In Sacco Rumen Degradation of Ensiled Maize Cobs Treated with Different Feed Additives

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DECLARATION

I hereby declare that this work is the product of my research efforts undertaken under the supervision of Dr. Aminu Nasiru and has not been presented anywhere for the award of a degree or certificate. All sources have been duly acknowledged.

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CERTIFICATION

This is to certify that the research work for this dissertation and the subsequent write-up by (Lawan Babangida SPS/15/MAS/00005) were successfully carried out under our supervision.

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APPROVAL

This dissertation has been examined and approved for the award of Masters Degree in Animal Science (Ruminant Nutrition and Management). Bayero University, Kano.

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DEDICATION

This research dissertation is dedicated to my beloved parents Late Malam Babangida Malami and Hajiya Rakiya Musa for their tireless guide, support and prayers towards accomplishing my studies successfully, may Almighty Allah shower his endless blessing upon them.

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Abstract

In sacco ruminal degradability is an important measurement in the determination of the nutritive value of feedstuffs. Two experiments were conducted to evaluate the effect of additives and ensiling period on *in sacco* degradability of maize cobs. The first experiment was to evaluate the effect of additives and ensiling period on proximate composition of maize cob silage. The experiment was laid in a 3x4 factorial RCBD with three ensiling period (3, 5 and 7 weeks) and three additives (urea, molasses, yeast) and control. The second experiment was to determine the effect of first experiment on *in sacco* degradability of maize cob treated silage. Orskov *et al.*, 1980 procedure was used to conduct the experiment. At the end of the experiments data generated were subjected to analysis of variance. Results obtained revealed that the physical properties of treated maize cobs were improved in urea and yeast treated cobs. There was also improvement with the increasing ensiling period from 3-7 weeks. The desirable pH (3.22-3.80) was obtained in all silages except the control at 3 and 5 weeks. Silage protein content increased significantly ($P<0.05$) with the urea (9.21%). Dry matter and crude fibre contents decreased significantly ($P<0.05$) after ensiling with urea and yeast based treatments. The highest dry matter and crude fibre was found to be 91.26 and 48.92% in the control. The crude protein contents increased after ensiling from 3-7 weeks while the crude fibre decreased with increasing ensiling time. The highest crude protein (10.95%) due to interaction was obtained in urea treated cobs at 7^{th} weeks. The highest dry matter and organic matter disappearances were recorded at 7^{th} week ensiling period for all the additives after 48 hours of incubation. The dry matter and organic matter degradability were increased by ensiling with urea and yeast after 7^{th} weeks. The highest organic matter potential degradability (PD) due to interaction was obtained in yeast at 7^{th} weeks (100%) while the highest effective degradability (ED) due to interaction was recorded in urea 7^{th} weeks (49.80%). Therefore, it can be concluded that the addition of urea or yeast improved the physical, nutritional and degradation characteristics of maize cob silage.

CHAPTER ONE

1.0 INTRODUCTION

1.1 BACKGROUND OF THE STUDY

Inadequate feed supply is a major constraint of livestock production in Sub-Saharan African countries, particularly in the late dry and early wet seasons (Arigbede, *et al.,* 2011). At this critical period areas open to grazing animals are almost bare ground with poor vegetative cover and low biomass (Muhammad & Kallah, 2013). This obviously adds to the poor performance of ruminant livestock.

Improvements of the performance of ruminants in Sub-Saharan Africa (Kaitho, *et al.*, 1998; Mekonnen, *et al.*, 2006, 2009; Mekoya, *et al.*, 2008) require the use of methods to extend the availability and quality of local feedstuffs especially to reduce feed cost. In order to accomplish this, farmers should be offered the option to choose available, abundant, and cheap feedstuffs. This option is pointed out to utilize crop residues and or agro industrial by product beside the available forages. However, the weakness of crop residues as feed is generally less palatable, low degradability and low in nutrients content. Feedstuff from agricultural wastes or crop residues are high in cell wall and low in nitrogen content or imbalance, therefore, the digestibility is low (Soeharto, 2004; Ginting, 2005) and these characteristics will inhibit feed intake.

Maize (*Zea mays*) cob can be considered to be one of the important potential crop residue available for ruminants feeding in country. Maize is indigenous to India (Indian corn) belongs to the Family: *Gramineae,* Genus*: Zea*, Species: *Mays*. It is grown in temperate and tropical countries of the world for its grain utility in both human beings and livestock

(Adebowale, 2004). The major residues obtained from this crop are maize husk (covering on seed), cob, shank and stover. Corn cob shanks are by-products of maize production and may be used as alternative feed resources for ruminants especially during dry season. These are the relatively available and abundant agricultural wastes used as livestock feeds in large scale farms. They are usually in medium density when they are finely ground and facilitate better uniformity with other ingredients especially concentrate feeds after grinding. Hence Corn cob shanks can be efficiently utilized in total mixed rations.

Improvement in the management of crop residue enables efficient utilization of this potentially useful feed resource for livestock production. One of the ways towards achieving self-sufficiency in protein for the teaming Nigerian population is through improved crop residue utilization (Jibrin, *et al.*, 2013). Enhancing digestibility of poor quality forages through physical or chemical processing has been practiced for many years. (Sewell, *et al.*, 2009; Duckworth, *et al.*, 2014; Chapple, *et al.*, 2015). Physical and chemical treatment disrupts intracellular bonds between cell wall components - cellulose, hemicellulose, and lignin - in order to increase surface area and microbial attachment (Williams, *et al.*, 1995) and, ultimately, improve digestibility of the forage (Hunt *et al.*, 1984; Gates, *et al.*, 1987). Applying both the physical and chemical treatment to crop residues has also been shown to increase its digestibility (Duckworth, *et al.*, 2014; Chapple, *et al.*, 2015).

While it might be assumed that fermentation characteristics of feedstuffs should be evaluated through in vivo trials, it is also obvious that in vivo experiments need high number of animals, with high financial costs and only the feed to be tested can be fed during trials.

Alternatively, *in sacco* techniques have been developed to allow its utilization on routine basis. Rumen degradability is routinely determined by use of the *in sacco* method. The nylon bag or *in-sacco* technique is a very robust and powerful tool with which several aspects of ruminant nutrition are studied (Orskov and Shand, 2004). It is particularly useful in describing characteristics of protein and other feed fractions in forages as well as in the rumen simulated techniques (Blummel and Orskov, 1993).

In Sacco (*in situ*) degradability is the most frequently used methods for determination of degradability parameters of dry matter, organic matter (OM), protein, fibre, and other nutrients of feeds (Van Vuuren, *et al.*, 1991). The rate and extent of drymatter fermentation in the rumen are crucial determinants of the nutrients utilized by ruminants (Kamalak ,*et al.*, 2005). The main factor influencing the rate of fermentation of feeds is the structure of the carbohydrate fractions, especially the extent of lignifications of the cell wall (Nagadi, *et al.*, 2000).

1.2 PROBLEM STATEMENT

In Nigeria as in most developing countries, feed supply has remained a major constraint in livestock production due to increasing cost of conventional feedstuffs and occasionally longer severe stress period. The main stress to livestock production in Nigeria is the limited availability of feed resource (Adegbola, *et al.*, 1998).

Crop residues that serve as alternative feed materials have not been fully utilized (Akinbamijo, *et al.*, 2002). The natural pasture grassland grazed by ruminants and crop residues from farm lands in northern Nigeria cannot meet the energy and protein requirement of the animals (Adegbola, *et al.*, 1998). During the period of feed shortages livestock's subsist on very poor quality forages and crop residues thus, resulting in low productivity. The digestibility and concentration of crude protein of crop residues is low due to high fibre content (Adegbola, *et al.*, 1998). However, if highly processed the potential of using crop residues as livestock feed may be improved and the general performance of the animal will also be enhanced. A potential for the use of maize cobs as a ruminant feedstuffs may be realized through the development of physical, chemical and biological treatments to disrupt the lingnocellulose complex (Adegbola, *et al.*, 1998).

1.3 JUSTIFICATION OF THE STUDY

The severity of feed shortage during dry season when available forages are dry and their protein contents are low lead to decrease in voluntary feed intake and low digestibility by animals leading to low or poor livestock performance (Lamidi, *et al.*, 2010). Therefore, it has become imperative for ruminant nutritionists to investigate ways of utilizing feedstuffs that are of no nutritional need to Man for livestock feed.

Ngele *et al.,* (2006) reported that unconventional feed materials could be conserved and their nutritional value improved by way of ensiling the feed materials which aim at controlling microbial fermentation that could improve the feeding value of a feed ingredient. Another way of achieving this is by using cheaper source of nitrogen in livestock diet, since protein are such costly component and important factor for growth.

Maize cob is one of such unconventional feedstuffs which are produced in large quantities in Nigeria and after harvest, large quantities of it are wasted year after year (Ngele *et al.,* 2006). Therefore, maize cobs could be used to feed animals after ensiling with yeast, urea or molasses (Lamidi, *et al.*, 2010).

The treatments will increase the nitrogen content of the diet and also improve digestibility and utilization of fibre by the ruminant animals. This study therefore aim at determining the effect of treating maize cobs with urea, molasses and yeast using *In Sacco* degradability technique described by Orskov, *et al.* (1980).

1.4 OBJECTIVES OF THE STUDY

The main objective was to determine the effect of ensiling maize cobs with urea, molasses, and yeast using *In Sacco* degradability technique described by Orskov, *et al.* (1980). While the specific objectives were to:

1) To determine the chemical composition of ensiled maize cobs
2) To assess the ensiling characteristics of ensiled treated and untreated maize cobs.
3) To evaluate the degradability of the ensiled maize cobs using *In Sacco* nylon bag techniques

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 RUMEN ECOSYSTEM

Ruminants offer an advantage over monogastric animals in that the rumen is well equipped with a wide range of symbiotic organisms which, under favourable conditions, break down otherwise indigestible roughage (Konimba, 1996). The microbes require a receptive environment for desirable fermentation patterns. Rumen microbial populations consist of three main groups- bacteria, protozoa and fungi. Although the type of substrate entering the ecosystem will mainly determine the population (Orpin, 1983), several of the bacteria, protozoa, and fungi species have been described in detail (Hungate, 1966). Microbial population and fermentation patterns vary with changing rumen environment. A continual supply of substrate, and salivary buffering salts and the removal of end products and residues will result in a relatively stable rumen environment, thus promoting high microbial populations and increased biomass (Konimba, 1996).

Rumen Bacteria

Several hundred species of bacteria have been found in the rumen and about 109-1010 bacteria per ml of rumen fluid have been estimated (Hungate, 1966). Among the different functional cellulolytic, amylolytic, and proteolytic bacteria, those which ferment cellulose are the most important. Cellulolytic and amylolytic bacteria both require ammonia (NH3) and branched chain fatty acids as growth factors. Dietary urea can provide NH3 and so promote efficient utilization of fibrous roughage, if the rumen pH does not fall below about 6.0

(Orskov and Ryle, 1990). Microbial efficiency is also associated with the availability of carbohydrates contained in the fibre (Konimba, 1996). For instance, it has been shown that tropical legumes are higher in protein and lower in fibre than their grass counterparts, and thus can serve as valuable supplements to straw or stover-based rations (Van Soest, 1994).

Rumen protozoa

Rumen fluid contains up to 106/ml protozoa (Konimba, 1996). The cilia of these organisms are restricted to tufts located mainly near the oesophagus; their function is the propulsion of food particles into the oesophagus. Two major groups of ciliate protozoa have been isolated, Holotrichs and Entidiniomorphs (Hungate, 1966). The main substrates for the Holotrichs are sugars and other soluble components, while the Entidiniomorphs survive on fibrous food particles or bacteria (Konimba, 1996). The positive effect of rumen defaunation on the digestibility of fibrous feeds and the live weight gain in sheep offered straw diets has been reported (Soetanto, 1986; Bird and Leng, 1989).

Rumen Fungi

It was only when Orpin (1983) discovered rumen fungi that they were considered as a functional group of microorganisms. Most of the fungal biomass is present as rhizoids infiltrating fibrous plant tissue. Orskov and Ryle (1990) reported that this group of microorganisms may be particularly important for the degradation of the plant structural materials which predominate in coarse roughage, although lignin does not appear to be susceptible to attack by rumen fungi

2.2 UTILIZATION OF CROP RESIDUES

Large quantities of crop residues are used as animal feed in many countries, but much is still wasted for various reasons or used for other purposes (Tesfaye, 2006). According to Timothy *et al.*, (1997), in south Asia, crop residues are used as compost and mulch for crop production, bedding for livestock, as substrate for growing mushrooms, fiber for paper manufacture and as fuel. In semiarid sub-Saharan Africa, they are used to control wind erosion and in the construction of roofs, fences, granaries, beds and doormats. With regard to the use of crop residues for animal feeding, Kossila (1985) reported that in both developed and developing countries, crop residues account for about 24% of the total feed energy suitable for ruminant livestock. The author further stated that if all crop residues were considered, the total production would on average give 3.4 tons and 6166 Mcal metabolizable energy (ME) per year in the whole world.

Sandford (1989) reported that in various parts of semiarid sub-Saharan Africa, cattle derive up to 45% of their total annual feed intake from crop residues, and up to 80% during critical period. Although crop residues are known to have such a significant contribution to the livestock feed requirements, there are varying opportunities for their use as animal feeds (Thole *et al.*, 1988). The greatest potential for the use of crop residues as animal feeds exists in the mixed crop/livestock systems (Kossila, 1985). Where crop and livestock production are segregated, most crop residues are wasted or they are used for non-feed purposes (Kossila, 1985). Generally, as production systems become more specialized, crop residues are likely to be included in ruminant diets in lower proportions or only at phases of production with lower nutritional requirements (Sandford, 1989). This is because, the specialized systems require animals of highest genetic potential and feeds of better quality to achieve higher milk yields mor animal growth rates (Klopfenstein and Owen, 1981). On the other hand, it was found that crop residues can be a suitable feed in specialized beef (Klopfenstein, *et al.*, 1987) and dairy (Klopenstein and Owen, 1981) enterprises, particularly during phases when animal nutritional demands are lowest.

Timothy, *et al.*, (1997) stated that the pattern of crop residue use is often dictated by population density, herd management practices and level of transport and marketing infrastructure. In areas with low population densities and where animals are herded communally, they observed open access to residues to occur as opposed to densely populated and heavily stocked areas in which restricted access to residues is practiced. Anderson (1978) reported that the extent to which crop residues are utilized also varies with geographic locations. In drier climates, the small amount of residues available makes it uneconomical to gather and remove it, whereas in areas where the topography is steep it is essential to leave residues on the soil to prevent water erosion and to allow adequate moisture penetration. Moreover, as residues must be collected and transported for efficient utilization, the financial capacity of the farmers to undertake such activities also becomes a major factor regulating their extent of utilization. The reliance on crop residues for livestock feeding increases as farm sizes decreases. In the case of Eastern Kenya, Fernandez-Rivera, *et al.*, (1995) reported that farmers with only two ha of land barely covered two-thirds of the feed needs of their livestock and are forced to exploit their crop residues to the full, to herd their cattle along road side and on waste lands, to rent grazing lands from other farmers or as a last resort, to purchase feed. Kayouli (1996) also stated that as pasture production declined, ruminant animals in the Sahel have become more dependent on crop residues which assumed progressively greater proportion of the total diet being mainly used during the dry season.

