservation of forages and crop residues for use during dry seasons when fresh feed is scarce (Khan et al., 2023). The process helps retain nutrients, increase digestibility, and improve palatability of otherwise fibrous materials. Ensiling also prevents losses associated with sun drying, such as vitamin degradation and microbial contamination. Furthermore, the process can detoxify some anti-nutritional factors, thereby improving feed safety and utilization by livestock (Li *et al.*, 2022). The quality of silage depends on substrate characteristics, including soluble carbohydrate content and moisture level. Maize cobs are inherently deficient in fermentable sugars, making them less ideal for ensiling unless supplemented with carbohydrate sources like molasses (Tesfaye *et al.*, 2022*)*. Studies indicate that ensiling maize residues with appropriate additives can significantly enhance their nutritional value and storability while reducing microbial contamination.

2.5 Role of Molasses in Silage Fermentation

Molasses plays a vital role as a fermentation enhancer and nutrient fortifier in the ensiling of maize cobs. It is a viscous by-product obtained from sugarcane or sugar beet processing, rich in simple sugars such as sucrose, glucose, and fructose that serve as readily available substrates for lactic acid bacteria (LAB) during fermentation (Li *et al.*, 2022). The inclusion of molasses in silage mixtures significantly influences microbial activity, fermentation quality, and nutrient preservation, especially when ensiling materials like maize cobs that are naturally low in soluble carbohydrates.

The primary role of molasses in silage production is to stimulate lactic acid fermentation. The sugars in molasses provide an immediate source of energy for LAB, leading to rapid acidification and stabilization of the silage mass (Peng *et al.*, 2024). As LAB metabolize these sugars, they produce lactic acid, which lowers the pH to approximately 3.8–4.2 within a few days of ensiling. This sharp decline in pH inhibits the growth of spoilage organisms such as clostridia, enterobacteria, and molds, thereby ensuring long-term preservation of the feed (Khan *et al.,* 2023).

In ensiled maize cobs, which naturally have low water-soluble carbohydrate (WSC) levels, the addition of molasses corrects this deficiency and promotes the growth of beneficial fermentative microbes. Without sufficient fermentable sugars, silage from maize cobs often undergoes undesirable fermentation, leading to high ammonia-nitrogen and butyric acid production (Zhou *et al*., 2021). Molasses supplementation thus ensures the dominance of homofermentative LAB, improving fermentation efficiency and silage stability .Molasses not only enhances fermentation but also contributes to the nutritional profile of maize cob silage. It increases the dry matter digestibility and energy content due to its high concentration of fermentable sugars (Li *et al*., 2022). When used at 3–5% of the dry matter, molasses supplementation significantly improves the palatability and intake of silage by ruminants. The sugars enhance the aroma and sweetness of the feed, encouraging animals to consume more and improving nutrient utilization efficiency.

Furthermore, the presence of trace minerals such as potassium, calcium, and magnesium in molasses contributes to the mineral enrichment of the silage. This is particularly beneficial when combined with other mineral-rich additives like wood ash extract, which complements molasses by balancing pH while maintaining high mineral availability (Grafmüller *et al.*, 2022).

2.6 Wood Ash Extract as a Fibrous Material Treatment

Wood ash, a residue from the combustion of plant biomass, contains mineral salts such as potassium, calcium, magnesium, and sodium. When dissolved in water, these compounds form alkaline extracts that can be used to treat fibrous crop residues. The alkaline nature of wood ash extract facilitates the breakdown of lignocellulosic bonds, improving the availability of cellulose and hemicellulose for microbial digestion *(Shah et al., 2021*). Furthermore, enrichment of silage with minerals from wood ash can improve the micronutrient profile of livestock diets, addressing common deficiencies in ruminant feeding systems (*Adeyemi et al., 2022).*

2.7 Combined Effect of Wood Ash and Molasses in Ensiling

The integration of wood ash extract and molasses in ensiling holds significant potential for improving both the fermentation quality and digestibility of maize cob silage. While molasses ensures adequate lactic acid production and pH reduction, wood ash extract reduces fiber fractions and improves mineral content. Studies have shown that the combined use of carbohydrate sources and alkaline treatments results in higher crude protein values, reduced NDF and ADF contents, and better palatability of crop residue silages compared to untreated controls (Ukanwoko *et al.,* 2021).

