PERFORMANCE OF GROWING AND LACTATING SOKOTO GUDALI CATTLE FED ENSILED ELEPHANT GRASS, WET BREWER'S GRAIN AND GLIRICIDIA FOLIAGE

BY

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A THESIS IN THE DEPARTMENT OF ANIMAL SCIENCE SUBMITTED TO THE FACULTY OF AGRICULTURE IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE DEGREE OF

DOCTOR OF PHILOSOPHY
UNIVERSITY OF IBADAN.

JULY, 2021

CERTIFICATION

I certify that this work was carried out by **Mr. Mofoluso Adewunmi Adesina** in the Department of Animal Science, University of Ibadan, under my supervision.

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DEDICATION

To My Lord and Saviour, Jesus Christ and all that follows Him in spirit and in truth.

ACKNOWLEDGEMENTS

I thank the Almighty God for my life and for provision of the resources with which this research was carried out. To Him be the glory.

My profound appreciation goes to my supervisor, Dr. Olorunnisomo O. A. for his support during the design, conduct and reporting of this work. Your patience and thoroughness are virtues that will ever remain with me. God bless you sir.

I am also indebted to my Lecturers in the Department of Animal Science for their enormous contributions to this work in the course of the Post graduate seminars. Your objective criticisms and guidance helped in no small measure to get the work to completion. Special mention must be made of the immediate past Head of Department Prof. A. E. Salako and the current Head of the Department Prof. D.O. Adejumo for making Post graduate study at the Department as comfortable as possible. Worthy of special appreciation are Prof O.O. Tewe (Late), Prof. O. J. Babayemi, Prof. M. K. Adewumi, Prof. A. B. Omojola, Prof. Olubunmi Olusola, Prof. T.O Ososanya; Drs. O. O. Ogunwole, A. O. Adebiyi, R.B. Omidiwura, Favour Agboola, Bosun Odu, Funmilayo Adeleye, O. A. Sokunbi, O.A. Abu, for their encouragement and very useful tips.

I also want to thank the entire post graduate students of the department of Animal Science for their encouragement and brotherliness.

I am immensely grateful to the authorities of National Agricultural Extension and Research Liaison Services (NAERLS) Ahmadu Bello University for the opportunity to undergo this study. Mr. Kunmi Adedokun and the entire South West Zonal staff are also appreciated for their understanding that "Eze must go to school" during this research work.

I also wish to appreciate my friends who constantly and "aggressively" pushed me on to finish this work: Professor and Dr. (Mrs) Adewunmi Dedeke, Professor Banky, Dr. Funmi Ogunleke, Prof. & Dr. (Mrs) Amos Adeleye. May God continually lift you up.

I owe a debt of gratitude to my parents Mr. Caleb Adesina and Late Mrs. Funmi Adams (Nee Isau) who taught me not to give up on my dreams. I also wish to appreciate my Senior Sister Mrs. Olusola O. Oludele for believing in me and looking forward to the successful completion of this work. My immediate junior sister Late Mrs. Olajumoke Toluade Adediran Nee Adams deserved a special appreciation for making me to understand that all eyes are on me and that I could not afford to fail to set examples for others to follow. I know what joy this would have brought to you but God knows best. My brothers; Doyin and Yemi Adams and sisters; Mrs ‘Bimpe Amu and Mrs. ‘Seun Afolabi are appreciated for their prayers and undestanding.

I am also indebted to the Pillars of Spiritual support that God gave me in Chrysolite Christian Evangelical Ministry, Drs. Michael Omotoso, Christianah Omotoso and Ephraim A. Ojo. May the work of the Kingdom continue to flourish in your hands in Jesus name.

The staff of the Teaching and Research Farm (Dairy Unit) of the, University of Ibadan are well appreciated for their co-operation and Support. Mr. Abe the supervisor, Mr. Tosin Williams, Mr. Adam Ado, Mr. Danladi, Mr. Abubakar, Baba Biu, and Baba Yeri – I thank you all. I must need appreciate the co-operation of the experimental animals used in this study. We became real friends and I am beginning to miss you all. Sera, Sauda, Stella, Susan, Suzi, Late Big Sam (Dr. Olorunnisomo’s Experimental animals), also from the general herd 275, 277, 363, 371, 372, 373 and 376- you were simply the best.