In summary, the use of crop residues for animal feeding not only improves animal production but it also increases the overall utilization efficiency of crops such as maize whose utilization efficiency is low (Tesfaye, 2006). In this regard, Alemu, *et al.,* (1991) stated that when only the grain is used for human consumption or for livestock feed, only about 39% of the energy and 20% of the protein are utilized.

2.3 MANAGEMENT OF CROP RESIDUES

The practices used in crop residue management (harvesting, handling, collection and storage) have effects on both the quantity and quality of the residues (Tesfaye, 2006). Owen and Aboud (1988) stated that as straws and stovers comprise leaf and leaf sheath (the more nutritious parts), the harvesting, handling and storing systems should minimize the loss of these parts. They further warned that delayed harvesting or relay harvesting in an intercropped field would be expected to cause greater loss of leaf and leaf sheath, with a consequent reduction in nutritive value. Emphasizing the importance of crop residue collection, Dyer, *et al*., (1975) stated that the energy required to produce the world's protein needs through ruminant animals could be provided if only 5% of the waste cellulosic materials could be economically collected and processed. According to Hilmerson *et al.,* (1984) and Owen and Aboud (1988) and, even if the effects of residue management are acknowledged, the difficulty of handling and storing of crop residues have not been given adequate attention by researchers.

The farmers' decision as to whether or not to collect and store crop residues depends on many factors which include the farmers' capacity in terms of having means of transportation (labour, capital, draught animal, etc.), availability of other feed resources, livestock population and market availability (Tesfaye, 2006). The availability of labour, large livestock population and easy access to markets encourage farmers to collect their residues from fields. Once collected and stored, due attention must be given also as storage problems such as pest infestation, moulding and fire may result in losses of the residues. Timothy, *et al.*, (1997) stated that combined with seasonal nature of their production, storage problems can create an annual cycle of brief peaks in crop residues availability followed by long periods of scarcity.

2.4 CHEMICAL COMPOSITION OF CROP RESIDUES

The chemical composition of roughages (DM basis) is variable. For instance, the crude protein content may range from as little as 30 g kg-1 in mature herbage plants to over 300 g kg-1 in young heavily fertilized grasses (McDonald, *et al.,* 1995). Fiber forms the bulk of most tropical roughages and is considered as the sum of cellulose, hemicelluloses (xylans, mannans, glucomannans, arabino-galactans) and pectin and all are inversely related to the crude protein content. Crude fiber may vary from 200 to as much as 450 g kg-1 in mature plant materials. In straws, the digestible cell contents constitute usually less than 250 g kg-1 of the total dry matter (FAO, 1982) and therefore, it makes a minor contribution to the evaluation of feeds depending on their nutritive value and nutritional importance. Generally, cellulose content falls within the ranges 200 - 300 g kg-1 DM and hemicelluloses within the range of 100 - 300 g kg-1 DM (McDonald, *et al.,* 1995). These polysaccharide components increase with the maturity of the plant. The lignin concentration increases in the same manner and adversely affects the digestibility of nutrients, except soluble carbohydrates (Akin and Benner, 1988).

In a review by Butterworth and Mosi (1985) the mean crude protein percentage for good quality hay was 7.7% (N content 12.3 g kg-1). Low protein in roughages is generally considered as one of the major constraints to optimum digestion. The range of neutral detergent fiber (NDF) content of 70-81% is reduced, compared to 73-83% for the untreated roughages. The high variability in chemical constituents could be attributed to the stage of maturity of the plant, plant part, harvesting regime, season, location and type of the roughage plant (McDonald, *et al.*, 1995).

The beneficial effects of feeding urea treated roughages to ruminants include increased metabolizable energy intake, increased animal performance and feed efficiency, increased availability of nutrients and improved rumen function (Pirie and Greenhalgh, 1978; Mgheni *et al.,* 1993). Habib, *et al.* (1998) improved the nitrogen content of wheat straw from 4.12 to 9.83% through ammoniation and reported that this improvement in nitrogen content (9.83%) is close to that found normally in the non-legume green fodders. The authors then concluded that the added nitrogen in straw is one of the main advantages of ammonia treatment, which could increase digestibility.

2.5 LIMITATIONS OF CROP RESIDUES

The most important factor influencing the production response of an animal is the total quantity of nutrients absorbed (Poppi, *et al.,* 2000). Thus, intake and digestibility are key parameters in any feed evaluation system, and of this, intake is the most important as it accounts for most differences between feed types. The prime physical factor in a plant which influences voluntary intake is the rate at which it is broken down to particles small enough to leave the rumen (Minson, 1982). Becker and Lohrmann (1992) suggested that the most significant effect of lignifications is on the rate of forage digestion rather than its possible relation to the proportion of dry matter ultimately digested. Plant maturation is accompanied by an increase in the proportion of fiber and a reduction in the protein and non-structural carbohydrates of the cell content (Egan, 1986).

In most tropical roughages, the quality of feed at the beginning of the rainy season is high but because of high temperatures, rapid physiological maturation takes place leading to early lignifications with the protein and phosphorus contents falling to very low levels while the fiber content increases (Becker and Lohrmann, 1992; McDonald, *et al.,* 1995; Nyamangara and Ndlovu, 1995). Lignifications confer resistance to roughage fiber, thus decreasing mechanical and microbial degradation in the rumen, which could explain the long retention time of tropical roughages in the rumen. Long retention time facilitates rumen fill and consequently decreases feed intake (Thorton and Minson, 1973; Aitchison, *et al.,* 1986*).*

Most tropical grass species belong to the C4 category of plants in which carbon dioxide is first fixed in a reaction involving a 4-carbon compound, oxalate (Egan, 1986), while temperate species belong to the C3 category of plants in which a 3-carbon compound, phosphoglycerate acts as an important intermediate in the photosynthetic fixation of carbon dioxide (Wilson, 1993). The low protein and sulphur contents usually found in tropical grasses are inherent characteristics of C4 plant metabolism (Egan, 1986) that is associated with survival under conditions of low soil fertility. In tropical grasses, starches are the main storage carbohydrates, but these are replaced by fructans in temperate ones.

The plant cell wall has been shown to be the primary restrictive determinant of forage intake (Van Soest, 1994). Tropical and subtropical forages are stemmier and have more cell wall than the temperate forage species (Meissner, 1997). These results in low digestibility, slow rate of fermentation and particle size reduction, which slow down the passage rate of residue from the rumen, increase rumen fill and thereby reduce intake (Minson, 1982). In South Africa, cell wall constituents that have been shown to be correlated with intake include NDF (Meissner *et al.,* 1991), ADF (Cloete and Kritzinger, 1985) and acid detergent lignin (ADL) (Pietersen *et al.,* 1993). Van Soest (1994) reported that the intake was limited above NDF concentrations of 550-600 g kg-1 DM but not below. Similar evidence was presented by Meissner *et al.* (1991). Non-cell wall constituents that limit the intake and digestibility of tropical and subtropical forages include phenolic compounds (ferulic, deferulic, P-coumaric acids and vanillin).

This limitation could be overcome by physical or alkali treatment or by improving the activity of the rumen microbiota. Treatment with alkali (e.g. ammonia and/or urea) hydrolyses lignin-hemicelluloses linkages, thus opening up the structure for bacterial attachment (Sundstol and Owen, 1984), and hence increasing the availability of roughage energy. Kossila (1985) indicated that if all the potentially available crop residues could be utilized for feeding, each herbivore would receive over 9 kg DM and about 17 Mcal ME/day, thus largely covering requirements. Unfortunately, a much lower level of utilization is possible because of problems of collection, transportation, storage and processing, alternative uses, seasonal availability, and more importantly, their poor feeding value. Smith (1993) stated that most crop residues are deficient in protein, essential minerals like sodium, phosphorous and calcium, and are rather fibrous (40 to 45% crude fiber). The consequences of such a profile for ruminants are a low intake (1.0 to 1.25 kg DM/100 kg live weight), poor digestibility of the order of 30 to 45%, and a low level of performance. Low intakes and poor digestibility result specifically from high cell wall lignin content and the chemical bonding between this fraction and the potentially nutritious cell wall constituents such as cellulose and hemicelluloses.

Preston and Leng (1986) also reported that when straws are fed to ruminants the primary limitations to production are: the slow rate of and low total digestibility, the rate at which straw particles break down to a size that can leave the rumen, the low propionate fermentation pattern in the rumen, and the negligible content of both fermentable nitrogen and by-pass protein. The mineral content of straws is generally low and imbalanced but deficiencies are unlikely to be manifested in animals at maintenance. For production of meat and milk, requirements for minerals are increased many folds and supplements should be supplied. Because of limited nutrients in fibrous feeds such as crop residues, Preston and Leng (1984) and Leng (1990) suggested several methods which improve the usefulness of these feed resources by establishing optimal rumen ecology with optimal ammonia (NH3) nitrogen, increasing the ratio between energy and protein, and providing supplemental bypass or protected protein and fat.

2.6 IMPROVEMENT OF CROP RESIDUES

Studies on factors influencing the quality of feeds have indicated that various factors substantially change nutrient concentration and availability to the animal. Among the major factors identified, genetic makeup of the plant, its environment and management practices are the major ones (Wilson, 1993). Thus, no absolute figures of nutritional characteristics of a feed could be established across regions and genotypes. Many techniques are available for improving the nutritive value of roughages. Methods currently employed to enhance digestibility and intake of the basal roughage diet range from physical through chemical treatment to supplementation.

2.6.1 Physical or Mechanical Treatment

Physical or mechanical treatments, such as chopping, grinding, pelleting and steaming have long been used to improve the nutritive value of low quality roughages, including maize stovers (Minson, 1963; Walker, 1984). All the above treatments cause physical disruption of cells and have limited effect on digestibility, but often improve roughage intake. Improved digestibility is partly a result of enlarged surface area caused by grinding and thus improving the possibility for the attachment of rumen microbes. Improved intake is achieved through a faster rate of passage through the rumen, which in turn might cause a decrease in digestibility. Besides, it is probable that species, age of the animal, origin of the plant material, and the conditions under which the material is fed also affect utilization of the feed irrespective of the particle size (Walker, 1984). This method facilitates maximal use of roughage by creating more favourable condition for the host animal to eat more feed.

2.6.2 Chemical Treatment

Several alkali compounds (NaOH, Ca(OH)z, KOH) have been tested , but sodium hydroxide has been the most successful in improving nutritive value of roughages (Church, 1984). The use of sodium hydroxide (NaOH) treatment to increase digestibility of straws has been known for more than a century. Homb 1984 involved the pressure cooking of straws in dilute solutions of sodium hydroxide, followed by washing with clean water to remove the alkali. Clearly this was an expensive method because of the severe processing and problems of environmental pollution. This method was later modified by Beckman (1992), who replaced pressure-cooking with simple soaking. In the Beckman method, rye straw is treated in 1.5% NaOH solution for three days and thereafter rinsed with water. This method of treatment increased the organic matter digestibility (OMD) of rye straw from 46 to 71%, which was lower than the 88% achieved by (Wilson and Pigden, 1993). Straw treated by the Beckman method turned out to be more expensive than other feeds (Wilson, 1993).

Although NaOH is effective in improving the digestibility of low quality roughage it has some drawbacks. The alkali solution is dangerous to handle. Besides being a potential pollutant in case of storage leakage, the large quantities of sodium (Na) being imported to the farm and excreted in urine and faeces are far above what is required for plant growth. In most countries NaOH is expensive and not available. Due to this concern it was necessary to look for alternatives that were cheap and effective improving the nutritive value of straw and safe for the environment. Treatment with ammonia (Sundstol and Coxworth, 1984) and urea (Jewell and Campling, 1986; Flachowsky, *et al.,* 1996) has resulted in increased forage digestibility, voluntary intake and animal performance. Accordingly, Djibrillou, *et al.* (1998) reported that urea and/or ammonia is preferred over other treatments as it has an added advantage of increasing the N content of the straw. As a result of several advantages over sodium hydroxide treatment, like ease of application, nitrogen addition and absence of undesirable residues, ammoniation is also a popular chemical method of upgrading crop residues (Sundstol, 1984). However, limited availability and increased regulation on transportation may limit the use of anhydrous ammonia in certain regions of the tropics.

Urea is widely available and has been used as a source of ammoniation to improve the feeding value of various grasses and crop residues (Sundstol and Coxworth, 1984). Urea treatment is relatively easy to apply and its ability to swell cellulosic fibers is as effective as that of NaOH (Khanal, *et al.*, 1999). In addition to the upgrading effect of urea treatment the added nitrogen from ammonia also enhances microbial activity in the rumen, resulting to increased synthesis of microbial protein.

2.7 SILAGE

Silage is a moist succulent feed produced as a result of controlled fermentation of fresh forage when stored under an anaerobic condition for a period of time. Silage is a fermented high moisture feed which are fed to ruminant animals such as sheep, goat and cattle, or used as biofuel feedstock for anaerobic fermentation of green forages. This process is refers to Ensiling, while the container which the process took place is known as silo. The fermentation takes place in the absence of air (McDonal, *et al*., 1995).

2.7.1 Preparation and stages of making silage

Most crops to be used for silage are permitted to mature or field dry to a moisture level of 650 – 750 g/ kg (250- 350 g/kg DM). Silage materials, containing below 250 g/kg DM (over 750 g/kg moisture) have a tendency to form very sour silage and usually lose considerable amounts of silage juices during storage, involving a considerable loss of nutrients. Silage materials with over 350 g/kg DM do not consolidate well and frequently develop spots of mould during storage as the result of excess entrapped oxygen which allows an aerobic fermentation to occur (Oladejo and Adetunji, 2012).

Silage crops are usually chopped into fairly small pieces, which will usually vary from 2.5 - 3 cm in length .This permits adequate consolidation and facilitates the mechanization of silage handling (McDonal, *et al*., 1995). Ground shelled maize, cane molasses, limestone, urea, mineral or organic acids, enzymes or bacteria may be added to reduce fermentation losses, improve silage quality and increase nutritive value. Activity begins as bacteria feed on the contents of damaged (chopped) plant cells. The final respiration of plant cells produces heat and carbon dioxide. During respiration, the oxygen supply is reduced and carbon dioxide is produced. This establishes an anaerobic condition for the optimal growth of lactic - acid – producing bacteria. The duration of this phase greatly influences silage quality (Oladejo and Adetunji, 2012).

Plant cell respiration ends .As lactic acid and volatile fatty acids are formed, the pH decreases, which helps to prevent the growth of undesirable bacteria and fungi. The number of microbes producing exclusively acetic and butyric acid (volatile fatty; acids) decreases rapidly as the level of lactic- acid - forming bacteria rises (Oladejo and Adetunji, 2012).

During the first few days, setting of the forage occurs. The seepage rate can increase rapidly, whereby the peak can occur on the fourth or fifth day. Seepage occurs when the plant cells rupture from presser and heating due to plant and fungal respiration. Silage is then fermented, beginning 3 –5 days after ensilage .It takes up to 20 days before completion. Phase four determines the success of silage making. The lactic -acid – producing bacteria dominate the silos bacteria population. As the lactic acid content of the silage increases, so does the level of acidity, which slows and stops, further bacterial and fungal action. Lactic acid production peak 3-15% of dry matter depending upon the substrate and the level of fermentable plant sugar .By the end of phase four, the silage is fermented (Lin, *et al.*, 1992).

