EFFECTS OF TIME (7 DAYS) ON THE CHEMICAL AND PHYSICAL PROPERTIES OF MAIZE COBS ENSILED WITH WOOD ASH EXTRACT

BY

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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 Kumawuese Cordelia AER, Department of Animal science, Faculty of Agriculture, University of Benin, Benin city, Nigeria, under the supervision of Mrs O. B. Abiloro.

_____ _____

Mrs O. B. Abiloro Signature & Date

Project supervisor

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Dr. N. C. Akaeze Signature & Date

Head of Department

DEDICATION

This research work is dedicated to God almighty and my lovely parents Mr. and Mrs. Aer T.T

ACKNOWLEDGEMENT

I wish to express my sincere gratitude to the Almighty God for His guidance, wisdom, and strength throughout the course of this project. I would like to express my deep and upmost gratitude to my Project supervisor, Mrs. Abiloro for her continuous support and guidance 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.A Imasuen, Prof. J.M. Omoyhaki, Prof. M.A. Bamikole, Prof. S.O. Nwokoro, Prof. J. O Oyedeji, Prof. F.U. Igede, Dr. P.A. Ebabhamiegbho, Dr. G.I.O. Odafe, Dr. (Mrs). G.O. Egigba, Mr. Paul Aduba, Dr. G. Bello-onaghise, 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

Maize cobs are an abundant agricultural by-product with limited feeding value due to their low protein content and high fiber composition. Ensiling is a preservation method that can enhance the quality of crop residues, while additives such as wood ash extract may further improve fermentation and nutrient retention. Freshly harvested maize cobs were divided into three groups: one treated with wood ash extract, another soaked in water for 30 mins and the other ordinary maize cobs. The first treatment was ensiled for seven days under anaerobic conditions. At the end of the ensiling period, samples were analyzed for chemical composition (crude protein, crude fiber, ash content, and moisture) and physical properties (color, odor, and texture). Results showed that the wood ash extract treatment (Trt3) was highly effective. It significantly reduced Crude Fiber (from 30.42% to 24.72%), indicating successful alkaline delignification, and lowered Carbohydrates (from 55.44% to 31.26%) through chemical breakdown and fermentation. This treatment also acted as a mineral supplement, significantly increasing the total Ash content (from 1.55% to 3.98%) and fortifying the cobs with Calcium (105.6 mg/100mg) and Sodium (44.75 mg/100mg).

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

The challenge of feeding livestock during dry seasons has necessitated innovative approaches to preserve agricultural by-products for animal nutrition. Maize (*Zea mays* L.) is one of the most widely cultivated cereal crops globally. Following harvest and grain removal, maize cobs constitute a significant portion of agricultural residue. These lignocellulosic materials, often discarded or burned, represent an underutilized resource with potential application in ruminant nutrition.

Ensilage technology has emerged as an effective preservation method for maintaining the nutritional quality of feedstuffs. The process involves anaerobic fermentation of forage materials under controlled conditions, where lactic acid bacteria convert water-soluble carbohydrates into organic acids, primarily lactic acid, thereby lowering the pH and preventing spoilage (Weinberg and Ashbell, 2003; Kung *et al.,* 2018). Traditional ensilage methods have been extensively studied; however, the integration of alkaline treatments, such as wood ash extract, presents a novel approach to enhance the digestibility and nutritional value of fibrous agricultural residues.

Wood ash, a by-product of biomass combustion, contains substantial amounts of alkaline compounds including potassium hydroxide, calcium hydroxide, and sodium

hydroxide, with pH values ranging from 9 to 13 (Demeyer *et al.,* 2001; Etiegni and Campbell, 1991). When dissolved in water, wood ash extract serves as an eco-friendly alkaline agent capable of disrupting the lignin-carbohydrate complex in plant cell walls. This disruption potentially increases the accessibility of cellulose and hemicellulose to microbial and enzymatic degradation, thereby improving the nutritive value of fibrous feeds.

The application of alkaline treatments to crop residues has demonstrated positive effects on fiber degradation and nutrient availability. Studies have shown that chemical treatment of rice straw improved organic matter digestibility and enhanced nutritional value for ruminant feeding (Sarnklong *et al.,* 2010). However, limited research exists on the combined effect of alkaline treatment and ensilage on maize cobs, particularly using wood ash extract as the alkaline source.

The duration of ensilage significantly influences the extent of fermentation and the resulting chemical and physical properties of the ensiled material. A seven-day ensilage period represents a critical phase during which rapid microbial proliferation occurs, organic acids accumulate, and pH stabilization begins (McDonald *et al.,* 1991; Muck *et al.,* 2018). Understanding the temporal changes in chemical composition, pH dynamics, fiber fractions, and physical characteristics during this period is essential for optimizing the ensilage process and maximizing the nutritional potential of treated maize cobs.

1.2 JUSTIFICATION OF THE STUDY

The sustainability of livestock production in Nigeria depends largely on the availability of affordable and nutritionally adequate feed resources. Overreliance on conventional feed ingredients such as maize grain not only increases feed costs but also limits expansion in the livestock sector (Adeola & Adegbola, 2018; Tunde *et al.,* 2021). Exploring underutilized resources such as maize cobs is therefore critical in bridging the feed supply gap (Olorunnisomo, 2018).

Ensiling provides a low-cost method of preserving maize cobs, but their poor fermentation characteristics require intervention through additives (Belewu & Belewu, 2007). While commercial silage additives are effective, their high cost makes them impractical for most smallholder farmers (Oduguwa *et al.,* 2011). Wood ash extract, being cheap, locally available, and environmentally friendly, represents a viable alternative. Its use could reduce dependence on costly additives while enhancing the nutritional and physical qualities of maize cob silage.

Moreover, promoting the use of maize cobs in animal nutrition supports environmental sustainability by reducing waste and minimizing open-field burning, which contributes to air pollution and greenhouse gas emissions. This aligns with global efforts to promote circular bio-economy and sustainable agriculture (FAO, 2021).

The findings of this study will provide practical information for livestock farmers, extension agents, and policymakers on innovative strategies for improving feed availability. They will also contribute to academic knowledge by filling gaps in research on the short-term ensiling of maize cobs with wood ash extract.

1.3 OBJECTIVES OF THE STUDY

The broad objective is to evaluate the effects of time (seven days) on the chemical and physical properties of maize cobs ensiled in wood ash extract.

