NUTRITIVE VALUE OF ENSILED CASSAVA (*Manihot esculentus*, Crantz) TOPS AND GUINEA GRASS (*Panicum maximum*) FOR THE WEST AFRICAN DWARF SHEEP

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ABSTRACT

Cassava Tops (CT), a crop residue, is available all year round but its potential utilisation is low. The Crude Protein (CP) and other nutrients in CT could be beneficial to ruminant livestock. Information on CT preservation and nutritive value is scanty. Therefore, the nutritive value of ensiled CT with Guinea grass to the West African Dwarf (WAD) Sheep was investigated.

Cassava tops and Guinea Grass (GG) of eight weeks re-growth with four energy additives were combined in ratio 3:6:1 into five treatments: 1 (CT + GG + cassava chips), 2 (CT + GG + Sorghum), 3 (CT + GG+ millet grains), 4 (CT + GG + sugar) and 5 (CT + GG + no additive). After 42 days of ensiling, silage characteristics, chemical composition: Dry Matter (DM), CP, ash, Neutral Detergent Fibre (NDF), and Acid Detergent Fibre (ADF) and acceptability by 8 WADS using Coefficient of Preference (CoP) procedure were determined. In a completely randomised design, 25 WAD sheep were fed with the five silages for 135 days to evaluate Dry Matter Intake (DMI), Daily Weight Gain (DWG), Dry Matter Digestibility (DMD), Packed Cell Volume (PCV) and Serum Total Protein (STP) using standard procedures. Carcass characteristics: dressing percentage, prima cuts, internal organs and external offals were measured. Further, effect of Length of Storage (LS) (72, 102, 132, 162, 192 and 222 days) on silage characteristics, chemical composition and the nutritive value of silage were assessed using *in vitro* fermentation technique to obtain potential extent of gas production (a+b), potential gas production (b), rate of gas production (c), Organic Matter Digestibility (OMD), Metabolisable Energy (ME) and Short Chain Fatty Acids (SCFA). Data were analysed using descriptive statistics and ANOVA at p=0.05.

The colour of the silages was olive green with pleasant odour, firm texture and pH range of 4.3 to 5.1. Dry Matter (27.1-28.8%), CP (21.8-24.9%), ash (7.6-9.4%), NDF (68.8-71.7%) and ADF (40.6-48.1%) of the silages differed significantly among treatments. Silages with cassava chips (1.19), sorghum (1.11) and millet (1.09) additives were more acceptable as CoP was above unity. The DMI (472.6-530.0 g/d) and DMD (75.8-84.7%) differed significantly while DWG was similar among treatments. The PCV and STP varied significantly and ranged from 27.0 to 33.7% and 6.08 to 8.20g/dl respectively. Dressing percentages ranging from 50.8 to 53.8%

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were significantly different. The Prima cuts (loin; 12.0-14.9%, rack; 15.6-18.9%, neck; 10.3-12.1%), liver (7.4-8.1%) and skin (1.5-1.8%) were significantly different. Relative weight of leg, shoulder, head, feet and other organs were not significantly different. The DM (28.0-29.6%), CP (23.7-27.1%), ash (8.8-10.0%), NDF (57.9-71.5%), and ADF (44.1-49.8%) were all significantly influenced by LS. Gas production (17.67-30.07 ml/96 hours), b (16.20-28.00ml), ME (6.09-7.68 MJ/kg DM), OMD (62.9-73.2%) and SCFA (0.48-0.78 mmol) were also significantly influenced by LS.

Cassava tops and Guinea grass ensiled with all additives used, had good silage properties and enhanced nutritive value. Preservation of silages was possible for seven months without loss of nutrients.

Keywords: Cassava tops, Silage additives, Nutritive value
Word count: 482

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CERTIFICATION

I certify that this work was carried out by Rachel Temitope, **AYANO**, in the Department of Animal Science, University of Ibadan, Nigeria under my supervision.

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DEDICATION

This work is dedicated to the Almighty God who is able to do exceedingly abundantly above all that we ask or think according to the power that worketh in us.

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CHAPTER ONE

1.0 INTRODUCTION

Inadequate feeds during the dry season is a serious problem in many areas where grazing is the main form of feeding for ruminant livestock. This season is noted for lower quantity and quality of grasses, especially in its energy and nitrogen. As a consequence, feed intake declines and animal productivity is curtailed. On the other hand, the rainy season is a period of surplus in terms of feeds for livestock.

Ruminant livestock production is mainly carried out by small holders who are largely dependent on natural forages for their feed resources. Natural forages grow freely along the road and on idle agricultural land. Green forages are plentiful during the rainy season. However, during the dry season, grasses for livestock will become a problem. The tedious daily harvesting of green forages at far distances throughout the year also poses problems for small-scale producers, particularly when family labour is insufficient (Aminah *et al*., 1999) and cost of hired labour is exorbitant. Fodder conservation is promoted with main objective of ensuring feed availability during periods of feed limitations. The dearth of fresh forages in the dry season in Nigeria and the consequent loss of body weight by ruminants necessitate that farmers embrace the technology of preservation of excess forages obtainable in the wet season to tide over the period of scarcity often experienced in the dry season.

Since grasses alone cannot supply the maintenance needs of the ruminants in the dry season (Adegbola, 1985), there is need for conservation and improvement of the nutritive values of the tropical forages. Excess forages available during the wet season can be conserved as silage to tide over the period of scarcity and prevent the loss in weight of animals associated with this period. The forage to be conserved should be available and in excess of the need of the animal during the wet season.

The low nutritive value of tropical grasses and roughages, commonly available for use in ruminant production systems for the tropics, highlights the need for low-cost supplementation to improve productivity. In this context, tree legumes such as *Luecaena*, *Gliricidia* and *Sesbania* are being promoted as protein supplement for livestock. Astonishingly, despite its availability and high protein content, there was little interest until recently to utilize fresh cassava forage in ruminant feeding. This reluctance is probably related to possibilities of

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cyanide toxicity. The potential supplemental protein value of cassava foliage has been documented.

Cassava has been rated as a key crop and a very promising potential feedstuff in quite number of states in Nigeria (PTFAFLF, 1992). Cassava remains one of the most popular locally produced food crops in Nigeria. The recent call by the federal government for increased production and the aggressive export of cassava products have stepped up cassava crop cultivation in Nigeria. Currently Nigeria is the world's largest producer of cassava crop with estimated annual production of 45 million tonnes. The rates of cassava by-products and residues availability were put at 0.035 and 0.045% respectively for cassava and cassava peels. Cassava tuber contains high level of energy and minimal level of crude protein and has been well used as readily fermentable energy in ruminant rations. Cassava is frequently rated low because its roots have low protein content. But unlike the roots that are essentially carbohydrate, cassava leaves are good sources of protein, vitamins which can provide a valuable supplement to the predominantly starchy diets and feeds. Cassava leaves compares favourably with other green vegetable, browse plant (e.g L*eucaena leucocephala, Giliricidia sepium)* generally regarded as good protein sources (Yousuf *et al*., 2007).

The principal part of the matured cassava plants expressed as a percentage of the whole plant is 6% leaves, 44% stem and 50% root tubers. The roots and leaves of the cassava plant are the two nutritionally valuable parts which offers potentials as a feed resource. The usage of cassava in traditional settings is largely by feeding of fresh or sun dried cassava roots and by-products to livestock largely reared around homes in cassava processing site.

Cassava has a unique characteristic in that it can be continuously harvested and marketed throughout the year. Cassava roots are the most common part of cassava used as livestock feed by farmers in the villages. Recently several studies have been undertaken in Nigeria and Southeast Africa on the possibility of using cassava leaves /foliages, which is a by-product after root harvesting, as a feed resources for small ruminants (Seng and Rodriguez, 2001; Van *et al.*, 2001;). It contains high crude protein up to 25 % on dry matter (DM) basis, a nutrient which is generally deficient in feeds for livestock in the tropics. Thus, it can potentially be used as a protein source for livestock. AFRIS (2004) reported a crude protein (CP) content of cassava leaves in the range of 22-29 % of dry matter (DM), whereas Seng *et al.*, (2001) showed that the foliage contained 21-24 % CP. Cassava leaves have also been reported to

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have high essential amino acid content, comparable to soybean meal. However, cassava leaf production is high during cassava tuber harvest; thus, these are abundantly available only in short periods of time. Feeding such high protein forage as a single feed to ruminants, as commonly practiced by farmers during the season when cassava leaf is abundantly available, is not an efficient feeding practice. This is because the excess protein consumed by ruminants will be excreted mainly in the urine and faeces, and it requires a lot of energy for the animal to metabolize and excrete the excess protein intake in this way (McDonald *et al.*, 1998). Like other forages, cassava leaf cannot stand for long time without any treatment, consequently the excess of cassava leaf are sometimes left in the field underutilized. Ensiling could be a suitable way of preserving the leaves but silage additives should be added to ensure successful fermentation (Pattersson, 1988).This opportunity could solve the problems of feed shortage particularly in the dry season, and at the same time improve feed quality. As silage, the excess cassava leaf available can be stored and utilized for a longer period of time as a protein feed supplement. Hang (1998), Kayouli and Lee (2000), Ly and Rodríguez (2001) reported that silage making is an appropriate method to conserve cassava leaf as feed. Feeding cassava leaf silage has been reported to increase livestock productivity including milk yield (IITA Annual Report 2004, Kavana *et al.*, 2005), body weight gain (Nhi *et al.*, 2001; Bunyeth and Preston, 2006). Preservation of the excess of cassava leaf will maximize and improve the efficiency of the excess cassava leaf utilization as feed. There is therefore the need to consider the effects of ensiling it in mixture with grasses such as Guinea grass (*Panicum maximum*).

Guinea grass (*Panicum maximum)* is one of the grasses that are abundant and available almost in all parts of the tropics and in almost all ecological zones in Nigeria but scarce in the dry season suggesting the need for conservation. Guinea grass is a tall, vigorous clump forming perennial grass with stems up to 3.5m. It produces high yields of palatable fodder and responds well to manuring but rapidly declines in nutritive values with age (FAO, 2003). However, Guinea grass like any other tropical grass rapidly decline in crude protein and soluble carbohydrate. It increases in crude fiber and lignin which leads to reduction in voluntary intake and digestibility (Bamikole *et al.*, 2004). Ajayi *et. al.* (2008) reported that if grass of any age is effectively managed it can strategically be exploited to ameliorate forage scarcity in the off season. Du Ponte *et al.* (1998) demonstrated that Guinea grass can be successfully ensiled, maintaining nutritive quality and minimal spoilage under tropical climatic conditions.

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Silages made from tropical grasses are poor in nutrient because of the low protein content. The production of good quality silage involves making a good balance between carbohydrate and protein content in the raw material. The balance can be obtained by ensiling legumes and grass together. In this way, sufficient fermentable carbohydrate for lactic acid bacteria are provided and simultaneously the protein content of the silage is increased (Assefa and Ledin, 2001; Nayigihuju *et al.*, 2002). In addition, the mixture of legumes and grass will increase biomass yield, crude protein content and the nutritive value of the resultant silage (Assefa and Ledin, 2001; Nayigihuju *et al.*, 2002). Preservation by ensiling can be an appropriate method, but require an anaerobic environment for adequate microbial processes depending on the time of ensiling and storing (Man, 2001). The advantage of this method is that plant materials can be ensiled at any time of the year, even when weather condition are not suitable for sun-drying. The ensiling process ensures not only increased length of storage and microbiological safety but also makes most food resources more digestible (Seng and Rodriguez, 2001).

1.2 Justification of the study.

Cassava foliage has long been recognized by researchers in Africa as an appropriate livestock feed and it has been used as an appropriate and cheap feed in many Countries. Cassava offers tremendous potential as cheap source of energy for livestock. Cassava is one of the most drought-tolerant crops and can be successfully grown on marginal soils giving reasonable yield where many other crops do not grow well.

Cassava leaves is a readily available product at the time of harvesting of the roots, cheap to get, less exposed to competition. These leaves a large proportion of cassava leaves and tender stem unutilized after the tuber have been harvested. Surprisingly, large tonnages of these leaves are currently discarded as waste after root harvesting. It has been found to be high in crude protein content with balance amino acid profile, vitamins and minerals. These attributes make cassava leaves a very good substitute for most of the conventional plant protein sources. With the improvement and development of high yielding and stable cassava leaves, higher productivity is being recorded in many African countries with Nigeria becoming the world's leading cassava producers. The increase in cassava production will lead to increase in leaf and roots product and these needs to be matched with diversification of usage of the leaves and roots beyond its traditional role of being a staple food.

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Forage conservation during the periods of high forage production is essential. Silage making of forages that are plentiful during the wet season is one of the answers to feed shortages in other parts of the year. Silage is quite moist and usually preferred by livestock to hay as it is more palatable and of higher feed value. The objective of silage making is to preserve forage for the dry season in order to ensure continuous feed for livestock, either to sustain growth, fattening or milk production, or to continue production in difficult period when market prices are high. In the tropical countries, plant growth coincides with the rainy season. However in the rainy season, it is difficult to sun dry and extending the drying period diminishes the nutritional quality of the product. Ensiling would appear to be the more attractive alternative way of conservation when the harvest coincides with the wet season. The organic acid produced during ensiling are similar to those normally produced in the digestive tract of the ruminant and therefore are used in the same manner. Silage making offers an option to secure feed during seasons of high production for conservation and storage for later use in period of relative shortage.

Hay made from cassava leaf and stem was shown to be good feed resource for ruminants, with a high voluntary feed intake of 3.1 % LW and 71 % dry matter digestibility (Wanapat *et al.*,1997). However, to produce good quality hay from cassava tops requires good weather for drying and special care must be taken to limit the loss of dry leaves. Ensiling could be a suitable way of preserving the leaves but silage additives should be added to ensure successful fermentation when the ensiled material, such as cassava tops has a high content of nitrogen and low concentration of water soluble carbohydrate (Patterson, 1988). Sugar cane molasses a common feed ingredient in the tropics is frequently used as an additive for ensiling tropical forages and improving silage quality. Kavana *et al.,* (2005) reported that cassava leaf silage has the potential of contributing a larger proportion of amino acids for milk synthesis than the maize bran and basal diet fed to lactating crossbred dairy cows. There was also an increase in milk fat percentage after feeding cassava leaf silage.

Cassava forage has been shown to be an excellent source of protein as a direct supplement or in concentrate mixture (Wanapat, 1995). Wanapat (1997) reported that cassava hay contained tannin-protein complex that could provide minimal by-pass protein and this lowered ruminal NH_3 -N and Blood Urea Nitrogen (BUN). Promkot and Wanapat (2003) reported that cassava hay had a content of bypass protein comparable with that in cotton cake. In comparism with Soy-bean meal (SBM) cassava hay has a higher concentration of Rumen Undergradable

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Protein (RUP) (Wanapat *et al.,* 2000a) and is beneficial because it can supply more total amino acid for absorption in the lower gut. Wanapat *et al. (*2000b) stated that cassava hay could help provide additional VFA necessary for milk synthesis.

The amino acid profile of cassava hay was relatively comparable with soy-bean meal (SBM) (Wanapat, 2003). Lysine, glutamine asparagine and arginine were higher in SBM but in cassava hay methionine was higher. Wanapat *et al.* (2007) clearly demonstrated that as levels of cassava hay to SBM ratio in concentrate linearly increased income over feed. This provides important data that cassava hay can be an alternative source of protein. He concluded that cassava hay as a protein replacement for SBM in concentrate for dairy cow resulted in similar milk yield while milk fat was improved. Increasing levels of cassava hay, SBM in concentrate significantly income over feed.

Many authors reported that ensiling of cassava leaves is an appropriate method to conserve them for dry season feeding (Limon, 1992; Du Thanh Hang 1998, Ly and Rodriguez, 2001). Ensiling has been reported as an effective way of reducing cyanide (HCN) content in cassava (Tewe, 1991; Nguyen Thi Loc *et al.*, 1996).

1.3 **General objective**

To evaluate the silage quality and effects of ensiled cassava top on voluntary intake and growth performances by the West African dwarf sheep.

1.3.1 Specific Objectives

- ✓ To determine the proximate composition of the ensiled cassava tops and Guinea grass.
- ✓ To determine the keeping quality and nutritive value of ensiled cassava tops and Guinea grass mixtures.
- ✓ To assess the effects of ensiled cassava top and Guinea grass mixtures on the intake, growth and digestibility of WAD Sheep.
- ✓ To assess the effects of ensiled cassava top and Guinea grass mixtures on haematological and carcass characteristics of WAD Sheep

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CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 WEST AFRICAN DWARF SHEEP

The West African dwarf sheep is a predominant breed of the sub humid tropics from southern West Africa through central Africa. Their colour is generally black piebald on white. The males are horned while the females are polled. Adult male weigh approximately 37kg. They have well developed throat ruff and are horned. Adult Ewes weigh about 25kg and can be bred at the age of 7 to 8 months. They tend to have short lambing interval of about 5 months. The prolificacy of adult ewes is low to moderate ranging from 1.15 to 1.50 lambs per lambing at less than 100kg per day with good feed conditions. The West African Sheep are indigenous to Nigeria and have long adapted to extreme weather conditions of nutrition, climate and diseases and might be more productive in their own environment than exotic breeds. Nigeria has basically four definite breeds of Sheep which are West African Dwarf Sheep, Balami(BAL), Yankasa and Uda(UD) (Olufunmilayo, *et al.*, 2000). The WAD Sheep is a small breed but not small in the genetic sense .The dwarf are physically weak and poor whereas the Sheep of West Africa has notable physical and sexual vigour and fitness that enable them to withstand the stress of the climate, disease and irregular feeding (Charray *et al*., 1992). WAD Sheep are tolerant to trypanosomiasis and other diseases allowing them to be grazing on land not available to other domestic livestock (Okoli *et al*., 2005). They also help balance the energy and protein supply during normal variation between seasons and years. WAD Sheep appears to withstand drought better than cattle. The WAD Sheep is the most prolific of all the domesticated ruminants' under tropical and subtropical conditions and are able to breed throughout the year. They have potential of converting plant materials to high quality animal protein (Kwamme, 2001).

WAD Sheep in the tropics is constrained by the following factors: Low genetic potentials; Seasonality of availability of feed and scarce water resources; High ambient temperature and Mortality. Odeyinka and Okunade (2005) stated that other constraints to indigenous small ruminant production in the tropics include diseases, accidents, seasonality of feed supply and theft

2.1.2 NUTRIENT REQUIREMENTS OF SHEEP

Nutrients of primary importance in sheep nutrition are water, energy, protein, minerals and vitamins. Clean fresh water should be supplied to livestock because adequate water consumption increase feed and forage intake thereby enhancing good performance.

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The water requirement of sheep increases when temperature rises *(*Rodney, 2001). The crude protein content of tropical pasture varies with age, part of the plant and the species of the plant, however, ruminants have the ability to convert low quality protein sources to high quality protein by bacteria action. They have the potential of converting plant materials to high quality animal protein *(*Kwamme, 2001). Proteins are essential nutrients for growth and repair of worn-out tissues. A growing sheep requires 14% CP *(*McDonald *et al.*, 1991). The amount of protein required by sheep depends on the functions performed by the animal and its physiological state.

The protein available for digestion in the small intestine consists of microbial protein and dietary protein that has escaped microbial breakdown in the rumen *(*Rodney, 2001).The performance of sheep is limited when energy supply in the feed consumed is insufficient. Pregnant and lactating ewes require a substantial amount of energy in their diet for optimum performance and efficient production *(*Rodney, 2001). Some micro-elements which are not essential to plant growth such as sodium and cobalt are critical to animal performances. Even the major nutrients such as phosphorus, potassium, nitrogen and calcium will affect production in animals if they are low in fodder plant *(*Aminah and Chen, 1990). The mineral content of forages exhibit variations depending on plant species, soil types, stage of maturity and level of fertilization. Under normal grazing situation the minerals that are most likely to be deficient are salt (sodium chloride) and phosphorus while the minerals that are normally provided in sufficient amount in natural feedstuffs include potassium, copper manganese, iron and magnesium *(*Rodney, *2001).*

2.2 Cassava

Cassava (*Manihot esculenta, crantz*) is an annual tuber crop grown widely in the tropics and subtropics. Cassava is an all season crop grown as food in several parts of Africa, Asia and Latin America (Longe, 1980; Rosling, 1987; Bradbury *et al.*, 1991). It can easily thrive in sandy-loam soil with low organic matter, receiving low rainfall and high temperature. It is a cash crop cultivated by small-holder farmers within the existing farming systems in many countries. Cassava is used mostly as a source of food for man and his animal. Its leaves when collected at harvest time, contained high level of protein and could be used as a protein supplement in ruminant. Cassava has been rated as a key crop and a very promising potential feedstuff in quite number of states in Nigeria (PTFAFLF, 1992).

Nigerian cassava production is the largest in the world; a third more than its production in Brazil and almost double the production of Indonesia and Thailand. Cassava production in other African countries, the Democratic Republic of the Congo, Ghana, Madagascar, Mozambique, Tanzania and Uganda appears small in comparison to Nigeria's substantial output.

2.2.1 Nutrient composition of cassava tops

Cassava leaves contain an average of 21% crude protein, but values ranging from 16.7 to 39.9% have been reported (Ravindran, 1991). Cassava leaves contain an average of 210 g/Kg^{-1} crude protein but values ranging from 147 to 400 gKg^{-1} have been reported according to Lancaster and Brooks (1983). Cassava leaves contain high level of crude protein (25%) some of which can apparently by-pass the rumen since it is in the form of tanin-protein complex (Wanapat, 1995). This improves protein nutrition by binding to plant protein in the rumen so preventing microbial degradation and increasing amino acid flow to the duodenum (Wanapat, 2007). In addition, Ravindran and Ravindran (1988) found that the crude protein content decreased from 38.1% in very young leaves to 19.7% in matured leaves. Although cassava leaves are rich in protein, they are also high in fibre content. This factor (high fibre content) may limit their nutritive value for monogastric animals especially poultry. The major factor that determines the fibre content of cassava leaves which is also common with other plant material is their stage of maturity, very young leaves contain only 8.3% crude fibre, but this increases to over 26% in mature leaves (Ravindran and Ravindran, 1988). Another factor which is sampling procedures, such as the inclusion of petioles, influences the fibre levels in cassava leaf content. Ravindran (1985) reported that fibre content in mature leaves could be lowered to about 17% by discarding the petioles during meal preparation. This wide variability is related to differences in cultivars, stage of maturity, sampling procedure, soil fertility and climate.

Cassava leaves are good sources of minerals. They are particularly rich in Calcium, Magnesium, Iron, Manganese and Zinc (Ravindran, 1991). Cassava leaves are also rich in ascorbic acid, vitamin A and contain significant amount of riboflavin. But considerable losses of vitamins, particularly of ascorbic acid occur during processing. Cassava foliage meal contains as high as 56,000IU of vitamin A when compared with 14,2000IU in Alfalfa meal, 66IU ground yellow maize and 264IU in flour. This high content of vitamin A is significant in the pigmentation of egg yolk and skin of poultry (Ravindran, 1991).

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2.2.2 Amino acid composition

Cassava leaf with its high content has adequate amino acid profile is deficient in methionine, possibly marginal in trytophan, but rich in lysine (Eggum, 1970). Some variation in the amino acid content of leaves has been reported and may be attributed to difference in stage of leaf maturity, sampling procedures, analytical methods and ecological conditions. The changes in amino acid composition in relation to maturity of leaves have been studied by Ravindran and Ravindran (1988). As the leaves mature, the general trend was for the amino acid concentrations to decrease. Of the essential amino acid, lysine and histidine showed the greatest decrease. The essential amino acid profile of cassava leaf meal compared favourably with that of alfalfa meal (Allen, 1984; Ravindran and Ravindran, 1988).

2.2.3 Anti-nutritional factors in cassava foliage

1. Cyanogenic Glucosides

Hydrocyanic acid is considered as an anti-nutritional factor that is released when fresh cassava foliage is fed to animals. Both leaves and roots of cassava contain HCN. The cyanide content of cassava leaves has been extensively studied. The normal range of cyanide content is from 20 to 80mg HCN per 100g fresh leaf weight, but samples containing as low as 8mg/1100g or over 400mg/1100g have also been reported. On dry basis (assuming 25% Dm in fresh leaves), the normal range of HCN content would correspond to 800 to 33200mg/kg. These leaves are substantially higher than the normal range of HCN reported for fresh cassava roots (Ravindran, 1991).

The HCN concentration, produced after the action of hydrolytic enzymes occurring in the plant on the cyanogenic glycosides, is influenced by the nutritional status and age of the plant (Ravindran and Ravindran 1988). As in other cyanogenic plants, the glycoside concentration in cassava leaves decrease with age (Lutaladio *et al.*,1984). Cyanide levels in the leaves are also influenced by the nutritional status of plant. The concentration of the glycosides normal range of cyanoglucosides content in fresh roots is from 15-400 ppm calculated as fresh weight but occasionally varieties with very low HCN content of 10 mg/kg or very high item content of 200 mg/kg have been reported.

The HCN contain of fresh cassava varied from 125 to 854 mg/kg fresh basic (Chew 1972; Ravindran 1991; Wanapat *et al.*, 2000a; Ngo Tien Dzung 2003; Murugueswari *et al.*, 2006).

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The wide variations observed in leaf cyanide levels may be attributed to genetic, physiological, edaphic and climatic differences, but have been exaggerated by problems associated with methodology of cyanide assay. Stages of leaf maturity are perhaps a major factor causing variations in the cyanide assay. Variation is also due to variety and management of cassava foliage. The bitterness in cassava leaves is also related to the presence of cyanogenic glucosides. Cadavid *et al.* (1998) reported that supplying N, P and K fertilizer to cassava significantly increased root and top biomass and reduced root HCN content. De Bruijn (1973) found that leaves produced during drought were reported to have high cyanide content. There are techniques to reduce HCN levels in both leaves and roots such as wilting, ensiling, sun drying, and boiling to make then safe for use as food for humans and animals (Ravindran 1991; Wanapat, *et al.*, 1997; Khieu 2005, Murugeswari *et al.*, 2006).

Cassava's food value is greatly compromised by the endogenous presence of cyanide glucosides. The glucosides, typified by Linamarin and Lotaustralin are hydrolyzed to hydrocyanic acid (HCN) by endogenous Linamarase when cassava tissues are disrupted by cutting, grating, cruising or other mechanical means (Bradbury and Hollyway, 1988). Therefore processing must seek to reduce the cyanide in cassava before use. Various processing methods have been used to reduce the cyanide content in cassava effectively, for example; grating, sun drying, boiling and fermenting can reduce cyanide considerably. Drastic decrease in the level of cyanide after ensiling implies that ensiling is an effective way of reducing HCN in cassava leaves and roots before feeding to dairy animal (Kavana *et al.*,2005).