.When properly ensiled, the silage remains in good condition .where by its low pH prevent further microbial activity. If insufficient acid production occurs during the first four phases, however, the silage may be subjected to break down and attach by un- desirable microbes Should this occur, the silage biochemistry becomes rather unpredictable? Butyric – acid – producing bacteria can use not only carbohydrates (sugar) but also lactic acid as food growth. In addition, these butyric – producing clostridia species can break down protein to amino acids, which are degraded to undesirable compounds including non-protein nitrogen (NPN). This leads to reduction in digestible protein. If this occurs, silage pH increases and causes undesirable fermentations to continue until much of the available energy is gone (Lin *et al.*, 1992).

2.8 MAIZE AS LIVESTOCKS FEED

Maize (Zea mays L.) is a member of the grass family (gramineae). It originated from South and Central America. It was introduced to West Africa by the Portuguese in the 10th century. Maize is one of the most important grains in Nigeria, not only on the basis of the number of farmers that engaged in its cultivation, but also in its economic and nutritional value. Maize is one of the most important cereal crops cultivated in the rainforest and the derived savannah zones of Nigeria (Oladejo and Adetunji, 2012). Maize has been in the diet of Nigerians for centuries, initially produced at subsistence quantity and has gradually become one of the most important crops. Maize is now grown to a commercial quantity on which many agro-based industries depend on as raw materials (Iken and Amusa, 2004; Oladejo and Adetunji, 2012). Maize is a staple food of great socio-economic importance in developing countries and it has a wide range of uses, these includes; baking, brewing industries and livestock feed. It is an important source of carbohydrates, protein, iron, vitamin, and minerals (Kudi *et al.*, 2011).

Major steps involved in the processing of maize are harvesting, drying, de-husking, shelling, storing and milling **(**Nwakaire *et al.*, 2011**)**. At harvest, maize usually contains too much moisture (about 20%-25%) which is a favorable environment for the growth of molds (fungi) and insects that normally cause grain damage. In order to avoid this, drying of the maize must be done to reduce the moisture content to about (11.8%-13%) for safe year-round storage (Folaranmi, 2008). Grain drying is the process for conditioning the grains for safe storage. Correct drying method preserves the quality, nutritive value and viability of grain. (Sahay, 2010).Over 90% of agricultural products are sun dried Arinze *et al.*, (1990). Ordinary sun drying of maize is very tedious, time wasting, having low hygienic level and has brought about reduction of nutritional contents such as vitamins in the dried maize as a result of it direct exposure to sunlight or more specifically ultraviolet radiation (Arinze *et al.*, 1990). Also, maize harvested during the rainy seasons are usually sold at cheap prices to corn roasters and used for other delicacies (Folaranmi, 2008; Olutoye, *et al.,* 2012).Farmers loose considerable amount of food crops annually due to primary factors such as insect infestation, rodent attack, molding during storage and transportation, deterioration in quality and an increase in broken and cracked grains (Ndrika, 1988).

2.8.1 Maize Cobs Silage

Maize cob silage is an important source of forage for ruminants in the Czech Republic. It is a highly digestible and palatable feed source valued for its nutritional composition. Well-fermented silage is readily consumed by animals and may improve their health and production characteristics (Varadyova, *et al.,* 2010). Ensiling is a method of long-term preservation and storage of fresh plant material under anaerobic and acidic conditions. The primary acid responsible for decreasing the pH of silage is lactic acid, which is produced by lactic acid bacteria (LAB) from water soluble carbohydrates (WSC). LAB occurs in varying quantities throughout the natural environment. Although it is well recognized that epiphytic LAB play an important role in silage fermentation, the number of epiphytic LAB in the standing crop is limited and variable (Muck, 1990; Lin, *et al.,* 1992). In view of the facts that the epiphytic microflora of fodder crops varies greatly and that LAB numbers are usually relatively low, it is very important to know their composition and structure because such knowledge enables successful application of microbial preservative additives (Cai, *et al.* 1998). Their absolute and relative numbers might be important in predicting fermentation adequacy and in deciding whether or not to apply a silage bacterial inoculant (Lin, *et al.*, 1992).

Various types of microbial additives can be used to improve silage fermentation (Reich and Kung 2010). Most commercially available inoculants contain homo-fermentative LAB, which are used with the objective of stimulating the rate and extent of fermentation so that either the concentration or the proportion of lactic acid in the total fermentation acids in the silage is as high as possible (Jalc, *et al.* 2009; Wilkinson and Davies, 2013). Chemical additives are added to ensiled forages to prevent or reduce the growth of such undesirable microorganisms as yeast or moulds, which are responsible for aerobic deterioration in silages. Inorganic acids, such as formic or sulfuric acids, have been used to improve silage preservation by direct acidification, whereas organic acids, such as propionic, benzoic, and sorbic acids, have been used to increase silage aerobic stability (Kleinschmitt, *et al.*, 2005; Queiroz, *et al.*, 2013). Chemical-based additives are useful for improving fermentation during unfavourable climatic conditions. They can be used when the dry matter (DM) content of ensiled matter is low (e.g. often during rainy weather), for high-protein fodder plants, or for silage with very high DM content (Huhtanen, *et al.*, 2013). Because of its high antimycotic activity, propionic acid usually constitutes the greatest percentage of those active ingredients used in commercial products today (Kung, *et al.*, 1998; Mills and Kung 2002). However, the nature and intensity of the effect of these additives may differ across plant species and with advancing stage of maturity (McEniry, *et al.*, 2014).

2.9 SILAGE ADDITIVES

Silage additives have been in use for a very long time (Owen, 1986), but it is only in the last 15 to 20 years that the availability of machinery, knowledge of silage fermentation processes, grassland management practices and awareness of the value of forage in the ruminant diet have contributed to the significant growth in additive usage . Jones (1994) observed that over 130 silage additives were available in UK. Over 50 million tones of silages were produced in 1994, but only about 18 million tones of these silages were treated with silage additive. Owen (1986) summarized the factors which may be regarded as important characteristics of silage additive and reported that silage additives should produce high quality stable silage with no secondary fermentation, which would improve animal performance. The silage additives should also be non- corrosive to machinery, and easy and safe to handle. Finally, the silage additives should be well-proven and backed by major company. Additives are used to improve silage preservation by ensuring that lactic acid bacteria dominate the fermentation phase .They can be divided into three general categories: Fermentation stimulants, such as bacterial inoculants and enzymes, Fermentation inhibitors such as propionic, formic and sulphuric acids, Substrate or nutrient sources such as maize grain, molasses, urea and anhydrous ammonia (Woolford, 1984; Henderson, 1993 and Bolsen, *et al.*, 1995).

A number of trials resulted in the conclusion that only strong acids, either alone or in combination with formaldehyde, have the potential consistently to modify fermentation (Thomas and Thomas, 1985). However, these additives have largely lost popularity due to both cost and handling difficulties on the farm. Bacterial inoculants have inherent advantages over other additives, due to their low cost, safety in handling, a low application rate and no residues or environmental problems. However, results of their application are variable, probably due to the differing ensilage conditions prevailing at the time of application .However, when the additives are applied together with enzymes, which degrade plant cell walls and starch providing addition sugars for fermentation to lactic acid. They appear to have achieved improvement in fermentation and nutritional quality of tropical grasses and legumes (Bolsen, 1999). On small scale farms, commercial additives, which comprise inoculants and enzymes, may be too costly. It is likely therefore that the third category of additive will be of most benefit to silage made in small holdings. Possibly the most important benefit of additives such as maize or sorghum grain or cassava meal improved dry matter in early cut crops when moisture content is high where rapid drying (wilting) is not possible or effluent is lost to the silage through seepage . Tropical grasses have been successfully ensiled when supplemented with maize meal (Onselen and Lopez, 1988) cassava meal (Panditharane, *et al.,* 1986) and sorghum grain (Alberto, *et al.*, 1993).

Molasses is the carbohydrate source used most frequently and is of particular benefit when applied to crops low in soluble carbohydrates such as tropical legumes and grasses. Good silages have been reported when molasses was applied at 3-5 % (Bareeba, 1977). However, if the treated silage has very low dry matter content, most of the carbohydrate source may be lost in the effluent during the first few days of ensilage in pits or bunkers. Applying urea or anhydrous ammonia to silages has an adverse effect on fermentation and nutrient quality of silages, particularly high

2.10 PRINCIPLES OF UREA TREATMENT

Chenost and Kayouli (1997) described the process of urea treatment as a simple technique consisting of spraying a solution of urea onto the dry mass of forage and covering with materials locally available so as to form a hermetic seal. The process involves the hydrolysis of urea into gaseous ammonia and carbonic gas through reaction with an enzyme called urease which is produced by ureolytic bacteria within the forage being treated. The ammonia thus generated provokes the alkaline reaction which gradually spreads and treats the forage mass. According to a report by Kayouli, (1996), urea treatment developed in Niger, was a simple technique that made use of locally available materials. Stovers and straws were treated with 5% urea (5 kg urea dissolved in 50 litters of water to treat 100 kg dry residue) and made into a stack using the traditional storage method and locally available air-tight system: silos made from *Andropogon gayanus* or briquettes made from clay and straw. Air-tightness was successfully ensured by tying with braids made from *Andropogon gayanus* and no plastic sheets were required.

The principle underlying urea treatment is that the ammonia generated from urea by bacterial and/or plant ureases in the ensiling process hydrolyses the chemical/physical bonds between lignin and the cellulose and hemicelluloses in the plant cell wall. The hydrolysis of these bonds makes the cellulose and hemicelluloses more accessible to microorganisms in the rumen and increases total fermentation and usually the rate of fermentation. Some chemical hydrolysis of hemicelluloses also takes place resulting in an increase in the portion of soluble carbohydrates in the straw (FAO, 1986). Response to urea treatment is thus a combination of the effect of the alkali on cell wall structure and the effect of added nitrogen on rumen microbial activity (Preston and Leng, 1984).

Chenost and Kayouli (1997) stated that the success in urea treatment depends on interdependent factors such as the presence of urease, the rate of urea applied, the moisture content, the ambient temperature, length of the treatment period, the degree of the hermetic sealing achieved during treatment and the quality of forage to be treated. From the report of Chenost and Kayouli (1997) regarding urea application rate, it is now well established that the optimum rates lie between 4 and 6 kg urea per 100 kg of straw matter which corresponds to treating with ammonia in a range of 2.27 to 3.4 kg (one molecule of urea, (60 g) generates two molecules of ammonia, that is 34 g). The level of 4 to 5 kg urea for treatment of 100 kg dry straw has been widely used in many countries such as Thailand, China and Sri Lanka (Chenost and Kayouli, 1997). In other countries, levels as high as 6 to 7 kg per 100 kg dry straws were used. Bui and Le (2001) on the other hand, stated that, though DM, crude fiber (CF) and organic matter (OM) degradability of rice straw treated with 4 or 5% urea were slightly higher than that of the straw treated with 2.25% urea plus 0.5% lime, the latter treatment seemed to be the reasonable alternative for farmers to accept the technique due to the fact that urea was rather expensive in Vietnam. In this case, the treatment time was 7 days. Nguyen *et al*. (1998) also suggested that 3% urea plus 0.5% calcium hydroxide may be more economical than 5% urea in treating rice straw provided that it has good effects on digestibility and intake of the straw by ruminants. The premise of their suggestion is that when urea level was from 3% to 5%, only 17.4 % of the additional urea nitrogen was fixed indicating loss of nitrogen when the level of urea applied is high due to the anaerobic activities of microorganisms. In addition, the authors remarked that the partial replacement of urea with calcium hydroxide could be technically and economically justified. Based on the available knowledge for urea treatment, Said and Wanyoike (1987) recommended that smallholders in Kenya should treat their maize stover with 5% urea (batches of 10 kg chopped stover sprinkled with urea solution made of 0.5 kg urea dissolved in 10 liters of water) for two weeks.

Preston and Leng (1984) indicated that, as a rule of thumb, 30 g N per kg digestible organic matter (DOM) is required to maximize the development of rumen microbes. According to Durand (1989), the total level of nitrogen required to optimize the activity of rumen microbes is 26 g N per kg DOM. In accordance with these recommendations, Nguyen (2000) stated that straw treatment with 4 % urea is an expensive way of supplying nitrogen as the level is required for effective treatment but is much greater than what is needed by the rumen microbes.

2.10.1 Performance of animals fed urea treated crop residues

In Niger, Kayouli (1996) observed that the consumption of urea-treated forages during dry season is often accompanied by an improvement in body condition of the animals and maintenance of live weight. The animals were also more resistant to diseases and their coat was improved (brighter hair). Thin and weak animals recuperated rapidly and milk from dairy cows increased significantly. Moreover, farmers have noted a positive effect on animal fattening in such a way that the fattening period was reduced with a consequent saving in concentrates. According to Preston and Leng (1986), the technique of using urea-treated forages also enables the use of animals with higher genetic merits as these animals can consume much of the digestible feeds to meet their requirements. Another positive effect of urea treated forages, observed by Kayouli (1996), is that feeding of such forages to draught oxen resulted in improved body condition with no loss of weight during ploughing period. Moreover, animals worked harder and longer (often ploughed 1.5 to 2 hours more per day) than those fed on untreated straws and stovers. Urea treatment increases the acceptability and voluntary intake of the treated straw as compared with the untreated straw when it is fed *ad libitum*. The increase in intake is very important because what and how much animals eat (their feed intakes) are the most important factors that determine the productivity of ruminants (Kayouli, 1996). In this regard, Wongsrikeao and Wanapat (1985) found a significant difference in dry matter intake between the urea treated and untreated rice straw with values of 5.87 and 7.32 kg per day for untreated and treated straw, respectively. In terms of animal performance, those animals that fed the urea treated straw gained 0.21 kg/day while those that fed the untreated straw lost 0.13 kg per day From feeding of 2.5% urea treated maize stover as a sole source of roughage to growing cattle, Tran and Nguyen (2000) found that the treated straw had positive effects upon intake, digestibility and growth rates of the animals during a 60-days feeding trial. In a trial which compared the relative effectiveness of ammoniation using urea and supplementing untreated rice straw with a molasses-urea block (MUB), Bui and Le (2001) found consistently higher growth rates for crossbred cattle on ammoniated straw compared with those on the MUB supplemented untreated straw (449 vs. 363 g per head per day). The improvement in growth rate due to urea treatment was 25% ($p<0.001$). The DM intake of the straw was also higher ($p<0.001$) for the group fed ammoniated straw than those fed the straw supplemented with MUB. Although moderate rates of live weight gain can be obtained with ruminants on diets based on treated crop residues, better animal performances require supplementation of such residues with nutrients that have beneficial effects on rumen function.