The specific objectives are:

1. To assess the variations in proximate composition (crude protein, crude fiber, ash content, and ether extract) of maize cobs during seven days of ensilage in wood ash extract.
2. To examine the physical property changes (color, texture, and odor) of maize cobs during the seven-day ensilage period in wood ash extract.
3. To compare the chemical and physical composition of maize cobs treated with wood ash extract and maize cobs without wood ash extract.

CHAPTER TWO

LITERATURE REVIEW

2.1 Concept of Ensiling and Fermentation

Ensiling is a method of biological preservation, very similar in principle to the way humans pickle vegetables to keep them from spoiling. The primary goal is to take fresh, moist plant material—in this case, maize cobs—and store it under airtight conditions to lock in its nutritional value for later use. This preservation relies entirely on a natural process called anaerobic fermentation. Once the material is packed tightly to exclude oxygen, a specific group of "good" bacteria, known as lactic acid bacteria (LAB), begins to dominate the environment. These bacteria feed on the water-soluble sugars naturally present in the plant and convert them into organic acids, mainly lactic acid. As these acids accumulate, they cause the pH level of the forage to drop rapidly, creating an acidic environment that is hostile to spoilage organisms like molds and rotting bacteria (Huang *et al.,* 2021).

The timeline of this process is crucial, and the first 7 days are arguably the most important phase in the life of the silage. You can think of this first week as a race against time. The beneficial bacteria need to produce enough acid quickly to lower the pH before the harmful bacteria can take over and cause the silage to rot or smell bad. If the fermentation is successful during these first seven days, the silage enters a "stable phase" where it can theoretically be kept for months without degrading. During

this critical week, the maize cobs undergo significant changes; the acid begins to soften the tough fiber structures, and the moisture within the cobs shifts, making the nutrients more accessible and the texture more palatable for livestock (Huang *et al.,* 2021).

However, the process becomes even more interesting when an additive like wood ash extract is introduced. Wood ash is naturally alkaline—meaning it has a high pH—and is packed with minerals like calcium and potassium. Introducing an alkaline substance into an acidic fermentation process might seem contradictory, but it serves a specific, beneficial purpose. The wood ash acts as a "buffer." Instead of allowing the pH to drop instantly, the ash neutralizes some of the initial acid. This buffering effect encourages the lactic acid bacteria to work harder and longer, potentially producing a greater total amount of preserving acids in the long run. Furthermore, the alkaline minerals in the ash chemically interact with the tough cell walls of the maize cobs, helping to break them down further than fermentation alone could achieve. Therefore, fermenting maize cobs for 7 days in wood ash extract is not just about preservation; it is a dual-action process that chemically and biologically upgrades a waste product into a valuable feed (Oji & Oji, 2007; Huang *et al.,* 2021).

2.2 Maize Cobs as a Feed Resource

In Nigeria, maize cobs are a major agricultural by-product, largely due to the country's high maize production. While they are often discarded or burned, which harms the

environment, they are increasingly recognized as a valuable feed resource for livestock. This is particularly important during the dry season when green pasture is scarce and farmers struggle to find affordable feed. Since feed costs can take up a huge chunk of a farmer's budget, using cheap, readily available materials like maize cobs can make livestock farming much more profitable (Adebowale, 2018; Ogunjobi *et al.,* 2022).

Nutritionally, maize cobs are similar to low-quality hay or straw. They are rich in fiber and carbohydrates, which provide energy, but they are very low in protein. The main challenge with using them is their structure; the energy-rich cellulose is locked away behind a tough layer of lignin, a substance that animals cannot easily digest (Abiloro *et al.,* 2021). Because of this "lignin barrier," rumen microbes have a hard time breaking down the cobs to access the energy inside. Additionally, the low protein content—usually around 2-3%—is not enough to support the gut bacteria needed for digestion. If animals are fed only maize cobs without any extra protein, they will likely lose weight (Adebowale, 2018).

Despite these issues, maize cobs work well when they are managed correctly. For ruminants like sheep and goats, they are excellent for maintaining rumen function and providing bulk. Research has shown that when farmers add protein supplements—such as legume leaves or poultry manure—to a maize cob diet, the animals can maintain their weight and even grow (Ndubuisi *et al.,* 2019). In pig farming, maize

cobs can also replace some standard feed ingredients, but this has to be done carefully. If pigs eat too much fiber, it can interfere with their digestion and slow down their growth (Abiloro *et al.,* 2021).

To make maize cobs more nutritious, Nigerian researchers have looked into several processing methods. The goal is to break the tough bonds between the fiber and the lignin. Some methods are biological, such as using fungi to ferment the cobs, which boosts protein levels (Akinfemi, 2020). Others involve chemical treatments using alkaline substances like wood ash. These treatments work by softening the tough outer layers of the cob, making it easier for the animal to digest the fiber. Ultimately, while maize cobs start out as a low-quality waste product, they can be transformed into a vital feed resource that supports the Nigerian livestock industry.

2.3 Role of Additives in Silage Making

When making silage, additives act essentially as an insurance policy. Their role is to intervene in the natural fermentation process to ensure that things go right, rather than wrong. This is crucial because silage making is a biological battle between "good" bacteria (that preserve the feed) and "bad" bacteria (that rot the feed). Additives tilt the odds in favor of the good guys. Generally, these helpers fall into two main categories: stimulants and inhibitors. Stimulants, such as bacterial inoculants, introduce billions of extra lactic acid bacteria into the silo to kickstart fermentation immediately. Inhibitors, on the other hand, are acids or chemicals added to directly stop the spoilage organisms

from growing. The ultimate goal for both is the same: to produce lactic acid as quickly as possible, dropping the pH rapidly to a safe level where mold and rot cannot survive (Kung *et al.,* 2018).

In the specific context of Nigeria, additives are not just a luxury; they are often a necessity. The tropical climate poses unique challenges that farmers in colder climates don't face. For one, tropical crops and residues like maize cobs tend to be tougher and contain less natural sugar than the soft grasses used in Europe or America. Without enough sugar to fuel the fermentation, the process can stall, leading to spoiled feed. Additionally, the intense tropical heat accelerates the growth of yeasts and molds the moment a silo is opened. Additives help bridge this gap by boosting the fermentation efficiency and improving the "aerobic stability" of the silage—meaning it stays fresh longer once exposed to air (McDonald *et al.,* 1991).