2. Tannins

The presence and role of condensed tannins in cassava leaves was discussed by Reed *et al.* (1982). Tannins in cassava leaves have been shown to increase with maturity (Gomez and Valdivieso 1984; Ravindran and Ravindran 1988) and also to vary between cultivars (Padamaja 1989). It was reported that tannin content in fresh cassava leaves varied from 30 to 50 g/kg DM (Ravindran 1993) and from 32.6 to 43 mg/kg in sun-dried cassava leaves (Wanapat 2003; Netpana *et al.*, 2001). This range of tannin levels has been explained as being beneficial to ruminants, as it enhances the use of the protein as well as playing an anthelminthic role for the control of nematode parasites (Barry and McNabb, 1999; Butter *et al.*, 2001). The reported values for tannins in cassava leaves, however, are smaller or lower

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than those of most plant leaves, including alfalfa, and are within safe limits if judiciously used for animal feeding.

A similar range of CTs was reported in fresh cassava top (31.4 g/kg) (Khang and Wiktorsson, 2004), in fresh cassava leaves (41.5 g/kg) (Seng and Preston, 2003), as well as in cassava hay from Vietnam (23.0 g/kg) (Dung *et al.*, 2005), and Thailand (40.0 g/kg) (Granum *et al.*, 2002). López *et al.* (2004) analysed different compounds of CT in some humid tropical fodder crops and showed that cassava forage contained 53.5 g/kg free CT, 9.3 g/kg bound to protein, 18.8 g/kg bound to fibre, and totally 81.6 g/kg.

They are capable of forming indigestible complexes with protein, thus increasing the amino acid requirements of animals fed diets containing cassava leaf meal. The condensed tannins can improve protein nutrition by binding to plant protein in the rumen so preventing microbial degradation and decreasing amino acid flow to the duodenum (Wanapat, 2001).

Condensed tannins contained in the forage has the potential to help control anthelmintic resistant gastro intestinal parasite (GIP). Numerous studies have shown the potentials of the tannin content in cassava leaves to play an anthelminthic role for the control of nematode parasites in ruminants (Seng and Preston 2003; Neptpana *et al.*, 2001; Le and Doung , 2005).

2.2.4 Productivity of Cassava Leaves

The potential yield of cassava leaves varies considerably, depending on cultivar, age of plant, plant density, soil fertility, harvesting frequency and climate. Leaf yield may also be related to agronomic, climate and soil fertility differences.

The leaf Dry matter (DM) yields are generally lower, if cassava leaves are to be obtained as a by-product at root harvest. Gomez and Valdivieso (1984) evaluating two 12-month cultivars, reported the leaf DM yields at root maturity to be only 1.2-1.8t/ha. In contrast, Ravindran and Rajaguru (1988) obtained a much higher leaf DM yields of 4.64t/ha. The higher yields in the latter study may be related to agronomic, climatic and soil fertility differences. Leaf production can be enhanced by harvesting cassava leaves during the growing season, but this would adversely affect root yields. However, several studies now have demonstrated that it is possible to harvest cassava leaves while maintaining acceptable yields of roots.

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Ravindran and Rajaguru (1988) harvested 6.75 tonnes Kg DM/ha by defoliating once during a seven-month growing season and obtained within 86% of the normal yields of roots. Dahniya *et al.*, (1981) recommended a harvesting frequency of two to three months, starting from 4 months for best all-round yields in 12month cultivars. FAO (1998) reported that with practices directed towards harvesting of foliage up to 6 tonnes of crude protein can be obtained per hectare per year.

2.2.5 Harvesting

The appropriate harvesting method under the current practice of small scale cassava production is to manually harvest the foliage by stem pruning. The foliage including tender stems could be wilted, chopped and used directly for ruminant feeding. Alternatively, the leaves could be stripped, dried and ground into a meal. However, if large scale foliage production is envisaged, development of a mechanical harvesting device could be desirable.

2.2.6 Processing and Storage

The existence of cyanogenic glycosides has made some form of processing a pre-requisite for the use of cassava leaves in animal feeding. Several studies have demonstrated that it is possible to produce cassava leaf meal (CLM) with low cyanide levels (Gomez and Valdivieso, 1985; Ravindran *et al.*, 1987). Simple sun-drying alone eliminates almost 90% of the initial cyanide content when combined with chopping and wilting, cyanide in the dried meal was reduced to levels which are safer for monogastric animals. This reduction is due to the action of endogenous linamarase on glycosides following loss of cell integrity (wilting) or tissue damage (chopping). The free tannin contents of cassava leaves are also considerably lowered during drying.

A simple procedure of processing cassava leaf meal is outlined below:

1. **Chopping:** Leaves are chopped manually 1aqor by means of a mechanical chopper. Leaves may also be bruised instead of chopping. Chopping not only increases cyanide elimination, but shortens the drying time.
2. **Wilting:** Leaves can be wilted by spreading out in shade or in a room with cross-ventilation. Duration of wilting may vary from few hours to few days. Leaves must be turned over regularly to avoid fermentation and mould formation.
3. **Drying**-Wilted leaves should be uniformly distributed in the drying floor and turned over as necessary. Once 12% moisture level is reached, the dry leaves can be preserved

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either in the form of leaf meal or pellets. Processing has little influence on the crude protein content of the leaf meal. Chopping of leaves however has been reported to cause slight reduction in the protein content (Ravindran *et al.*,1987).

CLM has excellent storage qualities from preliminary investigation. There was no mould or insect infestation even after 8months of storage, interestingly, the cyanide content declines during storage, but a gradual decline in the crude protein content was also observed (Ravindran *et al.,* 1987). Traditionally, cassava is fed to sheep and goats in the tropics and it can constitute 20-40 percent of compound livestock feeds especially in poultry and pigs with considerable reduction in production costs.

2.2.7 Cassava as dual-purpose crop

Cassava is a tuber crop grown widely in tropical and sub-tropical area. Cassava has been given considerable attention by a number of research institutes in developing countries because it is easy to grow and can survive on soils with poor fertility, where other crops would fail (Howeler and Cadavid 1990). It survives in soils with prolonged water deficit (Alves and Setter 2000; Wanapat *et al.,* 1997) and is tolerant to acidity (Cock and Howeler, 1978). It has high level of energy from roots and protein from the leaves, which both can be used for human and animal food. In addition, the recent work by Miech (2005), showed that stems can be used as fuel in a gasifier to generate electricity. The main product of mature cassava plant (at 12 months after planting), expressed as percentage of the whole part, were estimated as 6% leaves, 44% stems, and 50% tubers (Devendra, 1977). Cassava can be managed as a semi-perennial forage crop with high yields of fresh foliage of up to 20 tonnes/ha/harvest (Preston *et al.,* 2000) with repeated harvesting at 2-3 month intervals. However, this practice affects roots yield and a lower yield of stem in case of using them for gasification. Other options commonly practiced are to cultivate cassava for root production by collecting leaves when harvesting root. Gomez and Valdivieso (1984) reported that leaf dry matter yields at root harvesting were from 1.2 to 1.8 tonnes/ha.

2.2.8 Potential of cassava foliage as livestock feed

Considerable progress has been made in the use of cassava leaves as protein supplement in livestock feed (Wanapat, 2003). Beside the root, each hectare of cassava produces a large amount of leaves. The potential yield of cassava leaves varies depending on cultivar, soil fertility and climate. Cassava leaves, the residue after harvesting the root account for between

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2500 - 3000 kg, from which 600 - 800kg meal per hectare can be produced (Duong *et al.*, 1997)

2.2.8.1 Potential of cassava foliage for ruminants

Feeding fresh cassava foliage to cattle and goats did not show any effect of toxicity from HCN or tannin, when the cassava was managed as semi perennial forage with repeated harvests at 50-80 day interval under fertilization (Seng *et al.*, 2001; Seng and Rodriguez 2001; Theng *et al.*, 2003). In fattening cattle, Ffoulkes and Preston (1978) reported that the fresh foliage could be used as the sole source of protein and fibre for supplementing a liquid diet of molasses-urea, supporting growth rates of more than 800 g/day in fattening cattle. Similarly, Seng *et al*, (2001) reported that when fresh cassava foliage was given to local "Yellow" cattle fed rice straw and rumen supplement, the daily weight gain increased from 210 to 302g/day while Le and Doung (2005) reported that increasing levels of fresh cassava foliage increased total DM intake and rate of live weight gain from 138 to 160 g/day.

In Thailand, cassava hay has been successfully used for dairy cattle to improve milk yield and quality and reduce the need of concentrates (Wanapat 2001). Promkot and Wanapat (2003) estimated that cassava hay has a similar content of rumen undegradable protein as cottonseed meal (considered to be one of the best sources of bypass protein according to Preston and Leng, 1987). Chanjula *et al.* (2004) reported that increasing the level of cassava hay as a roughage source could enhance rumen ecology by increasing cellulolytic and proteolytic bacterial populations and fungal zoospores while the protozoal population was decreased.

Keo Sath *et al.* (2007b) reported that increasing levels of sun dried cassava foliage led to significant increases in total dry matter intake and daily weight gain of cattle fed untreated rice straw and a rumen supplement. Daily weight gain increased from 201 to 402 g/day and feed conversion was better with increasing levels of protein from sun-dried cassava foliage in the diet. The responses were linear over the range of cassava crude protein intakes from 0 to 1.6 g crude protein/kg live weight.

2.2.9 Use of cassava in ruminant feedings

Cassava foliage (leaves and stems): Leng and Preston (1976) suggested that ruminant feeding systems based on poor quality tropical foliages, crop residues or agro industrial by-products, in which protein is one of the first limiting factors, may require additional protein and roughage to maintain an efficient rumen ecosystem that will stimulate nutrient intake and improve animal performance.

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Several authors subsequently showed that cassava foliage could efficiently serve as a protein and roughage supplement to such diets. Moore (1976) demonstrated the feed value of cassava foliage for ruminants in a trial in which steers weighing 250 kg were fed *Pennisetum purpureum* with varying levels of cassava foliage. Feed intake, growth rate, and feed efficiency were improved in diets containing cassava foliage supplements. Another set of steers fed on a basal diet of chopped sugarcane supplemented with cottonseed cake, cassava foliage or *Desmondium distrotium* foliage showed respectively, similar growth rates of 0.66, 0.62 and 0.58 kg/day.

More recently, Smith *et al.* (1988) compared the rumen degradability of some foliages in cattle and goats. In all these ruminants a similarly high 48-hour degradability of 84.3% for cassava leaves was obtained which was higher than the degradability for *Leucaena leucocephala, Gliricidia sepium,* bamboo and oil palm leaves. Cassava foliage is thus a valuable feed material for ruminants. Fresh cassava foliage is a satisfactory protein supplement, but it should be wilted before feeding and prudently used for good results. Wilting not only lowers potential cyanide toxicity, but also reduces the free tannin levels and improves its acceptability to animals. The supplementation value of cassava foliage is comparable to those reported for tropical tree legumes (Johnson and Dajanagare, 1989). No adverse effects on performance have been reported even when higher leaves of wilted cassava foliage were offered to goats and sheep.

Cassava leaves have in vitro organic matter digestibility (IOMD) values of 44.9-78.7% (Onwuka *et al.*, 1989). Smith *et al.* (1988) showed that cassava leaves have high 48hours rumen degradability value thus making it a valuable food material for goats. Cassava leaves as sole feed may not be efficiently utilized (Onwuka, 1983) supplementing the leaves with energy sources did put the goats in positive balance and weight of 10-100g/d were obtained (Onwuka, 1983; Ahamefule *et al.*, 2000). Alli-Balogun *et al.* (2003) fed 1.0% and 1.5% of body weight equivalent of cassava to Yankasa sheep as supplement to Gamba grass and recorded weight gain of 39.2-41.2g/d. The leaves and petiole of the local variety of cassava were dried for 7days. DM intake, ME intake, growth rate and nitrogen utilization improved with increasing levels of cassava peels supplementation of the leaves (Onwuka and Akinsoyinu, 1989).

Wanapat *et al.* (2007) clearly demonstrated that increasing levels of cassava hay to soy-bean meal (SBM) ration in concentrate diet linearly increased income over feed thus resulted in more milk income. This provides important data that cassava hay can be an alternative

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source of protein replacing SBM in concentrate for a sustainable dairy production in the tropics. As reported by Wanapat and Khampa (2006), cassava hay is important as a protein and also as an anthelmintic in ruminants.

In the FAO Tropical Feeds Database (FAO, 1998), it is stated that cassava leaf meal can be mixed in concentrates for lactating cows at up to 35% without any harmful effect. Hay made from cassava and stem was shown to be a good feed resource for ruminants, with a high voluntary feed intake (3.1% of LW) and dry matter digestibility (71%) (Wanapat *et al.*,1997). Additional VFA necessary for milk fat synthesis were provided by cassava hay (Wanapat *et al.*, 2000b).

2.2.10 Preservation as silage

Ensiling is one among several techniques recommended for practical conditions to preserve the quality of feed materials during periods of excess yield/ production (McDonald *et al.*, 1991). An advantage of this method is that plant materials can be preserved at any time of the year; even when weather conditions are not suitable for sun-drying. The ensiling process ensures not only increased storage length and microbiological safety, but it also makes most food resources more digestible (Caplice and Fitzgerald, 1999). It has also been shown that fermentation of cassava leaf and foliage reduces toxicity levels of HCN (Chhay *et al.*, 2001; Sokerya *et al.*, 2009). Tropical crops/grasses often have low levels of fermentable carbohydrates compared to temperate forage crops (Catchpoole and Henzell, 1971). Additives are being recommended to improve fermentation and nutritive value of silages, and 4 to 5 % of molasses was suggested to be used (Henderson, 1993), as well as in tropical crops/grasses of low DM content. In the case of Cambodia 5 % sugar palm syrup has been used in the preparation of silage from cassava leaves (Chhay *et al.*, 2001). Besides easily fermentable ingredients such as sugar or molasses, grains and processed by-products such as maize or sorghum meal, rice bran and cassava meal can also be used as silage additives to provide a fermentable substrate (Mühlbach, 1999). It was shown by Phuc *et al.* (2000), that a pH of about 4 would normally have preserved the silage materials satisfactorily.

2.3 The Guinea grass

Guinea grass is a topical Africa pasture plant, predominant in the West Africa region especially in Nigeria. It grows widely in Nigeria due to its ease of establishment either by seeds or vegetable propagation (Bamikole *et al.*, 2004a; Ajayi *et al.*, 2008).

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Guinea grass (*Panicum maximum)* is one of the grasses that are abundant and available in all the ecological zones in Nigeria especially the derived savannah region and can be conserved for dry season feeding. Guinea Grass is probably the most valuable grazing grass in its area of distribution. It is particularly palatable, delivers a high leaf production and usually occurs in abundance in good veld. The spikelets are very popular amongst seed-eating birds. Guinea grass is used as forage for beef production. It is used as cultivated grass both for silage and hay (Akenova and Mohammed Salami, 1985; Du Ponte *et al.*, 1998).

Under good condition, its nutritional value is high having up to 12.5% crude protein, total digestible nutrient (TDN) of 10.2% and calcium phosphorus and magnesium (Agishi, 1985; Akenova and Mohammed Salami, 1985; MC Donald *et al.*, 1998)

Holm *et al.* (1977) and Whiteman (1980) stated that guinea grass is drought resistant because of the massive fibrous roots system. Although it is adapted to a wide-range of edaphic condition, it performs best in well drained light-textured (sandy, loamy or sandy clay) soil as it is susceptible to water logging. Paez and Gonzalez, (1995) indicate the ability to withstand temperature in the range of 38-40 °C. Burning does not cause long term damage as the grass-region as well after being swept by fire. It tolerates annual temperature of 12.2 to 27.8 °C, annual precipitation of 6.4 to 42.9 and pH of 4.3 to 8.4. It grows naturally in pen grassland.

Guinea grass is more slender smaller with tiner leaves. It is tall range from (0.5 – 4.5m) vigorous tufted perennial plant with culms mostly erect often robust glabrous to pubescent. Leaves are linear to linear-lanceotate (flat), bright green, 15-100cm and 5.3cm wide with 3-7 whorled however branches. Spikelet 3-4mm long. Inflorescence is a large muti-branched open panicle. Guinea grass can be cut when it is 60-90cm tall to achieve a high nutritive value but for higher yields, it can be harvested when it is 1.5m tall (Humphreys and Patridge, 1995; Aganga and Tshwenyane, 2004). Guinea grass is highest in caloric and protein content at heading stage and, for regrowth; it can be cut after 4-5 weeks (Jianxin, 2002). However, guinea grass like any tropical grass rapidly decline in crude protein and soluble carbohydrate. It increases in crude fiber and lignin which leads to reduction in voluntary intake and digestibility (Bamikole *et al.*, 2004a). Ajayi *et al.* (2008) reported that if grass of any age is

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effectively managed, it can strategically be exploited to ameliorate forage scarcity in the off season.

2.3.1 The role of Guinea grass as fodder crop

Guinea grass (*Panicum maximum)* is one of the grasses that are abundant and available in all the ecological zones in Nigeria and can be conserved for dry season feeding. Guinea Grass is probably the most valuable grazing grass in its area of distribution. It is particularly palatable, delivers a high leaf production and usually occurs in abundance in good veld. The spikelets are very popular amongst seed-eating birds. Guinea grass is used as forage for beef production. It is used as cultivated grass both for silage and hay.

Du Ponte *et al.* (1998) demonstrated that guinea grass can be successfully ensiled, maintaining nutritive quality and minimal spoilage under Hawaiian climatic conditions. They observed that the silage pH of all treatments dropped rapidly from day 0 (average pH: 5.67) to day 5 (average pH: 5.05) and continued to decline through day 30 (average pH: 4.69) of the ensiling process. They observed that silage production can be effectively integrated with pasture management in the dairy industry.

2.4 Silage

Silage is the material produced by controlled fermentation of a crop, retaining high moisture content. Its preservation is by means of an acidic fermentation of the sugars present in the forage by bacteria that grows on the herbage or by direct addition of acids or other preservatives. The common methods of preparing silage do not increase the nutritive value of a crop they only attempt to conserve what was available in growing plant when it was harvested (Mc Donald *et al.*, 1998).

The first essential objective in preserving crops by natural fermentation is the achievement of anaerobic condition. This is done by chopping the harvested crops, rapid filling of the silo and by adequate consolidation and sealing. Chopping facilitates compaction and thus reaching anaerobic stage, when most oxygen is removed, Clostridial growth is hampered and lactic acid fermentation is encouraged (Mc Donald *et al.*, 1991; Mc Donald *et al.*, 1998). Chopping releases plant juices stimulating the growth of lactic acid bacteria. Plant sugars produce the primary substrates for the lactic acid producing bacteria. It may increase silage intake by improving quality of fermentation and accelerating rate of passage of feed particle

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through the rumen. However, very fine chopped silage reduces the rumination and may decrease milk fat content. Sealing helps to prevent re-entry and circulation of air during storage so as to minimise the loss of nutrients by respiration. When oxygen is in contact with herbage for any period of time, aerobic microbial activity occur and the material decay to a useless inedible and frequently toxic product. Secondly, is to discourage the activities of undesirable micro organisms such as clostridia and entero-bacteria which produce objectionable fermentation products. The desirable lactic acid producing bacterial constitute only a small percentage of the total plant micro-flora prior to fermentation. During fermentation process lactic and acetic acid forming bacteria grow exponentially and become the predominant micro-flora. Encouraging the growth of lactic acid bacteria or use of chemical additives helps to inhibit these other micro organisms. Lactic acid bacterial ferment the naturally occurring sugars (mainly glucose and fructose) in the crop to a mixture of acid but predominantly lactic acid. The level of lactic acid in the silage depends on the sugar level of the plant at cutting, the degree of wilting, the quality of sealing and the preservation. Silage with a restricted fermentation will tend to have lower levels reflect dominance of lactobacillus fermentation. The lactic acid produced increases the hydrogen ion concentration to a level at which undesirable bacteria is inhibited. The exact critical pH at which inhibition occurs varies with dry matter content and the buffering capacity of the crop ensiled (Mc Donald *et al.,* 1998).Special attention and care need to be taken with regard to DM content. The correct DM content in the plant before ensiling is an important factor for the fermentation to succeed. Unexpected weather (dry, wet or hot) can damage the crop and increase losses (Mc Donald *et al.,* 1998).

Wilting of silage crop before ensiling helps to reduce the risk of adverse fermentation and produces higher dry matter silage with 50-65% moisture content (Van Soest, 1994; Mc Donald *et al.,* 1998). Wilting the forage before ensiling is recommended as a means of increasing dry matter content, the WSC on fresh weight basis and reducing losses from effluent and undesired fermentation (Humphreys, 1991, Nussio, 2005).Thus, if well managed often produces a more palatable feed than directly cut silage.

Quality of silage fermentation is influenced by several factors including; moisture water soluble carbohydrate content of the material degree of compaction and effectiveness of final sealing. The nutritional value of the silage produced depends firstly upon the species and stage of growth and secondly upon the changes resulting from the activities of plant enzymes

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and micro-organism during the harvesting and storage periods. The ensiled material passed through a sequential fermentation. The first stage of which involves the death of plant tissues and rapid exhaustion of oxygen followed by proliferation of bacteria and the development of an acid fermentation (Mc Donald *et al.*, 1991). Further, fermentation depends on the composition of the forage, the pH attained and the availability of oxygen and water. The best silages are those in which the original forage composition is least altered. Ensiling poor quality forages will not improve forage quality. Good preservation by fermentation depends on the production of lactic acid to stabilize the silage at a low pH, which in turn depends on an adequate supply of sugar to produce sufficient fermentation acids to overcome the potential buffering capacity of the forage.

The most important factor affecting silage quality is the availability of oxygen which promotes respiration, moulding, consequently heating and maillard reactions. This heat can lead to spontaneous combustion. The major variable affecting oxygen availability is packing density and the permeability of the walls of the silo. The rate of oxygen diffusion is a function of the permeability of the silo walls: the more the permeability, the more the dry matter loss and heating. Heat production within a silo is also significantly affected by the thermodynamics of the structure which involves solar radiation and colour of cover. Larger masses are prone to heating because there is less surface for radiation losses. (Van soest, 1994)

Losses in feed energy through the ensiling process occur in several ways: through initial plant respiration; anaerobic fermentation; aerobic decomposition particularly at surfaces; and effluent loss, especially in high moisture direct –cut-silage. For a crop to be suitable for making silage, it must contain adequate level of fermentable substrate in the form of Water Soluble Carbohydrate (WSC). It should have a relatively low buffering capacity and should have dry matter (DM) content in the fresh crop above 200g/kg. It should also ideally possess a physical structure which will allow it to compact readily in the silo or pit after harvesting. However, for crops that do not fulfill these requirements, pre treatments such as field wilting, fine chopping or the use of additives may be necessary. Silage making is useful only if the ensiled product is of good quality (well preserved with high digestibility and protein concentrate). The main prerequites for ensilable forage are that it should be harvested at a young stage of growth from a feeding value point of view and that it should contain enough sugars for fermentation. The material to be ensiled should be easily compactable and covered

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to exclude air. If the material is of adequate quality in sugars, molasses or another source of sugar may be added (t'Mannetje, 1999).

The purpose of ensiling grass is to preserve and minimise the loss of nutrients thus improving silage feeding value. Silage additives are used to enhance the ensiling process, which can result in improvements in animal performance, milk quantity and quality, body condition and fertility. Altering the fermentation process without quantifiable improvements in one or more of these categories is of minimal benefit

2.4.1 Silage additives

Silage additives can be used in order to enhance silage fermentation and their nutritional quality. They are classified according to their function: fermentation stimulants, fermentation inhibitors, aerobic deterioration inhibitors, nutrients and absorbents (McDonald *et al*., 1991). Additives should be used according to needs and silage properties. It should be emphasized that additives can improve silage quality and minimize losses, but cannot compensate for poor silage making and management.

Silage additives include feedstuffs, urea, ammonia, inoculants and acids. Their main functions are to either increase nutritional value of silage or improve fermentation so that storage losses are reduced. Response to additives depends on the species of forage that is being ensiled. Many different silage additives are available and are used for different reasons. Additives are used to improve nutrient composition of silage, to reduce storage losses by promoting rapid fermentation, to reduce fermentation losses by limiting extent of fermentation, and to improve bulk life of silage (increase aerobic stability).

It is controversial to what extent starch is an available substrate for LAB (Woolford, 1984). Jones (1988) recovered 100 and 90% of starch from barley and oats, respectively, added at the ensilage of ryegrass, attributing an improved fermentation to the substrate available from 3 to 4% of soluble carbohydrates or from fractions such as ß-glucan contained in the cereals, and not to a hydrolysis of starch.

The effects of adding molasses (5% w/w) or ground maize (5% and 10% w/w) to star grass (C*ynodon nlemfluensis*) alone or mixed with four levels (0, 15, 30, 45% w/w) of legume (*Desmodium uncinatum*) were studied in a laboratory trial by Sibanda *et al.* (1997). In general, both additives improved fermentation up to the level of 30% of legume inclusion, but

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addition of molasses resulted in lower levels of volatile N and higher lactic acid content compared to the control and both ground maize treatments. A first growth of Napier grass was hand-harvested under rainy conditions (8.6% DM, 67.6% NDF), chopped to 3 cm, treated with 4% molasses and/or 15% de-fatted rice bran (2.0% crude fat) on a fresh grass basis and ensiled in plastic bags. DM contents of silages were 13.4%, 20.1% and 22.5%, and spoilage losses were 5.6%, 0.3% and 3.0% for treatments with molasses, rice bran and their mixture, respectively. Treatment with plain rice bran had the highest content of acetic (6.7% of DM) and propionic (1.4% of DM) acids and ammonia-N, but the lowest content of lactic acid. The authors (Yokota *et al.,* 1998) concluded that the combination molasses and rice bran could improve the fermentation quality and enhance the utilization of the silage by goats, more than each additive as a single treatment.

Cassava (*Manihot esculenta*) tuber meal (72.1% WSC) and coconut (*Cocos nucifera*) oil meal (17.6% WSC) were both added (5% wet basis) to Guinea - A (*Panicum maximum*) with 17.7% DM and 6.3% WSC and to NB-21 (*Pennisetum purpureum* × *Pennisetum americanum*) with 16.3% DM and 9.9% WSC forages, chopped (1.5 cm) and ensiled in 2-kg laboratory silos. Both additives improved fermentation compared to untreated silages of both forages, with greater effects in silages with cassava tuber meal (Panditharatne *et al.,* 1986).