Research works done in Thailand and Australia depicted that the critical supplementary nutrients on a straw based diet are bypass protein, starch and long chain fatty acids. High rates of growth were obtained when the ammoniated straw (urea ensiling in Thailand and ammonia gas in Australia) was supplemented with starch, protein and oil in the by-product meals that are known to escape rumen fermentation (Elliot *et al*., 1978a and 1978b). Live weight gain of young Brahman bulls weighing 150 kg increased from 0.47 to 0.83 kg/day as the level of supplementation of ammoniated rice straw with a mixture of fat, protein and rice starch increased from 1 to 3 kg/day (Wanapat *et al.*, 1986). In another study on the effects of various levels of bypass protein supplementation on the body weight change of cattle given diet of ammonia treated or untreated rice straw, sole treated rice straw gave 52.1% more growth rate than the untreated one. The live weight gain further increased to as high as 639 and 365 g/day due to protein meal supplement on treated and untreated straw, respectively (Preston and Leng, 1986). By feeding urea treated wheat straw with limited amount of concentrate composed of cottonseed cake and wheat bran to Chinese cattle, Ma, *et al.* (1990) found considerable improvement in 48 hours degradability (69.4 and 47.3% for treated and untreated straw, respectively).

Moreover, the ammoniation resulted in faster and more efficient growth and was also cost effective. The percentage improvement obtained in daily weight gain, DM conversion and cost of feed per kg gain due to treatment were 341% (485 vs. 110g), 76.4% (10.8 vs. 44.3) and 64% (1.82 vs. 5.0 Yuan), respectively. In another study by Gao (2000), Chinese Yellow cattle (young bulls) of 160 to 210 kg live weight and 12 to 14 months of age were fed wheat straw treated with anhydrous ammonia or urea plus 1.0, 1.5 and 2 kg/day of cotton seed cake. Though the live weight gains of animals given the anhydrous ammonia treated straw were significantly higher than that of the animals given urea treated straw, daily weight gains of 602, 687 and 733 g were attained for urea treatment plus the 1.0, 1.5 and 2 kg/day of supplement, respectively.

From their study with yearling crossbred (Friesian x Malawi Zebu) cattle, Munthali, *et al.* (1992) reported the highest live weight gain for animals fed 4% urea treated maize stover supplemented with 2 to 3 kg maize bran per day. The authors attributed the improvement in live weight gain to the increased intake of energy and an accompanying improvement in the utilization of non-protein nitrogen in the urea treated straw.

2.10.2 <u>Effects of yeast treated crop residues on livestock</u>

The yeast used in ethanol production (*Saccharomyces cerevisiae*) has a by-product with the potential for animal feed, due to its high protein and vitamin content. Among the microorganisms studied, yeasts appear to meet the more favorable characteristics for using in animal feed. Moreira, *et al.* (2002) reported that the content in crude protein is variable (30 to 60%), the total nitrogen is about 80% of amino acids, 12% of nucleic acids and 8% of ammonia. Approximately 7% of total nitrogen occurs as free amino acids and in other compounds, such as flutationa, lecithin, Adelino acid, vitamins, enzymes and coenzymes in small quantities. Carbohydrates constitute 15 to 60% of the dry weight of yeast, being represented averagely as 33% trehalose, 27% glucans, 21% mannans and 12% glycogen. Meneghetti and Domingues (2008) reported that they recovered about 2.5 kg of dried yeast per hectoliter of alcohol produced. The yeast presented high content of lysine and threonine and deficiency of methionine and cystine. It is also considered as rich in vitamins B and D. According to Moreira, *et al.* (2002), dry yeast can be achieved in three distinct ways: Tapping the milk yeast, bottom vat and vinasse. After obtaining the wet product, there are two drying techniques: A rotating rolls (LSRR) and, more recently, the technology "spray-dryer (SCYSD).

Yeasts seem to be related to reduce the production of methane in the rumen by promoting increased competition between methanogenics and acetogenics bacteria. Possenti, *et al.,* (2008) affirms that in diets for ruminants, yeasts have been used to improve the symbiotic relationship between rumen microorganisms and their host, improving rumen fermentation processes in animals given diets rich in starch. Santos, *et al.*, (2006) reported that some researches indicate that cows under heat stress receiving diets rich in starch respond better to this type of additive. The use of *S. cerevisiae* cultures, or its extracts can improve weight gain and milk production with an intensity similar to ionophores (7.0-8.0%), arising from the response the increase in dry matter intake. Among the factors that could affect the response of cattle supplemented with yeast culture, there is the type of forage, the large proportion: concentrate ratio, the timing and level of supplementation. Santos *et al.*, (2006), on provide supplementation of 10 g of yeast culture / animal / day to steers fed 50 or 100% forage, dry mass basis, observed increase in rumen pH after 4 hours of feeding with 50% concentrate and significantly decrease in acetate: propionate ratio without changes in total concentration of volatile fatty acids. Gattass *et al.,* (2008) evaluated the effects of adding yeast culture (*S. cerevisiae* 1026) on the parameters of rumen fermentation of beef cattle fed 50% forage-based sorghum silage and 50% concentrate containing soybean hull pellets, sorghum grain, urea and mineral protein (% dry mass), two treatments were used, which consisted of the inclusion or not of *S. cerevisiae* (1 g/100 kg BW) to the diet in two of four daily meals. Franco *et al.,* (2004) working with steers fed diets containing 27 or 37% neutral detergent fiber (NDF) (40 or 60% alfalfa hay, dry mass basis, respectively) and provide 10 g of culture yeast/animal/day, increased their concentration of propionate in both NDF levels, although the total concentration of volatile fatty acids and ammonia were changed. Moreover, Greene (2002), working with diets with a higher proportion of roughage to concentrate, found no significant changes in rumen fermentation of the diets studied when provided a yeast culture. Results favored by the use of yeast (15.0 g/animal/day) were not confirmed by Franco *et al.*, (2004), in steers fed grass hay, supplemented with concentrate and yeast culture.

The inconsistency of results in literature regarding the use of yeast culture for ruminants makes the decision of using yeast in the diet difficult, especially considering the relatively high cost of commercial products available. Miranda, *et al.*, (2001) had no response to the supply of 5.0 g/animal/day of yeast in Simmental steers. Weight gain and DM intake average of 1.54 kg/day and 2.14% of body weight. The yeast, however, promoted an increase (6.3%) in weight gain. In an experiment of digestion and metabolism, led by Greene (2002), steers were fed 9.8 kg DM/day of a diet containing 90.0% concentrate and zero or 0.26% yeast in DM. The digestibility of DM (79.2×77.8%), crude protein (74.7×75.1%) and ADF (42.0×36.3%) showed no significant differences, but the pH of the rumen increased (5.8×6.5) with the addition of yeast. They also noted that the yeast increased the utilization of calcium and phosphorus in the diet. Aiming to evaluate the effect of supplementation level of living yeast (*S. cerevisiae*) on the average daily consumption of concentrate and the average daily weight gain of lambs on creep-feeding system, Neumann, *et al.*, (2008) tested the following treatments: T1 – 0 g animal/day, T2 - 0.4 g animal/day and T3 - 0.8 g animal/day. 27 lambs *Ile de France* from single birth (18 males and 9 females) with average weight of 19.5 kg and mean age of 40 days were used. The creep-feeding consisted of three periods of 21 days, totaling 63 days of supplementation. Neumann, *et al.*, (2008) observed no significant interaction between supplementation and evaluation period regarding the concentrate intake, average daily weight gain and feed conversion of gram of concentrate per 100 g of weight gain. There were no differences in live yeast supplementation level ranging from 0 to 0.8 g animal/day on intake (635.7 g/day) and weight gain (418 g/day) from *Ile de France* lambs born birth simple creep-feeding system, depending on the level of supplementation of living yeast. Results that favored the use of yeast have not been confirmed by Pereira *et al.,* (2001) in the digestibility study using steers diets based on cane sugar. The average DM intake was 89.1 g/kgBW0, 75 or 2.13% of body weight. The average digestibility of DM, CP, EE, NDF and total carbohydrates (CHOT) were 49.6, 54.3, 71.0, 31.6, and 50.9% respectively. They concluded that the use of yeast does not influence the consumption and digestibility.

2.10.3 Performance of animals fed molasses treated crop residues

Molasses is a by-product or end product of sugar cane (*Saccharum officcinarum* L.) or sugar-beet (*Beta vulgaris* L. *var. Conditiva*) resulting from the manufacture of raw or refined sugar. It is a viscous liquid and heavily condensed to separate in to a low degree, of which not all of sugar can be crystallized by the usual processes. It can be found in the market in liquid or solid (powder). Molasses contains an average of 5% protein, but is rich in energy, and a very palatable laxative (EMBRAPA, 2015). Valadares Filho, *et al,*. (2002) pointed out that molasses should be used, diluted in water at a ratio of 1:1 to 1:2, and given together with dried forages and concentrates, properly supplemented with protein. Molasses, by weight, has 67% of energy from corn, but offers the advantage of stimulating the multiplication of bacteria in the rumen, therefore leading to the digestion of fibrous feed. Since the cost of molasses is not more than

60% of the cost of corn, it can be mixed in a ratio to 1/3 of concentrated feed and the gradually introduced in the diet.

Molasses has been used widely as a food supplement in the diet of ruminants with good results, and the percentage composition of the feed used in cattle-will depend on the stage of the flock and the type of pasture (nutritional value of pasture). Najafpour and Shan (2003) asserted that molasses can vary from 85 to 92° Brix. The Brix content measured (in degree Brix), are very close to the concentration of sucrose in the product, 25 to 40% sucrose from 12 to 35% of reducing sugars, 2.5 to 9% crude protein, 7-15% ash, 3100 kcal/kg gross energy and 80% TDN. According to these authors, there are differences in the chemical composition of molasses produced from sugar cane grown on organic soils in relation to those of mineralized soils and it is possible that these differences may produce different effects when fed to animals. Molasses is an energy supplement used in order to stimulate consumption in feed for ruminants and as a reduction of powder to substitute other ingredients for the same purpose, provided it price is competitive. There are reports of supply of sugarcane molasses for cattle since 1890, originally used pure. This product has entered the match in the 30's and then to urea in 50 years. With time, other nutrients were added to the formulations true protein, lipids, minerals, vitamins, additives and even homeopathic ingredients (Freitas, *et al.,* 2003). High prices of protein food and alternative sources to providing adequate nitrogen for the animals has become necessary in order to minimize production costs in feed

2.11 NUTRIENT DIGESTIBILITY

Nutritive value is determined by nutrient concentration and nutrient digestibility. Nutrient concentration and digestibility data can be determined using digestion trials or by measuring chemical composition and applying this information to estimate digestibility. Nutritive value of feeds is determined by a number of factors, including composition, odor, texture and taste (Schneider & Flat, 1975). These factors are generally measurable in the case of the animal as digestibility and intake. Digestibility is simply a measure of the availability of nutrients. When digestibility is combined with intake data, one can make an accurate prediction of overall nutritive value, of the two factors, intake is relatively more important than digestibility in determining overall nutritive value because highly digestible feeds are of little value unless consumed by the animal in question (Khan, Nisa and Sarwar, 2003). However, digestibility usually provides a fairly reliable index of nutritive value because more digestible feeds are normally consumed to a greater extent than less digestible feeds. Only that portion which is soluble or is rendered soluble by hydrolysis or some other chemical or physical change can be taken up into the circulation and assist in supplying the animal body with material for building and repair of tissue or supply the energy necessary for body functions (Khan, *et al.*, 2003).

In digestibility trials, the feed under investigation is given to the animals in known amounts and the output of faeces measured (McDonald, Edward and Greenhalgh, 1995). The feed is given to the trial animals for at least a week before collection of feaces begins. The preliminary period is followed by a period when feed intake and faecal output are recorded. The trial is completed by analyzing samples of the feed used and the faeces collected (McDonald, *et al*. 1995). There are different techniques for measuring or estimating digestibility and these include:

2.11.1 Marker Technique (Indicator or Index Method)

In this method, in addition to the chemical analysis of the usual proximate nutrients, the content in the feed and faeces of an indigestible reference substance is determined. The substance may be a natural constituent of the feed (internal indicator) or it may be added to the feed (external indicator) (Khan, *et al.,* 2003). Substances used for this purpose include ferric oxide, chromic oxide, lignin, silica, chromogen, acid-insoluble ash (Van Keulen & Young, 1977) and indigestible acid detergent fiber (Waller, *et al.,*1980). A good marker must be strictly non-absorbable, must not affect or be affected by the gastrointestinal tract or its microbial population, must be physically similar to or intimately associated with feed material and its method of estimation in digesting samples must be specific and sensitive and not interfere with other analyses (Khan, *et al.,* 2003).

2.11.2 Difference Technique

Calculation of digestibility of a nutrient in a test diet is based upon the assumption that digestibility of a mixed diet is equal to the summation of the proportions of the diet supplied by each ingredient when fed alone (Khan, *et al.,* 2003). The digestibility of a nutrient in the test feedstuff being fed in the form of mixed feed is calculated as follows:

$$\text{Digestibility of nutrient in test feed (\%)} = \frac{(A) - (B)\,(C)}{D} \times 100$$

A = Digestibility of nutrient in total diet; B = Digestibility of nutrient in basal diet (usually already determined when fed alone); C = Proportion of total nutrient in diet supplied by basal diet; D = Proportion of total nutrient in diet supplied by test feed.

2.11.3 Nylon-Bag Technique (*in situ*)

The nylon-bag technique provides a means of ranking feeds according to the rate and extent of degradation of dry matter, organic matter, nitrogen or other nutritional parameters. It involves incubating samples of feeds in the rumen of fistulated animals for periods of 60 to 120 hours and subsequent determination of the disappearance of different feed components (Osuji *et al.,* 1993). The nylon technique uses bags (9cm x 18cm) made of nylon mesh (30-50µm) in which a sample of known weight is tightly sealed in the nylon bags and placed in the rumen of fistulated animal. After the required period of time, the sample is removed, washed, dried and weighed. Degradability (or disappearance) of the substrate is determined by the weight loss during the incubation periods. The dried residue may also be used for chemical analysis (Osuji, *et al.,* 1993). Nylon bag (or *in situ*) techniques, are, however, quite useful for evaluating kinetic aspects of digestion in ruminants through the use of multiple incubation times and computer models, rates of nutrient digestion can be estimated (Khan, *et al.,* 2003).

2.11.4 Menke *in vitro* Gas-Production Technique

The Menke *in vitro* gas-production (Menke, *et al.*, 1979) is commonly used to determine the amount of gas produced over a 24-hour incubation period. The amount released when a feed is incubated *in vitro* with rumen fluid is closely related to the digestibility of the feed. The gas produced is read either at a fixed incubation time, 24 hours or at a series of incubation time (sequential incubation) mainly 6, 12, 24, 48, 72 and 96 hours (Osuji, *et al.*, 1993). *In vitro* digestibility techniques provide a quick, inexpensive, and precise prediction of *in vivo* or conventionally determined digestibility in ruminants. The *in vitro* procedure does a better job of prediction than chemical composition because it accounts for all factors affecting digestibility, whether known or unknown, which is not possible with current chemical methods (Khan *et al.*, 2003).

2.11.5 Prediction Technique

Alternative measure of digestibility is the prediction of digestibility from chemical composition of the feed in question. This process involves development of multiple regression equations relating to various chemical components to *in vivo* digestibility. Generally, the digestibility estimates obtained from prediction equations are not as precise as one might, desire ($\pm$3 to 4% of values obtained from conventional trials), and at the present time, *in vitro* digestibility measurements are more extensively used to estimate digestibility than are prediction equations based on chemical composition (Khan, *et al.*, 2003).