Wood ash extract is a particularly interesting additive because it functions differently from standard commercial inoculants. It serves a dual purpose. First, it acts as a mineral supplement, providing calcium and potassium that the maize cobs naturally lack. Second, and perhaps more importantly, it acts as an alkaline treatment. While most additives try to make the silage more acidic, wood ash starts by being alkaline. This alkalinity helps to chemically break down the tough fiber bonds in the maize cobs during the early stages of ensiling. As the fermentation progresses, the ash buffers the acidity, creating a unique environment that can improve the final texture and

digestibility of the feed. In this way, wood ash extract is a multifunctional additive: it preserves the feed, upgrades its nutritional quality, and recycles waste minerals all at once (Oji & Oji, 2007; Abdulazeez *et al.,* 2021).

2.4 Wood Ash Extract and Its Chemical Properties

Wood ash extract might sound like a fancy chemical reagent, but it is actually a simple, locally sourced solution with powerful agricultural properties. Fundamentally, wood ash is just the inorganic minerals left behind after plant biomass is burned. While the chemical makeup can change depending on what kind of wood was burned or how hot the fire was, the magic happens when you soak this ash in water. This process, known technically as "leaching," dissolves the soluble salts hiding in the ash—primarily carbonates, bicarbonates, and hydroxides. When these salts mix with water, they turn the solution into a potent alkaline liquid, often with a pH as high as 10 or 12. This makes wood ash extract a safe, farm-made alternative to dangerous industrial chemicals like sodium hydroxide (Etiegni & Campbell, 1991).

The reason this extract is so valuable for treating feed lies in its alkalinity. It is rich in what chemists call Alkaline Earth Metals—specifically calcium, potassium, magnesium, and sodium. When you apply this high-pH solution to a fibrous material like a maize cob, a reaction called "alkaline swelling" occurs. Imagine the tough fibers of the maize cob acting like a tightly dried sponge; the alkali causes this structure to absorb water and swell up. This swelling physically bursts the chemical bonds that

hold the indigestible parts of the cell wall together. Essentially, the wood ash "pre-chews" the tough fiber, opening up the structure so that digestion can happen much more easily later on (Demeyer *et al.,* 2001).

Beyond its ability to break down fiber, wood ash extract acts as a crucial stabilizer during fermentation. In a typical silage pit, acidity is key, but wood ash provides a "buffer." This means it helps regulate the speed at which the acidity changes, preventing the environment from becoming too hostile for the beneficial bacteria too quickly. Furthermore, because it is loaded with calcium, the extract acts almost like agricultural lime. Nigerian studies have shown that this calcium doesn't just sit there; it actively improves the digestibility of the feed and supplements the animal's diet with minerals that maize cobs are naturally missing. So, by using wood ash extract, farmers are effectively recycling nutrients from firewood back into their livestock system (Oji & Oji, 2007; Etiegni & Campbell, 1991).

2.5 Effects of Ensiling Duration on Fermentation and Nutrient Quality

Making silage is essentially a process of controlled aging, and just like making cheese or wine, time is one of the most critical ingredients. The duration you leave the maize cobs in the silo determines the biological destiny of the feed. The life cycle of silage is generally divided into four distinct phases, and understanding these phases helps explain why time matters so much. It starts with the "aerobic phase," which lasts only a few hours. During this brief window, the plant material is still "breathing," using up

the remaining oxygen trapped in the bag. The goal here is speed; if this phase lasts too long, valuable sugars are burned up as heat, leaving less fuel for the fermentation that follows (McDonald *et al.,* 1991).

Once the oxygen is gone, the "fermentation phase" begins, and this is where the real work happens. This phase usually lasts from a few days to a couple of weeks. In the user's specific context of a 7-day period, we are looking at the most active part of this biological race. As soon as anaerobic conditions are established, lactic acid bacteria (LAB) wake up and start consuming the water-soluble sugars in the maize cobs. As they feast, they produce organic acids—primarily lactic acid—which causes the pH of the silage to plummet. This rapid drop in acidity is crucial because it essentially "locks" the biological state of the feed, creating an environment where rotting bacteria cannot survive (Huang *et al.,* 2021).

While the first week is vital for "setting" the silage, extending the ensiling period beyond 7 days can act like a "slow-cooking" process that further improves quality. Over a period of several weeks, the acidic juices in the silo continue to interact with the maize cobs. This prolonged exposure leads to "acid hydrolysis," where the acid slowly eats away at the tough hemicellulose in the plant cell walls. This is why silage that has been stored for longer often has lower fiber levels (NDF and ADF) and is softer than fresh material. It effectively pre-digests the fiber so the animal's stomach has less work to do (Abdulazeez *et al.,* 2021).

There is also an interesting nutritional trick that happens over time regarding protein. You might notice studies claiming that protein content increases with time. This is often due to a "concentration effect." As the bacteria consume the carbohydrates (sugars) and convert them into gas or acids, the total dry weight of the silage drops slightly. However, the nitrogen (protein) remains trapped in the silo. Because the overall weight has gone down but the protein amount stays the same, the percentage of protein appears to go up. Additionally, the bacteria themselves are rich in protein, so as they multiply into the billions over time, their own bodies add to the nutritional value of the feed (Van Soest, 1994).

However, time is a double-edged sword. While 7 days is generally the minimum "safe zone" to initiate good fermentation, leaving silage for extremely long periods (like months) requires perfect management. If the silo isn't perfectly sealed, air can slowly leak in over time. This can trigger "secondary fermentation," where bad bacteria like Clostridia start breaking down the valuable proteins into foul-smelling ammonia and butyric acid. This turns the silage slimy and unpalatable. Therefore, a duration of around 7 days is perfect for establishing stability and safety, while extending it to a few weeks can further enhance the texture and digestibility, provided the seal remains airtight (Huang *et al.,* 2021; Muck *et al.,* 2018).

2.6 Effects of Ensiling on the chemical composition of maize cobs with wood ash extract

Ensiling maize cobs with wood ash extract affects their chemical composition by enhancing nutrient preservation and modifying fiber fractions. This combinatorial approach addresses the fundamental limitation of lignocellulosic biomass: its resistance to degradation. While standard ensiling relies solely on microbial enzymes, the addition of wood ash extract acts as a chemical pre-treatment. The alkali causes the swelling of cellulose and the saponification of ester bonds, effectively increasing the pore size of the substrate. This structural opening allows the lactic acid bacteria (LAB) to penetrate deeper into the cob tissue, facilitating a more extensive fermentation (Van Soest, 1994).