Elephant grass was harvested at 75 days growth (19.4% DM, 72% NDF) and ensiled in 300-kg asbestos cement containers, either unwilted or wilted (29.6% DM), both materials with or without 8% ground sorghum grain (w/w). Wilting was achieved by exposing crushed forage stems for three hours in windrow after harvesting with a New Holland mower-conditioner. Sorghum addition to both wilted and unwilted silage increased DM contents, reduced ethanol and acetic acid contents and increased intake of digestible energy as measured in sheep (Alberto *et al.*, 1993). Silages of elephant grass cv. Guaçu were obtained, adding 0, 8, 16 or 24% (w/w) either of ground ear corn [maize] with husks, wheat bran or "sacharin" (urea-treated sugar cane, with 12.6% CP, 17.5% crude fibre in DM) to unwilted forage (12.4% DM, 10.4% WSC) harvested with a precision chopper (3 mm chop length) and packed into 200-litre plastic containers with a layer of ground hay at the bottom to absorb effluent (Andrade and Lavezzo, 1998a). Ground ear corn [maize] was more effective in increasing DM content and restricting lactic acid production while reducing ammonia-N, which reached 31.3% and 36.2% for the "sacharin" and wheat bran treatments, respectively (Andrade and Lavezzo, 1998b).

The fermentation pattern of wilted elephant grass cv. Taiwan-A146 silage (8 hour wilting, 26.6% DM, 6.74% WSC) did not differ from silages made of unwilted grass (23.5% DM,

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7.2% WSC) prepared with a cassava starch by-product added at 2, 4, 8 or 12% (w/w). According to the authors (Ferrari *et al.*, 1999), the relatively low lactic acid levels demonstrate that the substrate was not available to LAB.

2.4.2 Silage intake

Poor-quality silages are usually poorly consumed relative to hay or forage of comparable digestibility. In normal forages the limiting factor to intake appears to be NDF. The intake of poor silage does not reach this limit; other factors explain the low intake (Waldo and Jorgensen, 1981). In general, three hypotheses have been proposed to account for low intakes of poorly preserved silage (1) a toxic substance, perhaps an amine is produced by the fermentation; (2) the high acid content of extensively fermented silages reduces palatability; and (3) the depletion of readily fermentable substances deprives rumen organisms of critical energy substrates needed for growth. Silage intake is adequately understood and other mechanisms than these could be involved. For, example, it may be that alteration in physical structure renders silage more difficult to ruminate. This concept requires acceptance of the hypothesis that rumination time limits intake (Van Soest, 1994)

2.4.3 PRODUCTION OF SILAGE

The silage production process can be divided into four stages: (1) forage harvesting; (2) transport to the silo; (3) compaction; and (4) sealing (airtightness).

The first management decision to take when planning to make silage is on the amount of silage required, which depends on the following factors:

- Number and type of livestock to receive silage.
- Length of the feeding period.
- Percentage silage in the full ration.
- Material resources available (equipment, labour, finances, technical assistance, etc.).

This irrespective of the amount of silage to be made, the following principles for good silage apply:

1. The material to be conserved must have a high nutritive value.
2. The forage must not be contaminated with soil.
3. The forage should be chopped into pieces no longer than 2 cm to facilitate good compaction and reduce air retention.
4. It is necessary to expel the maximum amount of air within the forage before closing the silo preventing air and water penetration.

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5. The accumulation of the forage and sealing should be done in the shortest possible time.

6. During the feeding of the silage, the area exposed to air should be as small as possible and the time between opening and finishing the silo as short as possible (Ojeda, 1999).

Although the total silo capacity on a farm depends on the number and type of animals and the period of silage feeding, it is recommended that not all the silage required be kept in only one silo, to keep losses at a minimum. The best system is to create silos that can be emptied over short periods, so the actual silo size depends on the amount of silage per animal and the number of animals to be fed from that silo. The best strategy is to make silage at different times of the year and to feed it after approximately 60 to 70 days of conservation. This way the silage would have optimum fermentation and least chance of aerobic deterioration. However, the time of silage making also depends on the growing conditions and the availability of forage to be ensiled (Ojeda, 1999).)

2.4 .4 Phases of silage making

Once the fresh material has been harvested, chopped, compacted and well sealed the ensiling process then begin and undergo four (4) phases

- Aerobic phase: Oxygen trap within the forage is eliminated as a result of respiration of the plant material and aerobic activities of yeast and bacteria. This phase may take few hours only provided the forage is well compacted and sealed as soon as possible (Moran, 2005)
- Fermentation phase: This stage begins once the oxygen is gone and storage becomes anaerobic. A successful fermentation result in number of lactic acid producing bacteria dominate, reducing the pH to 3.5-4.5. (Moran, 2005)
- Stable phase: Once the PH level has dropped and water and air is not permitted to enter the storage (Silo) most micro organism of phase two (2) slowly decreases in number resulting in silage which is relatively stable. However, some acid tolerant micro organisms survive this period in an almost inactive state, along with others such as Clostridial and Bacilli which survive as spores (Moran, 2005)
- Feed out phase or aerobic spoilage phase: This phase begins when the storage site is uncovered for feeding out. This phase occurs in two (2) stages

Deterioration begins through degradation of the preserving organic acids by yeast and occasionally acetic acid bacteria, this result in a rise in pH and the second spoilage begins. This is associated with increasing temperature in the silage and activities by spoilage micro organism such as Bacilli, mould and Enterobacterial (Moran, 2005):

2.4.5 Evaluating Silage quality

Ensiling does not improve the quality of forage. The quality of the feed that is taken out of the silo can no better than the quality of the feed that was put into the silo. Silage quality can be accurately evaluated by subjective and integrated method of evaluation (Jianxin, 2002). The subjective method involves the use of criteria such as colour, smell, texture (structure) and pH value.

The pH is the simplest and quickest way of evaluating silage quality and may be determined on the farm using wide-range pH test papers such as bromophenol blue (range 2, 8-4, 4),bromocresol green (range 4, 2-5, 6) and methyl red (range 5, 4-7, 0). However the pH is influenced by the moisture content and the buffering capacity of the original materials. Silage that has been properly fermented will have a much lower pH (be more acidic) than the original forage. The lower the pH the better, since it indicates that a lactic acid type of fermentation as occurred.

Good silage usually preserves well the original colour of the standing plant (t'Mannetje, 1999; Jianxin, 2002.) When green raw material produces silage with green or yellow colour, it can be considered as good quality silage. Temperature is one of the important factors affecting silage colour. The lower the temperature during ensilage, the less will be the colour change. Above 30 °C, grass silage becomes dark yellow. Above 45 °C to 60 °C, the colour becomes closer to brown. Beyond 60 °C, the colour darkens towards black due to caramelization of sugars in the forage (McDonald *et al.,* 1995; t'Mannetje, 1999; Jianxin, 2002). However, the colour of the silage juice will also be a useful indicator of the quality. The lighter the colour of the juice of the silage suggests a better quality. However, silage quality can be misjudged by the colour. Jianxin (2002) reported that silage from red clover or Chinese milk vetch is often dark brown instead of light brown and may be considered failed silage despite its excellent quality.

The smell of the silage is a good indicator of the quality. According to Jianxin, (2002), good silage has a mild, slightly acidic and fruity smell resembling that of cut bread and of tobacco due to the presence of lactic acid. A rancid and nauseous smell denotes the presence of butyric acid and signifies failed silage. A musty smell is a sign of deficient compaction and presence of oxygen. A distinctive unpleasant smell, of sow' urine and faecal matter, signifies marked protein degradation during ensilage.

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Plant structures (stems and leaves) should be completely recognizable in the silage. A destroyed structure is a sign of severe putrefaction. A viscous, slimy appearance reveals the activity of pectolytic or sporulating micro organisms (McDonald *et al.*,1995; t'Mannetje, 1999; Jianxin, 2002).

Temperature is one of the important factors affecting silage colour. Lower temperature during ensiling reduces the colour changes of the original material. When the temperature goes above 30 °C, grass silage becomes dark-yellow. Above 45 °C to 60 °C, the colour becomes closer to brown. Beyond 60 °C, the colour darkens towards black due to caramelization of sugars in the forage (McDonald *et al.*, 1995; t'Mannetje, 1999; Jianxin, 2002).

2.4.6 Silage as feed resource

Meeting the nutritional needs of ruminants throughout the year is a major challenge facing livestock farmers in the tropics because of the seasonal availability of forage. Forage grows rapidly in wet season, with yields often exceeding animal requirements. If not cut and fed, it continues to grow and quickly becomes fibrous, lignified and low in crude protein content. This is particularly worrisome in the dry season when the energy needs of the animals cannot be met; resulting in serious weight losses (McDowell, 1987; Osakwe, 2006; Babayemi *et al.*, 2006).

Conservation can be achieved by sun-drying (hay), artificial drying, and addition of acids or by natural fermentation. However, silage is preferred to hay making, because it is less weather dependent and also because at the time when forages are of acceptable quality for conservation (early in the wet season) the weather is likely to be too unreliable for sun-drying needed for hay (Moran, 2005). This often leads to deterioration of the forage. Addition of acids and artificial drying methods are expensive and beyond the reach of the poor small animal holders. Hence the only feasible and cost effective option is natural fermentation through silage which can be done using fresh or preferably, wilted materials (Mohd Najib *et al.*, 1993; t'Mannetje, 1999).

Silage can be efficiently used for strategic off-season feeding. It is a means of increasing feed resource availability and a form of insurance, especially for calving dairy cows. It can be fed to reduce pressure on pasture when required. It can be an efficient supplement to grazing cattle during the dry season. It is an inexpensive homemade feed, resulting in the production

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of milk and beef at lower cost. It improves palatability, reduces significantly toxic substances present in some fresh forage to safe level concentration (cyanogenic glycosides in fresh cassava) and destroys harmful micro organisms possibly present in materials to be ensiled. It can provide a major diet source, as basal ration as well as a feed supplement for grazing animals.

2.4.7 Chemical composition of silage based diet fed to sheep

Oluwadamilare (1997) fed graded levels of cassava leaves in cassava-Guinea grass silage (0% 20%, 40% and 60%) to WAD goats and reported that nitrogen content increased with the levels of cassava leaves (1.7 g/100 g, 2.4, 3.1, and 3.8). The same trend also occurred with organic matter which increased with increased inclusion of cassava leaves (89.3, 89.7, 90.2 and 90.6). Santoso *et al.* (2006) reported that, Timothy silage fed to sheep had 13.4 g/100 g CP content, 90.8 Organic matter, and 29.1 g\100 g DM respectively. Nishida *et al.* (2007) evaluated the nutritive value of corn silage made from corn harvested at different days fed to sheep and reported 8.7 g/100g CP, 2.7 ether extract, 94.1 organic matter, 66.7% TDN and Metabolizable energy of 11.39 MJ/kg DM for corn harvested at 129 days while those harvested on 118 days silage had 8.9 CP, 94.8 OM, 3.0 ether extract, 70.7% TDN and ME of 11.84 MJ/kg DM. They also reported, 9.0 CP content, 94.7 OM, 2.8 ether extract, 70.6% TDN and ME of 11.78 MJ/kg DM for silage made from corn harvested on 107 days

Cone *et al.* (2006) investigated the post ruminal digestibility of crude protein from grass *Lolium perenne* silages in cow and reported CP content of 19.8 g/100 g, 26.7 DM, 10.5 Ash for silages with low DM while they reported DM of 48.2, 19.8 CP and 10.1Ash for grass silage with high dry matter content. Meneses *et al.* (2007), evaluated the nutritive characteristics of crude artichoke (*Cynara scolymus*) by-products ensiled for 50 days and reported that it contained 25.8% DM, 8.8 CP, 4.85 Ash, 50.9 NDF, 34.2 ADF, 7.6 lignin, 16.7 hemicellulose and 26.6 g/100 g cellulose respectively. The pH value reported after 50 days was 4.11 while the temperature in the silo was 26.5 ^{o}C

Kim *et al.* (2006) investigated the effect of replacing rice straw with wormwood (*Artemisia montana*) silage on intake, digestibility and ruminal fermentation characteristics of sheep and reported that it contained DM value of 25.2 g/100 g, 89.7 OM, 14.8 CP, 3.4 ether extract, 51.5 NDF, and 47.7 ADF respectively. The pH value of the silage was 4.15. Ngwa *et al.* (2002) investigated the effect of supplementing veld hay with silage from *Acacia sieberiana*

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fed to sheep and reported nutrient contents (g\100g) as CP (5.64), OM (94.4), NDF (70.26), ADF (44.94) and Hemicellulose (25.32).

2.4.7.2 Effects of feed on growth of ruminants

Kayouli *et al.* (1993) investigated the feed intake and performance of growing lambs when ensiled poultry litter based diet was substituted for commercial concentrates and soybean meal in a growing trial over 56 days and reported average daily gain of 252.8 g/d for lambs on silage while the average daily gain of 221.2 g/d was reported for lambs on commercial concentrate. The feed conversion (kg DM/d) was 6.1 for lambs on silage while 5.4kg DM/d was for lambs on commercial concentrate. Carcass yield was 47.5% for lambs on silage while those on concentrate was 45.1%.

2.4.8 Silage fermentation versus rumen fermentation

The ecology of the silo fermentation differs from rumen fermentation in that single group of organism tend to develop and take over the substrate. Lactic acid-producing organisms accomplish this with a resultant rapid acid production and drop in pH. These organisms are less efficient than many other organisms in terms of cell yield from a given amount of substrate because much of the energy of carbohydrate fermented is retained in the lactic acid. The need for control of substrate is a consequence of their lower efficiency (cell growth), so a larger portion of the fermented substrate is necessarily produced in the form of acid that inhibits competing organisms. Organisms, including yeasts that produce ethanol are similar in this regard except that osmotic pressure and inhibitory levels of ethanol are the means by which they control the substrate (Van Soest, 1994).

End product removal in the rumen has important effects on ecological balance. The salient effects are apparent when silage fermentation is compared to rumen fermentation. Both systems have the same substrate available and tend to be anaerobic, however silo presents characteristics of poorly buffered batch culture. The dominating feature of its fermentation is the growth of organisms that compete for control of the substrate. Under ideal condition in the silo, the lactic acid producing bacteria will drive down pH so as to shut out other competitor for the substrate. No cellulose is fermented in normal silage whereas cellulose digestion is dominant feature in a normal rumen. Silage fermentation is characterized by low efficiency and microbial yield. The higher microbial yield characteristic of the rumen is important in supplying the host animal with microbial protein. What is optimum for silage

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preservation is reverse in the case of the rumen. The important point here is that the more energy is expanded in silo fermentation, the less there is for the rumen. Fermentation acids other than lactic acid contain no energy for rumen bacteria use. (Van Soest, 1994).

2.5 *In vitro* gas production

Growth and yield of ruminants are largely limited by forage quality which is mainly reflected in low voluntary intake and digestibility (Minson, 1990). Intake and digestibility determination of feedstuffs *in vivo* is time-consuming, laborious and expensive, requires large quantities of feed and is unsuitable for large-scale feed evaluation (Coelho *et al.*, 1985; Carro *et al.*, 1994). Many attempts have been made to predict intake and digestibility using laboratory techniques.

The *in vitro* gas production method is accurate and predicts feed intake, digestibility, microbial nitrogen supply and animal performance (Blummel and Ørskov, 1993). For the past two decades, the technique had been used in advanced countries as an instrument to determine the amount of short chain fatty acids, carbon dioxide and metabolizable energy of feed for ruminants (Blummel and Becker, 1997; Getachew *et al.*, 1999). Methane is an important gas among gases produced by ruminants at fermentation, and has been reported (Babayemi and Bamikole, 2006a) to be an energy loss to the animals and when emitted, it contributes to the destruction of ozone layer. The *in vitro* fermentation technique is capable of quantifying the amount of methane (energy loss) production (Fievez *et al.*, 2005).

Gas production is an indication of quantitative VFA production. Since truly digested substrate is partitioned among VFA, gas, and microbial biomass, gas measurements only account for substrate that is used for gas production and does not consider substrate utilized for microbial growth. Accurate prediction of VFA production from gas production is a biologically important goal, since VFA is a major energy source for ruminants. Since inclusion of feed CP levels in the prediction equation of VFA from gas production sharply improved the predictive equation, this suggests that when high CP feeds are used, the influence of CP on VFA production is substantial. This statement is based upon the increased production of isovalerate and valerate as the CP content of the feeds increased. Although gas production reflects the amount of substrate used for VFA production, it has also been shown that gas production is positively related to feed intake (Blümmel and Ørskov, 1993) and microbial protein synthesis (Krishnamoorthy *et al.*, 1995).

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Degradation of forages in the rumen is a complex process, involving interactions among microorganisms (i.e., bacteria, protozoa, fungi) and between the microbial population and the host (Czerkawski, 1986). Fermentation characteristics of feeds in rumen fluid can be studied by *in vivo*, *in situ* and *in vitro* techniques, including the in vitro gas production technique of Menke *et al.* (1979), Theodorou *et al*. (1994) and Cone *et al*. (1996).

There are number of factors that affect rate of fermentation of feeds by rumen microorganisms and hence gas production. Among these are intrinsic characteristics of the carbohydrate fraction such as the proportion of starch or cellulose and the extent of lignifications of the cell wall. The extrinsic factor however, is the supply of fermentable nitrogen required by microorganisms to help them to synthesis cellular constituents such as protein and nucleic acids required for growth.

2.6 Methane

Ruminants depend on microorganisms to digest and ferment plant cell wall polysaccharides into energy sources, such as volatile fatty acids (VFA) and other organic acids. However, microbial fermentation in the rumen also produces waste products, such as carbon dioxide (CO2) and methane (CH4). Methane production in the rumen is an energetically wasteful process, since the portion of the animal's feed, which is converted to CH4, is eructated as gas. Approximately 6% of dietary gross intake energy is lost to the atmosphere as CH4 (Holter and Young, 1992; DeRamus *et al.*, 2003). Recently, emission of CH4 and other volatile organic compounds from ruminants, and their effect on air quality, has attracted the attention of air regulatory agencies in many parts of the world.

Methane contributes to climate change and global warming (Johnson and Johnson, 1995) by trapping outgoing terrestrial infrared radiation 20 times more effectively than CO_2, which leads to increased surface temperatures, and it indirectly affects atmospheric oxidation reactions that produce CO_2. Thus, there is increased worldwide interest in addressing mitigation of CH_4 in animal agriculture. There may be potential to reduce the extent of CH_4 production by manipulating diet and management practices that influence ruminal microbial fermentation.

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Due to the substantial amount of energy lost in the form of CH_4, and its deleterious impact on the environment, quantification of CH_4 produced from dairy rations by dairy cows is critical to formulation of feasible mitigation strategies. However, direct quantification of CH4 produced by animals requires complex equipment, its labour intensive, time consuming and expensive. An *in vitro* gas production technique would offer an alternative, allowing several diets and diet combinations to be evaluated simultaneously, but only if it accurately estimated animal CH4 emissions.

Methane is the most abundant organic gas in the earth's atmosphere, and there is evidence that CH4 concentrations have recently been increasing globally at a rate between 0.7% and 1.0%/year (Crutzen, 1995). Domestic ruminants are responsible for about 12.5% of global CH4 emissions (Crutzen, 1995). Methane emissions are influenced by the size of the animal, the quantity of feed consumed, and the efficiency by which the animal converts feed to products. Improving animal productivity decreases CH4 emissions per unit of animal product. The excretion of methane from the rumen can represent a loss of 8-10% of the digestible energy depending on the type of diet. Therefore, reducing methane production could benefit the ruminant energetically provided the efficiency of ruminal metabolism is not compromised.

2.7 Volatile fatty acids

The VFAs produce as end products of metabolism, provides the ruminant with a major source of metabolizable energy. Removal of these acidic products is vital for the continued growth of cellulolytic organisms in the rumen. The principal fatty acids in descending order of usual abundance are acetic, propionic. Butyric, isobutyric , valeric and isovaleric. The proportion of acetic, propionic and butyric acids can be markedly influenced by diet and status of the methanogen population in the rumen. Protozoa may also contribute significantly to the balance. Other organic acids may appear as products of microbial metabolism. Lactic acid is important when starch is a part of the diet and is itself fermented to acetate, propionate and butyrate. It appears only as a transient product 1-2 h after fermentation. Succinate and formate produced by some rumen species in pure culture do not normally appear as products in mixed cultures.

Rumen concentrations of VFAs are regulated by a balance between production and absorption whereby increased production rate induces higher VFA coincentration (Giesecke,

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1970). Since production rates vary, the rate and extent to which these acids are produced is indicative of microbial activity in the rumen. Bergman (1990) reported that the concentration and relative proportions of VFAs are related to the nature of the feed. Similarly, Firkins *et al.* (1986); Robinson *et al.* (1986) reported that the amount of VFA produced depend on the extent (effective degradability) of the feed ingested by the animals which subsequently determines the amount of treatment available for fermentation.

2.8 The rumen ecology

The rumen ecosystem is essentially a fermentation system that houses a vast array of different microbes. Ruminants typically browse low energy forages, such as grasses or other plant material, rich in potential (sugar-polymer plant fibres) but not easily accessible to the ruminant without rumen fermentation. These forages are primarily food for the microbes present in the rumen first and then, in turn, the products of these microbes are the feed for the ruminant. Microbes break down forage in the anaerobic rumen environment and the products of microbial fermentation provide the ruminant with metabolisable compounds, such as short chain fatty acids, while the microbes themselves account for around 90% of the amino acids entering the lower intestine.

The rumen environment appears to be controlled by: the type and quantity of food eaten, periodic mixing through contraction of the rumen, salivation and rumination, diffusion or secretion into the rumen, absorption of nutrients from the rumen and passage of container down the digestive tract (Preston and Leng, 1987). Under abnormal circumstances, the rumen environment is drastically disorganized. Sudden introduction of diet not included into the feed offered like grain, lacticacidaemia may occur because of the drop in ruminal pH, growth of streptococcus bovis and the accumulation of lactic acid. Saliva helps to maintain fluid state of the rumen environment and so facilitate access of micro-organisms to the plant containers. Population affects salivary flow and may be reduced by its presence. The protozoa rapidly assimilate starch and sugars and remove the need for copious salivation to maintain rumen pH. (Preston and Leng, 1987).

Saliva, a buffered bicarbonate solution of about pH 8, contains high concentration of sodium and phosphate ions. Both the saliva and bicarbonate movement across the rumen epithelium maintained the pH within narrow limits. (Preston and Leng, 1987). The buffered rumen liquor favoured the growth of anaerobic bacteria, fungi and protozoa with accumulation of VFAs in

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the fluid (up to 0.2 molar). For continuous fermentation however, the ruminal pH must be constantly maintained at neutral level and to VFAs absorption ensured. The biomass of microbes in the rumen is also maintained at a constant level by the passage of microbes down the digestive tract and by the death and lysis of the micro-organisms within the rumen. Methane and carbon dioxide are produced as the end products of fermentation. At low rumen pH, carbon dioxide comes out of solution and accumulates in a pocket the dorsal sac. Methane and carbon dioxide are largely eliminated by eructation (Dougherty *et al.*, 1964). At high pH, most of the carbon dioxide produced by fermentation or entering the saliva, is absorbed and excreted via the lungs.

2.8.1 Characteristics of rumen microorganisms

Ruminants' posses a complex stomach system, in which the stomach is divided into three or four compartments, the first and the largest of which is the rumen. It is here that continuous anaerobic fermentation takes place by microorganisms. The rumen is an extremely complex community of many microorganisms, protozoa, bacteria, fungi and probably other unknown microorganisms. When ruminants are born their rumen is germ-free, the unique flora and fauna start to establish after birth. Once established the rumen microbial community is very stable and will change only when the nutrients are changed (Cheng and Costerton 1980).

Fungi and mycoplasmas can account for about 8% of ruminal microbial biomass when animals are fed poor quality feed. These organisms play an important role maintaining rumen conditions and providing energy to the ruminant. There is an apparent interaction between fungi and fibre-digesting bacteria such that when fibre-digesting bacteria predominate they produce substances that inhibit the fungi

Protozoa can account for nearly 50% of the viable biomass in the rumen and, dependent on diet, can be indirectly associated with nearly the same level of the methane emissions. Due to their biomass and metabolic activities protozoa also contribute directly to production of VFAs in the rumen.

Feedstuffs consumed by ruminants are all initially exposed to the fermentative activity in the rumen prior to gastric and intestinal digestion. Dietary polysaccharides and protein are generally degraded by the ruminal microorganisms into characteristic end products, which in turn provide nutrients for metabolism by the host animal. The extent and type of

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transformation of feedstuffs thus determines the productive performance of the host. Fermentation of feedstuffs in the rumen yields short-chain volatile fatty acids (VFA) (primarily acetic, propionic and butyric acids), carbon dioxide, methane, ammonia and occasionally lactic acid. Some of the change in free energy is used to drive microbial growth, but heat also is evolved. Ruminants use the organic acids and microbial protein as sources of energy and amino acids, respectively, but methane, heat and ammonia can cause a loss of energy and nitrogen (N). The quality and quantity of rumen fermentation products is dependent on the types and activities of the microorganisms in the rumen. This, in turn, will have an enormous potential impact on nutrient output and performance of ruminant animals.

Ammonia plays a central role as an intermediate in the degradation and assimilation of dietary nitrogen by rumen bacteria. Ammonia is the major end-product of digestion of dietary protein and non-protein nitrogen (urea and amino acids) as well as the major source of nitrogen for synthesis by ruminal bacteria. Ruminal digestion results in the production of VFA and bacterial cells which are used as the major energy and protein sources, respectively, for metabolism by the host animal. As a result, nitrogen metabolism in the rumen is intimately related to the metabolism and utilization of nitrogen by ruminant tissues. Growth and production in ruminants is dependent on bacterial protein synthesised in the rumen and ammonia is of central importance in this process.

2.8.2 Microbial interactions in the rumen

Rumen microbial populations vary within an animal, with time after feeding, between days in the same animal and apparently, in animal in different countries on similar feeds (Hungate, 1975). However, the end-products of fermentation are virtually the same. Both on particulate digesta and on rumen epithelia tissue, bacteria associated with related organisms and function as a couple, one organism growing on the end-products of metabolism of another. The sequential fermentation process involving different species of organisms converting cellulose to VFAs well recognized, as are the interrelationships between hydrogen-producing and hydrogen utilizing organisms (Wolin, 1979). Within the rumen there are often very close associations of bacterial species, dependent on simple containers librated by each to mutual benefit of both (symtopic associations). These interactions of rumen bacteria appear to be highly beneficial and there appears to be little that can be done to manipulate these associations, other than inhibition of methanogenesis.