2.12 RUMEN DIGESTIBILITY

Ruminant diets in most developing countries are based on crop residues. These feeds are not balanced and are most often deficient in protein, mineral and vitamins and are highly lignified. Efficient and effective supplementation of locally mixed diets has greatly influenced the development of the rumen ecology (Suchitra and Wanapat, 2008), dry matter intake and subsequently meat and milk quantity. The extent to which foliage degrades in or escapes from the rumen is extremely important. If foliage protein is totally degraded, it provides ammonia and minerals for microbial growth (Leng, 1993). Local feed materials such as cassava roots/hay/silage, corn stover, cowpea husk, cotton seed meal, lercene leaves, moringa seeds etc have potentials in ruminant feeds to improve and increase the efficiency of the production system (Liu, *et al.,* 2001; Preston, 2001; Hossain and Becker, 2002; Hess *et al.,* 2003; Promkot and Wanapat, 2003). Smith, *et al.,* (1991) observed that the rate of degradation in each animal depends on the quantities of bags inserted which results in appreciable variation. Reduction in degradability or extensive variability of forages ranges from 44-63%, browse (58%), crop residues (39%), which suggest that during the dry season, there are high cell wall contents, forage quality is low to sustain animals and balance in crop residues for use as supplement will increase productivity. It also revealed that crop residues are well degraded.

Kanpukdee (2008) reported that the absolute value of rumen degradation depends on the way in which the materials are prepared and the pore size of the bags used. Preston (1986) reported that the rate of degradation is an important parameter in the assessment of fermentation in the rumen. Fistulated ruminant animals are valuable biological tools for researches concerning ruminant animal nutrition and physiology especially *in-vivo* studies of feed evaluation (Osuji, *et al.,* 1993).

Mbaya, *et al.,* (2011) observed that there is a great need presently for cannulation in small ruminants either for investigation of digestion as in evaluation of feed or collection of ruminant fluids, and this could be performed by many types of cannulae and techniques. However, several ruminal cannula and respective surgical techniques have been reported (Santra and Karim, 2002). Ruminal cannulae are made of plastics, rubber or even metal materials that should be placed and fixed properly to prevent leakages. Ruminal cannulation (or fistulation) was adopted practically for obtaining samples of ruminal ingesta, fluids or gases (Corley, Murphy, Lucena and Panno, 1999) and also *in-sacco* degradation studies (Osuji, *et al.,* 1993).

2.13 DEGRADATION OF FEEDS IN THE RUMEN

Degradation is one of the most important quantitative factors determining the nutritional value of feed protein, the supply of ammonia, peptides and branched-chain fatty acids to ruminal microorganisms, and the passage of undegradable proteins to the intestine (Hvelplund and Weisbjerg, 2000). The nylon bag technique described by Ørskov, Hovell, De and Mould (1980) for the determination of the degradation of feedstuffs in the rumen at various incubation periods can be used to screen feeds at the initial stages of assessing their nutritive values. Applying the equation of McDonald (1981), $y = a + b\ (1 - e^{-ct})$, to describe the course of degradation of the feeds, the constants, a, b, and c obtained can also be used to predict feed intake and growth rate (Orskov, Reid and Kay, 1988). Blummel and Ørskov (1993) reported that the *in vitro* gas production technique developed by Menke, *et al*. (1979) could also be used to determine gas production at various incubation periods and these values could be used to describe the course of fermentation of the feeds, by applying the equation of McDonald (1981). These workers reported high positive correlation between the in vitro gas production and the dry matter degradability values of feeds at the various incubation periods (Blummel, *et al.*, 1993).

The technique used to estimate ruminal fermentation by the incubation of small samples of feed in the rumen was first used by Quinn, *et al.,* in 1938, however, it was not until the introduction of mathematical tools capable of transforming the data of ruminal disappearance rates in values of effective degradability (Orskov and McDonald, 1979) that the method became widespread (Hvelplund and Weisbjerg, 2000). Today, the *in situ* method is the most widely used in research to determine estimates of rumen protein degradability, having been adopted in several countries (Schwab, *et al.,* 2003) as well as by the NRC (2001). Ørskov, *et. al.* (1980) observed that the nylon bag technique was not only a powerful tool for indexing the relative degradabilities of feedstuffs, but that it may also be used to study rumen processes, as it is possible to vary the factors within the bag, or within the rumen.

The *in-situ* procedure consists of placing feed samples in a nylon bag with a defined pore size (40-60 µm), and infusing them into cannulated animals (cattle, sheep or goats). The pores must be small enough to prevent the loss of particles and large enough to allow for access of microorganisms to the material. Due to the small quantity of incubated samples, they do not interfere with ruminal fermentation, and it is assumed that the conditions inside the bags are similar to those in the rumen (Orskov, *et. al.* 1980).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 EXPERIMENTAL LOCATION

The study was conducted at the Department of Animal Science Bayero University, Kano Teaching and Research Farm. Kano state lies on longitude 9^0 30' and 12^0 30' North and latitude 8^0 42' and 9^0 30' East in the semi-arid region in the northern Nigeria (Olofin, 2007). The mean annual rainfall vary from 600-1000mm (KNARDA 2001). The location has about 4-8 momths of dry season with maximum and minimum temperatures of 33^0C and 15.2^0C, respectively. The temperature goes as low as 10^0C during harmattan. The environment is condusive to different species of livestock production (cattle, sheep, goats, rabbits and poultry) (Muhammad, *et al.*, 2009).

3.2 EXPERIMENTAL DESIGN

A 3 x 4 factorial experiment in Randomized Completely Block Design (RCBD) was used, with four treatments and three replications for each treatment.

T0 = control (untreated maize cobs)

T1 = maize cobs + urea solution

T2 = maize cobs + molasses solution

T3 = maize cobs + yeast

3.3 MATERIALS USED

The materials used for this experiment were Maize cobs, Jar bottles, laboratory yeast, urea, and sugar molasses. The Maize cob was obtained from the Department of Agronomy Farm, Bayero University, Kano. The bottles and reagents were purchased in Kano metropolis.

3.4 SAMPLE PREPARATION

The Maize cob was crushed using a medium crushing machine at the Animal Science Laboratory at Bayero University, Kano. This served as mechanical treatment of the maize cobs, so as to increase the surface area for the fermentation. The bottles were properly soaked in salt solution, and further soaked in warm water 37^0C for 1hr and washed with detergent. The bottles were rinsed and dried under shade in a clean environment.

3.5 MAIZE COBS AND SILAGE PREPARATION

Before the ensiling, 12kg of maize cobs were chopped into smaller pieces of about 1cm. four combinations of maize cobs, treated with urea, molasses, laboratory yeast, and untreated maize cobs were used. Thirty six (36) bottles were made and each was filled with treated and untreated maize cobs, compressed and tightly closed. Each bottle was replicated three times and divided in to three ensilage periods of 3^{rd}, 5^{th} and 7^{th} weeks and stored under shade. At the end of each ensilage period, samples were drawn; sun dried and prepared for chemical analysis and degradability studies. Urea at a level of 1% dry matter of maize cobs was dissolved in 3000ml of water and mixed with raw maize cobs as described in the procedure of Roy and Rangnekar (2006). Yeast at level of 1% dry matter of maize cobs was prepared and dissolve in 3000ml of water, and mixed with raw maize cobs. Molasses at a level of 3% dry matter of maize cobs was diluted in 1000ml of water and mixed with raw maize cobs as demonstrated by Valadares Filho, *et al.*, (2002) who pointed out that molasses should be used, diluted in water at a ratio of 1:1 to 1:2, and given together with dried forages and concentrates, properly supplemented with protein. Raw maize cobs was prepared by adding 2000ml of water and ensiled directly.

3.6 QUALITY DETERMINATION OF ENSILED MAIZE COBS

After 3rd, 5th and 7th weeks, the fermentation was terminated and the silage was opened for silage quality evaluation. The assessed quality characteristics were colour, aroma, and pH according to Babayemi and Igbekoyi (2008). Immediately silage was opened, a laboratory thermometer was inserted to determine the temperature. The pH of was determined by adding 100ml of distilled water to 25g of each treatment in a beaker and a pH meter was inserted to determine the pH.

The conditions were scored for aroma, and color by three independent scorers on a subjective of 1-4 (Table 1).

Table 1: Description of Colour and Aroma Rating used as indices of Silage Quality

RATING	COLOUR	AROMA
1	Dark or deep brown	Putrid or rancid
2	Light brown	Pleasant
3	Pale yellow	Sweet
4	Yellowish green	Very sweet

Source: Muhammad, *et al.*, (2009)

3.7 CHEMICAL COMPOSITON OF ENSILED MAIZE COBS

Samples ensilaged maize cobs were analyzed for proximate composition (CP, CF, EE, DM, Nitrogen free extract and Ash) according to (AOAC. 2000). Neutral detergent fiber (NDF) and acid detergent fiber (ADF), were determined according to Van Soest, *et al.* (1991).

3.8 IN *SACCO* DEGRADABILITY

Degradability study of maize cobs was carried out in three fistulated Kano Brown bucks with an average age of 48 months old according to the nylon bag technique described by (Orskov, *et al.,* 1980). The animals were allowed ten days period to adjust to the new feeding and housing condition prior to suspension of bags. Samples were dried and ground through a 2mm sieve before rumen incubation. Triplicate samples of about 4g each was placed in nylon bags (bag size 80mmx140mm; pore size 45 μm) and suspended in the rumen of three fistulated bucks for 8, 12, 18, 24, 36, and 48 hrs (Orskov and Mc Donald 1979).

After removal from the rumen, the bags were dipped into cold water to stop microbial activity, washed with running water to remove rumen matter from outside the bags and then cleaned under running water for 30 minutes. Samples of 0hr were prepared by washing the bags containing the test samples for 30 minutes. The residues in the bags were oven dried at $60^{o}C$ for 48 hours as described by Nocek (1985). The bags were allowed to cool and their weights were recorded and used to calculate percent dry matter loss. The results from the *in-situ* study were fitted to model of $P=a+b\ (1-e^{-ct})$ (Orskov and Mc Donald 1979) to determine the degradation characteristics of incubated samples.

$P = a + b(1 - e^{-ct})$

Where

P = Potential degradability after time't'

a = Water Soluble Fraction (zero hour)

b = Insoluble but degradable fraction after time 't'

c = Rate of degradation of slowly degradable fraction b

t = Incubation length i.e. 8, 12, 18, 24, 36, and 48 hrs

e = exponential

3.9 STATISTICAL ANALYSIS

Data generated were analyzed for variance (ANOVA) using SAS (1999). Significant differences detected between the means were separated using Duncan Multiple Range Test (DMRT) and considered significant at probability level of 0.05.

CHAPTER FOUR

4.0 RESULT AND DISCUSSION

4.1 RESULTS

4.1.1 Effect of Additives on Maize Cob Silage Characteristics

The pH values, colour and aroma of treated and untreated maize cob silage are shown in Table 2: In terms of colour and aroma, the light brown colour and pleasant aroma was obtained in control (untreated maize cob). While silage treated with urea, molasses and yeast resulted in pale yellow colour and sweet aroma. The pH values were highest in control (4.57) compared to others.

Table 2 Effect of Additives on Silage Characteristics of Maize Cobs

	Parameters		
Additives	pH	Colour	Aroma
Control	4.57^{a}	Light brown	Pleasant
Urea	3.40^{b}	Pale yellow	Sweet
Molasses	3.80^{b}	Pale Yellow	Sweet
Yeast	3.63^{b}	Pale yellow	Sweet
SEM	0.11		

a,b,c,: means in the same row with different superscripts differ significantly ($p<0.05$),, SEM=standard error mean, 4.1.2 Effects of Ensiling Period on Maize Cob Silage Characteristics

The pH values colour and aroma of maize cob silage made at different ensiling period is presented in Table 3: The pH values of silages were significantly affected ($P<0.05$) by ensiling period. The pH values varied from 3.32 at 7th weeks, 3.83 at 5th weeks and 4.38 at 3rd weeks. In terms of colour and aroma, all silage made at different period was light brown and pleasant aroma at 3rd weeks, pale yellow colour and sweet aroma at 5th and 7th weeks respectively.

Table 3 Effects of Ensiling Period on Maize Cob Silage Characteristics

	Parameters		
Period	pH	Colour	Aroma
Week 3	4.38^{a}	Light brown	Pleasant
Week 5	3.83^{b}	Pale yellow	Sweet
Week 7	3.32^{c}	Pale yellow	Sweet
SEM	0.11		

a,b,c,: means in the same row with different superscripts differ significantly ($p<0.05$),, SEM=standard error mean,

4.1.3 Interaction Effects of Additives and Ensiling Period on Maize Cob Silage Characteristics

The pH values, colour and aroma of treated and untreated maize cob silage produced at different ensiling period is presented in Table 3: The results revealed that silage made without additives (control) at 3rd and 5th ensiling period produced highest pH values (4.76 and 4.44) and had light brown colour with pleasant sweet aroma. Silage made with additives at different ensiling period produced least pH values and was all resulted in pale yellow colour and sweet aroma.

Table 4: Interaction Effect between Additives and Ensiling Period on Maize Cob Silage Characteristics

		Parameters		
Additives	Period	pH	Colour	Aroma
Control	3	4.76	Light brown	Pleasant
	5	4.44	Light brown	Pleasant
	7	3.54	Pale Yellow	Sweet
Urea	3	3.45	Pale Yellow	Sweet
	5	3.40	Pale Yellow	Sweet
	7	3.22	Pale Yellow	Sweet
Molasses	3	3.80	Pale Yellow	Sweet
	5	3.71	Pale Yellow	Sweet
	7	3.61	Pale Yellow	Sweet
Yeast	3	3.65	Pale Yellow	Sweet
	5	3.45	Pale Yellow	Sweet
	7	3.29	Pale Yellow	Sweet
SEM		0.07		
LOS		*		

a,b,c,: means in the same row with different superscripts differ significantly ($p<0.05$),, SEM=standard error mean, 4.1.4 Effect of Additives on Chemical Composition of Maize Cob Silage

The chemical composition of maize cob silage made with treated and untreated maize cob is presented in Table 5: The results revealed significant (P>0.05) difference in all parameters evaluated. Control had the highest DM content (91.26%) while yeast had the lowest DM content (88.36%). Molasses and yeast had the highest ASH content (5.68 and 5.55%) than urea and control. Urea was highest in CP (9.21%) and control had the lowest CP value (3.79%). Control had the highest CF content (48.92%) while the least value was obtained in yeast (33.01%). The highest ether extract (EE) value was recorded in molasses (2.09%) while the least value was recorded in urea (1.38%). Control recorded the highest nitrogen free extract (NFE) value (54.66%) and the yeast recorded the least value (37.64%). On the values of acid detergent fibre (ADF) and neutral detergent fibre (NDF), control recorded the highest values (65.79%) and 79.94%) while yeast recorded the least ADF value (44.24%) for NDF, urea recorded the least value (69.67%).