Studies on ensiled maize cobs treated with alkaline additives like wood ash extract show a significant decrease in acid detergent fiber (ADF) and neutral detergent fiber (NDF) content over the ensiling period, indicating partial breakdown of hemicellulose and lignocellulosic bonds which improves digestibility (Abdulazeez *et al.,* 2021). The mechanism of this fiber reduction is rooted in the solubilization of hemicellulose. In an alkaline environment provided by the wood ash, the hydrogen bonds holding the hemicellulose to the cellulose are disrupted. Consequently, a portion of the insoluble NDF fraction is converted into soluble sugars. These released sugars do not disappear but become available substrates for the rumen microbes (Oji & Oji, 2007).

The alkaline minerals in wood ash extract, such as calcium and potassium, increase pH buffering capacity, helping maintain an environment conducive to lactic acid bacteria activity, thereby preserving crude protein and other nutrients during fermentation (Oji & Oji, 2007). This phenomenon is known as "buffered fermentation." In typical silage, the pH drops rapidly, inhibiting LAB activity once it hits pH 4.0. However, the alkaline cations (Ca^{2+}, K^{+}) from the wood ash neutralize some of this acid. This buffering effect prevents the pH from dropping too quickly, allowing the LAB to remain metabolically active for a longer duration and produce a higher total quantity of lactate (McDonald *et al.,* 1991).

Specifically, the presence of wood ash extract during ensiling has been reported to reduce fiber content while increasing crude protein concentration compared to untreated maize cobs, owing to microbial and chemical modifications facilitated by the alkaline nature and mineral content of the extract (Abdulazeez *et al.,* 2021; Oji & Oji, 2007). The observed increase in crude protein is often partially attributed to the synthesis of microbial single-cell protein. As the LAB proliferate in the nutrient-rich, buffered environment, their biomass—which is high in protein—contributes to the total nitrogen content of the silage. Additionally, the alkaline conditions inhibit the activity of plant proteases, ensuring that the nitrogen present in the maize cobs is retained as true protein rather than being degraded into volatile ammonia (Muck *et al.,* 2018).

These alterations result in silage with improved physical properties, nutrient availability, and overall feeding value. Furthermore, the pH in such silages generally stabilizes within desirable ranges during a 7-day ensiling period, which protects the silage from spoilage and nutrient loss. In conclusion, the combined effect of ensiling duration and wood ash extract treatment improves the chemical composition of maize cob silage by reducing fiber fractions, enhancing crude protein content, and stabilizing pH, leading to better silage quality and nutritive value.

2.7 Effects of Ensiling on the Physical Properties of Maize Cobs with Wood Ash Extract

The ensiling process transforms the physical look, feel, and even the smell of the maize cobs. These physical changes, often called "organoleptic properties," are actually the farmer's first clue that the process is working correctly. If you were to touch raw maize cobs, they are typically hard, woody, and dry. However, after being ensiled with wood ash extract, they become significantly softer and more pliable. This physical softening is a direct result of the chemical breakdown described earlier; as the "skeleton" of the cell wall—the hemicellulose and lignin—is broken down by the acid and alkali, the cob loses its rigidity. This makes the feed much easier for animals to chew and digest (Oji & Oji, 2007).

The texture also improves because of how the treatment manages water. The salts found in wood ash are "hygroscopic," which is just a scientific way of saying they

love to hold onto water. They help keep moisture locked inside the plant tissue, preventing the nutrient-rich juices from draining away to the bottom of the silo. This keeps the silage moist and uniform. Furthermore, as the tough cell walls break down, the "bulk density" of the feed improves. This means the feed packs down much tighter. For the farmer, this saves storage space, but for the animal, it is even more important: it means they can eat a larger weight of food before their stomach feels physically full, helping them get the nutrients they need to grow (Holmes & Muck, 1999).

Visual and smell changes are also critical markers of quality. During the 7-day fermentation period, the color of the maize cobs typically shifts from a pale white or yellow to a light brownish-yellow or golden color. This color change is a good sign that the acids have successfully penetrated the tissue. More importantly, the smell tells a story. A successful fermentation produces a distinct, pleasant aroma often described as "fruity" or "acidic," similar to vinegar or yogurt. This smell comes from the lactic acid and volatile fatty acids produced by the bacteria. If the silage smells foul, rancid, or like ammonia, it indicates that the process failed and the protein is rotting. The wood ash treatment helps ensure that the pleasant, acidic smell is achieved by protecting the process against bad bacteria (Abdulazeez *et al.,* 2021).

Temperature is another physical factor that changes during the process. In the very first stage of ensiling, before the oxygen is used up, the silo naturally heats up slightly as the plant material "breathes." However, a good silage pile should cool down quickly

once the air is gone. If the maize cobs are treated with wood ash and packed tightly, this heat is managed effectively. If the material remains hot for too long, it literally burns up the energy in the feed, turning it dark brown like toast. Therefore, proper ensiling results in a cool, stable mass that preserves the energy content of the cobs for the animal, rather than losing it as heat (McDonald *et al.,* 1991).

CHAPTER THREE

3.0 RESEARCH METHODOLOGY

3.1 Location of Research

The experiment was carried out at Animal science Laboratory of Faculty of Agriculture, University of Benin, Edo state. University of Benin, Ugbowo campus is located between Latitude 6°20 and 39°N if the Equator and Longitude 5°36 and 6°E of the Greenwich Meridian in the forest Zone with an average temperature of 27.6°C (NAA,2014).

3.2 Collection of Experimental Materials

3.2.1 Collection of Maize cobs

The maize cobs were obtained from Cob Vendors at New Benin market in Benin-City, Edo State, Nigeria. The cobs were collected immediately after shelling of maize grains to ensure freshness.

3.2.2 Collection of wood Ash Extract

The wood ash was obtained from Buka in university of Benin, Benin city, Edo state, Nigeria. The wood ash was sieved through a 2mm mesh to remove large particles and debris.

3.3 Processing and Handling of Experimental Materials

3.3.1 Processing and Handling of Maize cobs

The maize cobs were pre-crushed into bits by continuously pounding the cobs with a mortar and pestle. This allowed for further grinding by the milling machine. The milled cobs were soaked in clean water for 30 minutes, after which it was sieved out to remove some moisture from it.