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There are marked interactions between protozoa and bacteria. Protozoa ingest and digest bacteria and reduce the bacterial biomass floating free in solution in the rumen (Hungate 1966; Coleman, 1975), and this may reduce the rate at which bacteria colonise ingested food particles. With readily digestible feeds, this may not be significant but with refractory feeds, predation may increase the lag phase of degradation of particles. Protozoa effectively compete with bacteria for the soluble sugars and starches, storing these carbohydrates within their cells. In this way the protozoa reduce the severity of acidosis on some diets. On sugar-based diets (e.g. sugarcane) the protozoa biomass is probably larger than the bacterial biomass.

Eadie and Gill (1971) found that the number of flagella protozoa (motile zoospores) increased following defaunation of the rumen. If these flagellates were zoospores, then it suggests that protozoa either 'compete' for nutrients with fungi or reduce fungal growth in other ways. For instance Orpin (1975) observed predation by protozoa on the non-motile, flagellates (zoospores). Elimination of protozoa in the rumen leads to an increase in the number of bacteria in the liquid pool. In studies with sheep using total faecal collection procedures, the apparent digestibility of dry matter was increased by 18% when protozoa were not present (Soetanto, 1986). Interactions among microorganisms with the rumen are complex and not always to the advantage of the host. Large protozoa populations in the rumen have been shown to reduce animal productivity, apparently largely lowering the amino acid to energy ratio in the absorbed products of digestion. However, it appears that protozoa reduce the biomass of bacteria and of fungi in the rumen of animals on diets high in fibre and thus may reduce the rate of digestion of fibrous feeds (Preston and Leng, 1987).

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CHAPTER THREE

EXPERIMENT ONE

Preparation, quality and *in vitro* fermentation of ensiled cassava tops and Guinea grass mixture

3.1 Introduction

The shortage of feed in terms of quality and quantity especially during dry season is one of the problems faced by farmers in the livestock industry. Forage, crop residue and by products are usually consumed fresh by domestic animals when they are abundant during rainy season, but the excess can be conserved to overcome feed shortage during the dry season. Conservation can be achieved when the harvested forage is stored at a maximum level below 20 % (hay) while forage preserved in an anaerobic (without air) environment with a pH of 3.6 to 5.0 is termed silage.

Hay making is difficult in tropical regions at the time when forage is of acceptable quality for conservation (early in wet season) the weather is likely to be too unreliable for sundrying. Artificial drying is expensive and facilities are not widely available. Hence, the most reliable means for forage conservation is by silage making. Ensiling is thus a potent general method for forage preservation and also a form of treatment to occasionally salvage the underutilized pastures for better acceptability and degradability.

Tropical grasses and legumes are not naturally ensilage material, largely because at cutting they have a low content of water soluble carbohydrate (WSC) which is essential to successful ensilage (Mc Donald *et al.*, 1991). The levels of fermentable carbohydrate can be improved through addition of additives which are used to improve silage preservation by ensuring that lactic acid bacteria dominate the fermentation phase. This result in it having a higher buffering capacity and protein being susceptible to proteolysis (Mc Donald *et al.*, 1991) hence, ensiling (Topps and Oliver, 1993). However, there are several practices that contribute to improving levels of fermentable carbohydrates, reduce buffering and prevent proteolysis, and can therefore assist in producing good quality silage. These practices include; mixing legumes with cereal crops; wilting; using silage additives and conserving in small-scale silos.

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3.2 Materials and methods

3.2.1 Experimental site

The experiment was carried out within the University of Ibadan campus, Ibadan, Nigeria. The location of the study is 7º27'N and 3º45'E at altitude 200 - 300 m above sea level; mean temperature of 25 - 29 ºC and the average annual rainfall of about 1250 mm.

3.2.2 Collection of Cassava tops

Fresh cassava foliage was obtained from a nearby farm around the University immediately after root harvesting. The leaves with petioles was separated from the stem and chopped into small pieces of about 3 - 4 cm with knife. The chopped cassava tops was spread under the shade for 12 hours over night and allowed to wilt to reduce the moisture content of the leaves. Representative samples of known weights were taken for dry matter analysis by drying in the oven for 48 h at 65ºC until a constant weight was obtained.

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3.2.3 Collection of Guinea grass

Guinea grass (*Panicum maximum*) of eight (8) weeks old re-growth was harvested from the established paddock. The plot was rouged to remove obnoxious weeds. In order to achieve 8 weeks old grass. The whole plot was cut back at 20cm above ground. The grass was totally harvested leaving the edge rows uncut. The harvested grasses were weighed in order to determine the expected amount for the making of silage. Representative samples of known weight were taken for dry matter analysis by drying in oven for 48h at 65^{o}C until a constant weight was obtained. The harvested samples were wilted for two hours in order to reduce the moisture content. The grass was chopped into 2-3 cm lengths, spread under shade and allowed to wilt to reduce water content of the grass.

3.2.4 Silage additives

Four (4) energy additives was used and this includes: - Cassava chips, sorghum grain, millet grain and sugar. All the grains were crushed before use.

3.2.5 Experimental layout

Cassava tops, guinea grass and additives were ensiled in triplicate as ratio 3:6:1 (30%, 60%, and 10%) respectively as follows;

- Treatment 1: Cassava tops + Guinea grass +cassava chips
- Treatment 2: Cassava tops + Guinea grass + sorghum grain
- Treatment 3: Cassava tops + Guinea grass + millet grain
- Treatment 4: cassava tops + Guinea grass + sugar
- Treatment 5: Cassava tops +Guinea grass + no additive

3.2.6 Silage preparation

The cassava foliage and Guinea grass were chopped for ease of compaction and consolidation for silage. The grass weighing 30 kg, cassava foliage 15 Kg and additive 5 kg in three replicates for the different treatments were filled in a 50 kg capacity plastic. The plastic was lined internally by polythene sheets. Each layer was compacted manually to displace the air until the containers were filled. The final compaction was made after which the polythene sheet was wrapped over the material. Sand bags were later rolled on the filled material and were left to ferment for 42 days.

3.2.7 Determination of silage quality

After forty two (42) days of ensiling, the silage was opened for silage quality assessment. Silage characteristics that were measured include temperature, pH, colour, smell and texture. Immediately the silage was opened, a laboratory thermometer was inserted to determine the temperature. Sub sample from different point and depth were mixed together for dry matter determination by oven- drying at 65° C until a constant weight was achieved. The samples were milled and stored in an air tight container until it was ready for chemical analysis. pH meter was used to determine the pH level, colour assessment was ascertained using visual observation with the aid of colour chart. The odour or smell of the silage was relatively assessed as to whether nice or pleasant or fruity. Structure of the silage was determined whether it is separable, visible or collapsible.

3.2.8 Chemical composition

Proximate (Crude protein, crude fibre, ether extract and ash) contents of the silage were carried out in triplicates as described by AOAC (1990).

The neutral detergent fibre (NDF) and acid detergent fibre (ADF) were determined as described by Van soest *et al.* (1991).

3.2.9 The *in vitro* gas production technique

Rumen fluid was obtained from three West African dwarf goats using suction tube before the morning feed. The animals were previously fed with concentrate feed (40% corn, 10% wheat offal, 10% palm kernel cake, 20% groundnut cake, 5% soybean meal,10% dried , brewers grain, 1% common salt, 3.75% oyster shell and 0.25% fish meal) and 60% *P. maximum* at 5% body weight. The rumen liquor was collected into the thermo flask that had been pre-warmed to a temperature of 39ºC from the goats before they were offered the morning feed. Incubation was as reported (Menke and Steingass, 1988) using 120 ml calibrated syringes in three batch incubation at 39 ºC. Into 200 mg sample in the syringe was introduced 30 ml inoculums containing four layers cheese cloth strained rumen liquor and buffer ($NaHCO_3$ + Na_2HPO_4 + KCl + NaCl + $MgSO_4.7H_2O$ + $CaCl_2.2H_2O$) (1:4, v/v) under continuous flushing with CO_2. The gas production was measured at 3, 6, 9, 12, 15, 18, 21, 24 36 48, 60, 72, 84 and 96 h. At post incubation period, 4 ml of NaOH (10 M) was introduced to estimate methane production as reported by Fievez *et al.* (2005). The average of the volume of gas produced from the blanks was deducted from the volume of gas produced per sample.

The volume of the gas produced at intervals was plotted against the incubation time, and from the graph, the gas production characteristics were estimated using the equation $Y = a + b (1 – e^{-ct})$ described by Ørskov and McDonald (1979), where Y = volume of gas produced at time 't', a = intercept (gas produced from the soluble fraction), b = gas production from the insoluble fraction, c = gas production rate constant for the insoluble fraction (b), t = incubation time. Metabolizable energy (ME, MJ/Kg DM) and organic matter digestibility (OMD, %) were estimated as established (Menke and Steingass, 1988) and the value of short chain volatile fatty acids (SCFA) was calculated as reported (Getachew *et al.*, 1998) : ME = 2.20 + 0.136*Gv + 0.057*CP + 0.0029*CF; OMD = 14.88 + 0.889Gv + 0.45CP + 0.651 XA; SCFA = 0.0239*Gv – 0.0601; where Gv, CP, CF and XA are net gas production (ml/200 mg DM), crude protein, crude fibre and ash of the incubated samples respectively.

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3.2.10 Acceptability study

Eight West African dwarf rams weighing 12 – 14 kg were used to evaluate the free choice intake of ensiled *Panicum maximum*, (Guinea grass) with cassava tops. In triplicates, 1 kg each of the ensiled cassava tops and Guinea grass were placed in strategic locations in plastic feeding troughs. The rams were allowed to feed from 09:00 to 16:00 h daily and for upward of 7 days. The forage preferred was assessed from the coefficient of preference (COP) value, calculated from the ratio between the intakes for the individual forages, divided by the average intake of the forages (Karbo *et al.*, 1993; Babayemi *et al*., 2006a). Consumption was measured by deduction of remnants from the amount of feed served. Therefore, silage was inferred to be relatively acceptable provided the COP was greater than unity (1).

3.2.11 Statistical analysis

Data were analysed using analysis of variance (SAS, 1999). Significant means were separated using the Duncan multiple range F-test. Experimental model of the design is:

$Yij = \mu + \alpha_1 + \sum ij,$

where Y ij = individual observation,

μ = general mean of population,

α_1 = treatment effect and

$\sum ij$ = composite error effect.

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3.3 RESULTS

Table 1 shows the silage characteristics of ensiled cassava tops and Guinea grass mixture

The colour was observed to be the same in all the silages. The structures were firm and indestructible, Differences were not observed in the smell of the silage as all the silages were characterized by pleasant odour. The pH of the silage is presented in Fig 1.

3.3.2 Chemical composition of ensiled cassava tops and guinea grass mixture

Table 2 shows the chemical composition of ensiled cassava tops and guinea grass mixture with different additives and there were significant ($p > 0.05$) differences among the different silages. DM content ranged between 27.12g/100g DM in silage with sorghum additive to 28.80g /100g DM in silage with millet additive. CP varied from 21.88g/100g DM in silage with sugar additive to 25.60 g/100g DM in millet additive. The Crude fibre content of the silage was highest in silage with sorghum additive (32.49g/100g DM) but similar to the values obtained in silage with sugar additive (31.95g/100g DM), millet grain (31.91 g/100g DM) and cassava chips (31.89 g/100g DM) and differed significantly ($P<0.05$) from silage with no additive (31.12 g/100g DM). Ash was highest in silage with no additive (9.62 g/100g DM) and lowest in silage with sugar additive (7.56g/100g DM). The NDF content of the silage ranged between 68.81and 76.39g/ 100gDM while ADF ranged between 40.64 and 48.06g/ 100g DM.

Table 1: Effects of additives on colour, texture, smell and temperature of ensiled cassava tops and Guinea grass mixture

Additives	Silage quality indicators			
	Colour	Texture	Odour/ smell	Temperature (° C)
60 % GG + 30 % CF+ 10% cassava chips	Olive green	Firm	Pleasant	29
60 % GG + 30 % CF+ 10% Sorghum grain	Olive green	Firm	Pleasant	29
60 % GG + 30 % CF+ 10% millet grain	Olive green	Firm	Pleasant	28.5
60 % GG + 30 % CF+ 10% sugar	Olive green	Firm	Pleasant fruity	29
60 % GG + 40 % CF+ 0% additive	Yellowish green	Firm	Pleasant	29

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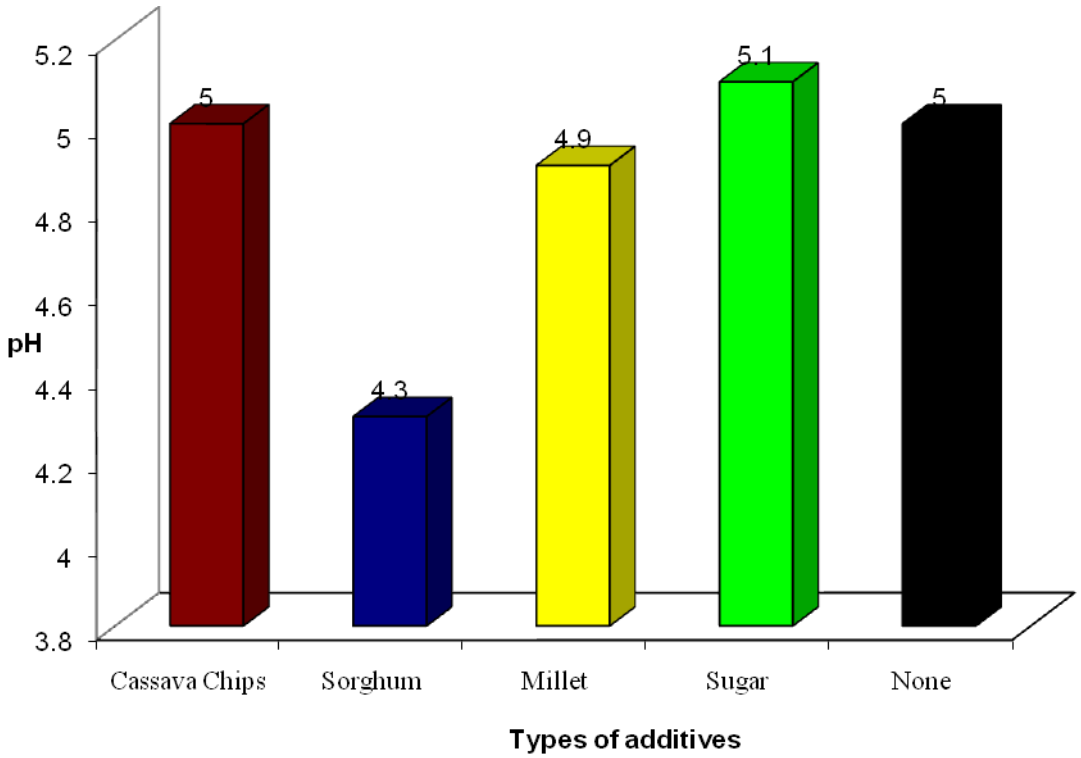

Fig 1:Effect of additives on pH of ensiled cassava tops and Guinea grass mixture

Table 2: Effects of additives on chemical composition (g/100g DM) of ensiled cassava tops and Guinea grass mixture

Treatment	DM	Crude protein	Crude fibre	Ash	NDF	ADF	Ether extract
60 % GG + 30 % CF+ 10% cassava chips	28.80^{a}	23.74^{ab}	31.89^{a}	9.42^{a}	71.66^{b}	43.44^{c}	8.41^{b}
60 % GG + 30 % CF+ 10% Sorghum grain	27.12^{c}	23.85^{ab}	32.49^{a}	8.51^{b}	71.47^{b}	44.48^{b}	8.32^{b}
60 % GG + 30 % CF+ 10% millet grain	28.80^{a}	25.60^{a}	31.91^{a}	9.41^{a}	76.39^{a}	40.64^{d}	10.13^{a}
60 % GG + 30 % CF+ 10% sugar	27.52^{bc}	21.88^{b}	31.95^{a}	7.56^{c}	69.39^{c}	44.81^{bc}	8.83^{b}
60 % GG + 40 % CF+ 0% additive	28.06^{b}	24.94^{a}	31.12^{b}	9.62^{a}	68.81^{c}	48.06^{a}	8.39^{b}
SEM	0.18	0.75	0.20	0.14	0.39	0.31	0.16

GG- Guinea grass, CT- Cassava tops

^{ab} means on the same row with different superscripts are significantly different (P<0.05)

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3.4 In vitro gas production

3.4.1 Incubation of ensiled cassava tops with Guinea grass incubated for 96 Hrs

Table 3 presents the *in vitro* fermentation parameters of ensiled cassava tops with Guinea grass incubated for 96 Hrs. There were no significant ($p > 0.05$) differences in insoluble fraction (b), potential gas production (a+b) gas production rate (c), and time (t) of the incubated samples. The highest values were obtained from silage with millet additives (5.50 ml, 27.50 ml, 33.00h, and 31.50ml respectively). Significant variations ($p < 0.05$) however existed between ensiled samples in the value of y, the highest being from silage with millet additive (22.25 ml) and the least from silage with cassava chips (12.50ml).

Methane (ml/200 mg DM) production (Fig 2) ranged from 12.5 to 20 among the silages, the least and the highest being from silage with cassava chips additive and millet additives respectively.

The value for the ME, OMD and SCFA ranged from 6.66, 52.94 and 0.62 to 7.11, 58.18, and 0.77 respectively. Silage with millet additives recorded the highest.

Table 4 shows the acceptability of the ensiled cassava tops and Guinea grass mixture that the goats had free choice on. Based on their COP values of more than unity, Treatment with cassava chips, sorghum and millet grain additives were preferred compared to Treatment with sugar and no additives.

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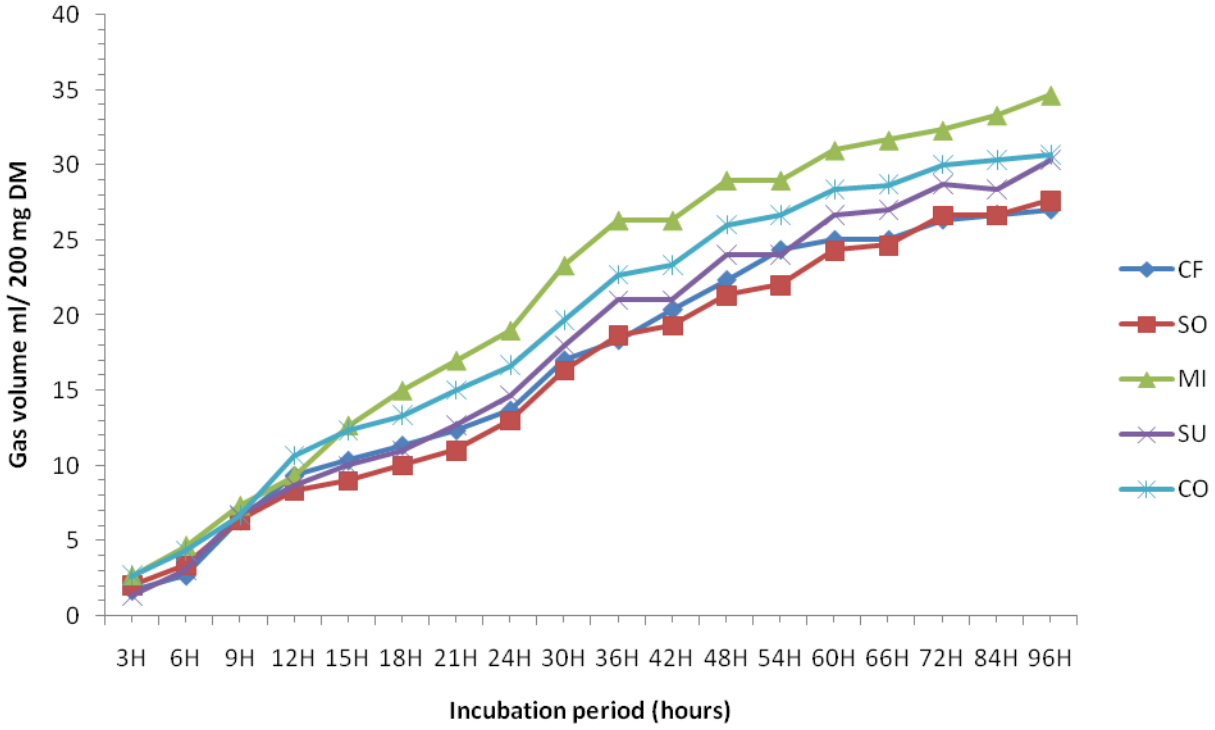

Fig 2: ***In vitro*** **gas production of ensiled cassava tops and Guinea grass mixture with different additives.**

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Table 3: *In vitro* fermentation parameters of ensiled cassava tops with Guinea grass incubated for 96 Hrs.

Treatments	A	B	a+b	c	t	Y
60 % GG + 30 % CF+ 10% cassava chips	3.00	22.25	25.25	0.033	19.50	12.50^{c}
60 % GG + 30 % CF+ 10% Sorghum grain	3.50	22.25	25.75	0.031	25.50	15.50^{bc}
60 % GG + 30 % CF+ 10% millet grain	5.50	27.50	33.00	0.032	31.50	22.25^{a}
60 % GG + 30 % CF+ 10% sugar	3.00	28.00	31.00	0.036	27.00	19.50^{ab}
60 % GG + 40 % CF+ 0% additive	5.00	23.75	28.75	0.031	21.00	15.00^{bc}
SEM	0.93	2.55	2.40	0.004	5.60	1.85

GG- Guinea grass, CT- Cassava tops

b = insoluble but fermentable fractions; a+b = potential extent of gas production; c = fractional rate constant; ^{ab} means on the same row with different superscripts are significantly different (P<0.05)

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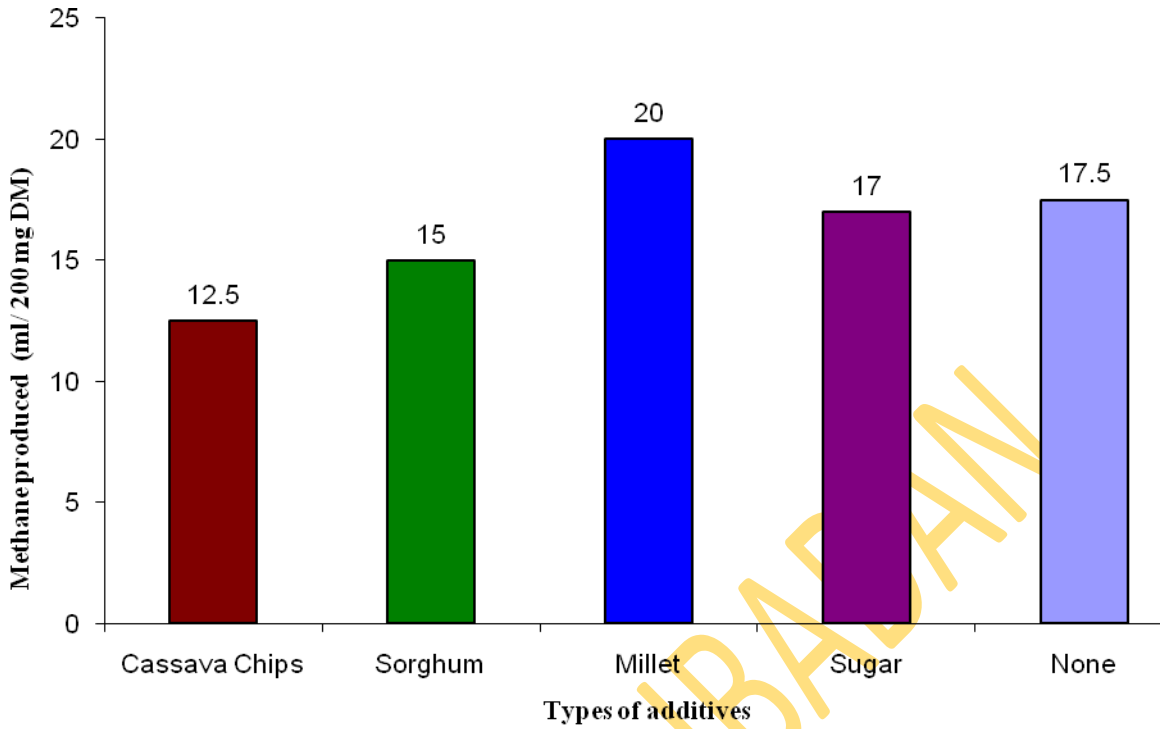

Fig 3: Methane production of ensiled Cassava tops and Guinea grass mixtures

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Table 4: Coefficient of preference of ensiled cassava tops and Guinea grass mixture with different additives

Treatment	Mean daily consumption (g\DM)	Coefficient of preference (COP)
60 % GG + 30 % CF+ 10% cassava chips	906.14	1.19
60 % GG + 30 % CF+ 10% Sorghum grain	836.86	1.11
60 % GG + 30 % CF+ 10% millet grain	838.29	1.09
60 % GG + 30 % CF+ 10% sugar	730.43	0.88
60 % GG + 40 % CF+ 0% additive	797.57	0.94

GG - Guinea grass; CF-Cassava foliage

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3.4 Discussion

3.4.1 Silage quality

All silage exhibited positive traits, which is a reflection of their successful ensilage, as indicated by colour and good structure, odor and pH. The colours were close to the original colour of both the grass and cassava foliage and this was slightly different from the finding of Oduguwa *et al*. (2007). Good silage usually preserves the original colour of the pasture or any forage (t'Mannetje, 1999). The olive green colours obtained in the present study were in order. The olive green colour was closed to the original colour of the grass, which was an indication of good quality silage that was well preserved (Oduguwa *et al*., 2007). Also the different yellow colour was in accordance with the report of Kung and Shaver (2002) that when a green plant material that is ensiled produces yellow colour, it can be classified as well made silage. The yellowish green colour produced by silage with no additive might be due to absence of any of the additives. (Kung and Shaver, 2002).

The texture were firm and indestructible, implying that there were no viscous or slimy appearances of the material. t'Mannetje (1999) earlier reported that the structures of the original plant materials ensiled should be visible and recognizable. When the structure of the silage is altered and tending towards obliteration, it is probably a symptom of acute disintegration. McDonald (1995), t'Mannetje (1999).

Differences were not observed in the smell of the silage as all the silages were characterized by pleasant. The only exception for the smell was the silage that exhibited pleasant – fruity smell. Kung and shaver (2002) reported that pleasant smell is accepted for a good or well made silage.