Table 5: Effect of Additives on Chemical Composition of Ensiled Maize Cob

	Parameters							
Additives	DM	ASH	CP	CF	EE	NFE	ADF	NDF
Control	91.26^{a}	4.44^{c}	3.79^{c}	48.92^{a}	1.71^{c}	54.66^{a}	65.79^{a}	79.94^{a}
Urea	90.74^{b}	4.38^{b}	9.21^{a}	37.51^{c}	1.38^{d}	50.42^{b}	48.72^{c}	69.67^{c}
Molasses	90.55^{b}	5.68^{a}	5.85^{b}	40.93^{b}	2.09^{a}	47.51^{b}	54.58^{b}	72.89^{b}
Yeast	88.36^{c}	5.55^{a}	9.04^{ab}	33.01^{d}	1.84^{b}	37.64^{d}	44.24^{d}	67.73^{d}
SEM	0.22	0.02	0.47	1.03	0.12	0.96	1.05	1.08

a,b,c,: means in the same row with different superscripts differ significantly (p<0.05), DM = Dry Matter; CP = Crude Protein; CF = Crude Fiber; EE = Ether Extract; ADF = Acid Detergent Fiber; NDF = Neutral Detergent Fiber; SEM = Standard Error of Mean, 4.1.5 Effect of Ensiling Period on Chemical Composition of Maize Cob Silage

The result of effects of ensiling period on chemical composition of maize cob silage are shown in Table 5: The mean value of all parameters evaluated varied significantly ($P<0.05$). The DM percentage was highest at 3 week ensiling period (90.44%) compared to 5th and 7th weeks respectively. ASH was highest at 7th weeks (5.49%) and lowest at 5th weeks (4.89%). Crude protein CP content was highest at 7th weeks (10.78%) while the least CP content was obtained at than 3rd weeks (4.89%).CF content was highest at 3rd weeks (44.34%) and lowest at 7th weeks ensiling period (37.02%). Ether extract was highest at 5th weeks (1.80%) and lowest at 3rd weeks (1.68%) Acid detergent fibre (ADF).was highest at 3rd week ensiling period (55.76%) compared to 5th and 7th weeks. The highest neutral detergent fibre (NDF) was recorded at 3rd weeks (74.58%) while least value was obtained at 7th week ensiling period (68.95%).

Table 5 Effect of Ensiling Periods on Chemical Composition of Maize Cob

	Parameters							
Period	DM	ASH	CP	CF	EE	NFE	ADF	NDF
Week 3	90.44^{a}	4.89^{b}	4.89^{c}	44.34^{a}	1.68^{b}	50.69^{a}	55.76^{a}	74.58^{a}
Week 5	90.23^{ab}	5.00^{b}	10.24^{b}	42.52^{b}	1.80^{a}	45.78^{b}	52.46^{b}	73.84^{a}
Week 7	90.04^{b}	5.49^{a}	10.78^{a}	37.02^{c}	1.79^{a}	46.21^{b}	51.78^{b}	68.95^{b}
SEM	0.29	0.16	0.49	1.38	0.13	1.39	1.72	1.27

a,b,c,: means in the same row with different superscripts differ significantly ($p<0.05$), DM = Dry Matter; CP = Crude Protein; CF = Crude Fiber; EE = Ether Extract; ADF = Acid Detergent Fiber; NDF = Neutral Detergent Fiber; SEM = Standard Error of Mean, 4.1.6 Interaction Between Additives And Ensiling Period On Chemical Composition Of Maize Cob Silage

The effects of interaction between additives and ensiling period on chemical composition of maize cob silage are presented in Table 6: Additives and ensiling period significantly affect the nutrients composition of the silage. Percent dry matter (DM) of silage made without additives (control) at 3rd weeks ensiling period was highest (93.83%) while yeast at 5th weeks was least (87.52%). The trend indicated that DM decrease with increase in ensiling period. Percentage ASH was significantly ($P<0.05$) greater in molasses (7th weeks) 6.42%, followed by yeast 7th week (6.33%) compared to control 3rd weeks (3.07%). Crude protein percentage were higher in urea 7th weeks (10.95%) followed by yeast 7th weeks (10.07%) while the least was obtained in control 7th weeks (3.79%). Percent crude fibre was highest in control 3rd weeks (49.89%) while the lowest CF interaction was recorded in urea 3rd weeks (26.21%). The highest ether extract ware obtained in yeast 5th weeks (2.77%) and control 7th weeks (2.77%) while the least was recorded in urea 5th week (0.40%). The nitrogen free exract was highest in urea 3rd week (62.67%) and lowest was recorded in yeast 3rd week (33.29%).The ADF and NDF were significantly ($p<0.05$) greater in yeast 3rd weeks: ADF (69.37%) NDF (89.03%) compared to control 5th week ADF (4.33%) ND (58.00%).

Table 6: Interaction Effect between Additives and Ensiling Period on Chemical Composition of Ensiled Maize Cobs

		Parameters							
Additives	Period	DM	ASH	CP	CF	EE	NFE	ADF	NDF
Control	3	93.83	3.07	3.79	49.89	0.53	57.03	55.07	67.63
	5	90.43	4.30	4.89	34.47	1.83	49.31	41.33	58.00
	7	89.53	5.95	5.44	28.21	2.77	57.63	46.33	77.57
Urea	3	90.18	4.55	9.34	48.70	2.23	62.67	41.67	63.33
	5	92.52	4.70	10.25	37.65	0.40	45.67	58.50	74.67
	7	89.52	5.25	10.95	26.21	1.50	42.92	46.00	71.00
Molasses	3	89.55	6.42	5.50	35.67	2.67	49.74	51.03	78.33
	5	90.45	6.20	6.65	37.93	2.20	50.02	46.00	69.03
	7	91.65	4.41	7.22	49.19	1.40	42.77	66.70	70.10
Yeast	3	88.18	5.50	9.50	49.86	1.27	33.29	69.37	89.03
	5	87.52	4.81	9.55	49.00	2.77	40.87	64.00	74.10
	7	89.47	6.33	10.07	23.90	1.50	38.87	64.00	76.70
SEM		0.04	0.03	0.05	0.25	0.02	0.26	0.19	0.25
LOS		*	*	*	*	*	*	*	*

a,b,c,: means in the same row with different superscripts differ significantly ($p<0.05$), DM = Dry Matter; CP = Crude Protein; CF = Crude Fiber; EE = Ether Extract; ADF = Acid Detergent Fiber; NDF = Neutral Detergent Fiber; SEM = Standard Error of Mean, 4 1.7 Dry Matter (DM) Disappearance (%) Of Untreated Maize Cob

The results of dry matter disappearance of untreated maize cob at different ensiling period is presented in fig 1. The untreated maize cob disappearance curve revealed that 7th weeks silage had the greatest disappearance values during 0-48 hours incubation (14.09, 21.48, 31.52, 34.59, 38.71, 49.68 and 49.97 %). followed by 5th weeks and finally the least was 3rd week silage. Therefore, none of the silage attained 50% DM degradation after 48 hours.

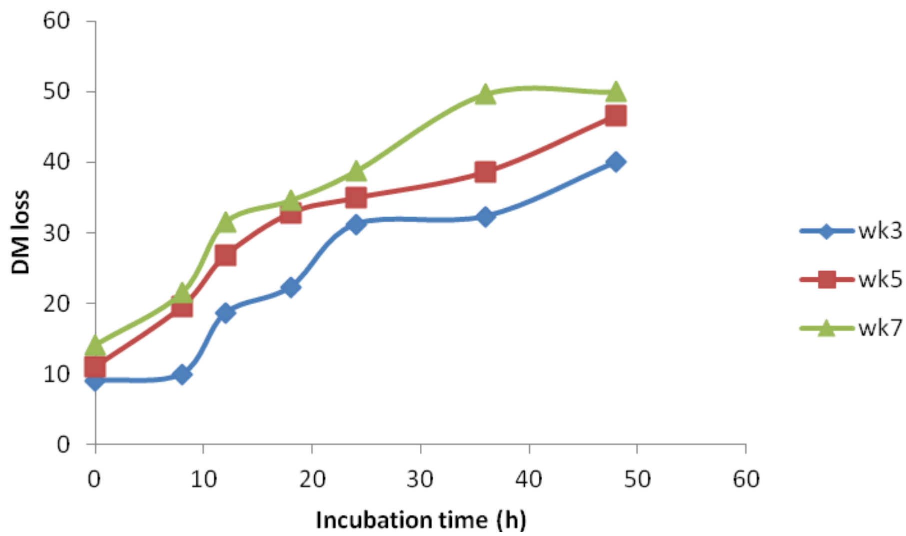

Fig. 1: Dry matter Disappearance (%) of Untreated Maize

4.1.8 Dry Matter (DM) Disappearance (%) Of Urea Treated Maize Cob

The results of dry matter disappearance of urea treated maize cob are shown in Fig 2. The urea dry mater curve revealed that, maize cob treated with urea and ensiled at 7th weeks produced greatest DM disappearance values after 48 hours incubation period (28.68, 39.32, 47.01, 48.97, 52.28, 57.98 and 72.07 %), followed by 5th weeks and the least was 3rd weeks ensiling period. Therefore the difference between the ensiling period interns of disappearances from 0-18 hours incubation was not very much.

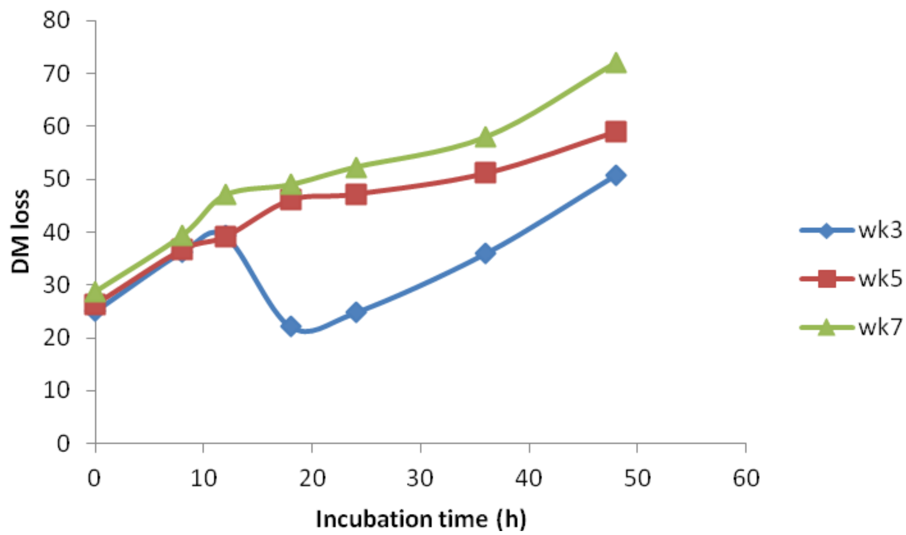

Fig. 2: Dry matter disappearance of maize cob treated with urea

4.1.9 Dry Matter Disappearance (DM) Of Maize Cob Treated With Molasses

The results of dry matter disappearance of molasses treated maize cob at different ensiling period are shown in Fig 3. The dry matter disappearance curve revealed that molasses treated maize cob at 7th weeks produced greatest DM disappearance (60.96%) after 48 hours followed by 5th weeks (57.84%) and least was three weeks (44,49%) after 48 hours incubation period.

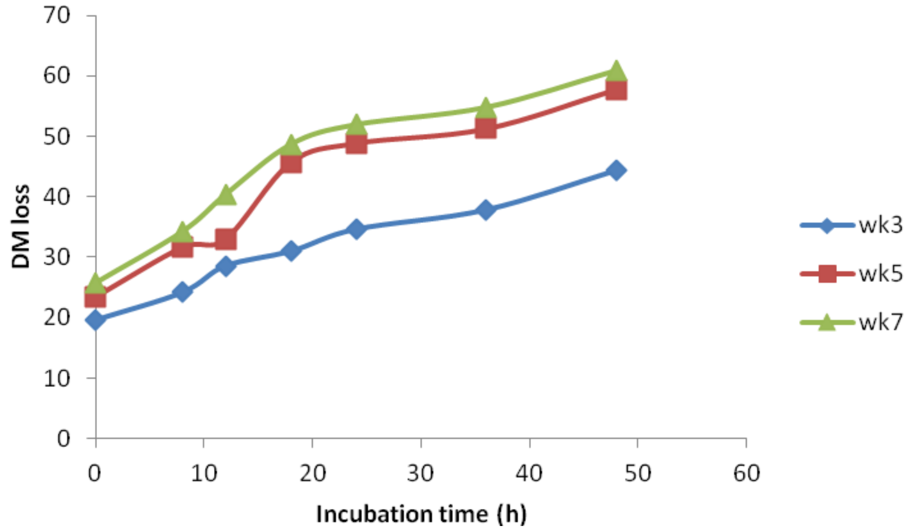

Fig. 3: Dry matter Disappearance (%) of Molasses treated Maize cob

4.1.10 Dry Matter Disappearances (%) Of Maize Cob Treated With Yeast

Fig 4 revealed that maize cob treated with yeast at 7th weeks had the highest DM disappearance followed by 5th weeks and the least was recorded at 3rd weeks ensiling period. after 48 hours incubation period.

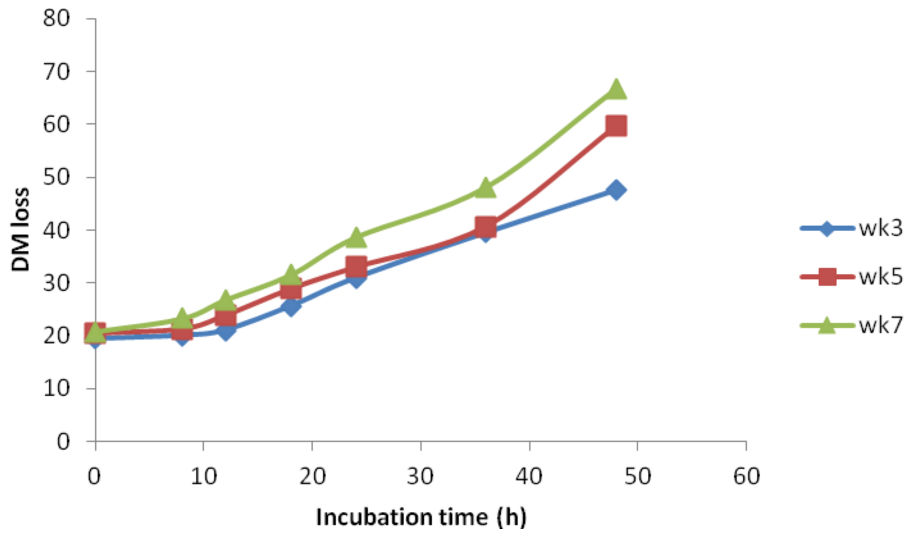

Fig. 4: Dry matter Disappearance (%) of yeast treated maize cob

4.1.11 Effects of Additives on Dry Matter (DM) Degradation Characteristics of Maize Cob Silage

The results of the rumen degradation characteristics of treated and untreated maize cob silage are shown in Table 7: The soluble dry matter fraction (a) were significantly different ($P<0.05$) among the additives. The (a) value was significantly ($P<0.05$) higher in urea (5.90%) and lower for control. The effective degradability were significantly affected by additives ($P<0.05$). The highest (ED) was recorded in urea (28.41%) and the lowest was obtained in control (18.36%).Others DM degradation parameters were not significant ($P<0.05$).