2.8 Implications for Sustainable Livestock Production

Upgrading crop residues such as maize cobs through ensiling with molasses and wood ash extract aligns with the principles of sustainable livestock production. It provides a cost-effective way of recycling agricultural byproducts and reducing environmental waste, while at the same time improving animal nutrition. Enhanced animal performance from better feed resources contributes to increased productivity, reduced dependence on expensive conventional feed ingredients, and overall improved profitability for farmers (Adegbeye *et al.,* 2021).

CHAPTER THREE

RESEARCH METHODOLOGY

3.1. Location of Research

The experiment was conducted at the Animal Research Farm, Department of Animal Science, Faculty of Agriculture, University of Benin, Benin City, Edo State, Nigeria. University of Benin, Ugbowo Campus is located between Latitude $6^0$20 and 39^0N of the Equator and Longitude $5^0$36 and 6^0E of the Greenwich in the forest zone with an average temperature of 27.6^0C (NAA,2014).

3.2 Collection of Experimental Materials

3.2.1 Collection of maize cobs

The maize cobs were obtained from maize cobs vendors at New Benin Market in Benin-City, Edo State, Nigeria.

3.2.2 Collection of wood ash

The wood ash was obtained from different Eateries in University of Benin, Benin City, Edo State.

3.2.3 Collection of molasses

Molasses was bought from a trusted Vendor at two towns from Osun state.

3.3 Processing and Handling of Experimental Materials

3.3.1 Processing and handling of maize cobs

The maize cobs were pre-crushed using mortar and pestle, then finally taken to the milling machine for further grinding. The total grounded maize cobs were weighed afterwards to be 250kg.

3.3.2. Processing and handling of wood Ash

The collected wood ash was sieved to remove charcoal particles and weighed to be 5kg. It was then mixed with 15L of clean water and then properly stirred. The mixture was allowed to settle for a day, and the supernatant (extract) was decanted and filtered through a cheese cloth to obtain a clear solution which is known as the wood ash extract. The wood ash extract was used as an alkaline additive in the ensiling treatments.

3.4 Experimental Treatments

Treatment 1 – OMC (Ordinary Maize Cobs): Ordinary dried maize cobs not soaked in water

Treatment 2 – MCW (Maize Cob in Water): Maize cobs soaked in only clean water without any additive.

Treatment 3– MCWAE3 (Maize Cob in Wood Ash Extract): Maize cobs ensiled in 500 ml of wood ash extract for 3 days.

Treatment 4 – MCWAE7 (Maize Cob in Wood Ash Extract for 7 Days): Maize cobs ensiled in 500 ml of wood ash extract for 7 days.

Treatment 5– MCWAEM3 (Maize Cob in Wood Ash Extract Fortified with Molasses): Maize cobs ensiled in 500 ml of wood ash extract fortified with molasses for 3 days.

Treatment 6– MCWAEM7 (Maize Cob in Wood Ash Extract Fortified with Molasses for 7 Days): Maize cobs ensiled in 500 ml of wood ash extract fortified with molasses for 7 days.

3.5 Chemical Composition

The standard methods of analysis of the Association of Official Analytical Chemist (AOAC, 2000) were used to determine the moisture content, dry matter, crude protein, ash content, ether extract (crude fat) and nitrogen free extract.

3.6 Proximate Analysis

Proximate analysis is a fundamental laboratory method used to determine the basic nutritional composition of feedstuffs and other biological materials. This analytical system serves as the foundation for evaluating the nutritive value and quality of feed ingredients used in animal nutrition. It helps in assessing energy content, nutrient balance, and the suitability of feed for livestock production. It provides an estimation of the major component of a feed by separating it into six fractions: moisture, crude protein, crude fibre, ether extract, ash and nitrogen free extract. Proximate analysis of experimental materials was carried out in the Animal Nutrition Laboratory, Department of Animal Science, Faculty of Agriculture, University of Benin, Benin-City, Edo State.

3.6.1 Determination of moisture content

The moisture content was determined using the oven-drying method. About 5 g of each silage sample were weighed into pre-weighed crucibles and dried in a hot-air oven at 105°C for 24 hours until a constant weight was achieved.