The pH value in the present result was within the range of 4.5-5.5 as classified to be pH for good silage by Meneses *et al*. (2007). Kung and Shaver (2002) in their interpretation of silage analysis report stated that a good quality grass and legume silage-pH values in the tropics ranges between 4.3 and 4.7. This result was higher than 3.2 obtained by Oduguwa *et al.* (2007) but lower than 5.4 reported by Oluwadamilare (1997). The pH reduction indicates proper fermentation since Patterson (1990) noted that an increase in pH during storage was associated with an increase in ammonia-nitrogen and a decrease in total acids. The low pH together with elevated levels of lactic acid showed that the herbage contained sufficient amounts of soluble carbohydrates to effectively preserve the silage. This can be attributed to

the high buffering capacity and low DM content of the legumes, which favours the production of other organic acids other than lactic acid (Woolford, 1984; McDonald *et al*., 1991). The pH showed that the herbage contained sufficient amount of soluble carbohydrate to effectively preserve the silage. The pH was between 4.3 and 5.1 showing that silage was well preserved. Silages with high CP (23-24 %) have high pH of between 4.7 and 5.0 (Kung and Shaver, 2002)

The pH value in the present result was within the range of 3.9 – 5.0 classified to be pH for good silage (Meneses *et al.,* 2007). Generally pH is one of the simplest and quickest way of evaluating silage quality. However pH may be influenced by the moisture content and buffering capacity of the original materials. Silage that has been properly fermented will have much lower pH (be more acidic) than the original forage. Kung and Shaver (2002) in their interpretation of silage analysis stated that a good quality grass and legume silage-pH values in the tropics ranges between 4.3 and 4.7 this indicates that silage with additives (cassava chips, sorghum, millet and sugar) are better ensiled compare to that with no additive. These were however higher than those of Oduguwa *et al*. (2007). Additives are used to improve silage preservation by ensuring that lactic acid bacteria dominate the fermentation phase. Possibly the most important benefit of additives such as maize or sorghum grain or cassava meal is to improve DM in early-cut crops when moisture content is high and where effluent is lost to the silage through seepage. Tropical grasses have been successfully ensiled with maize meal (Van Onselen and Lopez, 1988), cassava meal (Panditharane *et al*., 1986) and sorghum grain (Alberto *et al*., 1993). The decrease of pH in the silage was probably due to fermentation of WSC by lactic acid bacteria that produced organic acids leading to a decrease in pH (McDonald *et al*., 2002).

3.4.2 Chemical composition of silage

The effect of the different additive was significant on the chemical composition of the silage Silage with DM content between 25 and 35% are considered to be good (Patterson 1998). According to Akinola (1989) partial wilting increases DM content, this reduces bacterial activity in the silage. Wilting the forage before ensiling is recommended as a means of increasing dry matter content, the WSC on fresh weight basis and reducing losses from effluent and undesired fermentation (Humphreys, 1991, Nussio, 2005). The effluent observed in this study was rather negligible.

Protein is limiting in grass and therefore, there is a need for supplementation of grass silage with richer protein sources. Grass silage in Nigeria can be fortified with energy or protein sources by ensiling with cassava leaf, browse pods and industrial by-products. In order to enhance the CP supplementation for WAD goats, Igbekoyi (2008) ensiled Guinea grass with *Albizia saman* pods to obtain 14-18% CP. The CP exhibited within the range (21.88 and 25.60 g/100 g DM) reported was lower than those reported by Oluwadamilare (1997) who reported 31.9% CP for cassava/Guinea grass mixtures and Oduguwa *et al.* (2007) but similar to what Kavana *et al.* (2005) who reported 21.86% for cassava leave silage. The variations could be attributed to difference in varieties as well as the stage at which the crop was harvested, soil fertility, climate and sampling procedure. Variations in crude fiber level could be due to stage of maturity

Consequently, the CP content (21.88-25.60 %) of the silage was higher than 11–12% suggested by NRC (1985) as adequate to meet requirements of growing sheep, and was not below the level at which it could be considered deficient (Norton, 1994). The crude protein content was higher than the minimum protein requirement of 10–12% suggested by ARC (1985) for ruminants and the recommended for moderate growth of early-weaned sheep (NRC, 2001). The increase may be due to the cassava/guinea grass mixtures which give both energy and protein. Ether extract is the lipid fraction, which is a major form of energy reserve in the plant. The energy derivable from the plant is what the animal uses for its body maintenance and production. The ash content represents the inorganic (mineral matter) content in a feed. Its value is mainly in the contents of phosphorus, calcium, or potassium and large amounts of silica (Bogdan 1977).

NDF and ADF concentrations of the forage were much higher than recommended values of 25% for ruminants (NRC, 2001). However, their concentrations were not too high to hinder intake and animal production (Meissner *et al*., 1991; Buxton, 1996). Acid detergent fibre is inversely correlated with the digestibility of a feed; the lower the ADF, the higher the digestibility. NDF or neutral detergent fibre (NDF) is correlated with the level of dry matter intake by ruminant; the lower the NDF, the higher the level of intake. The NDF content reported in this experiment was higher than results from Oduguwa *et al.* (2007), but ADF was in the range reported. Ensilage had average effect on the structural carbohydrate. Stage of Maturity is the major factor contributing to the variability in fibre content. The chemical

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composition of the silage suggests that any of the additives could be used but this will depend on their availability and cost.

3.4.3 **The *in vitro* gas production**

In vitro gas method primarily measure digestion of soluble and insoluble carbohydrates (Menke and Steingass, 1988) and the amount of gas produced from a feed on incubation reflects production of VFA which are a major source of energy for ruminant. Gas arises directly from microbial degradation of feed and indirectly from buffering of acids generated as a result of fermentation.

Generally, gas production is a reflection of degradable carbohydrate and therefore, the amount depends on the nature of the carbohydrates (Demeyer and Van Nevel, 1975**;** Blummel and Becker, 1997). The presence of FA in silages may also affect gas volume measurements in carbonate buffered in vitro measures, where about half of the gas volume is accounted for by CO_2 released upon buffering SCFA (Blummel and Ørskov, 1993). The fermentation is relatively intensive during the first 24 hours of incubation, after which it reaches a stationary phase. The kinetics of gas production appears to be determined by two distinct phases; the first one corresponds to the degradation of the soluble fraction of the tested mixtures and the second to the insoluble but potentially fermentable fraction. The same profile in the gas production kinetics between the 2 mixtures is probably due to their chemical composition.

The silage with millet grain additive had the highest methane (CH_4) production and since CH_4 is a dietary energy loss and green house gas emission contributing to global warming (Johnson and Johnson, 1995) and thus causes ecological problems (Hu *et al.*, 2005), this may not interfere with its effective utilization by ruminants because CH_4 emissions rise with increasing digestibility of the ration (up to approx. 72 % digestibility) and for higher digestibility, CH_4 emissions are lowered insignificantly which may be explained by a reduction of the crude fibre content of the ration in exchange for N-free extracts to yield the higher digestibility (Pelchen and Peters, 1998).

Methane (ml/200 mg DM) production) ranged from 12.5 to 20 among the silages, the least and the highest being from silage with cassava chips additive and millet additives respectively. In most cases feedstuffs that show high capacity for gas production are also

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observed to be synonymous for high methane production. Methane production connotes an energy loss to the ruminant and many tropical feedstuffs have been implicated to increase methanogenesis (Babayemi *et al*., 2004; Babayemi and Bamikole, 2006a; Babayemi and Bamikole, 2006b) as an integrated part of carbohydrate metabolism (Demeyer and Van Nevel, 1975). Methane is the most abundant organic gas in the earth's atmosphere, and there is evidence that CH_4 concentrations have recently been increasing globally at a rate between 0.7% and 1.0%/year (Crutzen, 1995). Domestic ruminants are responsible for about 12.5% of global CH_4 emissions (Crutzen, 1995). Methane production in the rumen is an energetically wasteful process, since the portion of the animal's feed, which is converted to CH_4, is eructated as gas. Methane production is metabolic component of anaerobic fermentation in the rumen. It represents a significant energy loss to ruminant.

In most cases, feedstuffs that show high capacity for gas production are also observed to be synonymous for high methane production. The silage with millet additive would be a better option if utilized for feeding regime when taken into consideration its 'a+b,' energy content and CH_4 coupled with its high short chain volatile fatty acid which is an indication of energy content (Fievez *et al.*, 2005).

3.4.4 Acceptability study

Although there are many ways of assessing the nutritive value of feeds for ruminants, the direct intake by animals remains the authentic method. In recent times, cafeteria technique have been used to access the acceptability of some forages (Bamikole *et al*., 2004b; Babayemi, 2007). In the present study the acceptability of ensiled cassava foliage and Guinea grass mixture showed that silages with cassava chips (1.19), sorghum (1.11) and millet (1.09) additives were more acceptable as CoP was above unity compared to Treatment with sugar and the control (0.94 and 0.88 respectively). Reason for high preference for cassava chips, millet grain and sorghum additives could be linked to their high crude protein content and sweet tastes. Small ruminants prefer sweet and generally reject bitter plants (Krueger *et al*., 1974). A number of factors may influence acceptability of feed by small ruminants. Provenza and Cincotta (1994) reported that plant physical structure and chemical composition are the most vital factors that influence preference for food. Oldham and Alderman (1980) reported that sometime ad *libitum intake* by animals is increased by an increase in crude protein content of diets. Crude protein of the silages were high (21.88-25.60%) above ruminant requirements (NRC, 1985).

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CHAPTER FOUR

4.0 Effects of Length of Storage on quality and *in vitro* gas production of ensiled cassava tops and Guinea grass mixture.

4.1 Introduction

One of the most important factors determining the profitability of any livestock enterprise is the optimal level of feeding. This aim is the most problematic to achieve during the dry season when available feed is scarce and of low nutritive quality (Sowande *et al.*, 2008). It is therefore a common feature to find well fed and robust small ruminant in the rainy season to have appreciably lost weight in the following dry season. The challenge to Animal Scientists and researchers is feed production and utilization in the dry season to stem the cyclic pattern of weight gain and loss between seasons.

Cassava leaves contain an average of 21% crude protein but values ranging from 16.7 to 39.9% have been reported (Ravindran, 1991). Cassava leaves was reported to be abundant and left unutilized when the tuber has been harvested. These when properly preserved and utilized can make them cheap sources of nutrient especially dietary energy and fermentable products for small holder ruminant production. The high content crude protein in cassava leaf or foliage (leaves and stem) makes it a particularly useful source of roughages for ruminants (Smith, 1992). Cassava leaves have been commonly used as feed for ruminant animals by small holder famers only during cassava crop harvesting season when the leaves were abundantly available. The excess leaf available can be stored for a long period of time as a protein feed supplement (Hang, 1998). The cassava leaves could be preserved in form of hay or silage. However, in the rainy season it is difficult to sundry and extending the drying period diminishes the nutritional quality of the product. Ensiling would therefore be sustainable alternative way of preserving the leaves.

Guinea grass is one of the most nutritive grasses used as livestock feed. It is widely distributed across all ecological zones in Nigeria. The availability of this grass declines gradually as dry season approaches after the period of surpluses in the wet season. The high crude protein content of cassava leaves and the decline in quantity of guinea grass in dry seasons are reasons for believing that silage made from them could be a source of feed for ruminant animals to guarantee year round feed availability for such animals.

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4.2 Materials and methods

4.2.1 Sampling of ensiled forage

Silage Materials prepared in study 1 were sampled monthly (after the initial 42 days fermentation) for 6 months (72, 102, 132, 162, 192 and 222 days). Silage characteristics, in vitro fermentation and Chemical composition were determined as in study 1

4.2.2 Experimental procedure

The experiment was a 5×6 factorial arrangement in a completely randomized design to examine the effects of additives (Cassava chips, Sorghum, Millet , Sugar and None) and length of storage (72, 102, 132, 162, 192 and 222 days)

4.2.3 Chemical Analysis

After 72,102, 132, 162, 192 and 222 days (6 months) in storage, a representative samples of the silages were taken different storage containers based on the different additives used for chemical analysis

4.2.3 Statistical Analysis

Analysis of variance was used to determine the effects of additives, length of storage and their interactions on the contents of DM, CP,CF ASH, EE, OM and NDF using the General Linear Models procedure of SAS (SAS, 1999) The analytical model was as follows:

$Y_{ijk} = \mu + A_i + L_j + (AL)_{ij} + e_{ijk}$

Where Y_{ijk} is the dependent variable (e.g. DM, CP), μ is the overall mean.

A is additives effect ($_I$ =1, 2, 3) and L is length of storage ($_j$ = 1, 2, 3, 4),

$(AL)_{ij}$ is the interaction between additives and length of storage, and

e_{ijk} is the residual error, assumed to be normal and independently distributed.

The differences between means were assessed using the Duncan Multiple Range F-test (SAS, 1999).

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4.3 RESULTS

4.3.1 Effects of additives and length of storage on the silage characteristics and chemical composition of ensiled cassava tops and Guinea grass (Main effects)

The effects of additives and length of storage on the colour, texture, smell and chemical composition of ensiled cassava tops and guinea grass are presented in Tables 5, 6, 7 and 8 respectively.

The effects of additives on colour of ensiled cassava tops and Guinea grass mixture stored for six months showed that silage with cassava chips had change in colour after 222 days. Silage with sorghum, millet and sugar additives retained their colour, while that without additives changed colour after 132 days. Silage however retained the firm structure throughout the period under study

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Table 5: Effects of additives on colour of ensiled cassava tops and Guinea grass mixture stored for six months

Length of storage (days)	Types of Additive				
	Cassava Chips	Sorghum	Millet	Sugar	None
72	olive green	olive green	olive green	olive green	olive green
102	olive green	olive green	olive green	olive green	olive green
132	olive green	olive green	olive green	olive green	Brownish green
162	olive green	olive green	olive green	olive green	Brownish green
192	olive green	olive green	olive green	olive green	Brownish green
222	Brownish green	olive green	olive green	olive green	Brownish green

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Table 6: Effects of additives on Texture of ensiled cassava tops and Guinea grass mixture stored for six months

Length of storage (days)	Types of Additive				
	Cassava Chips	Sorghum	Millet	Sugar	None
72	Firm	Firm	Firm	Firm	Firm
102	Firm	Firm	Firm	Firm	Firm
132	Firm	Firm	Firm	Firm	Firm
162	Firm	Firm	Firm	Firm	Firm
192	Firm	Firm	Firm	Firm	Firm
222	Firm	Firm	Firm	Firm	Firm

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Table 7: Effects of additives on smell of ensiled cassava tops and Guinea grass mixture stored for six months

Length of Storage (days)	Types of Additive				
	Cassava Chips	Sorghum	Millet	Sugar	None
72	Pleasant fruity	Pleasant fruity	Pleasant fruity	Fruity	Fruity
102	Pleasant fruity	Pleasant fruity	Pleasant fruity	Fruity	Fruity
132	Fruity	Fruity	Fruity	Fruity	Fruity
162	Fruity	Fruity	Fruity	Fruity	Fruity
192	Fruity	Fruity	Fruity	Fruity	Fruity
222	Slightly fruity	Fruity	Fruity	Fruity	Fruity

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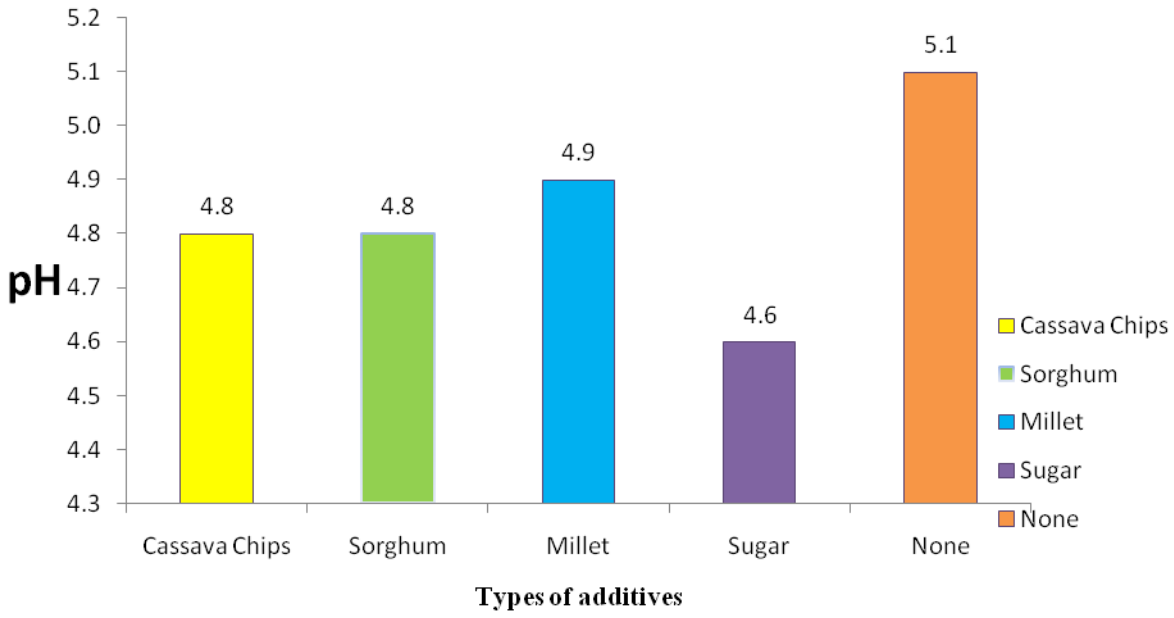

Fig 4: Effect of additives on pH of ensiled cassava tops and Guinea grass mixture with different additives

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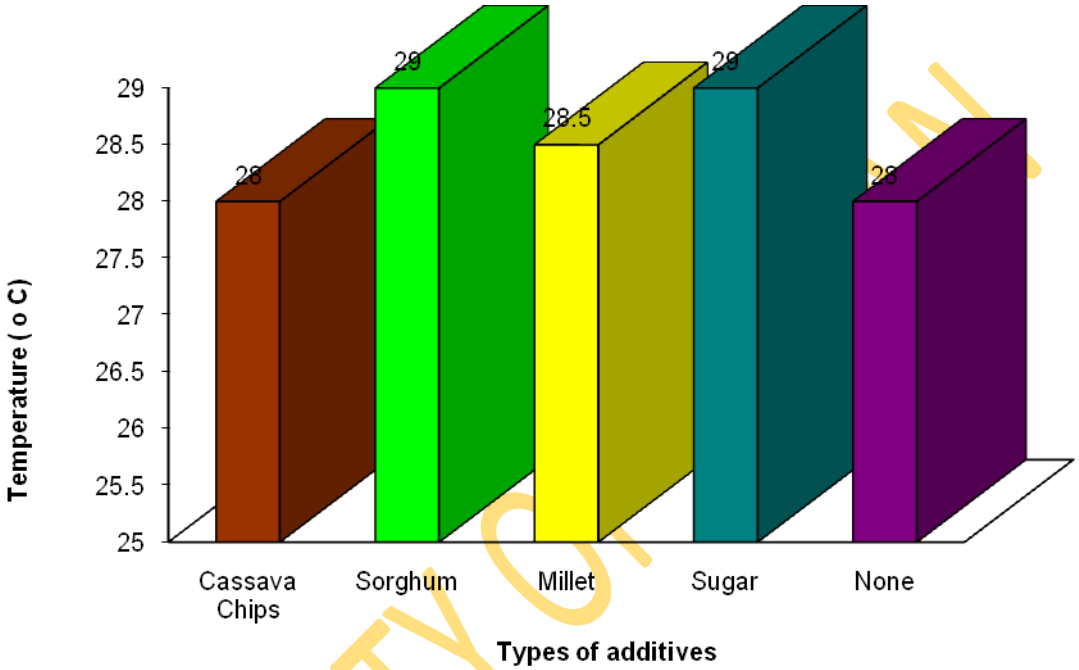

Fig 4: Effect of additives on temperature of ensiled cassava tops and Guinea grass mixture

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Table 8: Chemical composition (%) of ensiled cassava tops and Guinea grass mixture with different additives

Types of additive	Parameter						
	Dry Matter	Crude Protein	Crude Fiber	Ash	Ether Extract	NDF	ADF
Cassava chips	29.83[a]	23.89[c]	30.67[c]	9.77[a]	11.17[b]	63.45[c]	44.44[d]
Sorghum	28.14[e]	25.12[b]	31.64[a]	9.18[c]	10.44[c]	62.14[c]	47.52[b]
Millet	28.79[c]	25.53[b]	31.26[b]	9.20[c]	11.34[b]	65.79[b]	44.47[d]
Sugar	29.17[b]	26.47[a]	30.77[c]	9.40[b]	11.72[a]	67.50[a]	47.52[b]
None	28.46[d]	23.22[b]	31.51[a]	9.65[a]	11.60[a]	66.36[ab]	50.40[a]
SEM	0.17	0.21	0.07	0.05	0.08	0.53	0.32

[abcd]Means on the same row with different superscript, differ significantly (P< 0.05);

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Table 9: Chemical composition of ensiled cassava tops and Guinea grass mixtures stored for six months

Length of Storage (days)	Parameter						
	Dry Matter	Crude Protein	Crude Fiber	Ash	Ether Extract	NDF	ADF
72	28.00^{a}	24.00^{cd}	31.87^{b}	8.90^{d}	8.82^{c}	71.54^{a}	44.16^{d}
102	29.63^{a}	25 .68^{b}	31.90^{b}	8.83^{d}	8.41^{d}	71.16^{a}	47.60^{b}
132	29.15^{b}	27.13^{a}	33.72^{a}	9.12^{c}	8.93^{b}	68.79^{b}	44.16^{d}
162	28.68^{c}	24.52^{b}	30.05^{c}	9.81^{b}	14.10^{a}	57.85^{d}	47.28^{b}
192	28.93^{b}	24.02^{cd}	29.52^{d}	10.04^{a}	14.10^{a}	58.78^{d}	46.07^{c}
222	28.52^{c}	23.73^{d}	29.98^{c}	9.95^{ab}	13.10^{b}	62.18^{c}	49.80^{a}
SEM	0.17	0.23	0.08	0.06	0.09	0.58	0.36

^{abcd}Means on the same row with different superscript, differ significantly (P< 0.05);

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4.3.2 INTERACTIONS AMONG ADDITIVES AND LENGTH OF STORAGE ON THE CHEMICAL COMPOSITION OF ENSILED CASSAVA TOPS AND GUINEA GRASS

4.3.2.1 EFFECT OF INTERACTION OF ADDITIVES AND LENGTH OF STORAGE ON THE DRY MATTER AND CRUDE PROTEIN CONTENTS OF ENSILED CASSAVA TOPS AND GUINEA GRASS

Table 10, shows the interaction of different types of additives and length of storage on the dry matter (DM) and crude protein (CP) content of ensiled cassava tops and guinea grass mixture. The result showed that there were significant ($p < 0.05$) differences in between the DM content interaction among additive and length of storage. When silage with millet additive stored for 72 days (28.80 g/100 g DM) had the highest value which was similar to that of cassava chips additives (28.29 g/100 g DM) with the lowest value in silage with sorghum additives (27.12 g/100 g DM). When stored for 102 days, silage with cassava chips additives had the highest Dry matter (32.08 g/100 g DM) and the lowest was in silage with sorghum additive (28.09 g/100 g DM) which were similar to those with millet grain (28.47 g/100 g DM) and sugar (28.91 g/100 g DM) additive. After 132 days of storage, the dry matter ranged between 28.71 and 29.80 g/100 g DM which was highest in silage with sorghum additives. The DM values after 162 days showed a range of 27.61 to 30.07g/100 g DM with the highest value in silage with cassava chips additives. Among the different additives after 192 days, silage with sugar (31.67g/100 g DM) additives was highest ($p < 0.05$). There was a significant($p < 0.05$) decrease in the DM content after 222 days of storage with the highest value in sugar (29.87g/100 g DM) and lowest in sorghum (27.3g/100 g DM).

The crude protein (CP) content of the silage with additives and at different length of storage followed no definite pattern though the values differed significantly ($p < 0.05$) among each other. Silage stored for 72 days with millet grain additives had the highest (25.60 g / 100 g DM) value of DM but similar to those with none, sorghum and cassava chips additives (24.94, 23.85 and 23.74 g / 100 g DM respectively). Silage with sugar additive had the highest CP content (30.19, 28.22, 28.22, 26.43, and 27.83g/100 g DM) after 102, 132, 192 and 222 days of storage respectively

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Table 10: Dry Matter and Crude Protein (g/100 g DM) of ensiled cassava tops and Guinea grass mixture as affected by type of additive (A) and Length of Storage (LS,days)

Parameter	Length of Storage (days)	Types of additive							
		Cassava chips	**Sorghum**	**Millet**	**Sugar**	**None**	SEM	Length of Storage	**A X LS**
DM	72	28.29^{dx}	27.12^{ez}	28.80^{bx}	27.52^{dxy}	28.06^{cdy}	0.18	**	**
	102	32.08^{ax}	28.09^{cz}	28.47^{bz}	28.91^{cz}	30.60^{ay}	0.30	**	**
	132	28.95^{cx}	29.80^{av}	28.71^{bz}	29.46^{bcw}	28.81^{by}	0.01	**	**
	162	30.07^{bv}	29.06^{bw}	28.54^{bx}	27.61^{dz}	28.13^{by}	0.01	**	**
	192	28.29^{dx}	27.46^{dz}	29.57^{aw}	31.67^{av}	27.64^{cdy}	0.05	**	**
	222	29.27^{cxy}	27.31^{dez}	28.63^{by}	29.87^{bx}	27.53^{dx}	0.23	**	**
	SEM	0.15	0.09	0.11	0.28	0.18			
	Types of additive		**	**	**	**			
Crude Protein	72	23.74^{bcxy}	23.85^{bxy}	25.60^{bx}	21.88^{ey}	24.94^{bx}	0.75	**	**
	102	25.59^{aby}	24.94^{by}	23.48^{cy}	30.19^{ax}	24.21^{by}	0.71	**	**
	132	26.03^{az}	27.35^{axy}	26.91^{byz}	28.22^{bx}	27.13^{cy}	0.30	**	**
	162	23.99^{abcy}	24.56^{by}	29.34^{ax}	24.27^{dy}	20.45^{dz}	0.38	**	**
	192	21.05^{dz}	25.20^{bx}	25.24^{bx}	26.43^{cw}	22.18^{cy}	0.34	**	**
	222	22.92^{cdz}	24.83^{by}	22.62^{cz}	27.83^{bx}	20.41^{dz}	0.35	**	**
	SEM	0.65	0.50	0.55	0.41	0.40			
	Types of additive	**	**	**	**	**			

^{abcd}Means on the same column with different superscript, differ significantly (P< 0.05);

^{vwxyz}Means on the same row with different superscript, differ significantly

**: Significant

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4.3.2.2 EFFECT OF INTERACTION OF ADDITIVES AND LENGTH OF STORAGE ON THE CRUDE FIBRE AND ASH CONTENTS OF ENSILED CASSAVA TOPS AND GUINEA GRASS

Storage of the silage with sugar additives for 72 and 132days resulted in a significantly ($p < 0.05$) higher crude fibre (CF) (31.95 and38.19 g/100 g DM) content while those ensiled with cassava chips additives after 162 and 222 days had the highest CF (32.70 and32.69 g/100 g DM) content (Table 11). Lowest CF (31.12g/100 g DM) after 72 days of storage was recorded in the silage with no additives, that of 102 and 132 days (27.32 and31.13g/100 g DM) was recorded in cassava chips additives, and after 192 and 22 days (26.49 and 26.18g/100 g DM) were in silage with sugar additives

The Ash (9.62, 9.42 and 9.41 g/100 g DM) contents was similar ($p > 0.05$) in silage with none, millet grain and cassava chips additives stored for 72 days but differed significantly from those of sorghum (8.51g/100 g DM) and sugar (7.56 g/100 g DM) additives. After 102 days of storage. Silages ensiled with sugar (9.67 g/100 g DM), sorghum (9.47 g/100 g DM) and cassava chips (9.34 g/100 g DM) had similar ash content which was significant ($p < 0.05$) different from that with millet grain (8.23g/100 g DM) and that without any additive (7.44g/100 g DM). The Ash content of silage with millet grain was lowest ($p < 0.05$) when stored for 192 and 222 days than those stored ensiled with cassava chips, sorghum, sugar and none additives which differed ($p < 0.05$) significantly among each other.