3.3.2 Preparation of Wood Ash Extract

The required amount of the sieved wood ash was mixed with 10 liters of clean water in a plastic container. The moisture was stirred thoroughly and allowed to stand 24 hours at room temperature. After 24 hours, the mixture was filtered through a cheese cloth to obtain a clear extract. The extra wood ash extract was stored in a clean plastic container.

3.4. EXPERIMENTAL TREATMENTS

Treatment 1(UMC)- This was ordinary maize cobs which was not soaked in water. This served as the control.

Treatment 2(WMC)- This was ground maize cobs soaked in water for 30 minutes, sieved and sun-dried.

Treatment 3(MCWAE$_7$) - This is milled maize cobs soaked in water for 30 minutes, sieved and ensiled in 1 liter of wood ash for 7 days and then sun-dried.

3.5 CHEMICAL COMPOSITION

The standard methods of analysis of the Association of Official Analytical Chemist (AOAC, 2003) 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 composition analysis refers to the determination of the major constituents of feed and it is used to assess if a feed is within its normal compositional parameters or somehow has been adulterated. This method partitioned nutrients in feed into six components: water, ash, crude protein, ether extract, crude fiber and NFE. Proximate analysis of experimental materials was carried put in the Central Laboratory, Faculty of Agriculture, University of Benin, Benin-City, Edo state, with little modification by Isikhuemen and Efenudu *et al* (2020).

3.6.1 MOISTURE DETERMINATION

Moisture is determined by the loss in weight that occurs when a sample is dried to a constant weight in an oven. About 2g of a feed sample is weighed into a silica dish previously dried and weighed. The sample is then dried in an oven for 650°C for 36 hours, cooled in a desiccator and weighed. The drying and weighing continues until a constant weight is achieved.

Since the water content of feed varies very widely, ingredients and feed are usually compared for their nutrient content on moisture free or dry matter (DM) basis.

%DM = 100 - %Moisture

3.6.2 ASH

Ash is the inorganic residue obtained by burning off the organic matter of feedstuff at 400-600°C in Muffle furnace for 4 hours. 2g of the sample is weighed into a pre-heated crucible. The crucible is placed into the Muffle furnace at 400-600°C for 4 hours or until whitish-grey ash is obtained. The crucible is then placed in the desiccator and weighed.

3.6.3 ETHER EXTRACT

The ether extract of a feed represents the fat and oil in the feed. Soxhlet apparatus is the equipment used for the determination of ether extract. It consists of 3 major components: an extractor, comprising the thimble which holds the sample; condenser for cooling and condensing the ether vapor and a 250ml flask.

Procedure: About 150ml of an anhydrous diethyl ether (petroleum ether) of boiling point of 40-60°C is placed in the flask. 2-5g of the sample is weighed into a thimble and the thimble is plugged with cotton wool. The thimble with content is placed into the extractor. The ether in the flask is then heated. As the ether vapor reaches the condenser through the side arm of the extractor, it condenses to liquid form and drop

back into the sample in the thimble. The ether soluble substances are dissolved and are carried into solution through the siphon tube back into the flask. The extraction continues for at least 4 hours. The thimble is removed and most of the solvent is distilled from the flask into the extractor. The flask is then disconnected and placed in an oven at 65°C for 4 hours, cooled in a desiccator and weighed.

3.6.4 CRUDE FIBRE

The organic residue left after sequential extraction of feed with ether can be used to determine the crude fiber. However, if a fresh sample is used, the fat in it could be extracted by adding petroleum ether, stir, allow it to settle and decant. Do this three times. The fat-free material is then transferred into a flask or beaker. 200ml of pre-heated 1.25% H_2SO_4 is added and the solution is gently boiled for about 30 minutes, maintaining constant volume of acid by the addition of hot water. The Buckner flask funnel fitted with Whatman filter is pre-heated by pouring hot water into the funnel. The boiled acid sample mixture is then filtered hot through the funnel under sufficient suction. The residue is then washed several times with boiling water (until the residue is neutral to litmus paper) and transferred back into the beaker. Then 200ml of pre-heated 1.25% Na_2SO_4 is added and boiled for another 30 minutes. Filter under suction and washed thoroughly with hot water and twice with ethanol. The residue is dried at 650°C for about 24 hours and weighed. The residue is transferred into a crucible and

placed in Muffle furnace (400-600°C) and ashed for 4 hours, then cooled in a desiccator and weighed.

3.6.5 CRUDE PROTEIN

Crude protein is determined by measuring the nitrogen content of the feed and multiplying it by a factor of 6.25. This factor is based on the fact that most protein contains 16% nitrogen. Crude protein is determined by Kjeldahl method. The method involves: Digestion, Distillation and Titration.

Digestion: Weigh about 2g of the sample into a Kjeldahl flask and add 25 ml of concentrated sulphuric acid, 0.5g of copper sulphate, 5g of sodium sulphate and a speck of selenium tablet. Apply heat in a fume cupboard slowly at first to prevent undue frothing. Continue to digest for 45 minutes until the digesta become clear pale green. Leave until completely cool and rapidly add 100ml of distilled water. Rinse the digestion flask 2-3 times and add the rinsing to the bulk.

Distillation: Markham distillation apparatus is used for distillation. Steam up the distillation apparatus and add about 10 ml of the digest into the apparatus via a funnel and allow it to boil. Add 10 ml of sodium hydroxide from the measuring cylinder so that ammonia is not lost. Distil into 50 ml of 2% boric acid containing screened methyl red indicator.

Titration: The alkaline ammonium borate formed is titrated directly with 0.1N HCl. The titre value which is the volume of acid used is recorded. The volume of acid used is fitted into the formula which becomes:

VA = volume of acid used

W = weight of sample

% Crude protein = %N x 6.25

3.6.6 NITROGEN FREE EXTRACT (NFE)

NFE is determined by mathematical calculation. It is obtained by subtracting the sum of percentages of all the nutrients already determined from 100.

%NFE = 100 – (%Moisture + % CF + % CP + % EE + % Ash)

NFE represents soluble carbohydrates and other digestible and easily utilizable non-nitrogenous substances in the sample.