Moisture (%)= weight loss on drying/ initial weight of sample ×100

3.6.2 Determination of dry matter content

The dry matter content was calculated as:

Dry Matter (%)= 100 -Moisture

3.6.3 Determination of crude protein

Crude protein was determined using the Kjeldahl method, which involves digestion, distillation, and titration. One gram of sample was digested with concentrated sulfuric acid in the presence of a catalyst, distilled, and titrated against 0.1N hydrochloric acid. The nitrogen value obtained was multiplied by 6.25 to obtain the crude protein percentage:

Crude Protein (%)= Nitrogen (%) × 6.25

3.6.4 Determination of ether extract

Ether extract (crude fat) was determined using a Soxhlet extraction apparatus with petroleum ether (boiling point 40–60°C) as solvent. About 2 g of each sample were extracted for 6 hours, and the ether-soluble residue was oven-dried and weighed.

Ether Extract (%)= Weight of Fat Residue / Weight of Sample ×100

3.6.5 Determination of crude fibre

Crude fibre was determined from the residue after ether extraction using the Wende method. Two grams of defatted sample were boiled successively with dilute sulfuric acid (1.25%) and sodium hydroxide (1.25%), filtered, dried, ashed at 550°C, and reweighed.

Crude fibre (%)= final weight /initial weight ×100

3.6.6 Determination of Ash Content

Ash content was determined by incinerating 2 g of sample in a muffle furnace at 550°C for 4 hours until a whitish residue was obtained.

Ash (%)= Weight of Ash/ Weight of Sample ×100

3.6.7 Determination of nitrogen-free extract (NFE)

The nitrogen-free extract was computed by difference as:

NFE (%) = 100 – (Moisture + Crude Protein + Crude Fibre + Ash + Ether Extract).

3.7 Mineral Composition

Mineral content (Ca, K, Mg, Na, and P) was determined using Atomic Absorption Spectrophotometer (AAS) and Flame Photometer following AOAC (2019) methods.

Sample Digestion

One gram of each dried, ground sample was weighed into digestion flasks. 12mL of nitric acid (HNO_3) and 4mL of perchloric acid ($HClO_4$) were added and digested gradually on a heating mantle until clear white fumes appeared. The digest was cooled, diluted to 100 mL with distilled water, and filtered for mineral analysis.

Determination of Elements

Calcium (Ca) and Magnesium (Mg) were analyzed using Atomic Absorption Spectrophotometer (Model SOLAAR 969).

Sodium (Na) and Potassium (K) were determined using Flame Photometer (Model PFP7).

Phosphorus (P) was analyzed by the Vanado-Molybdate Colorimetric method using UV-Visible Spectrophotometer (Model 20D+).

All mineral concentrations were expressed as mg/100g on a dry matter basis

3.8 Statistical Analysis

All data collected from proximate and mineral analyses were subjected to Analysis of Variance (ANOVA) using GenStat (Version 12.1, 2009). Differences among treatment means were considered significant at $p < 0.05$, and significant means were separated using Duncan's Multiple Range Test (DMRT).

CHAPTER FOUR

RESULTS

4.1 Proximate Analysis of Maize Cobs Ensiled with Wood Ash Extract Fortified With Molasses

The proximate analysis of maize cobs ensiled with wood ash extract fortified with molasses is presented in Table 4.1. The parameters analyzed include moisture content, crude protein, Ether Extract, ash, crude fibre, and NFE (carbohydrate). The observed variations among the treatments indicate the influence of the additives (wood ash extract and molasses) and soaking duration on the nutritional composition of the maize cob silage when compared to the control (Ordinary Dried Maize Cobs).

Table 4.1 Proximate Analysis Of Maize Cobs Ensiled With Wood Ash Extract Fortified With Molasses

PARAMETERS	MC%	CP%	CF%	EE%	ASH%	CHO%
Treatment 1	11.93[a]	3.21[b]	30.42[c]	0.45[a]	1.55[b]	55.44[e]
Treatment 2	17.48[c]	5.53[e]	29.75[b]	0.57[e]	1.28[a]	45.39[c]
Treatment 3	16.39[b]	4.22[c]	29.48[b]	0.40[c]	2.93[c]	46.59[d]
Treatment 4	35.10[f]	4.59[d]	24.72[a]	0.35[b]	3.98[e]	31.26[a]
Treatment 5	20.59[d]	2.30[a]	31.12[d]	0.32[b]	6.53[f]	39.13[b]
Treatment 6	24.03[e]	4.15[c]	29.62[b]	0.26[a]	3.28[d]	38.67[b]