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Table 11: Crude fiber and Ash (g/100 g DM) of ensiled cassava tops and Guinea grass mixture as affected by type of additive and Length of Storage (LS, days)

Parameter	Length of Storage (days)	Types of additive							
		Cassava chips	**Sorghum**	**Millet**	**Sugar**	**None**	SEM	Length of Storage	**A X LS**
Crude Fiber	72	31.89^{bx}	32.49^{ax}	31.91^{cx}	31.95^{cx}	31.12^{cy}	0.20		
	102	27.32^{ez}	31.48^{by}	34.44^{aw}	32.78^{bx}	33.49^{av}	0.20		
	132	31.13^{cz}	31.87^{aby}	33.84^{by}	38.19^{ax}	33.55^{ay}	0.20		
	162	32.70^{aw}	32.16^{ax}	29.47^{dy}	26.49^{ez}	29.41^{dy}	0.16		
	192	28.32^{dz}	29.47^{cy}	28.43^{ez}	29.05^{dy}	32.31^{bx}	0.15		
	222	32.69^{ax}	32.39^{ax}	29.45^{dy}	26.18^{ez}	29.19^{dy}	0.10		
	SEM	0.11	0.20	0.10	0.17	0.23			
	Types of additive	**	**	**	**	**			
Ash	72	9.42^{cx}	8.51^{dy}	9.41^{abcx}	7.56^{dz}	9.62^{cx}	0.14		
	102	9.34^{cx}	9.47^{cx}	8.23^{dy}	9.67^{bcx}	7.44^{dz}	0.13		
	132	9.39^{cy}	7.33^{ez}	9.47^{abxy}	9.53^{cx}	9.89b^{cw}	0.04		
	162	9.92^{bxy}	10.00^{ax}	9.88^{axy}	9.44^{cy}	9.80^{bc12}	0.16		
	192	10.95^{ax}	10.01^{ay}	8.92^{cz}	10.16^{ay}	10.16^{by}	0.08		
	222	9.60^{bcyz}	9.78^{byz}	9.30^{bcz}	10.03^{aby}	11.02^{ax}	0.17		
	SEM	0.12	0.05	0.15	0.15	0.1`3			
	Types of additive	**	**	**	**	**			

^{abcd}Means on the same column with different superscript, differ significantly (P< 0.05);

^{xyz}Means on the same row with different superscript, differ significantly

**: Significant

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4.3.2.3 EFFECT OF INTERACTION OF ADDITIVES AND LENGTH OF STORAGE ON THE ETHER EXTRACT AND NEUTRAL DETERGENT FIBRE CONTENTS OF ENSILED CASSAVA TOPS AND GUINEA GRASS

The Ether extract (EE) contents (table12) of silage with sugar (8.83g/100 g DM), cassava chips(8.41 g/100 g DM) none(8.39 g/100 g DM) and sorghum (8.32 g/100 g DM) after 72 days of storage were similar ($p > 0.05$) but lower ($p < 0.05$) than that ensiled with millet grain (10.13 g/100 g DM). Silage with sorghum additive (9.54 g/100 g DM) had the highest EE content after 102 days.

The silage with sugar stored for 132 days had higher ($p < 0.05$) EE (9.72g/100 g DM) followed by that ensiled with cassava chips (9.68 g/100 g DM), millet grain (8.71 g/100 g DM), none (8.68g/100 g DM) while silage with sorghum additive had the least (8.09 g/100 g DM) EE content.

Silage ensiled with millet grain (76.39g/100 g DM), cassava chips(71.66 g/100 g DM) and sorghum additives (71.4 g/100 g DM) had similar ($p > 0.05$) Neutral detergent fibre when stored for 72 days which were lower ($p < 0.05$) than those ensiled with none (68.80 g/100 g DM)and sugar additive (69.39 g/100 g DM).The lowest NDF content were recorded after 162 days of ensiling with cassava chips (48.10g/100 g DM),sorghum (58.10g/100 g DM), millet grain (58.17g/100 g DM) and that without any additives (62.00g/100 g DM). Silage with sugar additive was however lowest (58.50g/100 g DM) after ensiling for 192 days.

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Table 12: Ether extract and Neutral Detergent Fibre (NDF) (g/100 g DM) of ensiled cassava tops and Guinea grass mixture as affected by type of additive and Length of Storage (LS, days)

Parameter	Lenght of Storage (days)	Types of additive							
		Cassava chips	Sorghum	Millet	Sugar	None	SEM	Length of Storage	A X LS
Ether Extract	72	8.41^{dy}	8.32^{dy}	10.13^{dx}	8.83^{cd} y	8.39^{cy}	0.16	**	**
	102	7.57^{ez}	9.54^{cx}	7.70^{fz}	8.41^{dy}	8.85^{cy}	0.17	**	**
	132	9.68^{cx}	8.09^{dy}	8.71^{ey}	9.72^{cx}	8.68^{cy}	0.19	**	**
	162	14.83^{ax}	11.83^{bz}	14.17^{by}	15.00^{a} x	14.67^{ay}	0.20	**	**
	192	13.50^{bz}	13.17^{ay}	14.67^{ay}	15.50^{a} x	14.17^{b} y	0.22	**	**
	222	13.50^{by}	11.67^{bz}	12.67^{cy}	12.83^{b} y	14.83^{ax}	0.27	**	**
	SEM	0.20	0.15	0.16	0.31	0.14			
	Types of additive	**	**	**	**	**			
NDF	72	71.66^{ax}	71.47^{ax}	76.39^{ax}	69.39^{a} y	68.80^{b} y	0.39	**	**
	102	68.12^{bz}	63.80^{by}	74.07^{ax}	74.32^{a} x	75.48^{a} w	0.21	**	**
	132	70.44^{abx}	63.35^{bz}	66.84^{by}	74.77^{a} w	66.54^{cy}	0.60	**	**
	162	48.10^{dy}	58.10^{cx}	58.17^{dx}	62.87^{b} cx	62.00^{d} x	2.70	**	**
	192	60.00^{cx}	57.43^{cy}	55.80^{dy}	58.50^{c} xy	62.17^{d} y	1.28	**	**
	222	62.40^{cx}	58.67^{cy}	63.50^{cx}	63.17^{b} cx	63.17^{d} x	0.82	**	**
	SEM	0.89	0.50	0.88	2.51	0.58			
	Types of additive	**	**	**	**	**			

^{abcd} Means on the same column with different superscript, differ significantly (P< 0.05);

^{wxyz}Means on the same row with different superscript, differ significantly

**: Significant

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4.4.1 Effects of additives and length of storage on *In vitro* gas production of ensiled cassava tops and Guinea grass incubated for 96 h (Main effects)

The effect of additive on the *in vitro* gas production of the silage is shown in Figure 6 and the effect of length of storage on *in vitro* gas production pattern is shown in figure 7. The highest and the lowest gas production were obtained from silages with millet additive and with sorghum additives respectively, while the highest gas production was recorded after 72 days of storage and the lowest from 102 days of storage.

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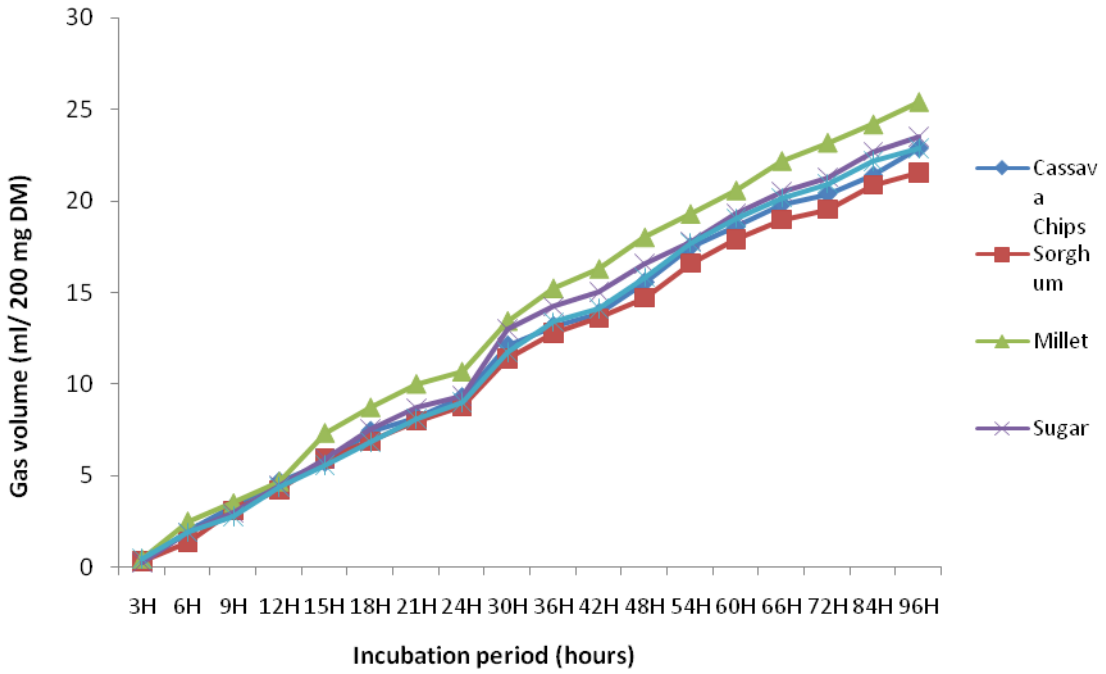

Fig 6: In vitro gas production of ensiled cassava tops and Guinea grass mixture with different additives.

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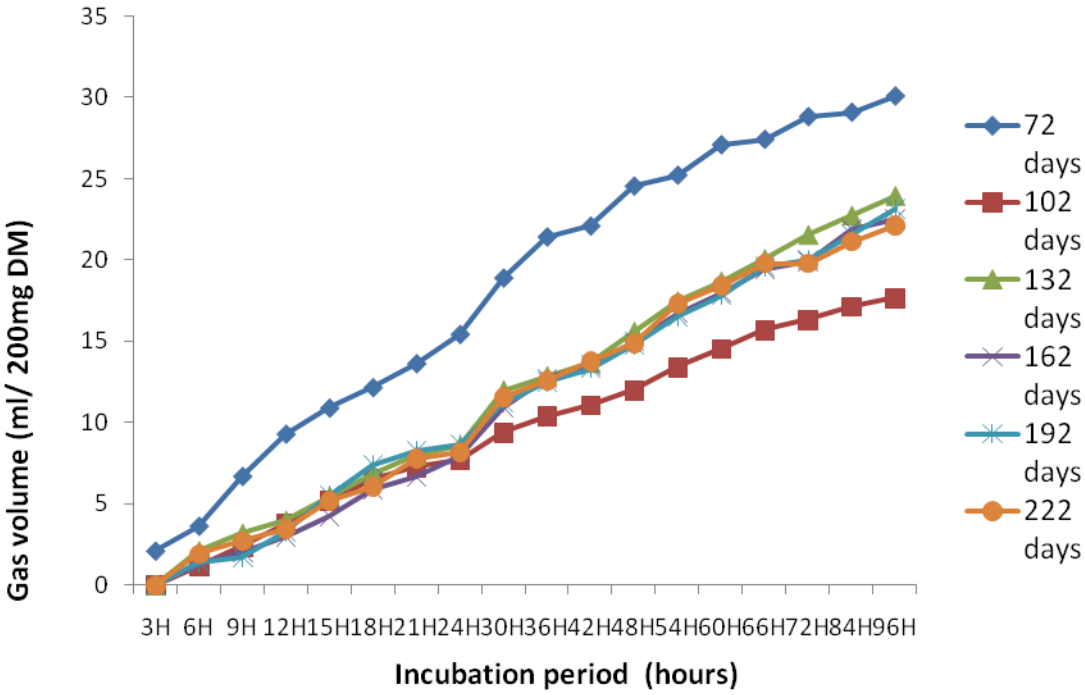

Fig 7: In vitro gas production of ensiled cassava tops and Guinea grass Mixture stored for six month

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4.4.2 Effects of additives and length of storage on *In vitro* gas production of ensiled cassava tops and Guinea grass incubated for 96 h (Main effects)

Table 13 shows the effect of additives on *In vitro* gas production characteristics of ensiled cassava tops and Guinea grass mixtures incubated for 96 h. The effect of additive on the different silage on insoluble but fermentable fractions (b) was not significant but significant effect were recorded for potential extent of gas production (a+b), fractional rate constant(c), Metabolizable energy (ME); organic matter digestibility (OMD), short chain fatty acid (SCFA)

Table 14 shows the effect of length of storage on *In vitro* gas production characteristics of ensiled cassava tops and Guinea grass mixtures stored for six months. The effect of length of storage of the different silage on insoluble but fermentable fractions (b), potential extent of gas production(a+b), fractional rate constant(c), Metabolizable energy (ME); organic matter digestibility(OMD) and short chain fatty acid (SCFA) were all significant. The highest values were recorded in silage after 72 days of storage (28.00ml, 30.07ml, 0.0030ml/h^{-1}, 13.37ml/200mg Dm, 7.68 MJ/Kg,73.16 % and 0.78 mmol) while the lowest were recorded after 102 days of storage.

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Table 13: *In vitro* gas production of ensiled cassava tops and Guinea grass mixtures with different additives incubated for 96 h

Types of additives	Fermentation Characteristics						
	B	a+b	C	Y	ME (MJ/Kg)	OMD (%)	SCFA (mmol)
Cassava chips	20.83	22.89^{ab}	0.022^{ab}	10.11	6.70^{ab}	65.95^{b}	0.61^{ab}
Sorghum	20.11	21.56^{b}	0.022^{ab}	9.83	6.59^{b}	65.95^{b}	0.58^{b}
Millet	23.17	25.39^{a}	0.020^{b}	10.28	7.14^{a}	69.29^{a}	0.67^{a}
Sugar	21.56	23.50^{ab}	0.029^{a}	12.22	6.93^{ab}	67.72^{ab}	0.62^{ab}
None	21.00	22.89^{ab}	0.021^{b}	10.22	6.66^{ab}	66.19^{ab}	0.61^{ab}
SEM	1.05	1.17	0.001	0.89	0.16	1.06	0.03

^{abc} Means within the column with different superscripts differed significantly ($P < 0.05$); b = insoluble but fermentable fractions; a+b = potential extent of gas production; c = fractional rate constant; ME = Metabolizable energy; OMD = organic matter digestibility; SCFA = short chain fatty acid;

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Table 14: *In vitro* gas production characteristics of ensiled cassava tops and Guinea grass mixtures stored for six months

Length of Storage (days)	Fermentation Characteristics						
	B	a+b	C	Y	ME (MJ/Kg)	OMD(%)	SCFA (mmol)
72	28.00^{a}	30.07^{a}	0.030^{a}	13.37^{a}	7.68^{a}	73.16^{a}	0.78^{a}
102	16.20^{c}	17.67^{c}	0.021^{b}	6.40^{c}	6.09^{c}	62.91^{b}	0.48^{c}
132	21.47^{b}	23.93^{b}	0.019^{b}	11.27^{ab}	7.03^{b}	70.31^{a}	0.63^{b}
162	21.00^{b}	22.53^{b}	0.020^{b}	11.27^{ab}	6.69^{b}	65.51^{b}	0.60^{b}
192	21.40^{b}	23.13^{b}	0.019^{b}	9.20^{b}	6.74^{b}	64.47^{b}	0.61^{b}
222	19.93^{b}	22.13^{b}	0.023^{b}	11.60^{ab}	6.59^{b}	64.75^{b}	0.59^{b}
SEM	1.15	1.28	0.001	2.18	0.18	1.64	0.03

a,b,c, : means within the column with different letters differed significantly (P<0.05);
b = insoluble but fermentable fractions; a+b = potential extent of gas production; c = fractional rate constant;ME= metabolizable energy, OMD= Organic matter digestibility, SCFA= short chain fatty acid

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4.3.3 INTERACTIONS AMONG ADDITIVES AND LENGTH OF STORAGE ON *IN VITRO* GAS PRODUCTION CHARACTERISTICS OF ENSILED CASSAVA TOPS AND GUINEA GRASS

Table 15 and 16 shows the interaction among the different additives and length of storage On *in vitro* fermentation characteristics of ensiled cassava tops and Guinea grass mixture. The interaction between length of storage and types of additives had no significant (P> 0.05) effect on insoluble but fermentable fractions (b), potential extent of gas production(a+b), fractional rate constant(c), Metabolizable energy (ME); organic matter digestibility(OMD),and short chain fatty acid (SCFA) during the 72, 132 and 192 days of storage

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Table 15a: Effect of different additives on *in vitro* fermentation characteristics of ensiled cassava tops and Guinea grass mixtures stored for six months

Parameter	Length of Storage (days)	Types of additive							
		Cassava chips	Sorghum	Millet	Sugar	None	SEM	Length of Storage	**A X LS**
b (ml)	72	25.33^{a}	25.67^{a}	32.00^{a}	29.00^{a}	28.00^{a}		Ns	Ns
	102	8.00^{by}	19.33^{abx}	15.33^{cxy}	19.00^{bx}	19.33^{abcx}		**	**
	132	24.33^{a}	18.67^{ab}	18.33^{bc}	22.33^{ab}	23.67^{ab}		Ns	Ns
	162	25.33^{ax}	12.33^{by}	20.00^{bcxy}	22.00^{abx}	24.33^{abx}		**	**
	192	21.67^{a}	20.00^{ab}	25.33^{ab}	22.67^{ab}	17.33^{ab}		Ns	Ns
	222	20.33^{xy}	24.00^{ax}	27.67^{ax}	14.33^{by}	13.33^{cy}		**	**
	SEM	2.50	2.69	2.32	2.73	2.63			
	Types of additive		**	**	**	**			
a+b (ml)	72	27.00^{a}	27.67^{a}	34.67^{a}	30.33^{a}	30.67^{a}		Ns	Ns
	102	9.00^{by}	21.33^{abx}	16.33^{cxy}	20.33^{bx}	21.33^{abx}		**	**
	132	27.33^{a}	20.33^{ab}	21.33^{bc}	25.33^{ab}	25.33^{abc}		Ns	Ns
	162	28.33^{ax}	13.13^{by}	21.33^{bcxy}	23.33^{abx}	26.33^{abx}		**	**
	192	23.33^{a}	21.33^{ab}	27.33^{ab}	24.33^{ab}	19.33^{abc}		Ns	Ns
	222	22.33^{axyz}	25.33^{axy}	31.33^{ax}	17.33^{byz}	14.33^{cz}		**	**
	SEM	2.77	2.80	2.77	2.96	3.06			
	Types of additive								

^{abcd}Means on the same column with different superscript, differ significantly (P< 0.05);

^{xyz}Means on the same row with different superscripts, differ significantly

**: Significant Ns: Not significant

b = insoluble but fermentable fractions; a+b = potential extent of gas production;

A: Types of additive **LS:** Length of Storage (days)

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Table 15b: Effect of different additives on *in vitro* fermentation characteristics of ensiled cassava tops and Guinea grass mixtures stored for six months

Parameter	Length of Storage (days)	Types of additive							
		Cassava chips	Sorghum	Millet	Sugar	None	SEM	Length of Storage	A X LS
C(ml/h^{-1})	72	0.033^{a}	0.029^{a}	0.027^{a}	0.035^{a}	0.026		**	**
	102	0.024^{ab}	0.019^{b}	0.024^{a}	0.016^{b}	0.021		**	**
	132	0.019^{ab12}	0.022^{ab1}	0.013^{c2}	0.024^{ab1}	0.018^{12}		**	**
	162	0.021^{ab1}	0.020^{b1}	0.014^{bc2}	0.024^{ab1}	0.020^{1}		**	**
	192	0.015^{b2}	0.021^{ab1}	0.021^{ab1}	0.021^{b1}	0.016^{12}		**	**
	222	0.021^{ab12}	0.020^{b2}	0.023^{a12}	0.028^{ab1}	0.022^{12}		**	**
	SEM	0.004	0.002	0.02	0.004	0.003			
	Types of additive		**	**	**	**			
Y	72	11.33^{a}	14.00^{a}	14.67^{ab}	16.67^{a}	10.67		Ns	Ns
	102	4.33^{b}	5.00^{c}	5.67^{c}	7.33^{b}	9.67		Ns	Ns
	132	12.67^{a12}	10.67^{abc12}	7.00^{c2}	14.33^{ab1}	11.67^{12}		**	**
	162	14.33^{a}	7.67^{bc}	8.33^{bc}	12.67^{ab}	11.33		Ns	Ns
	192	8.67^{ab12}	10.67^{abc12}	8.67^{bc12}	12.33^{ab1}	5.67^{2}		**	**
	222	9.33^{ab2}	11.00^{ab2}	17.33^{a1}	10.00^{ab2}	10.33^{2}		**	**
	SEM	4.07	1.73	2.05	2.52	2.58			
	Types of additive	**	**	**	**	**			

^{abcd} Means on the same column with different superscript, differ significantly (P< 0.05);

^{123}Means on the same row with different superscript, differ significantly

**: Significant Ns: Not significant

c = fractional rate constant; Y = volume of gas produced

A: Types of additive **LS:** Length of Storage (days)

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Table 16: Effect of different additives on *in vitro* fermentation characteristics of ensiled cassava tops and Guinea grass mixtures stored for six months and incubated for 96h

Parameter	Length of Storage (days)	Types of additive							
		Cassava chips	Sorghum	Millet	Sugar	None	SEM	Length of Storage	A X LS
ME (MJ/Kg)	72	7.25^{a}	7.35^{a}	8.40^{a}	7.59^{a}	7.82^{a}	0.34	Ns	
	102	4.91^{by}	6.55^{abx}	5.78^{cxy}	6.71^{abx}	6.50^{abcx}	0.40	**	
	132	7.43^{a}	6.55^{a}	6.66^{bc}	7.28^{ab}	7.22^{ab}	0.40	Ns	
	162	7.45^{ax}	5.44^{by}	6.80^{bcx}	6.78^{abx}	6.98^{abx}	0.41	**	
	192	6.60^{b}	6.57^{ab}	7.38^{ab}	7.05^{ab}	6.12^{bc}	0.41	Ns	
	222	6.57^{by}	7.09^{axy}	7.78^{abx}	6.17^{byz}	5.34^{cz}	0.41	**	
	SEM	0.38	0.39	0.38	0.41	0.42			
	Types of additive	**	**	**	**	**			
OMD(%)	72	70.33^{ab}	71.36^{a}	77.99^{a}	72.49^{ab}	73.63^{a}	2.27	Ns	
	102	52.18^{cy}	65.56^{abx}	62.39^{cx}	67.89^{abcx}	66.54^{abx}	2.62	**	
	132	71.16^{ab}	66.01^{ab}	67.99^{bc}	74.96^{a}	71.45^{ab}	2.63	Ns	
	162	72.15^{ax}	58.72^{by}	66.24^{bcx} y	63.79^{bcxy}	66.64^{abx} y	2.66	**	
	192	63.53^{b}	64.37^{ab}	69.05^{bc}	67.32^{abc}	63.08^{bc}	2.73	Ns	
	222	66.33^{abxy}	69.66^{ax}	72.09^{abx}	59.85^{cy}	55.80^{cy}	2.68	**	
	SEM	2.49	2.59	2.54	2.69	2.71			
	Types of additive	**	**	**	**	**			
SCFA (mmol)	72	0.71^{a}	0.72^{a}	0.89^{a}	0.78^{a}	0.79^{a}	0.06	Ns	
	102	0.28^{by}	0.57^{abx}	0.45^{cxy}	0.55^{bx}	0.57^{abcx}	0.07	**	
	132	0.72^{a}	0.55^{ab}	0.57^{bc}	0.67^{ab}	0.67^{ab}	0.07	Ns	
	162	0.74^{ax}	0.38^{by}	0.57^{bcxy}	0.62^{abx}	0.69^{abx}	0.07	**	
	192	0.62^{a}	0.57^{ab}	0.71^{ab}	0.64^{ab}	0.52^{bc}	0.07	Ns	
	222	0.59^{axy}	0.67^{axy}	0.81^{ax}	0.47^{by}	0.40^{cy}	0.07	**	
	SEM	0.07	0.07	0.07	0.07	0.07			
	Types of additive	**	**	**	**	**			

^{abcd} Means on the same column with different superscript, differ significantly (P< 0.05);

^{xyz}Means on the same row with different superscript, differ significantly

**: Significant Ns: Not significant

ME = metabolizable energy; OMD = organic matter digestibility; SCFA = short chain volatile fatty acid;

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4.3 Discussion

The silage colours were close to the original colour of the forages were retained and nutrients not denatured which showed that most chllorophyl were retained. This was in agreement with the findings of Oduguwa *et al*. (2007) . The smell was good for all treatment. The low pH together with elevated levels of lactic acid showed that the herbage contained sufficient amounts of soluble carbohydrates to effectively preserve the silage. This can be attributed to the high buffering capacity and low DM content of the legumes, which favours the production of other organic acids other than lactic acid (Woolford, 1984; McDonald *et al*., 1991). Additives are used to improve nutrient composition of silage, to reduce storage losses by promoting rapid fermentation, to reduce fermentation losses by limiting extent of fermentation, and to improve shelf life of silage (increase aerobic stability).

The chemical composition of the silage fluctuated widely during the period under study. The DM content was within the range for good silage and within the range of values reported for good silage. Effluents were not detected during the ensiling. Reduction in CP content could be attributed to the degradation of protein during ensiling which resulted in higher non protein nitrogen in the silage than in the herbage before ensiling (Whittenbury, *et al.*, 1967). High protein in the diet and especially in the forage should be desired as it largely determines the intake and digestibility (Babayemi *et al*., 2003). The crude protein contents of the silages were still within the acceptable range for ruminant performance (ARC, 1980; NRC 1985), and 8 % suggested by Norton (1994) for ruminal function.