Table 7: Effects of Additives on DM Degradation Characteristics of Ensiled Maize Cob

	Parameters							
Additives	a	b	c	A	B	PD	ED	LT
Control	-6.54^{b}	66.75	0.066	4.82^{c}	56.09	61.00	18.36^{c}	0.711
Urea	5.90^{a}	67.95	0.057	17.12^{a}	56.76	65.95	28.41^{a}	0.000
Molasses	-0.09^{ab}	66.09	0.053	7.07^{b}	58.88	63.53	20.57^{bc}	0.212
Yeast	-6.35^{b}	70.45	0.051	8.84^{b}	54.69	73.88	21.64^{b}	0.510
SEM	1.46	2.77	0.01	0.42	3.79	7.70	0.50	0.17

A = Washing Loss, B = Rumen Degradability Fraction, C = Degradation Constant (fraction/hour), A + B = Potential Degradability (PD), a = Quickly Soluble Fraction, b =Insoluble but Degradable Fraction, c = Degradation Rate, ED = Effective Degradation

4.1.12 Effect of Ensiling Period on Dry Matter (DM) Degradation Characteristics of Maize Cob Silage

The results of effects of ensiling period on DM degradation characteristics are presented in Table 8: The results revealed that no significant difference was observed for all the parameters evaluated except The Values for effective degradability. The effective degradability (ED) obtained at 3rd weeks was higher (24.44%) compared to 5 and 7th weeks (21.12% and 21.18%).

Table 8: Effect of Silage Period on DM Degradation Characteristics Of Maize Cob

	Parameters							
Period	a	b	c	A	B	PD	ED	LT
Week 3	0.15	70.90	0.065	10.06	60.94	71.00	24.44[a]	0.533
Week 5	-2.56	75.33	0.057	8.80	65.53	73.33	21.12[b]	0.410
Week 7	-2.87	79.87	0.048	9.53	68.34	77.87	21.18[b]	0.411
SEM	1.67	2.69	0.01	0.90	3.92	3.84	0.77	0.27

A = Washing Loss, B = Rumen Degradability Fraction, C = Degradation Constant (fraction/hour), A + B = Potential Degradability (PD), a = Soluble Fraction, b =Insoluble but Degradable Fraction, c = Degradation, ED = Effective Degradation

4.1.13 Interaction Effects Between Additives And Ensiling Period On Dry Matter (DM) Degradation Characteristics Of Maize Cob Silage.

Table 9: shows the degradability parameters of treated and untreated maize cob ensiled at different ensiling period. The results obtained for the interaction between additives and ensiling period on DM degradation characteristics were significantly not affected by additives and ensiling period for all the parameters evaluated except readily degradable fraction (A). The

highest (A) value was recorded in urea 3rd weeks (14.80%) and the lowest was obtained in control at 3rd weeks (3.53%).

Table 9: Interaction Effect of Additives and Ensiling Period on Dry Matter Degradation Characteristics

		Parameters							
Additives	Period	a	b	c	A	B	PD	ED	LT
Control	3	-3.33	58.17	0.036	3.53	51.30	54.83	18.67	2.133
	5	-11.76	72.98	0.100	4.73	56.53	61.27	18.27	3.121
	7	-3.94	71.09	0.036	6.20	60.43	66.90	18.13	2.141
Urea	3	13.44	70.64	0.023	21.30	62.83	84.07	31.43	0.321
	5	7.98	70.43	0.050	15.27	63.16	78.43	26.00	0.000
	7	-3.72	76.79	0.080	14.80	58.27	73.03	27.80	2.120
Molasses	3	-4.49	51.55	0.156	5.73	41.17	46.87	24.30	2.113
	5	0.74	50.84	0.030	7.17	44.40	51.57	17.80	0.000
	7	3.48	51.87	0.013	8.30	47.07	55.37	19.60	0.000
Yeast	3	-5.15	85.25	0.046	9.67	70.47	80.14	23.37	3.123
	5	-7.19	86.37	0.050	8.03	71.00	79.18	22.40	4.112
	7	-7.28	84.71	0.063	8.83	83.60	92.00	19.17	4.122
SEM		1.23	2.69	0.01	0.35	3.70	3.60	0.41	0.18
LOS		NS	NS	NS	*	NS	NS	NS	NS

A = Washing Loss, B = Rumen Degradability Fraction, C = Degradation Constant (fraction/hour), A + B = Potential Degradability (PD), a = Soluble Fraction, b = Insoluble but Degradable Fraction, c = Degradation Rate, ED = Effective Degradation

4.1.14 Organic Matter (OM) Disappearance (%) Of Untreated Maize Cob

The results of organic matter of untreated maize ensiled at different period are shown in Fig 5. The curve revealed that silage produced at 7th weeks recorded highest OM disappearances values during 8-48 hours (13.08, 21.15, 30.51, 33.91, 37.73, 49.05 and 48.44%) followed by 5th weeks and the least was recorded at 3rd week ensiling period (39.57%) after 48 hours.

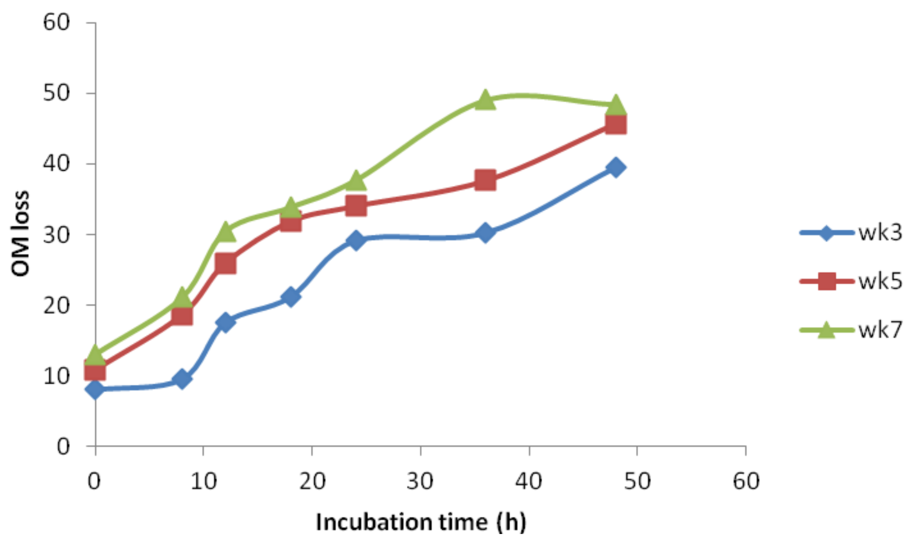

Fig. 5: Organic matter Disappearance (%) of Untreated Maize cob

4.1.15 Organic Matter OM Disappearance (%) Of Maize Cob Treated With Urea

The results of organic matter disappearance of urea treated maize cob ensiled at different period are shown in Fig 6. Curve revealed that 7th weeks silage recorded the highest OM disappearance, followed by5th weeks and the least was obtained in 3rd weeks ensiling period after 48 hours of incubation in the following order 70.69>57.83>50.36 %.

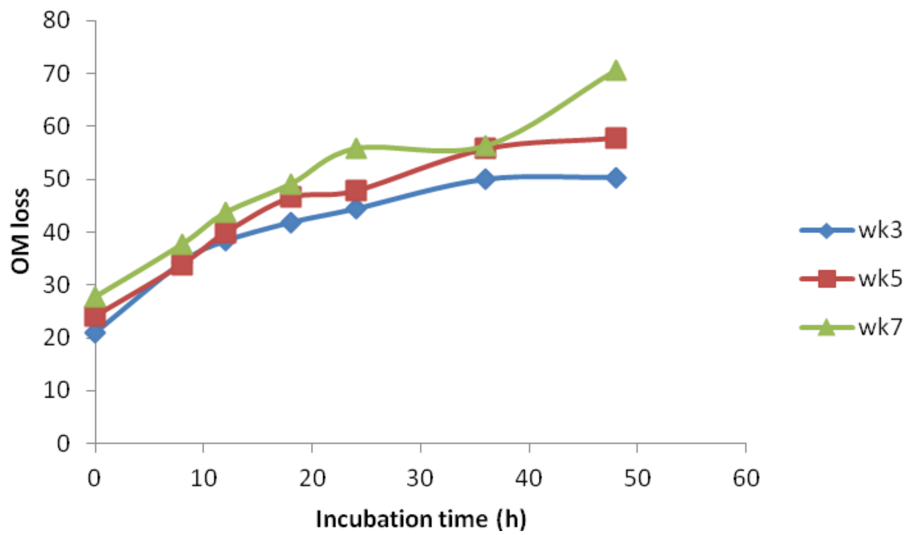

Fig .6: Organic matter Disappearance (%) of Urea treated Maize cob

4.1.16 Organic Matter Disappearance (%) Of Maize Cob Treated With Molasses

Results of organic matter disappearances of maize cob treated with molasses at different ensiling period are shown in Fig 7. The OM disappearance of maize cob treated with molasses revealed that 7th weeks ensiling period produced highest OM disappearance during 0-48 hours (22.67, 33.52, 40.21, 48.62, 51.94, 53.96 and 60.48 %) followed by 5th weeks (57.21%) and finally 3rd weeks (44.44%) after 48 hours. The trends indicated that there is increased in the disappearance values as the ensiling period increase.

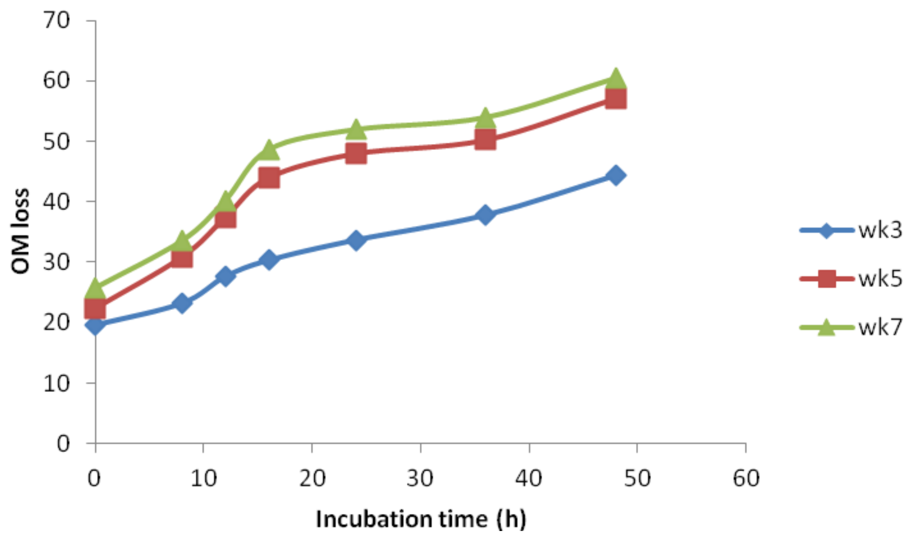

Fig. 7: Organic matter Disappearance (%) 0f Molasses treated Maize cob

4.1.17 Organic Matter Disappearance (%) Of Yeast Treated Maize Cob

The results of OM disappearance of maize cob treated with yeast at different ensiling period are shown in Fig 8. The organic matter disappearance curve revealed that, silage produced after 7th weeks had the highest organic matter disappearance values during 8-48 hours (22.23, 26.73, 30.59, 37.60, 46.99 and 55.79 %) followed by5th week and 3rd weeks after 48 hours incubation period (49.99%) and (46.67%). The curve also revealed that from 24-48hours there was no much differences between the ensiling period in terms of OM disappearance.

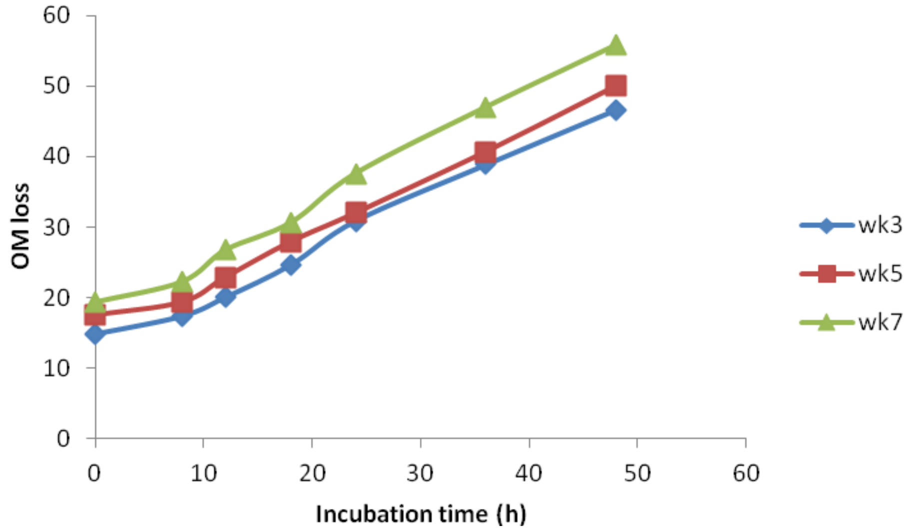

Fig. 8: Organic matter Disappearance (%) of Yeast treated Maize cob

4.1 18 Effect of Additives on Organic Matter Degradation Characteristics of Ensiled Maize Cob

The result of the rumen degradation characteristics of ensiled maize cob is shown in Table 10. The soluble organic matter fraction (a) were significantly affected ($P<0.05$) by additives. The (a) value is significantly ($P<0.05$) higher for urea (30.29%) and lower for control (3.95%). The amount degraded in the rumen with time (b) was significantly ($P<0.05$) higher for yeast (65.60%) and lower for urea (40.83%), The degradation rate (c) of OM with time ranged from 0.056/h for molasses to o.oo8/h for yeast and the values were significantly ($p<0.05$) different from each other. The additives differ significantly in potential degradability (PD) of organic matter in the following order yeast>molasses and urea>control. The effective degradability (ED) of all additives were significantly differ ($P<0.05$). Urea had the highest value (44.44%) and control recorded the lowest (26.10%).

Table10: Effect of Additives on OM Degradation Characteristics of Ensiled Maize Cob

	Parameters							
Additives	a	b	c	A	B	PD	ED	LT
Control	3.95^{d}	44.97^{c}	0.045^{a}	10.62^{c}	38.09^{c}	48.94^{c}	26.10^{d}	0.045^{a}
Urea	30.92^{a}	40.83^{c}	0.029^{b}	23.11^{a}	47.52^{b}	68.42^{b}	44.44^{a}	0.026^{b}
Molasses	11.86^{c}	48.78^{b}	0.056^{a}	22.54^{a}	42.14^{bc}	64.69^{b}	37.18^{b}	0.045^{a}
Yeast	15.89^{b}	65.60^{a}	0.008^{c}	17.12^{b}	61.39^{a}	78.48^{a}	29.22^{c}	0.008^{c}
SEM	0.71	1.38	0.00	0.44	1.66	1.87	0.76	0.00

A = Washing Loss, B = Rumen Degradability Fraction, C = Degradation Constant (fraction/hour), A + B = Potential Degradability (PD), a =Soluble Fraction, b =Insoluble but Degradable Fraction, c = Degradation Rate, ED = Effective Degradation

4.1.11 Effect Of Ensiling Period On Organic Matter Degradation Characteristics Of Maize Cob

There was significant different in the rapidly degraded fraction (a) at different ensiling period. Five and seven weeks ensiling period recorded higher (a) values (17.29% and 17.22%) and lower value was recorded at 3rd weeks ensiling period (12.47%). The amount of OM degraded in the rumen (b) was also significantly ($P<0.05$) higher for 7th weeks but lower for 3rd and 5th weeks (54.09% and 59.86%). The degradation rate of OM (c) ranged from 0.035 for yeast to 0.003/h for control were significantly ($P<0.05$) different from each other. The potential degradability (PD) was highest for 7th weeks (76.37%) and lowest was obtained for3rd weeks (66.56%). The effective degradability (ED) was highest for 7th weeks (38.94%) and lowest for 3rd weeks (28.91%).