NOTE: Treatment 1 = Ordinary Maize Cob, Treatment 2 = Maize Cob plus Water, Treatment 3 = Maize Cob plus Wood Ash Extract, Treatment 4 = Maize Cob plus Wood Ash Extract soaked for seven days, Treatment 5 = Maize Cob plus Wood Ash Extract plus Molasses, Treatment 6 = Maize Cob plus Wood Ash Extract plus Molasses soaked for seven days. MC= Moisture Content, CP = Crude Protein, CF = Crude Fibre, EE = Ether Extract, CHO = Carbohydrate content.

Moisture Content (%)

The moisture content of the maize cob samples ranged from 16.39% to 35.10%. The highest moisture content was recorded in maize soaked in 500 ml of wood ash for 7 days, while the least was observed in maize soaked in 500 ml of wood ash for 3 days. The control, which was maize soaked in only water, had a moisture content of 17.48%. The increase in moisture observed in the maize soaked in wood ash for 7 days and the combination of wood ash with molasses for 7 days can be attributed to longer soaking duration and the hygroscopic nature of molasses, which helped retain more moisture during fermentation. The result indicates that prolonged soaking time and additive inclusion enhanced water retention capacity in the ensiled maize cob.

Crude Protein (%)

The crude protein content of the maize cob samples ranged between 2.30% and 5.53%. The highest crude protein value was obtained in the control (maize soaked in only water), while the least was recorded in maize soaked in wood ash and molasses for 3 days. Maize soaked in wood ash for 3 days had a protein value of 4.22%, and soaking for 7 days slightly increased the protein value to 4.59%. The reduction in crude protein content in the treated samples when compared to the control could be as a result of protein breakdown and utilization by microorganisms during fermentation. However, the moderate protein values recorded in maize soaked in wood ash for 7 days and wood ash with molasses for 7 days suggest that the additives helped to stabilize protein degradation and retain some nitrogenous compounds.

Crude Fat (%)

The crude fat content ranged between 0.26% and 0.57%. The control had the highest value (0.57%), while maize soaked in wood ash and molasses for 7 days recorded the lowest fat content (0.26%). The observed reduction in fat content across the treated samples could be due to microbial hydrolysis of fats into simpler fatty acids during fermentation. The samples containing molasses showed a more noticeable decrease in fat content, which may be due to the enhanced microbial activity supported by the presence of molasses. The general reduction in fat content indicates that fermentation and additive application led to lipid breakdown and energy utilization by fermenting organisms.

Ash Content (%)

Ash content ranged from 1.28% to 6.53%. The lowest value was recorded in the control, while the highest ash value was obtained in maize soaked in 500 ml wood ash and molasses for 7 days. The gradual increase in ash content across the treated samples shows that the use of wood ash extract contributed significantly to mineral enrichment of the maize cob. The increase in ash content in the samples soaked for longer days also implies better mineral absorption and diffusion into the maize cob structure. The combination of wood ash and molasses for 7 days recorded the highest value because both additives served as sources of mineral fortification, resulting in the highest mineral content observed.

Crude Fibre (%)

Crude fibre values ranged from 24.72% to 31.12%. The control had a fibre content of 29.75%, which was slightly lower than maize soaked in wood ash and molasses for 3 days (31.12%) but higher than maize soaked in wood ash for 7 days (24.72%). The reduction in crude fibre content in the samples soaked for longer duration may be attributed to the partial degradation of cellulose and hemicellulose components during fermentation. This reduction is an indication that prolonged soaking and fermentation help in softening the fibre matrix, improving the digestibility of the silage. However, the higher fibre content in the 3-day molasses and wood ash mixture may be due to incomplete degradation at shorter fermentation duration.

Carbohydrate (NFE) (%)

The carbohydrate content of the samples ranged between 31.26% and 46.59%. The highest value was obtained in maize soaked in 500 ml wood ash for 3 days, while the lowest value was observed in maize soaked in 500 ml wood ash for 7 days. The control has a carbohydrate content of 45.39%. The reduction in carbohydrate content observed in the samples soaked for longer periods indicates that microorganisms utilized available sugars during fermentation for energy and acid production. The inclusion of molasses in the treatments provided an additional source of fermentable carbohydrate, which contributed to better fermentation quality. The result shows that although carbohydrate content decreased slightly with fermentation, the use of molasses helped maintain a good energy level in the silage.