The fibre contents (NDF, ADF, Lignin, cellulose and hemicellulose) have implication on the digestibility of plants. The neutral detergent fibre (NDF), which is a measure of the plants' cell wall contents, is the chemical component of the feed that determines its rate of digestion. NDF is inversely related to the plants' digestibility (McDonald *et al*., 1995; Gillespie 1998). The higher the NDF, the lower the plant's digestible energy. The values obtained for the grasses may imply a moderately high cell wall contents. Reduced NDF content in silage could be attributed to monosacharides that provide additional sugar for lactic acid production during fermentation (Muck, 1993). Reduced effect on ADF could be attributed to the fact that ADF does not provide sugars for lactic acid production during fermentation. The metabolic regulation of intake in ruminants has to a large extent been related to the production and absorption of nutrients (e.g. acetate and propionate) in the rumen (Forbes, 1995). This could be attributed to the fact that ADF does not provide sugars for lactic acid production during

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fermentation. The chemical profile suggests a potential use in ruminant livestock production as they fell within the recommended value. The ensiling process ensures not only increased Storage Length and microbiological safety, but it also makes most food resources more digestible (Caplice and Fitzgerald, 1999).

There are many factors that may determine the amount of gas to be produced during fermentation, depending on the nature and level of fibre, the presence of secondary metabolites (Babayemi *et al*., 2004a) and potency of the rumen liquor for incubation. It is possible to attain potential gas production of a feedstuff if the donor animal from which rumen liquor for incubation was collected, got the nutrient requirement met. Generally, gas production is a function and a mirror of degradable carbohydrate and therefore, the amount depends on the nature of the carbohydrates (Demeyer and Van Nevel, 1975**;** Blummel and Becker, 1997).

The highest gas production was recorded in silage with millet additives. The high gas volume produced by the silages could be due to high crude protein in feed which enhances microbial multiplication in the rumen, which in turn determines the extent of fermentation. Increasing the duration of ensilage reduced the *In vitro* gas production. This may be due to the decrease in WSC which is a source of energy for microorganisms in the rumen (Van Soest, 1994), and agrees with Ben Salem *et al*. (2005) who found a decline in gas production as anaerobic storage period was prolonged.

The presence of fatty acids in silage may also affect gas volume measurements in carbonate buffered *in vitro* measure, where about half of the gas volume is accounted for by Co_2 released upon buffering SCFA (Blummel and Orskov, 1993)

The ME values of the silage (7.00 -8.16 MJ/Kg) were within the ranges reported by Menke and Steingass (1988), where the ME values of various European feeds ranged from 4.5 to 15 MJ kg−1 DM. In vivo organic matter digestibility (OMD) is defined as the proportion of feed OM apparently digested in the total digestive tract. OMD is a measure of energy available to ruminants and is used in protein evaluation systems (Vérité *et al*., 1987; Tamminga *et al*., 1994) to calculate rumen fermentable OM, which in turn is used to estimate rumen microbial protein synthesis.OMD reported in this study was within the range of 44.789 -78.7 % reported by Onwuka *et al*. (1989) for Cassava leaves have in vitro organic matter digestibility

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(IOMD). Feivez *et al.* (2005) reported that the level of SCFA is an indicator of the energy value of diets therefore the lower SCFA of these treatments are indication of their low energy contents.

Blummel and Ørskov (1993) reported that gas production is associated with volatile fatty acid (VFA) production following fermentation so the more the fermentation of diet the greater the gas production. Variation between total gas productions could be explained by the differences in the total VFA production and molar proportion of VFA (Beuvink and Spoelstra, 1992). Doane *et al.* (1997) found a significant correlation between gas production and VFA production.

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CHAPTER FIVE

5.0 VOLUNTARY INTAKE AND PERFORMANCE OF WAD SHEEP FED ENSILED CASSAVA TOPS AND GUINEA GRASS MIXTURE

5.1 Introduction

Livestock productivity in the tropics has suffered major setbacks due to inadequate quantity and quality feed supplied to the animals especially during the dry season (Peters, 1998). During the rainy season, forages are relatively available and animals may gain weight easily and remain thrifty *(*Babayemi, *et al.,* 2003). Osakwe (2006) reported that the low nutrient content of tropical forages is the most limiting factor affecting the performance of ruminants consequently resulting in low productivity. When nitrogen content of feed is less than one percent, the ruminant's appetite is depressed and voluntary feed intake is reduced (Minson, 1990). Therefore, animal production and consumption of animal products are low in the humid tropics compared to developed countries (Kizilsimsek *et al*., 2005).

Cassava foliage has been reported to be nutritious to ruminants when fed either fresh, dried or made into silage *(*Wanapat *et al.,* 2000a*;* Fasae *et al.,* 2009a, b). Cassava foliage is rich in crude fibre and protein which can be used to meet the nutrient requirement of livestock. Cassava foliage is a good source of protein and has been reported to increase livestock productivity including milk yield (IITA Annual report 2004, Kwamme, 2001*)* and body weight gain *(*Nhi *et al.,* 200l, Bunyeth and Preston 2006).

Guinea grass is one of the most nutritive grasses used as livestock feed. It is widely distributed across all ecological zones in Nigeria. The availability of this grass declines gradually as dry season approaches after the period of surplus in the wet season.

Improved nutritional strategy is a key factor to improving the productive capacity of livestock animals. Adequate nutrition is one of the ways to enhance the productivity of WAD sheep *(*Yusuf *et al.,* 2010). This study therefore aimed at assessing the effect of ensiled cassava tops and Guinea grass mixture on the performance of WAD sheep

5.2 Materials and methods

5.2.1 Experimental Sites

The experiment was conducted at the Sheep and Goat unit of the Teaching and Research Farm Ladoke Akintola University of Technology, Ogbomoso, Oyo State, between the period of November 2010 to March 2011. Ogbomoso is located in the derived savannah Zone of latitude $8^0 26^1$N and longitude $4^0$29f with a mean annual rainfall of 1247mm and mean annual temperature of about 27^0C.

5.2.2 Experimental animals and management

Twenty (25) male West African Dwarf sheep age 12-14 months were purchased from local markets around the University farm. The animals were confined for one-month adaptation period. During this period they were treated against ecto and endoparasitic infections by bathing them with a solution of diasuntol at 4 ml per 4 litres of water Ivomec injection. They were also be vaccinated against Peste de petits ruminante (PPR) disease. Feed, water and salt lick were provided *ad-libitum*.

The animals were housed in individual pens made of low walls of 1 m x 1.5 m in size and each pen was about 220 cm long and 121 cm wide. The floor of the pen was made of concrete and the roof of the goat unit which housed the pens was made of corrugated iron sheets. The pens were cleaned and washed thoroughly with warm detergent to remove dirts and obnoxious odour prevailing in the house. The pens were further disinfected with Morigad while the surroundings were fumigated with formalin. The overgrown weeds and grasses were sprayed with grammozone to check the growth. The feeding and drinking troughs were washed and disinfected and the whole house was left to rest for two weeks before usage. Wood shaving was spread on the floor of the pen as bedding containers.

5.2.3 Animal feeding

The rams were weighed on arrival, rested, watered and tagged for easy identification. Rams were fed with the feedstuff (including maize bran, cassava peels, and wheat offal), which they consumed from where they were purchased during the acclimatization periods. The animals were placed on prophylactic treatment through the administration of antibiotics (long acting). Animal were also treated against endoparasites and ectoparasites using 10% of Levamisol and diazintol respectively. They were allowed to adapt for 1 month, which consists of 4 hr daily grazing and concentrate supplementation.

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After adaptation, the animals were randomly grouped into five treatments in a completely randomized design comprising five animals per diet. They were individually kept in separate pens that were previously embedded with wood shavings. Feeders and drinking trough were placed in the pens for free access to feed and fresh water daily. Feed were offered at approximately 4% of their body weight. Voluntary feed intakes were estimated as the difference between feed offered and feed refusal. The animals were weighed prior to feeding to minimize error due to "fill" in the morning on a weekly basis to calculate average weight gain.

A one hundred and thirty five (135) day feeding trial was initiated and carried out during November, 2010 to March 2011. Changing of bedding was done fortnightly while the rams were dipped in diasuntol and given antibiotics when the need arose.

5.2.4 Experimental diets: In a completely randomized design with five replicate sheep were randomly distributed to treatment diet which is ensiled as follows.

Treatment 1: 30% cassava tops + 60% Guinea grass + 10% cassava chips.

Treatment 2: 30% cassava tops + 60% guinea grass + 10% sorghum grain.

Treatment 3: 30% cassava tops + 60% guinea grass + 10% millet grain.

Treatment 4: 30% cassava tops + 60% guinea grass + 10% sugar

Treatment 5: 40% cassava tops + 60% guinea grass + 0% additives.

5.2.5 Digestibility trials

Fifteen rams were used for determining the digestibility and N-balance of the diets. The animals were housed individually in metabolic cages in a completely randomized design. The animals were offered the feed during seven days adaptation period prior to 7 days collection period; water and salt licks were provided throughout the metabolic period. The animals were weighed at the beginning and end of the digestibility trials. The animals were supplied the experimental diets as in growth trial. During seven days collection period, total faeces were collected and weighed daily. A 10% sample of total faeces was stored in a freezer at – 10 $^{\circ}$C. After 7 day collection period, daily samples from each animal were bulked, mixed, dried in an oven at 60 ^{o}C and milled for chemical analysis. All urine were collected and measured daily in the morning using measuring plastic containers. At collection 2 ml of 10 % sulphuric acid was added to 10 % aliquot of the urine in each

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container to prevent microbial growth and loss of nitrogen. Ten percent of total urine was sampled daily and stored at – 4 ºC for nitrogen analysis. Daily feed was served at 4 % body weight. Feed refusal was sampled daily and mixed for the entire collection period on an individual basis using an air tight plastic bag.

5.2.6 Chemical analysis

The dried samples of supplemental feeds, remnants and dried faeces were ground through a 1mm mesh screen for analysis. Two grammes of milled samples in duplicate were used for proximate analysis. Crude protein determination was by kjeldahl technique which involved the digestion of the samples in concentrated sulphuric acid which converted the sample nitrogen to ammonium sulphate. After digestion the digest was cooled, diluted to mark with distilled water in 250 ml volumetric flasks. The digest was distilled and titrated in a kjeldhal apparatus with 60 % sodium hydroxide which changed the sample nitrogen into ionized ammonium. The solution was then distilled, and the distillate containing the ammonium was automatically titrated with acid. The percent CP was obtained by multiplying the percent nitrogen content obtained by 6.25 (AOAC, 1990).

5.2.6 Blood collection

Blood samples were collected and at the end of the growth trial to analyze for haematology and biochemical components. Blood samples were taken before morning feeding via jugular vein puncture into two blood tubes. One containing an anticoagulant (Disodium salt of ethylene diamenetetracetic acid (EDTA)) and the other with no anticoagulant from which serum was harvested for biochemical analysis. Packed Cell Volume (PCV), Haemoglobin (Hb), red blood cell (RBC) and total white Blood Cells (WBC) were determined. Mean Corpuscular volume (MCV), Mean Corpuscular haemoglobin (MCH) and Mean Corpuscular haemoglobin concentration (MCHC) were calculated from PCV, Hb and RBC as established (Jain, 1986). The serum total protein (STP) was obtained by the biuret method.

5.2.6 Statistical analysis

The experimental design was completely randomized design (CRD). Data generated were subjected to the analysis of variance procedure of SAS (1999). Significant means were separated using the Duncan Multiple range test of the same package. Experimental model of the design was: $Y_{ij} = \mu + \alpha_i + \Sigma_{ij}$

Where: Y_{ij} = Individual observation μ = general mean of the population

α_i = treatment effect Σ_{ij} = composite error effect.

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5.0 RESULTS

The performance characteristics of WAD sheep fed on ensiled cassava tops and guinea grass mixture are shown in Table 17. The final body weight (kg) and dry matter intake (g/day) of rams on different silages were significantly ($P < 0.05$) different from each other, with sheep fed silage with millet additive having the highest value. The diets had no influence on the body weight gain (kg) and daily body weight gain (g/day). Animals on silage with millet additive (41.67 g/d) showed the best body weight increase while animals on silage with sugar additive (30.93 g/d) showed the least. The values for dry matter intake ranged from 459.28 to 530.01 g/day. The silages with different additive had no significant ($P < 0.05$) effect on the Feed conversion ratio (FCR) of the ram.

Apparent digestibility (%) of ensiled cassava tops and Guinea grass mixture by WAD sheep is shown in Table 18. The Dry matter, Crude protein, crude fibre and ether extract differ significantly ($P <0.05$) among the diets while Ash and organic matter digestibility were not significantly ($P > 0.05$) affected. The highest DM, CP and CF digestibility value were recorded in silage with no additive (84.69, 90.58 and 70.97% respectively) and the lowest were recorded in silage with sugar additives (75.78, 84.14 and 83.50% respectively). The ether extract digestibility was highest in silage with sorghum (89.14%) and lowest in silage with sugar additive (73.31 %).

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Table 17: Performance characteristics of WAD sheep fed on ensiled cassava tops and guinea grass mixture

Parameter	60 % GG + 30 % CF+ 10% cassava chips	**60% GG + 30% CT+ 10% Sorghum grain (Diet 2)**	**60% GG + 30 % CT + 10% millet grain (Diet 3)**	**60% GG + 30% CT+10% sugar (Diet 4)**	**60 % GG+ 40% CT + 0% additive (Diet 5)**	**SEM**
Initial body weight (kg)	13.25	13.50	13.63	12.63	13.00	
Final body weight (kg)	17.43^{ab}	18.13^{ab}	19.25^{a}	16.75^{b}	17.76^{b}	0.66
Body weight gain (kg)	4.13	4.63	5.63	4.13	4.56	0.59
Daily body weight gain (g/d)	30.93	34.26	41.67	30.56	33.80	
Dry matter intake, total (g/d)	483.89^{b}	487.92^{b}	530.01^{a}	459.28^{c}	472.59^{bc}	4.39
Dry matter intake, total, metabolic (g/kgW0.75)	103.16^{b}	103.82^{b}	110.45^{a}	99.20^{c}	101.36^{bc}	1.07
Feed conversion ratio	15.99	15.34	12.96	16.04	14.89	1.87

^{ab}means on the same row with different superscripts are significantly different ($P < 0.05$)

CF = Cassava tops GG= Guinea grass

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Table 18: Apparent digestibility (%) of ensiled cassava tops and Guinea grass mixture by WAD sheep

Treatment	Apparent digestibility					
	Dry matter	Crude protein	Crude fibre	Ash	Organic matter	Ether extract
60 % GG + 30 % CF+ 10% cassava chips	80.06^{ab}	87.25^{ab}	79.46^{ab}	60.62	82.01	82.62^{c}
60 % GG + 30 % CF+ 10% Sorghum grain	82.29^{ab}	89.48^{ab}	80.04^{ab}	59.02	84.13	89.41^{a}
60 % GG + 30 % CF+ 10% millet grain	76.87^{ab}	87.25^{ab}	74.86^{ab}	55.38	79.13	84.58^{bc}
60 % GG + 30 % CF+ 10% sugar	75.78^{b}	84.14^{b}	70.97^{b}	49.08	78.20	73.31^{d}
60 % GG + 40 % CF+ 0% additive	84.69^{a}	90.58^{a}	83.50^{a}	68.31	85.95	88.75^{ab}
SEM	2.52	1.80	2.96	6.53	2.28	1.42

^{abcd} Means on the same column with different superscript, differ significantly (P< 0.05);

GG- Guinea grass, CT- Cassava top

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Table 19 shows the total digestible nutrients (TDN) in the silage with different additives. The TDN ranged from 79.49 to 86.71. The silage with no additive had the highest TDN value of 86.71 while the one with sugar additive had the least TDN value of 79.49. There were significant differences among the TDN in the silages but none between silages with cassava chips and sorghum additive and no additive. Similarly the difference between the TDN in the silages with millet, Cassava chips and sorghum were not significant.

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Table 19: Total digestible nutrients by WAD sheep fed on ensiled cassava tops and Guinea grass mixture

PARAMETERS (%)	60 % GG + 30 % CF+ 10% cassava chips	60 % GG + 30 % CF+ 10% Sorghum grain	60 % GG + 30 % CF+ 10% millet grain	60 % GG + 30 % CF+ 10% sugar	60 % GG + 40 % CF+ 0% additive	SEM
CRUDE PROTEIN	15.82^{ab}	16.40^{ab}	16.73^{ab}	14.78^{ab}	17.17^{ab}	0.58
CRUDE FIBRE	23.95^{ab}	24.50^{ab}	23.71^{a}	21.57^{ab}	26.36^{ab}	1.81
ETHER EXTRACT	3.87^{ab}	4.40^{ab}	4.75^{a}	3.48^{ab}	4.15^{ab}	0.37
NITROGEN FREE EXTRACT	34.29	35.11	30.18	35.30	33.83	1.56
TOTAL DIGESTIBLE NUTRIENT	82.76^{abc}	85.91^{ab}	81.31^{b}	79.49^{c}	86.71^{a}	1.59

^{ab} means on the same row with different superscripts are significantly different (P<0.05)

GG- Guinea grass, CT- Cassava top

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Table 20 shows the haematological values of West African Dwarf (WAD) sheep fed ensiled cassava tops and Guinea grass mixture. There were significant differences ($p < 0.05$) in the haematological parameters measured among the different additives used in ensiling the different silages fed to WAD sheep, except for the insignificant differences ($P > 0.05$) in WBC, RBC, MCV and MCH. There was significant difference between PCV, Hb, MCHC, lymphocytes and neutrophils. The PCV was higher (33.67%) in diet containing sorghum grain and lower (27.00%) in diet with cassava chips as additives and the control. Hb value ranges between 9.00 and 11.22. There was significant difference also in MCHC which ranged between 33.33% and 33.34%. There was no significant difference in MCV and MCH in all diets.

The RBC counts in the sheep ranged between 9.00 to11.22.g/dl; while the total WBS counts range was7400 -10900.The relative differential leucocyte counts (DLC) showed that Percentage distribution of leukocytes had significant differences. Lymphocyte and Neutrophils ranged between 60.33% - 67.50% and 29.50%-37.33% respectively. Eosinophil values were significantly higher ($p < 0.05$) in the WAD sheep fed silages ensiled with cassava chips (1.50%), millet grain, sugar and the control, than sorghum additive.

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Table 20: Heamatology of WAD Sheep fed ensiled cassava tops and Guinea grass mixture

	Treatment					
Parameter	60 % GG + 30 % CF+ 10% cassava chips	60 % GG + 30 % CF+ 10% Sorghum grain	60 % GG + 30 % CF+ 10% millet grain	60 % GG + 30 % CF+ 10% sugar	60 % GG + 40 % CF+ 0% additive	SEM
PCV, %	27.00[b]	33.67[a]	32.00[a]	31.00[a]	27.00[b]	0.87
Hb, g/dl	9.00[b]	11.22[a]	10.67[a]	10.33[a]	9.00[b]	0.29
WBC	7550	8983	8675	10900	7400	1228.07
RBCs, $x10^6$/m	6.46	8.17	7.42	7.64	6.82	0.66
MCHC, %	33.33[b]	33.34[a]	33.33[b]	33.33[b]	33.33[b]	0
MCV, fl	0.45	0.42	0.43	0.41	0.4	0.04
MCH, Pg	15.05	13.95	14.4	13.63	13.36	1.23

Percentage distribution of leukocytes	60 % GG + 30 % CF+ 10% cassava chips	60 % GG + 30 % CF+ 10% Sorghum grain	60 % GG + 30 % CF+ 10% millet grain	60 % GG + 30 % CF+ 10% sugar	60 % GG + 40 % CF+ 0% additive	SEM
Lymphocytes, %	64.00[ab]	60.33[b]	62.50[ab]	66.00[ab]	67.50[a]	1.73
Neutrophils, %	32.50[b]	37.33[a]	32.00[b]	30.00[b]	29.50[b]	1.39
Eosinophils, %	1.50[a]	0.00[b]	1.50[a]	1.00[a]	1.50[a]	0.43
Monocytes, %	2.00[b]	2.33[b]	4.00[a]	3.00[b]	1.50[b]	0.49

[ab] means on the same row with different superscripts are significantly different (P<0.05)

GG- Guinea grass, CT- Cassava top

Packed Cell Volume (PCV), Haemoglobin (Hb), Red blood cell (RBC), white Blood Cells (WBC), Mean Corpuscular volume (MCV), Mean Corpuscular haemoglobin (MCH) and Mean Corpuscular haemoglobin concentration (MCHC)

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Table 21: Blood biochemistry of WAD Sheep fed ensiled cassava tops and Guinea grass mixture with different additives.

	Treatment					
Parameters	60 % GG + 30 % CF+ 10% cassava chips	60 % GG + 30 % CF+ 10% Sorghum grain	60 % GG + 30 % CF+ 10% millet grain	60 % GG + 30 % CF+ 10% sugar	60 % GG + 40 % CF+ 0% additive	SEM
Glucose, mg/dl	73.74	85.86	74.75	69.19	45.08	13.38
Cholesterol, mg/dl	49.42	91.33	103.76	68.79	110.12	18.51
Total protein, g/dl	8.20^{a}	6.87^{ab}	7.68^{a}	7.63^{a}	6.08^{b}	0.45
Albumin, g/dl	4.56^{a}	3.42^{b}	3.70^{b}	4.31^{a}	4.27^{a}	0.09
Urea, mg/dl	13.72^{ab}	11.83^{b}	13.46^{ab}	16.15^{a}	13.17^{ab}	1.01
AST, IU/l	12.38^{a}	7.07^{bc}	8.84^{b}	5.30^{c}	6.19^{c}	0.69
ALT, IU/l	27.40	11.49	15.03	26.54	17.68	4.98
ALP, IU/l	90.71^{a}	81.06^{ab}	76.10^{b}	59.86^{c}	49.15^{c}	3.92

AST= Aspartate Amino Transferase

ALT= Alanine Amino Transferase

ALP= Alkaline phosphatase

^{abc} means on the same row with different superscripts are significantly different (P<0.05)

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5.2 Discussion

The high dry matter intake (DMI) of rams on the silages with different additives could be as a result of the succulent nature of the silage coupled with the high CP content. The level of DMI is influenced by several factors, such as body composition of animals (composition of body fat), environmental conditions especially climate, genetic factors, weight of animals, type of management, feed composition and quality (ARC, 1980). Dry matter intake was high. This could be as a result of the succulent nature of the silage coupled with it higher CP content. However, it has been observed that DMI could be favorably influenced by dietary CP level (Karim *et al*., 2001; Karim and Santra, 2003).Overall, DMI of sheep were within the 310 to 870 g/day values reported by ARC (1980) and McDonald *et al*. (1987) as adequate for sheep with body weight of 20 to 35 kg. However NRC (1985) reported that DMI could go up to 1000 to 1300 g/day for growing sheep. Some factors, e.g. low pH (Shaver *et al*., 1985) as well as high contents of acetic acids (Wilkins *et al*., 1971) and lactic acids (Mc Leod *et al*., 1970) have been attributed to the reduced intake of silage.

Ensiled cassava tops and guinea grass mixture increased total N supply and together with an increase in diet digestibility would have contributed to better performance in the supplemented groups. According to several authors it is likely that the increasing CP intake leads to an increased bacterial population in the rumen, thereby increasing the availability of fermentable nitrogen, and later to an improved digestion of fibre in the rumen (McDonald *et al*., 1998; Ash,1990; Khang and Wiktorsson, 2004).

Feed type is an important factor that affects sheep growth and performance. Andrews and Orskov (1970) reported that ADG of growing lambs improved as dietary protein level increased in the diets. Our observation on the influence of CP content on ADG is in agreement with Kanjanapruthipong and Leng (1997), Warly *et al*. (1994), Hossain *et al*. (1995) and Thu and Uden (2001) who reported that the level of protein in the diets would improve DMI, digestibility and maximizes efficiency of microbial cell synthesis in the rumen for live-weight gain.

According to FAO (1995), the energy value of silage and the efficiency of its utilization, are largely determined by the relative balances of glucogenic energy, long chain fatty acids and essential amino acids absorbed by the animal. It could then mean that this diet contained a balance of nutrients, which efficiently interacted to give the highest average daily gain. Sainz

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and Wolff (1990) reported that the rate of fat deposition relate more to the amount of energy available in excess of requirements for maintenance and lean growth. Variation in average daily gains of the rams could be attributed to variation in nutrient supply in the silage (Oddy and Sainz, 2002). Daily body weight gain (g/d) ranged between 30.9 to 41.7 g/d but lower than findings of Marjuki *et al., (2008*) who reported between 41.4 to 45.0 g/d. Feeding cassava leaf silage has been reported to increase body weight gain (Nhi *et al.*, 2001 and Bunyeth and Preston, 2006). Alli-Balogun *et al.*, (2003) fed 1.0% and 1.5% of body weight equivalent of cassava leaf to Yankasa sheep as supplement to Gamba grass and recorded weight gain of 39.2-41.2 g/d. Andrews and Orskov (1970) reported that ADG of growing lambs improved as dietary protein level increased in the diets. Our observation on the influence of CP content on ADG is in agreement with Kanjanapruthipong and Leng (1997), Warly *et al*. (1994), Hossain *et al.* (1995) and Thu and Uden (2001) who reported that the level of protein in the diets would improve DMI, digestibility and maximizes efficiency of microbial cell synthesis in the rumen for live-weight gain.

Food and agriculture organization (1995) classified digestibility of feed as; high (> 60%), medium (40-60%) and low (< 40%). Apparent digestibility was high for all the nutrients except the medium value obtained for ash. The Dry matter digestibility (DMD) in the present study was higher than the value (71% DMD) obtained by (Wanapat *et al*., 1997) for cassava tops hay and 50% DMD observed by (Man and Wlktorsson, 2001). This difference could be as result of stage of maturity, preservation method and additive inclusion may explain the difference. The higher crude protein (CP) digestibility of animals fed with the different silage could be attributed to the amount of cassava tops which is the primary source of protein in the diet. The high intake resulting in higher protein digestibility may be connected to the nature of the silage. High crude protein in the diet has been considered an important factor that enable high intake of the silage Crude protein digestibility was higher than 47.2% reported by Taiwo *et al*., (1995). Digestibility of CP often increases as CP intake decreases because metabolic faecal N usually makes up a larger part of faecal N at low intake than at high intake (Wheeler *et al.*, 1975). The daily DM intake and apparent DM digestibility showed a continuous increase with increasing levels of wilted cassava foliage in the diets which is a logical consequence of the increasing CP content in the diet. Ash digestibility signifies that animals were able to utilize the mineral in the feed efficiently. The improved nutrient digestibility of the ram might be due to their relatively low fibre but high nitrogen content that facilitated the growth and activity of rumen microorganisms (Adu and Olaloku,

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1976). The different silage mixture had CP that supported high DMI, digestibility and possibly microbial protein synthesis.