3.7 MINERAL ELEMENT DETERMINATION

The determination of mineral contents was carried out using Atomic Absorption Spectrophotometer (AAS model: SOLAAR 968 Unicam Series) for Calcium, Flame Photometer for Sodium and Potassium and Spectrophotometer (model Spectronic 20D+) for Phosphorus. It followed methods described by AOAC (2003). For wet digestion of samples, 1g of the powdered sample was weighed in digestion flask. 12ml

of concentrated HNO_3 was added and kept overnight at room temperature. 4ml of $HClO_4$ was added to the mixture and heated in the digestion block; starting at 50°C and gradually increasing to 250°C. The appearance of fumes at 70-80 minutes signaled completion if digestion. The mixture was allowed to cool before transferring into 100ml volumetric flask and thereafter made to mark with distilled water. The wet digested solution was stored in plastic reagent bottle for use in determination of minerals following the principles and procedures expounded by Gul and Safdar (2009).

3.8 STATISTICAL ANALYSIS

Data obtained from the experiment was subjected to an ANOVA using GENSTAT 12th edition. Means were separated using Duncan Multiple Range Test (DMRT) at significance level of $p<0.05$.

CHAPTER FOUR

4.0 RESULTS

4.1 Physical Properties of Maize cobs

The physical properties of untreated maize cobs, maize cobs soaked in water and maize cobs ensiled in wood ash extract are shown in Table 4.1 below.

Table 4.1 Physical properties of treated and untreated maize cobs

Treatment	Colour	Texture	Odour
Trt1	Light yellowish-brown colour	rough, coarse and powdery	slightly vegetal
Trt2	Carton brown colour	less rough and slightly sticky	slightly sweet
Trt3	Dark brown colour	smooth, soft and slimy	fresh, slightly sour

Note: Trt1(UMC) - untreated maize cobs, Trt2(WMC) – Water soaked maize cobs, Trt3 ($WAEMC_7$) - maize cobs soaked in wood ash for 7 days.

4.2 Chemical Composition of Maize Cobs

The data on the chemical composition of maize cobs that served as treatment is presented in Table 4.2

Table 4.2 chemical composition of treated maize cobs and untreated maize cobs

Parameters	MC	CP	E. E	Ash	Fiber	CHO
Trt1	11.93[a]	3.21[a]	0.45[b]	1.55[b]	30.42[c]	55.44[c]
Trt2	17.48[b]	5.53[c]	0.57[c]	1.28[a]	29.75[b]	45.39[b]
Trt3	35.10[c]	4.59[b]	0.35[a]	3.98[c]	24.72[a]	31.26[a]

Not e: Trt1(UMC)- Untreated maize cobs, Trt2(WMC)- Water soaked maize cob, Trt3($WAEMC_7$)- wood ash extract maize cobs ensiled for seven days, MC-Moisture Content, C.P- Crude Protein, E.E- Ether Extract, C.F- Crude Fiber, CHO- Carbohydrate. Mean values with the same letters along the same column are not significantly different at 5% probability level ($p>0.05$).

The Moisture Content (MC) followed a logical and predictable trend, with the lowest value seen in Trt1, (11.93%). Moisture increased in Trt2 (17.48%) as a result of soaking and was highest in Trt3 (35.10%), which is consistent with it being treated with a liquid extract and ensiled for seven days.

The Crude Protein (CP) showed its highest value in Trt2 (5.53%). This is not an addition of protein but rather a concentration effect; the water-soaking process leached out soluble carbohydrates, making the remaining protein a larger percentage of the final dry matter. The CP in Trt3 (4.59%) was also significantly higher than in Trt1 (3.21%), which is attributed to this same concentration effect, potentially combined with the presence of microbial protein from the fermentation process.

Ether Extract (E. E), which was also highest in Trt2 (0.57%) due to the same concentration effect. However, the E. E. was lowest in Trt3 (0.35%), suggesting that microorganisms may have used fats as an energy source during the 7-day ensiling period.

The Ash content was lowest in Trt2 (1.28%). This indicates that the 30-minute soaking process leached out (washed away) soluble minerals. Conversely, Trt3 (3.98%) had the highest ash content by a significant margin, which is the expected and direct result of adding mineral-rich wood ash extract to the cobs.

The Crude Fiber (CF) analysis revealed one of the most important findings. Trt3 (24.72%) showed a significant reduction in fiber compared to Trt1 (30.42) which

served as the control. This demonstrates the success of the treatment, as the alkali in the wood ash effectively broke down the tough, indigestible lignocellulosic structure of the maize cobs.

The Carbohydrate (CHO) content was reduced by both treatments, but most significantly in Trt3. The drop in Trt2 (45.39%) is likely due to the leaching of soluble sugars. The very large reduction in Trt3 (31.26%) is due to two factors: the chemical breakdown of complex fibers by the alkali and the consumption of simple sugars by microorganisms during the 7-day fermentation.

4.3 Mineral Analysis of Maize Cobs

The mineral analysis of maize cobs that served as different treatments is presented in table 4.3

Table 4.3 Mineral composition of treated maize cobs and untreated maize cobs

Parameters	N(mg/100mg)	P(mg/100 mg)	K(mg/100 mg)	Ca(mg/100 mg)	Zn(mg/100 mg)	Na(mg/100 mg)
Trt1	501.4^{a}	68.79^{c}	329.1^{c}	87.30^{a}	1.637^{c}	37.91^{a}
Trt2	893.5^{c}	36.15^{b}	247.7^{a}	96.50^{b}	1.040^{a}	39.86^{b}
Trt3	741.4^{b}	27.51^{a}	301.3^{b}	105.6^{c}	1.307^{b}	44.75^{c}

NOTE: Trt1 (UMC)- untreated Maize cobs, Trt2(WMC)- maize cobs soaked in water, Trt3($WAEMC_7$)-Wood ash extract maize cobs ensiled seven days, Ca- Calcium, K- potassium, Na- sodium, P- phosphorus, Zn- Zinc, N- Nitrogen. Mean values with the same letters along the same column are not significantly different at 5% probability level ($p>0.05$).

The table presents the mineral composition of various treatments, showing the concentrations of key minerals expressed in milligrams per 100 grams. Here's an explanation of each mineral parameter:

Nitrogen(N), (mg/100mg): Trt2 (893.5 mg/100mg) recorded the highest N value, which was significantly greater than both Trt3 (741.4 mg/100mg) and Trt1 (501.4 mg/100mg). The experimental treatment (Trt3) also resulted in a significantly higher Nitrogen content compared to the dry control (Trt1).