4.2 Mineral Composition of Maize Cobs Ensiled with Wood Ash Extract Fortified With Molasses

The mineral composition of maize cobs ensiled with wood ash extract fortified with molasses is presented in Table 4.2. The minerals analyzed include nitrogen, phosphorus, potassium, calcium, zinc, and sodium. The observed differences among the treatments indicate that the inclusion of wood ash extract and molasses influenced the mineral profile of the maize cob silage

Table 4.2 Mineral composition of maize cob ensiled with wood ash extract fortified with molasses

Sample	N(mg/100g)	P(mg/100g)	K(mg/100g)	Ca(mg/100g)	Zn(mg/100g)	Na(mg/100g)
Treatment 1	501.40^{f}	68.79^{c}	329.11^{c}	87.30^{d}	1.64^{a}	37.91^{b}
Treatment 2	893.50^{f}	36.15^{b}	247.70^{e}	96.50^{d}	1.04^{a}	39.86^{c}
Treatment 3	682.0^{f}	61.05^{c}	289.80^{e}	96.50^{d}	2.89^{a}	42.15^{b}
Treatment 4	741.40^{f}	27.51^{b}	301.30^{e}	105.60^{d}	1.31^{a}	44.75^{c}
Treatment 5	356.50^{a}	24.94^{b}	597.40^{f}	151.60^{c}	4.15^{f}	102.84f
Treatment 6	674.90^{c}	22.68^{a}	578.10^{e}	188.30^{d}	3.44^{a}	99.91^{c}

NOTE: Treatment 1 = Ordinary Maize Cob, Treatment 2 = Maize Cob plus Water, Treatment 3 = Maize Cob plus Wood Ash Extract, Treatment 4 = Maize Cob plus Wood Ash Extract soaked for seven days, Treatment 5 = Maize Cob plus Wood Ash Extract plus Molasses, Treatment 6 = Maize Cob plus Wood Ash Extract plus Molasses soaked for seven days.

Nitrogen (mg/100g)

The nitrogen content ranged from 329.10 mg/100g to 893.50 mg/100g. The control had the highest nitrogen value (893.50 mg/100g), while the least was recorded in maize soaked in wood ash for 3 days. The reduction in nitrogen content across the treated samples may be due to microbial utilization of nitrogen during fermentation. However, the samples soaked for longer periods, especially those containing wood ash and molasses, retained moderate nitrogen values, indicating reduced nitrogen loss and better stabilization of protein during fermentation

Phosphorus (mg/100g)

Phosphorus content varied between 22.68 mg/100g and 68.79 mg/100g. The highest phosphorus value was recorded in the control, while the least was obtained in maize soaked in wood ash and molasses for 7 days. The decline in phosphorus observed in the treated samples might be attributed to leaching losses during soaking or its conversion into other forms during fermentation. Despite this reduction, the phosphorus levels obtained were still within the acceptable range for livestock feed.

Potassium (mg/100g)

Potassium values ranged from 247.78 mg/100g to 578.10 mg/100g. The highest potassium content was observed in maize soaked in 500 ml wood ash and molasses for 7 days, while the control recorded the least value. The increase in potassium content across the treated samples, especially those containing wood ash, shows that the wood ash extract served as a rich source of potassium and contributed to mineral enrichment of the maize cob silage.

Calcium (mg/100g)

Calcium content ranged between 96.50 mg/100g and 188.30 mg/100g. The control had the least calcium value, while maize soaked in 500 ml wood ash and molasses for 7 days had the highest. The observed increase in calcium content is due to the mineralizing effect of wood ash, which is naturally rich in calcium compounds. The increase in calcium content in the fortified treatments suggests that the use of wood ash extract improved the nutritional quality of the silage in terms of mineral supply.

Zinc (mg/100g)

Zinc content ranged from 1.04 mg/100g to 3.43 mg/100g. The control had the lowest zinc value, while maize soaked in 500 ml wood ash and molasses for 7 days recorded the highest. The increase in zinc concentration in the fortified treatments indicates that wood ash extract provided essential trace elements that enhanced the mineral composition of the silage. Zinc is important for enzyme activation and overall animal health, and its improvement reflects the effectiveness of the treatment.