The TDN obtained in this study was above the TDN values of 70.6%, 70.7% 66.7% from corn silages (Nishida *et al*., 2007). This suggests that cassava tops based silage compares favourably with silage made from corn in terms of TDN and can serve as an alternative replacement to the expensive conventional corn silage there by reducing the cost of production.

Haematology and blood biochemistry measurements may vary depending on factors such as sex, age, weather, stress, season, pregnancy status and physical exercise (Kaneko *et.al*., 1997). Significant changes in these parameters are used to draw inference in clinical investigation. It may give some insight as to the animals' production performance potential. PCV and Hb levels indicate the nutritional status of the animal. Mean PCV values obtained in this study were within the range of 21 – 35 % reported by Daramola *et al*. (2005). This finding suggested that WAD sheep have the tendency for compensatory accelerated production (CAP) of PCV in case of infection and stress. Compensatory accelerated production has been shown to return PCV to normal level following infection (Dargie and Allonby, 1975). Comparative studies showed that PCV varies proportionatately with serum protein; this suggested that PCV is beneficial in assessing the protein status and possibly forecasting the degree of protein supplementation in sheep at different physiological states. The total WBC count was higher in this study than values obtained for Red Sokoto goats (Tambuwal *et al*., 2002), cattle in Nigeria (Oduye and Fasanmi 1971) and Nigerian buffaloes (Olusanya *et al* ., 1976). The value of WBC obtained for all rams depict absence of infection since elevation of WBC suggest infection by microorganism especially bacteria (Meyer and Harvey, 1998). However, the values obtained in this study fell within the broad range recorded for Red Sokoto goats (Tambuwal *et al.,* 2002) and cattle (Benjamin 1978; Schalm *et al.,* 1975) and suggestive of well developed immune system of the WAD sheep to proffer good health. Haemoglobin (Hb) concentration in this study fell within the range of high values obtained for Red Sokoto goats (Tambuwal *et al,* 2002). West African Dwarf sheep seem to possess relatively high Hb values, and this is an advantage in terms of the oxygen carrying capacity of the blood. This higher RBC values that were observed in the intensively managed goats in the present study may be due to higher plane of diet and veterinary care given to them. Rekwot *et al.* (1987) observed that White Fulani that were fed with high

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protein diet (14.45% crude protein) had higher erythrocyte values than those on low protein diet (8.51%).

WAD sheep seem to possess protective system, providing a rapid and potent defense against any infectious agent and this is probably the physiological basis for the adaptation of this species to this ecological zone characterized by high prevalence of diseases. The values of the PCV, HB, RBC, and WBC obtained for the Ram fed ensiled cassava tops and guinea grass with different additives were within the physiological normal range (PCV:19.00-38.00 %) (Hb 8.00-14.00gm/dl)(RBC 8.00-18.00*10^{-6}ml)(WBC 4.00-13.00*10^{3}ml)(MCHC: 32-38%), (MCV: 10.2-11.0fl) and (MCH, 30-32pg) (Mitruka and Raswnley, 1977).

Wide variation in leucocytes number is a reflection of the leucocytes' response to infection. Lazzaro (2001) noted that depressed level of lymphocytes might indicate either an exhausted immune system or elevated neutrophil level in an active infection in sheep, like other ruminants there are more lymphocytes than neutrophils in circulation (Olusanya *et al*., 1976).Osueni (2001) and Lazzaro (2001) observed an increase in neutrophils and this is associated with a decrease in lymphocyte and vice versa. Neutrophils and lymphocyte have been noted to fight pathogens once they have passed the barrier of the shin into the cell (Politis *et al.*, 2002) therefore increase number will increase immunity, thus suggestive of a well developed immune system in the WAD sheep with such number of immune cells to offer good health.

According to Otesile *et al*. (1991) serum biochemistry is a generalized medium of assessing the health status of animals. Differences in serum biochemical parameters may be caused by nutrition, environment and hormonal changes (Chineke *et.al*., 2002). Concentration of blood components of sheep were used to monitor nutrient status (e.g. serum glucose) and blood urea nitrogen (BUN) and associated muscle mass (e.g. creatinine). Glucose is one of the metabolites measured as an indicator of the energy status of the animal. Normal glucose levels in the ram indicate adequate synthesis in the liver from propionate metabolism as the major glucose precursor (Houtert, 1993). Fisher *et al*. (1974) reported that the concentrations of blood glucose and protein albumin are respectively the preferred indicators of adequacy of diets in terms of energy and protein. Based on the different dietary regimes it could be concluded that the efficiency of utilization of available dietary protein and energy were responsible for the variations in the concentration of blood glucose of the ram.

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Concentration of specific blood components have been used to monitor nutrient status (e.g. serum glucose and blood urea nitrogen [BUN], Hammond *et al*., 1994) and have been associated with overall muscle mass (e.g. creatinine, Morgan *et al*., 1993; Myer *et al*., 1996) in ruminants.

Serum proteins are important in osmotic regulation, immunity and transport of several substances in the animal body (Jain, 1986). Blood urea N is an indication of efficiency of utilization of dietary protein. Eggum (1989) reported that the blood urea N is highly inversely correlated with net protein utilization. Ruminants are not efficient utilizers of dietary protein (Beever, 1982). A positive correlation exists between level of protein (N) intake and BUN concentration (Pfander *et al*., 1975; Preston *et al*., 1965; Karnezos *et al*., 1994). In ruminants, BUN can be influenced by dietary N-to-energy ratio, level of forage intake, and protein degradability in the rumen (Hammond *et a*l., 1994). Feeding cattle on a low nutritional plane decreased metabolic body rate and the required maintenance energy (Hornick *et al.,* 2000). The BUN concentration in ruminants has been used as an indicator of excess N consumption relative to energy (Hammond *et al*., 1994). This explains why the urea N of the rams fed the different silages had high average daily gain because nearly all the ingested protein is used for protein synthesis (Kaneko, 1989). A high level of serum urea has been attributed to excessive tissues protein catabolism associated with protein deficienecy (Oduye and Adadevoh, 1976). The concentration of blood urea-N concentration (BUN) was higher in sheep on silage with sugar additive than others. BUN concentration of the rams was higher than values reported by Adegbola *et al*. (1987) and Aregheore and Oluokun (1989) for the West African Dwarf sheep. Diets may be implicated for the variations in BUN concentration of the West African Dwarf sheep used.

Enzymes are protein catalysts present mostly in living cells and are constantly and rapidly degraded although, renewed by new synthesis (Coles, 1986). According to Zilva and Pannall (1984), normal enzyme level in serum is a reflection of a balance between synthesis and their release, as a result of the different physiological processes in the body. Transaminase enzymes are those mostly responsible for the synthesis of non-essential amino acids through the process known as transamination according to Carola *et al*. (1990). In this study, a wide range in the observed value for the transaminases could be an indication that the silage did not differ in their effects on enzyme secretion mechanism. According to Keele and Neil (1971), serum levels of AST are significantly high under disease and morbid conditions

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involving injuries to large numbers of metabolically active cells. However, the result of this study suggests a contrary situation in this regard thus indicating the potential of the silage in the feeding of rams. The ALP level can be influenced by Pregnancy, blood pH and disease (Kelly, 1974), the animal in this study were apparently healthy, non pregnant and these parameters could not have been influenced by these factors.

The values obtained for all the biochemical indices fall within the range quoted by Mitruka and Raswnley (1977). The values of the glucose, total protein, Serum albumin, Blood urea, AST, ALT and AlP obtained for the Ram fed ensiled cassava tops and guinea grass with different additives were within the physiological range (glucose: 55.0-131mg/dl), (total protein: 5.70 – 9.10g/dl), Albumin: 2.70-4.55g/dl), blood urea: 15.0-36.0mg/dl), (AST:40-123IU/l), (ALT:25-70IU/l) and (ALP:69.5-105IU/l) (Mitruka and Raswnley, 1977).

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CHAPTER SIX

6.0: CARCASS EVALUATION STUDY

Nutrition is the most important factor limiting livestock production in Nigeria while seasonal variation has an important influence on feed production. Inadequate nutrition occurs during dry season which forms impediment to the development of ruminant production in the tropics (Proverbs, 1990). This is due to long period of drought with attendant prevalence of inadequate and poor quality roughages for animal consumption (Bawala *et al*., 2006). It further lessens the animal's ability to withstand exposure to pathogenic organisms (Youseff, 1990) with concomitant reduction in performance which result into low dressing percentage.

In Nigeria, ruminant production is limited by the low quality of available grasses and straws especially in the dry season. Grains and other conventional supplements are too expensive for many resource-poor farmers due to the heavy competition between man and livestock industries for these conventional feed sources. The inability of livestock keepers to meet the nutrient requirements of animals and protein intake in particular is the militating factor that leads to reduced per caput protein intake of the human populace. To ameliorate this deficiency and increase animal protein and/or productivity, preservation of forages during period of abundance and when the nutrient content is high is necessary.

The high crude protein content of cassava leaves and the year round availability are reasons for believing that silage made from them could be a source of feed for ruminant animals. This experiment was designed to determine the effect of ensiled cassava tops and Guinea grass mixture on the carcass quality of West African dwarf sheep.

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6.2 Materials and methods

6.2.1 Experimental Sites

The study was carried out at the Slaughter house of the Teaching and Research farm of Ladoke Akintola University of Technology, Ogbomoso

6.2.2 Slaughter procedure and carcass evaluation:

After the 135-day feeding trial in experiment 5, 10 rams were randomly selected from all 25 experimental animals (2 animals /treatment) and were sacrificed for the carcass evaluation study.The rams were starved for 12 hours and weighed prior to Slaughter. The animals were bled by cutting the throat and then Slaughtered by severing the head at its articulation with the atlas. The dressed carcasses were weighed after 24 hours chilling in a cold room maintained at -5^{o}C. The chilled carcass weight divided by the live weight before Slaughter and multiplied by 100 was given as the dressing-out percentage. The chilled carcass weight was taken as the weight of the animal after the removal of the head, skin, thoracic, abdominal and pelvic cavity contents (including the diaphragm and the kidneys) and the limbs distal to the carpal and tarsal joints after storing in a chilling chamber for 24 hours. Other carcass components, organs and muscles were also weighed.

The procedure of Palsson (1939) as adopted by Omojola and Attah (2006) for the jointing of the carcass for lambs was followed. The frozen carcass was divided down the spinal column using a meat band saw. Each half was weighed. The left was divided into the following cuts. The leg (thigh) was severed at the attachment of the femur to the acetabulum. The loin consisted of the lumbar region plus a pair of ribs and the ends (spare ribs plus belly) of six abdominal ribs. The shoulder consisted of the scapula, humerus, radius, ulna, carpals and the sets which are made up of the breast and the neck. Each of the cuts was weighed and the weight was doubled in each case before being expressed as a percentage of the chilled carcass weight. All body components such as head, skin, kidneys, liver, heart, lungs and spleen were weighed and classified in terms of their respective percentage with respect to live weight of the animal. Carcass length (CL), depth of chest was measured. Carcass length was recorded from the cranial edge of the symphysis pelvis to the cranial edge of the first rib.

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6.3 STATISTICAL ANALYSIS

The data obtained were subjected to analysis of variance (ANOVA) technique of statistical analysis system (SAS) and Duncan multiple range test was employed for mean separation.

Experimental model of the design was: $Y_{ij} = \mu + \alpha_i + \Sigma_{ij}$

Where: Y_{ij} = Individual observation

μ = general mean of the population

α_i = treatment effect

Σ_{ij} = composite error effect.

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6.3 Results

Table 22 shows the carcass measurement in WAD sheep fed ensiled cassava tops and Guinea grass mixture with different additives. Carcass length and hot carcass weight were not significantly ($p>0.05$) affected by the different silages fed. Carcass from rams on silage with no additive had the highest (28cm) and the lowest from those fed silage with millet additive (25.5 cm). Hot carcass weight ranged between 15.08 -17.08 cm, Empty body weight, Depth of chest and Dressing percentage were significantly affected by the silages fed. Empty body weight ranged between 8.75 and 9.88 Kg. Depth of chest was highest (11.5cm) in carcass from rams fed silage with cassava chips and lowest in those fed sorghum additive (10.50 cm). The dressing percentage was also significantly affected by the different silages. Rams fed silage with Cassava Chips additives had the highest percentage (53.77 %) which was similar to those fed millet additive (51.99%) and without additives (52.03%). Rams fed on silage with sorghum additives had the lowest Dressing percentage (50.89%)

Table 23 shows the body weight, carcass and wholesale cut of WAD sheep fed ensiled cassava tops and Guinea grass mixture with different additives. Live body weight ranged between 17.25 and 19.00 Kg. Values of the warm carcass ranged between 8.75 and 9.88 Kg. Carcass from rams on cassava chips (9.88 Kg), millet grain (9.88 Kg) and no additives (9.75 Kg) were similar but significantly different from those fed silage with sorghum (9.25 Kg) and sugar additives (9.88Kg). The legs gave the highest percentage (34.32 – 36.82%). This was followed by shoulder (23.05 – 24.44%), rack (18.58 – 22.54%) and loin (12.00 – 14.85%) in that order. The leg and the shoulder were however not significantly affected ($P>0.05$) by the different silages fed but the Rack, Neck, Brest and Flank were significantly ($P<0.05$) affected. The percent weight of leg neck, shoulder and breast were higher in rams fed silage with Sugar additives while that of rack was highest ($P>0.05$) in Rams fed silage with Cassava chips additives while that of the loin was highest ($P>0.05$) in rams fed silage with millet additives.

Table 24 shows the percentage of external offal, internal offal and blood as influenced by ensiled cassava tops and Guinea grass mixture with different additives. The percentage of the head and the feet were not significantly affected but the skin was significantly affected by the different silages. The percent weight of skin relative to slaughter weight was highest in rams fed silage with millet additives and the control thought similar to those fed silage with

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sorghum and sugar additives. The proportion of feet relative to Slaughter weight followed the same pattern in skin. It ranges from 3.27 to 3.59 in the same animal with the same treatment.

The heart, kidney, spleen and pancreases were not significantly ($P<0.05$) affected by the different silages. The liver and the testis were however significantly affected ($P>0.05$). The values obtained for the liver indicated that there was a significant increase in the liver weights of those rams on silage with cassava chips, Sorghum, millet and control but significantly different from those fed silage with sugar additive.

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Table 22: Carcass measurement in WAD sheep fed ensiled cassava tops and Guinea grass mixture with different additives

Parameter	**60 % GG + 30 % CF+ 10% cassava chips**	**60 % GG + 30 % CF+ 10% Sorghum grain**	**60 % GG + 30 % CF+ 10% millet grain**	**60 % GG + 30 % CF+ 10% sugar**	**60 % GG + 40 % CF+ 0% additive**	**SEM**
Carcass length (cm)	25.5	26.5	25.5	26	28	0.85
Hot carcass weight (kg)	16.76	16.68	17.08	15.08	17.05	0.71
Empty body weight (kg)	9.88^{a}	9.25^{b}	9.88^{a}	8.75^{c}	9.75^{a}	0.15
Depth of chest (carcass) (Cm)	11.50^{a}	10.50^{c}	11.25^{ab}	11.00^{abc}	10.75 ^{bc}	0.2
Dressing %	53.77^{a}	50.83^{b}	51.99^{ab}	50.89^{b}	52.03^{ab}	0.81

^{ab} means on the same row with different superscripts are significantly different (P<0.05)

GG- Guinea grass, CT- Cassava top

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Table 23: Body weight, carcass, and some wholesale cuts proportion as influenced by ensiled cassava tops and Guinea grass mixture with different additives

Parameter	60 % GG + 30 % CF+ 10% cassava chips	60 % GG + 30 % CF+ 10% Sorghum grain	60 % GG + 30 % CF+ 10% millet grain	60 % GG + 30 % CF+ 10% sugar	60 % GG + 40 % CF+ 0% additive	SEM
Live (body) wt. (kg)	18.38	18.25	19	17.25	18.75	0.56
Warm carcass (kg)	9.88^{a}	9.25^{b}	9.88^{a}	8.75^{c}	9.75^{a}	0.15
Leg (% carcass)	36.82	36.75	36.34	38.05	34.32	1.55
Loin (% carcass)	12.23^{bc}	12.00^{c}	14.85^{a}	14.06^{abc}	14.23^{ab}	0.65
Rack (% carcass)	18.90^{a}	18.17^{ab}	17.88^{ab}	16.53^{ab}	15.60^{b}	0.78
Neck (% carcass)	10.71^{bc}	11.72^{ab}	10.39^{c}	12.15^{a}	11.89^{ab}	0.37
Shoulder (% carcass)	23.66	23.05	23.64	24.44	23.52	1.03
Breast (% carcass)	10.11^{a}	12.47^{a}	12.01^{ab}	12.63 ^{a}	12.24^{a}	0.62
Flank (% carcass)	4.05^{a}	3.26^{b}	3.68^{ab}	3.43^{ab}	4.06^{a}	0.2

^{ab} means on the same row with different superscripts are significantly different (P<0.05)

GG- Guinea grass, CT- Cassava top

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Table 24: Percentage of external offal, internal offal and blood as influenced by ensiled cassava tops and Guinea grass mixture with different additives

Parameter	60 % GG + 30 % CF+ 10% cassava chips	60 % GG + 30 % CF+ 10% Sorghum grain	60 % GG + 30 % CF+ 10% millet grain	60 % GG + 30 % CF+ 10% sugar	60 % GG + 40 % CF+ 0% additive	SEM
Head (% live wt)	8.38	8.17	7.85	7.98	8.24	0.19
Skin (% live wt)	7.42^{b}	7.55^{ab}	8.07^{a}	7.80^{ab}	8.09^{a}	0.18
Feet (% live wt)	3.33	3.46	3.47	3.59	3.27	0.13
Testes (% live wt)	1.49^{b}	1.82 ^{ab}	1.43^{b}	1.53^{b}	2.00^{a}	0.12
Blood (% live wt)	4.70^{a}	5.40^{a}	4.67^{b}	5.10^{ab}	4.90ab	0.17
Heart wt(% live wt)	0.53	0.52	0.52	0.52	0.52	0.04
Lungs (% live wt)	1.33	1.44	1.69	1.36	1.45	0.14
Liver (% live wt)	1.72^{a}	1.75^{a}	1.70^{a}	1.52^{b}	1.69^{a}	0.03
Kidneys (% live wt)	0.28	0.32	0.32	0.32	0.28	0.01
Spleen (% live wt)	0.23	0.18	0.21	0.21	0.22	0.02
Pancrease (% live wt)	0.52	0.31	0.57	0.25	0.43	0.11

^{ab} means on the same row with different superscripts are significantly different (P<0.05)

GG- Guinea grass, CT- Cassava top

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6.2 DISCUSSION

Dressing percentage is the proportion of the live weight of the animal which is sold as meat. It is a trait of economic importance. The dressing percentage of sheep in this study is higher than values given by Gatenby (2002), who gave dressing percentage to be between 40 and 50% but within the range given by Aduku and Olukosi (2000) who gave dressing percentage of sheep to be between 45 and 65%. Values reported in this study 50% dressing percentage reported as standard for lamb carcass by Ashbrook (1995). Kayouli *et al.* (1993) investigated the feed intake and performance of growing lambs. Carcass yield was 47.5% for lambs on silage while those on concentrate was 45.1%. Increasing dressing percentage may be due to sex, breed, degree of fatness, age, pre slaughter weight, gut fill, slaughter by product and nutrition. Nutrition is the most important factors because animals on good plane of nutrition dress better (Warriss, 2000). Heavily muscled and blocky animals dress higher while pregnant ones particularly those in advance stage of pregnancy dress lower (Alaku,1997)

Factors affecting Dressing percentage are fill or gut content, place of nutrition, sex of animals, high weight and pregnancy. Animals on high plane of nutrition have higher dressing percent than poorly fed animals which was manifested in this study. Also, males animals usually dress higher than female animals. In this experiment, only male animals (Rams) were used. Also animals in this experiment were skinned hence dressed higher.

The percentage weight of the skin relative to slaughter weight was highest in rams fed silage with millet additives with a value of 8.09%. The skin by inference contributed between 7.42 and 8.09 to the amount of meat consumed when such ram in singed and a similar proportion is reduced when skinned.

The leg gave the highest percentage(34.32-38.05) followed by shoulder(23.05-24.44), rack (18.58-22.54), loin (11.20-14.85), neck (10.39-12.15), breast (10.11-12.63) and flank (3.26-4.06). The percentage weight of leg and shoulder were higher in silage with sugar additive while that of rack was highest in rams fed silage with cassava chips additives The relative weight of neck has highest value in rams fed silage with sugar additive. The various wholesale cuts were significantly influenced by the different silages. This indicates proper tissue development as a result of good nutrient intake and utilization

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The relative values for internal organs were not significantly different except for the liver. The values obtained for the liver indicated that there was a significant difference in the liver weight of the ram fed silage with sugar additive. This result is in agreement with result of Ani and Okeke (2003) and Abeke *et. al.* (2009) who reported increase in weights of liver and few organs like pancrease having fed diets containing unconventional feedstuffs processed by cooking roasting and fermentation.

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CHAPTER SEVEN

7.1 SUMMARY, CONCLUSION AND RECOMMENDATION

7.2 SUMMARY

The feeding quality of ensiled cassava tops, a crop residue available all year round with Guinea grass mixture was investigated in these series of studies. Cassava, an all season crop grown as food in all ecological zones of Nigeria, and used mostly as a source of food for man and his livestock. Its leaves which elsewhere are left to rot away on the field if collected at harvest time contain high level of protein and could be used as a protein supplement in ruminant feeding systems.

Cassava tops and Guinea grass was ensiled with four energy additives (cassava chips, sorghum, Millet grains and sugar) and after 42 days, silage characteristics, chemical composition were analysed. Acceptability of the silage by West African Dwarf sheep was investigated using the Coefficient of Preference (CoP). Effects of length of storage on silage characteristics, chemical composition and nutritive value of silage were assed using the *in vitro* fermentation techniques over a period of six months (72, 102, 132, 162, 192 and 222 days). A feeding trial was also carried out to access the utilization of ensiled cassava tops and Guinea grass by 20 West African Dwarf sheep over 135-days. Carcass evaluation of the West African dwarf sheep fed the different silages was also done. The experiments were replicated and standard methods were utilized in their designs analyses and execution

Silage characteristics showed that the colour of the silages was olive green with pleasant odour, firm texture and pH range of 4.3 to 5.1. The nutrient composition of the silages gave dry Matter (27.1-28.8%), crude protein (21.8-24.9%), ash (7.6-9.4%), neutral detergent fibre (68.8-71.7%) and acid detergent fibre (40.6-48.1%) which differed significantly among treatments. Silages with cassava chips (1.19), sorghum (1.11) and millet (1.09) additives were more acceptable as Coefficient of preference was above unity. After six months of storage, the different silages retained their olive green colour except for the silage with no additive that changed to brownish green, firm texture and fruity smell with pH with the range for good silage. The dry Matter (28.0-29.6%), crude protein (23.7-27.1%), ash (8.8-10.0%), neutral detergent fibre (57.9-71.5%), and acid detergent fibre (44.1-49.8%) were all significantly influenced by Length of Storage. Gas production (17.67-30.07 ml/96 hours), b (16.20-28.00ml), ME (6.09-7.68 MJ/kg DM),

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OMD (62.9-73.2%) and SCFA (0.48-0.78 mmol) were also significantly influenced by length of storage.

The daily dry matter intake (472.6-530.0 g/d) and dry matter digestibility (75.8-84.7%) differed significantly while daily weight gain and feed conversion ratio were similar among treatments. Heamatology and serum biochemistry revealed that the Packed Cell Volume, heamoglobin and Total Protein, albumin, urea, Aspartate amino transferase and alkaline phosphatase varied significantly and ranged from 27.0 to 33.7%, 9.0 to 11.2 g/dl, 6.08 to 8.20g/dl, 3.4 to 4 6g/dl, 11.8 to 13.7 mg/dl, 5.3 to 12.4IU/l and 49.2 to 90.7 IU/l respectively. Dressing percentages ranging from 50.8 to 53.8% were significantly different. The wholesale cuts (loin; 12.0-14.9%, rack; 15.6-18.9%, neck; 10.3-12.1%), liver (7.4-8.1%) and skin (1.5-1.8%) were significantly different. Relative weight of leg, shoulder, head, feet and other organs were not significantly different.

7.3 Conclusion

The chemical constituents of ensiled cassava tops and Guinea grass mixtures were high suggesting that it can be used successfully in diets of small ruminants, especially during the dry season.Cassava tops and guinea grass mixtures can be preserved successfully for six months and will still be a good feed resource for fattening rams without any serious effect on its nutritive value. However, to make excellent silage, a relatively cheap and available nutrient additive such as millet, cassava chips or sorghum may be needed.

The results from this study have demonstrated that ensiled cassava tops and guinea grass mixture with different additives promote efficient nutrient utilization and performance by WAD sheep. Suggesting its usefulness as nutritious and palatable diets for ruminants. Since optimal performance of animals fed with ensiled cassava tops and guinea grass mixture affirms the efficiency of the diets to the animals. It can thereby be concluded that supplementation of cassava chips as an additive in ensiled cassava tops and guinea grass will improve the performance of the WAD rams. The silages offered had no negative effect on the haematological and serum biochemical constituents of the rams and no clinical signs of diseases were shown throughout the period of the experiment.

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7.4 RECOMMENDATION

Since cassava tops is available all year round in Nigeria, it can be preserved as silage (for ready use) and it will go a long way to sustain ruminant animals during the off-season. The use of suitable additives like cassava chips, millet grain and sorghum that can furnish readily fermentable carbohydrates is a pre requisite to proper ensiling process, though such use will depend on availability and cost. There is the need to be mindful of the stage of growth of the grass for silage production because guinea grass losses its nutrients as it grow older.

The positive response in terms of improved weight gain, intake and digestibility of nutrients by the rams indicates a sustainable feedstuff for ruminants. Therefore cassava tops and Guinea grass silage can be recommended to the farmers because it produces animal with high dressing percentage which is of importance to the butcher. The excess grass during the raining season can be preserved as silage for use in feeding animals during the dry season when the grass is very low in quality and quantity. This is also economical and saves the farmers stress of buying conventional feeds during this period thereby increasing their productivity and profit.

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