Phosphorus(P), (mg/100 g): Phosphorus content was highest in the control group, Trt1 (68.79 mg/100mg). Trt2 (36.15 mg/100mg) and Trt3 (27.51 mg/100mg) showed a significant reduction in Phosphorus, with Trt3 having the lowest concentration.

Potassium (K), (mg/100mg): A similar trend to Phosphorus was observed for Potassium. The Trt1 (329.1 mg/100mg) control group retained the highest potassium concentration. Both wet treatments had significantly lower values. Interestingly, the ensiled group Trt3 (301.3 mg/100mg) retained significantly more K than the simply wet group Trt2 (247.7 mg/100mg), which had the lowest concentration.

Calcium (Ca), (mg/100mg): Calcium content showed a positive response to the experimental treatment. Trt3 (105.6 mg/100mg) had the highest concentration of Calcium, which was significantly higher than the dry control Trt1 (87.30 mg/100mg). The value for Trt2 (96.50 mg/100mg) was statistically intermediate, showing no significant difference from either Trt1 or Trt3.

Zinc (Zn), (mg/100mg): All three treatments were statistically different from one another. Trt1 (1.637 mg/100mg) had the highest concentration, while Trt2 (1.040 mg/100mg) had the lowest. The ensiled group Trt3 (1.307 mg/100mg) was intermediate, but represented a significant loss compared to the dry control.

Sodium (Na), (mg/100mg): Trt3 (44.75 mg/100mg) recorded the highest sodium concentration, followed by Trt2 (39.86 mg/100mg), and finally the control Trt1 (37.91 mg/100mg). All three treatments means were significantly different from each other.

CHAPTER FIVE

5.0 DISCUSSION

5.1 PHYSICAL PROPERTIES OF TREATED AND UNTREATED MAIZE COBS

The physical properties of the control groups, Treatment 1 (UMC) and Treatment 2 (WMC), established a baseline for the experiment. Treatment 1 presented the expected characteristics of raw, unprocessed agricultural residue: a light yellowish-brown colour, a rough, coarse, and powdery texture, and a simple vegetal odour. Treatment 2 demonstrated the immediate effects of hydration; the colour darkened to a carton brown as water was absorbed, and the texture became less rough and slightly sticky. This stickiness, combined with a slightly sweet odour, suggests that the presence of moisture alone initiated minor microbial activity on the surface, likely the beginning of sugar fermentation by naturally occurring yeasts.

Treatment 3 ($WAEMC_7$) showed a profound transformation. The dark brown colour is a clear indicator of the alkaline reaction from the wood ash extract, which initiated the chemical breakdown of the plant's structural components, particularly lignin. This chemical degradation is strongly supported by the dramatic shift in texture to "smooth, soft, and slimy." The alkali in the wood ash effectively hydrolyzed the hemicellulose and disrupted the rigid fiber bonds, resulting in the soft consistency. Most importantly,

the "fresh, slightly sour" odour is the classic hallmark of successful silage fermentation. This aroma indicates that lactic acid bacteria successfully metabolized the available sugars to produce lactic acid, which effectively preserved the material while inhibiting the growth of spoilage microbes.

5.2 PROXIMATE COMPOSITION OF TREATED AND UNTREATED MAIZE COBS.

The proximate composition analysis showed distinct variations between the control and the treated sample. The observed differences indicate that the treatments had a significant effect on the nutritional quality and chemical composition of the sample.

Crude Fiber (CF): The primary objective of treating high-fiber residues like maize cobs is to improve digestibility, which was successfully demonstrated in Treatment 3($WAEMC_7$). The crude fiber (CF) in the wood ash ensiled group (Trt3) was significantly reduced from 30.42% to 24.72%. This is a classic outcome of alkaline treatment. Wood ash is an effective and economical alkaline source, and its high pH (often 10-12) works to break the ester bonds linking lignin to hemicellulose and cellulose (Baba *et al.,* 2010). This process, known as saponification or delignification, solubilizes the fiber components, making the structural carbohydrates more accessible for digestion and lowering the overall measured crude fiber. This chemical breakdown was amplified by the 7-day ensiling process.

The **carbohydrate (CHO)** content in Trt3($WAEMC_7$) plummeted to 31.26%, a massive reduction from the control's (Trt1) at 55.44%. This is a two-fold effect:

(1) the alkaline hydrolysis broke down complex carbohydrates (fiber)

(2) the anaerobic fermentation process consumed the available water-soluble carbohydrates (WSC).

As noted by researchers, the success of ensiling depends on the fermentation of WSC by microbes (Gao *et al.,* 2024), which convert these sugars into organic acids. This microbial consumption represents a loss of the CHO fraction, but it is a necessary part of the preservation process.

Ash content: The ash (total mineral) content provides a clear story of the two treatments. Trt3 ($WAEMC_7$) showed the highest ash (3.980%), a direct and beneficial consequence of the treatment. Wood ash is a potent source of minerals, and studies have confirmed that treating maize with wood ash significantly enriches the final product with essential minerals, particularly potassium (K), magnesium (Mg), iron (Fe), and zinc (Zn) (Bello *et al.,* 2010). In stark contrast, Trt2 (water soaked) had the lowest ash content (1.283%). This demonstrates a significant nutritional drawback of simple soaking. Soaking crop residues, even for short periods, is known to cause the leaching of soluble components, including soluble minerals. Studies on soaking lentils, for example, have shown a significant reduction in total ash content (Islam *et al.,*

2024). This confirms that while soaking may seem like a simple pre-treatment, it can inadvertently reduce the feed's mineral value.

Crude protein (CP): The most complex result was the crude protein (CP), which was highest in Trt2 at 5.527%. This is not an addition of protein; it is a concentration effect. As demonstrated by the ash and CHO data, the water-soaked maize cobs (Trt2) washed away a significant portion of the feed's dry matter (soluble carbohydrates and minerals). With this fraction removed, the remaining insoluble components namely protein and fat are mathematically concentrated and thus register as a higher percentage of the remaining dry matter. The CP in Trt3 (4.590%) was also higher than the control (3.207%). This is likely due to a combination of

(i) this same concentration effect (as carbohydrates were consumed during fermentation)

(ii) the accumulation of microbial protein. Research on ensiling by-products has shown that this process can increase the final crude protein content, partly by capturing non-protein nitrogen and converting it into microbial biomass (Kwak *et al.,* 2008).

The **Ether Extract (E.E),** or crude fat, was lowest in Trt3(0.3467%). This is also a direct chemical consequence of the alkali. These saponified fats become water-soluble and are then leached out, reducing the final E.E content.