Table 11: Effect of Silage Period on OM Degradation Characteristics of Maize Cob

	Parameters							
Period	a	b	c	A	B	PD	ED	LT
Week 3	12.47^{b}	54.09^{b}	0.0029^{b}	16.29^{c}	50.26^{b}	66.56^{b}	28.91^{c}	0.033
Week 5	17.29^{a}	59.86^{b}	0.032^{ab}	18.41^{b}	50.55^{b}	67.47^{b}	34.86^{b}	0.032
Week 7	17.22^{a}	59.98^{a}	0.035^{a}	20.35^{a}	56.05^{a}	76.37^{a}	38.94^{a}	0.028
SEM	0.30	3.41	0.03	0.93	3.36	3.54	1.26	0.00

A = Washing Loss, B = Rumen Degradability Fraction, C = Degradation Constant (fraction/hour), A + B = Potential Degradability (PD), a =Soluble Fraction, b =Insoluble but Degradable Fraction, c = Degradation Rate, ED = Effective Degradation

4.1.20 Interaction Between Additives And Ensiling Period On Organic Matter Degradation Characteristics Of Maize Cob Silage

Table 12 show degradability characteristics of OM of treated and untreated maize cob at different ensiling period.. Additives and ensiling period significantly ($P<0.05$) increased OM degradability of all parameter evaluated. The soluble fraction (a) was highest in urea 7th weeks (36.64%) and lowest was recorded in control 3rd weeks (-2.70%). Fraction degraded in the rumen (b) fraction was highest in yeast 5th weeks (87.62%) and lowest was obtained in urea 3rd weeks (28.27%). Values obtained for the rate of degradation (c) for molasses was highest at 7th weeks (0.070/h) and lowest at 3rd weeks (0.013/h). For the urea the rate of degradation was highest at 3rd weeks (0.052/h) and lowest at 7th weeks (0.019/h). The values of potential degradability (PD) values were highest for yeast at different ensiling period and the lowest was recorded in control at 3rd weeks (44.40%). The effective degradability (ED) of OM was highest in urea 7th weeks (49.80%) and lowest in control 3rd weeks (20.13%). Yeast at 7th weeks recorded highest lag time (0.093) hours compared to urea at 7th weeks (0.009 hour).

Table 12: Interaction Effects of Additives and Ensiling Period on OM Degradation Characteristics

Additives	Period	Parameters							
		a	b	c	A	B	PD	ED	LT
Control	3	-2.70	47.08	0.043	8.07	36.30	44.40	20.13	0.042
	5	8.60	40.23	0.051	10.73	37.40	48.80	27.40	0.043
	7	5.95	47.68	0.052	13.07	40.57	53.63	30.77	0.052
Urea	3	24.61	28.27	0.052	21.00	32.23	53.23	39.23	0.052
	5	31.50	37.36	0.015	24.13	44.73	62.20	44.30	0.026
	7	36.64	50.51	0.019	24.22	65.59	89.81	49.80	0.001
Molasses	3	18.64	54.51	0.013	19.57	53.60	73.17	29.97	0.012
	5	16.68	42.17	0.054	22.37	36.47	58.87	39.00	0.054
	7	12.36	49.67	0.070	25.70	36.37	62.03	42.57	0.070
Yeast	3	9.32	86.13	0.010	16.53	78.90	95.43	26.30	0.010
	5	12.40	87.62	0.060	16.40	83.60	100.00	28.73	0.006
	7	13.93	86.07	0.093	18.43	81.67	100.00	32.63	0.009
SEM		0.25	7.08	0.00	0.19	0.79	0.92	0.09	0.03
LOS		*	*	*	NS	*	*	*	*

A = Washing Loss, B = Rumen Degradability Fraction, C = Degradation Constant (fraction/hour), A + B = Potential Degradability (PD), a =Soluble Fraction, b =Insoluble but Degradable Fraction, c = Degradation Rate n, ED = Effective Degradation

4.2 DISCUSSION

4.2.1 Effects of Additives, Ensiling Period and Interaction on Physical Features of Maize Cob Silage

Results of colour, aroma and pH characteristics of maize cob silage ensiled with different additives at different ensiling period indicates that all silage were adequately fermented with light brown, pale yellow colour, pleasant and sweet aroma. Kung and Shaver (2002) in their interpretation of silage analysis stated that pleasant or sweet aroma are accepted for a good or well made silage. The result was also in agreement with Oduguwa, *et al.,* (2007) who reported that close to the original colour of ensiled material (pale yellow colour, light brown and sweet or pleasant taste) was an indication of good quality silage.

pH value is one of the simplest ways of evaluating silage. Silage that has been properly fermented will have much lower pH (moderately acidic to slightly acidic). The pH values obtained ranged (3.22-3.80) in this study were similar to Babayemi (2009) of 3.38-4.61 when by-products of orange were ensiled with additives.

4.2.2 Effect of Additives, Ensiling Period and their Interaction on Nutrient Composition of Maize Cob Silage

The dry matter values of silage made with different additives at different ensiling period are comparable. The higher DM percentage observed in the control (91.26%) compared to additives agreed with value (91.34%) reported by (Kamarloiy, *et al.,* 2008); (Baba *et al.,* 2018). The present study indicates that there was no much variation on the DM content ($P<0.05$) due to ensiling time in the presence or absence of additives, DM may decreased or increased which may depends on different factors such as biochemical or microbial reaction during ensiling period. The higher ash content observed in molasses and yeast may be attributed to their effects in the silage. The higher ash content observed at 7th week ensiling period is an indication that increased in the ensiling period may increased the overall ash content of the silage. The CP content in the current study ranged from (3.79%) in control and (9.21%) in urea. The higher CP content at 7th weeks ensiling period was also supported by Snijders, *et al.,* (2004). Due to interaction the highest CP content was observed in urea at 7th week ensiling period may be due to readily available energy and nitrogen which was used by microorganism for their growth, and increased microbial protein in the silage (Tolera and Sundstol, 2000). The higher NFE in control compared to additives may be due to addition of water for proper compactness during ensiling.

Furthermore, the lower fibre (CF, NDF and ADF) observed in urea (37.51%), molasses (40.93%) and yeast (33.01%) is an indication that treatment of agricultural by-products by urea, yeast or molasses release ammonia which react with the lignocelluloses materials and improved their feeding values (Tolern and Sundstol, 2000). The ADF and NDF contents of maize cob decreased as the ensiling period increased, this decrease was mainly due to a decreased in HC content. The fall in NDF content of lignocelluloses materials was due to hemicelluloses degradation by ammonia (Van soest and Hartley 1984). The decrease in NDF agreed with Suksombat, W. (2004).who found that NDF decrease with urea treatment for different ensiling period. The CP values ranges between 9.05%-9.21% observed in all additives at different ensiling period in this study meet the 7.0% or 70g/kg minimum requirement for ruminants (ARC, 1984). The fibre components of urea treated maize cob (ADF and NDF) 48.72% and 69.67% were within the range values reported in previous studies (Tadesse, *et al.,* 2014). The decrease of ADF in urea at different ensiling period observed in this study is an indication that urea treatment enhance nitrogen content of lignocellulosic materials, and the increase was significant with increase of storage period which help in disturbing the cell wall components that caused a decline in these components (Tadesse, *et al.,* 2014).

4.2.3 Dry Matter Disappearance of Treated and Untreated Maize Cob at Different Ensiling Period

The result of dry matter disappearance of treated and untreated maize cob indicated that, the disappearance features of untreated (control), urea, molasses and yeast at different ensiling period varied slightly among the additives from the curve, Control at 7^{th} weeks recorded highest DM disappearance followed by 5^{th} weeks and the least was three weeks (39.98%). The ruminal DM disappearance values increased as the incubation time increased for all ensiling period during (0-48 hours). The observed values were in accordance with the values reported by Chumpawadee, Sommart and Pattarajinda (2005). For urea, DM disappearance at 7^{th} weeks produced the highest disappearance value compared to other weeks. This was a reflection of their high CP content of the urea. The results were comparable with what was obtained by Chumpawadee, Sommart and Pattarajinda (2005).

Molasses DM disappearance revealed that 7^{th} weeks ensiling period produced greater DM disappearance value (60.96%) compared to other weeks. The present findings of nutrients disappearance agreed with the report of Chumpawadee, Sommart and Pattarajinda (2005).

Yeast DM disappearance values increased with the increased of incubation period from 0-48 hours for all ensiling period. The higher DM disappearance observed after 48 hours at both ensiling period were above 50%. This implies good digestibility potential for this additive when used when used as additives for ruminant livestock. (Ehargava and Orskov,1987).

4.2.4 Organic Matter Disappearance of Treated and Untreated Maize Cob Ensiled at Different Period

Organic matter disappearances from the incubated test maize cob ensiled with urea, molasses, yeat and untreated at different ensiling period was high at 48 hours. The highest disappearance values of untreated maize cob after 48 hours at 3rd, 5th and 7th weeks were (39.57%), (45.70%) and (48.44%).The low Om disappearance values obtained in control could be attributed to high fibre content of the untreated maize cob which implies that they need some form of treatment or need to be supplemented to meet the requirement of animals. Girma *et al.,* (1994) observed that agricultural by-products with low degradability values need to be supplemented.

Urea were 50.36% (3rd weeks), 57.83% (5th week) and 70.69% (7th week) after 48 hours. This implies good digestibility potential for this additive when harnessed as feed resources for ruminant livestock, as 48 hours degradability is often considered to be equivalent to digestibility (Ehargava and Orskov, 1987). The values agreed with the values reported by Chumpawadee, Sommart and Pattarajinda (2005).

Molasses OM disappearance was 44.44% at 3rd weeks, 57.21% at 5th weeks and 55.79 at 7th weeks after 48 hours incubation period. The extent of OM degradation after 48 hours of incubation was good for all additives at different ensiling period as it was above 50 %. This implies good digestibility potential for these additives when harnessed as feed material for ruminant animals (Ehargava and Orskov, 1987).

4.2.5 Effect of Additives, Ensiling Period and their Interaction on Dry Matter Degradation Characteristics of Ensiled Maize Cob

The result showed that readily degradable fraction (a) increased significantly for urea treated maize cob compared to control. Urea treatment was reported to cause partial break down of bond between the lignin and other cell wall components that lead to rumen bacteria to degrade fibrous materials in the rumen (Ngyauen and Sandstol, 2002). The effective degradability (ED) of DM depends on how long the feed remain in the rumen. The effective degradability obtained in this study was predictable if fed to the animals and retained in the rumen. The effective degradability of treated maize cob were better than untreated and were similar to earlier reports of Osuji, *et al.,* (1993) and Reddy (2001). The effective degradability was highest at 7th weeks compared to 3^{rd} and 5^{th} weeks respectively. The amount degraded in the rumen (a) fraction was better for urea at different ensiling period. The trend indicated that (a) fraction values increased with increase in the ensiling period in urea treated maize cob and this agreed with Marson, *et al.,* (1990) who reported that urea treatment of roughage might affect the lignin itself or its linkage.

4.2.6 Effect of Additives, Ensiling Period and their Interaction on Organic Matter Degradation of Ensiled Maize Cob

The estimate of OM ruminal degradation of treated and untreated maize cob fermented at different period revealed that additives and ensiling period influenced all the parameters evaluated. Lower values of degradability were obtained in the control (untreated maize cob) and at 3^{rd} weeks ensiling period, implies that they need some form of treatment (Girma, *et al.,* 1994). The results also showed that *in sacco* degradability of OM increased significantly for treated maize cob compared to untreated maize cob. OM degradability for all parameters evaluated indicates that rapidly degradable fraction (a), fraction degraded in the rumen (b), degradation rate (c), potential degradability (PD), effective degradability (ED) and lag time

(LT) increased with increasing ensiling period and their values are comparable with report of Kariuki, *et al.*, (2001). for Nappier grass supplemented with various level of Desmodium and Ipomoea batatus. The interaction detected for the mean degradation values for all additives at different ensiling period obtained in the present study were considered acceptable for ruminant nutrition based on the 40-50% range recommended by FAO (1986). From this degradability study, it was clear that additives improved the nutritive value of fibrous feed materials thus, enhanced their degradability characteristics.

CHAPTER FIVE

5.0 SUMMARY, CONCLUSION AND RECOMMENDATION

5.1 SUMMARY.

This study was designed to evaluate the effect of different additives, ensiling period and their interaction on physico-chemical characteristics and *in sacco* rumen degradation characteristics of maize cob using three fistulated kano brown bucks. The experiments were conducted at the Research and Teaching Farm, Department of Animal Science, Bayero University, Kano. The experimental design was 3x4 factorial experiments in a randomized completely block design (RCBD) consisting four treatments, three ensiling period (3^{rd} 5^{th} and 7^{th} weeks), each treatment replicated three times.

The result of the study revealed that additives and ensiling period improved both physical, nutritional and degradation characteristics of maize cob. The result also showed that the colour and aroma of all silage made at different ensiling period were light brown, pale yellow colour, pleasant and sweet aroma. Also indicates that additives and ensiling period lowered the pH values of silage made with additives compared to control. Furthermore, urea, molasses and yeast at 7^{th} weeks ensiling period produced much lower pH values. Urea and yeast at 7^{th} weeks had significantly ($p<0.05$) higher CP content as well as lower CF, ADF and NDF values. Yeast at 3^{rd} week had better CP content and low CF content at 7^{th} weeks ensiling period.

The result obtained from *in sacco* rumen degradation study revealed that percent dry matter and organic matter degradation/disappearance of maize cob treated with additives at different ensiling period after 48 hours incubation period were 50% and above degradable. Furthermore additives at 7^{th} weeks ensiling period produced greatest organic matter disappearance values. Therefore, from this degradability study, revealed that urea and yeast treatment at different ensiling weeks improved maize cob nutritive value and degradation characteristics (Dry matter and OM degradation).

5.2 CONCLUSION

Based on the results of the study;

1. It is concluded that additives and ensiling period (urea or yeast and 7th weeks ensiling period) improved the physical, nutritional and degradation characteristics of maize cob
2. Urea and yeast at 7th weeks ensiling period had at least 50% organic matter degradation at 48 hours incubation period, indicating that additives and ensiling time had a positive effect on degradation characteristics of maize cob
3. Urea and yeast treated maize cob ensiled for 7th weeks had the greatest dry matter and organic matter disappearance values.

5.3 RECOMMENDATIONS

The following recommendations are made

1. Silage made from urea or yeast ensiled for 7th week period is recommended during ensilage and degradability studies.
2. Further investigation is needed to conduct in vivo feeding trial with maize cob ensiled with urea or yeast to justify the present finding.

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