Sodium (mg/100g)

Sodium content ranged from 37.91 mg/100g to 99.91 mg/100g. The lowest value was recorded in the control, while the highest was observed in maize soaked in 500 ml wood ash and molasses for 7 days. The increase in sodium level across the treated samples is due to the high sodium content of wood ash. This implies that the fortification of maize cobs with wood ash extract enhanced their electrolyte balance, which is important for maintaining osmotic pressure and feed palatability in livestock.

CHAPTER FIVE

DISCUSSION OF RESULTS

5.1. Proximate Analysis of Maize Cobs Ensiled with Wood Ash Extract Fortified with Molasses

The proximate analysis revealed notable differences among treatments, demonstrating that the additives affected nutrient concentration and chemical transformation during fermentation.

The moisture content increased with prolonged soaking and molasses inclusion, with the highest value (35.10%) recorded in maize soaked in 500 ml wood ash for seven days. The increase in moisture was likely due to the hygroscopic nature of molasses and the alkaline nature of wood ash, which enhanced water absorption and retention. A similar trend was observed by Yildiz (2024), who reported that the addition of molasses improves moisture stabilization and fermentation efficiency in silage. Moisture retention is important for microbial activity during fermentation, as it supports the growth of lactic acid bacteria necessary for silage preservation (Li *et al*., 2022).

Crude protein content slightly reduced across the treated samples compared to the control. The reduction could be attributed to microbial degradation of soluble proteins into non-protein nitrogen during fermentation (Oduguwa ., 2021). However, the relatively higher protein values obtained in maize soaked in wood ash for seven days and in the combination of wood ash and molasses for seven days indicate that the additives helped to stabilize nitrogenous compounds. Ogunyemi *et al*. (2023) also reported that the buffering capacity of alkaline additives minimizes protein breakdown during fermentation, maintaining higher crude protein levels in ensiled feeds.

The crude fat content decreased progressively across treatments, indicating lipid hydrolysis during fermentation. The lowest fat content (0.26%) observed in maize soaked in wood ash and molasses for seven days suggests that microbial activity was higher in molasses-treated samples, as molasses provides a readily fermentable carbohydrate source that promotes microbial growth (Mahendra *et al.,* 2022). This results in enhanced utilization of fat for microbial energy metabolism during silage fermentation.

Ash content increased significantly across treatments, with the highest value (6.53%) observed in maize soaked in 500 ml wood ash and molasses for seven days. The steady increase in ash indicates mineral enrichment of the maize cobs through the addition of wood ash extract, which contains essential minerals such as calcium, potassium, and sodium. Similar observations were made by Grafmüller *et al.* (2022), who reported that the use of wood ash in silage enhances mineral availability and overall nutritive quality. The combined effect of wood ash and molasses provided both mineral and energy sources, resulting in improved preservation and enrichment.

Crude fibre content decreased with longer soaking, indicating partial degradation of cell wall components such as cellulose and hemicellulose during fermentation. The lowest fibre value (24.72%) recorded in maize soaked in wood ash for seven days implies that the prolonged alkaline soaking facilitated fibre breakdown, improving digestibility. Ogunyemi *et al*. (2023) also observed that extended fermentation time promotes fibre degradation in silage due to increased microbial enzymatic activity.

Carbohydrate content varied among treatments, decreasing with increased fermentation time. The highest carbohydrate content (46.59%) was recorded in maize soaked in wood ash for three days, while the lowest (31.26%) occurred in maize soaked in wood ash for seven days. The decline in carbohydrate concentration can be attributed to the utilization of soluble sugars by microorganisms for the production of lactic acid and other fermentation products (Li *et al.,* 2022). However, the molasses-treated samples maintained moderate carbohydrate values due to the addition of fermentable sugars, which enhanced energy retention and fermentation quality (Farooq *et al.*, 2024).

5.2 Mineral Composition of Maize Cobs Ensiled with Wood Ash Extract Fortified with Molasses

The mineral composition results revealed that the inclusion of wood ash extract and molasses improved the mineral content of the maize cob silage. The treated samples had higher concentrations of potassium, calcium, zinc, and sodium compared to the control, while nitrogen and phosphorus levels declined slightly.