5.2 MINERAL COMPOSITION OF THE SAMPLE

The mineral composition of the treatments revealed significant values. These differences indicate that the treatment method had a positive effect on the mineral profile of the product, improving its nutritional value and possible application in animal feed and human nutrition.

The **Nitrogen (N)** content, a key indicator of crude protein, was highest in Trt2(WMC) at 893.5 mg/100mg. This value was statistically superior to both Trt3 (741.4mg/100mg) and Trt1 (501.4mg/100mg. This significant increase is likely a biological effect: the 7-day high-moisture ensiling process in Trt2 created an ideal environment for the proliferation of microbial biomass (bacteria, yeasts, etc.) (Li *et al.,* 2018). These microbes synthesize their own protein as they multiply, thereby increasing the total nitrogen content of the silage (Olorunnisomo, 2012). Trt3 was also significantly higher than Trt1, but its alkaline (high-pH) environment may have been less optimal for microbial growth than the purely wet conditions of Trt2, resulting in a lower Nitrogen value.

For **Phosphorus (P),** Trt1 retained the highest level at 68.79 mg/100mg. Both ensiling treatments resulted in a significant loss of P, with Trt3 showing the greatest depletion (27.5mg/100mg). The loss in Trt2 (36.15mg/100mg) is likely due to leaching, as a portion of Phosphorus is water-soluble and can be lost in silage effluent (Keppens *et al.,* 2011). The severe Phosphorus depletion in Trt3, however, points to a chemical

antagonism. Wood ash creates a high-pH (alkaline) environment and adds a large amount of calcium. In these conditions, phosphate ions (PO_4^{3-}) readily bind with calcium ions (Ca^{2+}) to form highly insoluble calcium phosphates, "locking up" the mineral and making it unavailable (Ippolito *et al.,* 2011).

Potassium(k): A significant finding was that Trt1 had the highest Potassium (K) concentration at 329.1 mg/100mg. Both wet treatments caused a significant loss of this mineral. The wet soaked cobs (Trt2) had the lowest value (247.7mg/100mg), which is a clear indicator of leaching. Potassium is not bound to any structural components in plants and exists as a soluble ion (K^+) in cell sap, making it extremely susceptible to being washed away in silage effluent (Muck & Shinners, 2017). This also explains the result in Trt3 (301.3mg/100mg); although wood ash is a known source of potassium (Park *et al*., 2012), the amount lost to leaching during the wet ensiling was evidently greater than the amount added by the ash, resulting in a net loss compared to the dry control.

The results for **Calcium (Ca)** clearly demonstrate the effect of the wood ash. The wood ash treatment (Trt3) was statistically highest at 105.6 mg/100mg (b). This is a straightforward case of mineral fortification. Wood ash is well-known to be a rich source of calcium, primarily in the form of calcium carbonate ($CaCO_3$) (Demeyer *et al.,* 2001). Therefore, its addition acted as a direct supplement, significantly boosting the Calcium content of the cobs. Trt2 (96.50mg/100mg) was not statistically different

from the control (87.30mg/100mg), indicating the wet-soaking process itself has little effect on calcium levels.

Zinc (Zn): The trend for the trace mineral Zinc (Zn) mirrored that of Potassium. Trt1 showed the highest concentration at 1.637 mg/100mg, which was statistically superior to both treated groups. Trt2 had the lowest level (1.040mg/100mg). This loss is also attributable to leaching. Like other soluble minerals, trace elements including zinc can be dissolved and lost in the effluent that drains from silage, especially in high-moisture systems (Keppens *et al.,* 2011).

Sodium (Na): Similar to Calcium, the Sodium (Na) results clearly show the additive effect of the wood ash. Trt3 had a significantly higher Na concentration at 44.75 mg/100mg than both the trt1 (37.91 mg/100mg) and Trt2 (39.86 mg/100mg). While its concentration varies, sodium (often as Na_2O) is a known component of wood ash (Obi, 2011). As with calcium, the wood ash acted as a direct mineral supplement, fortifying the maize cobs with sodium.

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATION

6.1 CONCLUSION

The results of this study clearly demonstrated that the treatment methods applied to maize cobs significantly influenced their proximate and mineral composition. The proximate analysis revealed that Trt3 effectively reduced crude fiber (CF) content, confirming its potential to improve the digestibility and feeding value of high-fiber residues. The observed decline in fiber from 30.42% to 24.72% highlights the delignifying capacity of alkaline substances present in wood ash. This treatment also increased the ash content, reflecting a beneficial mineral enrichment effect.

Although Trt2 produced a higher apparent crude protein (CP) percentage (5.527%), this was largely due to a concentration effect resulting from the leaching of soluble fractions rather than an actual increase in protein quantity. Trt3, however, recorded both improved CP and enhanced mineral composition, suggesting a dual benefit from the fermentation and mineral fortification processes. The reduction in ether extract (E.E) in Trt3 was attributed to saponification reactions induced by the alkaline environment, further confirming the chemical transformations that occurred during treatment.

The mineral composition results showed that the treatments significantly altered the elemental profile of the maize cobs. Trt3 notably enhanced calcium (Ca) and sodium (Na) levels due to the mineral richness of the ash, thereby improving the nutritional quality of the product for potential livestock feeding. However, both ensiling and soaking led to substantial reductions in phosphorus (P), potassium (K), and zinc (Zn), which are sensitive to leaching and pH-induced precipitation.

In Conclusion, Treatment 3 which is the 7 days ensiled maize cobs is advisable and suitable for feeding monogastric animals compared to the untreated maize cobs because the fiber content in treatment 3 was significantly reduced from 30.42% to 24.72% and also there was a significant increase in the mineral content as well.

6.2 RECOMMENDATION

1. Further studies should explore different ensiling durations and levels of wood ash to determine the best conditions for improving nutrient quality and mineral retention.
2. Feeding trials with pigs and poultry should be carried out to assess growth performance and nutrient utilization of the treated maize cobs.
3. The use of wood ash with other natural additives such as molasses or beneficial microbes should be explored to enhance fermentation and mineral availability.

4. Farmers should be encouraged to adopt wood ash ensiling as a simple, low-cost, and sustainable method of improving maize cob quality for livestock feed.
5. Research and extension agencies should create awareness and train farmers on proper preparation and mineral fortification of wood ash–treated feeds.

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