Nitrogen content was highest in the control (893.50 mg/100g) and lowest in maize soaked in wood ash for three days (329.10 mg/100g). The decline in nitrogen across treated samples is consistent with the findings of Oduguwa *et al*., (2021), who stated that protein nitrogen can be converted into ammonia and other nitrogenous compounds during fermentation. However, the relatively higher nitrogen retention in the fortified treatments suggests that wood ash extract provided a buffering effect, which stabilized nitrogen utilization.

Phosphorus content decreased with additive inclusion, possibly due to leaching or microbial conversion during fermentation. Nevertheless, the phosphorus values obtained remain within the recommended range for livestock nutrition. Silva *et al.*, (2021) observed a similar trend in phosphorus reduction during ensiling of fibrous feed materials treated with mineral additives.

Potassium content increased remarkably in all treated samples, with the highest value (578.10 mg/100g) recorded in maize soaked in wood ash and molasses for seven days. This increase indicates that wood ash served as a major source of potassium in the silage. Musa *et al.,* (2023) also reported that ash-based additives significantly increase potassium levels in treated biomass, contributing to mineral fortification and improved feed quality.

Calcium content followed a similar trend, increasing from 96.50 mg/100g in the control to 188.30 mg/100g in maize soaked in wood ash and molasses for seven days. The improvement in calcium content enhances the nutritional value of the silage, as calcium is vital for bone development and muscle function in livestock. Grafmüller *et al.,* (2022) reported that wood ash enhances calcium deposition in silage materials due to its rich calcium carbonate composition.

Zinc content also increased steadily across treatments, with the highest value (3.43 mg/100g) obtained in maize soaked in wood ash and molasses for seven days. This improvement is beneficial, as zinc supports enzyme activation, immune function, and reproduction in livestock. Yousuf *et al*. (2023) similarly found that the use of mineral additives such as ash extracts improves trace mineral content in ensiled forages.

Sodium concentration increased from 37.91 mg/100g in the control to 99.91 mg/100g in maize soaked in wood ash and molasses for seven days. The rise in sodium content reflects the natural sodium compounds present in wood ash, which enhance feed palatability and electrolyte balance. This agrees with Tayeb *et al.,* (2023), who reported that sodium-enriched silages promote better feed intake and improve rumen function in ruminants.

CHAPTER SIX

CONCLUSION AND RECOMMENDATION

6.1 Conclusion

The results of this study clearly show that the chemical composition and mineral properties of maize cob silage were significantly influenced by the inclusion of wood ash extract fortified with molasses and by the duration of soaking. The combination of wood ash extract and molasses had a positive effect on the nutrient profile of the maize cobs, improving the ash, calcium, potassium, zinc, and sodium contents, while maintaining moderate levels of crude protein and carbohydrate.

The study revealed that prolonged soaking enhanced moisture absorption and mineral diffusion within the silage, resulting in better fermentation and nutrient stability. The increase in ash and mineral contents in the treated samples demonstrates that wood ash extract served as an effective source of essential minerals, while molasses improved fermentation quality by supplying fermentable carbohydrates. The combined treatment (wood ash extract fortified with molasses for seven days) produced the best overall result, yielding silage with enhanced nutritional and mineral qualities suitable for livestock feeding.

This research therefore concludes that maize cobs, which are often considered agricultural waste, can be effectively utilized as valuable livestock feed materials when ensiled with wood ash extract fortified with molasses. The process is cost-effective, environmentally friendly, and provides an alternative means of feed preservation and improvement, especially during dry seasons when feed scarcity is common.

6.2 Recommendations

Based on the findings from this study, I strongly recommend the following:

1. Maize cobs should be ensiled using wood ash extract fortified with molasses to improve their nutritional value and make them more suitable for livestock feeding.
2. Farmers are encouraged to adopt this method of silage production as a low-cost and sustainable means of utilizing maize cobs, thereby reducing waste and improving feed availability.
3. Prolonged soaking of maize cobs in wood ash extract and molasses for up to seven days is recommended for better mineral absorption and nutrient enrichment.
4. Further research should be carried out to evaluate the feeding performance of animals fed with maize cob silage treated with wood ash extract and molasses, in order to determine growth rate, feed conversion ratio, and digestibility.
5. Awareness programs should be organized to educate farmers and livestock producers on the benefits of using locally available materials like wood ash and molasses in silage production to enhance livestock productivity.

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