It is also with a grateful heart that I acknowledge the guidance of an Angel in the person of Dr. Kike Ilori who painstakingly guided me through the turnitin process and the formatting of the draft thesis. Your dedication to duty and strict adherence to rules gives hope of a better Nigeria. May the Lord bless you and increase your area of influence. Nigeria will be better with many more people of your disposition.

Finally, a deep appreciation goes to my soulmate and best half, my “Olori” Julianah Adejoke Adesina ACA, (a.k.a. Mama Adewunmi). Words will fail me to pen your contributions to this work, you sacrificed a lot to make this happen. You are a rare gem. My children, Debra Toluwanimi and David Ayomikun are also well appreciated for their understanding and support in the course of this work. I pray I’ll be able to make it up to you somehow. May you be greater than our imaginations in Jesus’ name

ABSTRACT

Forage conservation through ensiling is used to provide feed for cattle during the dry season. Low protein content of grass silages limit their utilisation which could be improved by ensiling grass with high protein feedstuffs like Wet Brewer's Grain (WBG) and Gliricidia Foliage (GF). There is dearth of information on the utilisation of combined WBG and GF ensiled with Elephant Grass (EG) on performance of Sokoto Gudali (SG) cattle. Hence, the performance of SG cattle fed EG enhanced with WBG and/or GF were assessed.

Four iso-nitrogenous silages: T_1- (EG control); T_2- (EG +WBG); T_3- (EG +GF); T_4-(EG +WBG + GF) were prepared using standard procedures. Physical characteristics (pH, colour, aroma, texture) and chemical composition [Dry Matter (DM); Crude Protein (CP) and fibre fractions] of silages were determined at day 22. The Coefficient of Preference (CoP) of the silages were determined using six SG heifers following standard procedures. Another 12 heifers were housed in individual pens and adapted for total faecal collection for the determination of digestibility. Dry Matter Intake -DMI (kg/day) and Daily Weight Gain-DWG (kg/day) were assessed in an 84-day trial using 16 SG heifers in a completely randomised design. In another 120-day feeding trial, 16 multiparous SG cows were allocated in a randomised complete block design to the diets. Daily Milk Yield –DMY (kg/day), Milk Composition (MC) were determined and the Feed Conversion Ratio (FCR) calculated. Data were analysed using descriptive statistics and ANOVA at $\alpha_{0.05}$.

Silage pH ranged from 3.90 to 4.90; colour varied from olive to deep green. Aroma was pleasant to very pleasant and texture was firm for all silages. The DM of 28.7±0.3% (T_2) was significantly higher than 26.9±0.3% (T_4), 26.4±0.2% (T_1), 25.3±0.3% (T_3) while CP ranged from 24.1±0.2% (T_1) to 25.1±0.3% (T_3). The neutral detergent fibre of T_1 (52.1±0.8%) was significantly higher than 48.7±0.3% (T_3), 42.0±0.1% (T_4) and 38.4±0.5% (T_2) while acid detergent fibre were 28.9±0.1% (T_1), 23.9±0.3% (T_3), 21.8±0.1% (T_4) and 20.0±0.1% (T_2). The acid detergent lignin ranged from 8.50±0.1% (T_2) to 11.0±0.1% (T_3). The CoP were 0.65 (T_3), 0.96 (T_1), 1.01 (T_4) and 1.38 (T_2), indicating that only T4 and T2 were acceptable to the cattle (CoP >1). Digestibility of T_2 (70.88 ±0.7) was significantly higher than T_1 (60.40±0.9), T_3 (65.78±0.3) and T_4 (68.41±0.4). The DMI of 4.76 (T_1), 4.79 (T_3), 5.23 (T_4), 5.49 (T_2) differed significantly showing that the consumption of T_2 was higher. The DWG of animals on T_3 (0.61±0.01), T_4 (0.61±0.02) and T_2 (0.62±0.01) were similar but all differed significantly from T_1 (0.49±0.01). The DMY of animals on T_2 (5.11±0.3) was significantly higher than T_4 (4.80± 0.1), T_3 (4.40±0.1) and T_1 (3.86±0.1) while the milk composition were similar. The FCR (Milk) were 1.91 (T_3), 2.02(T_4), 2.05 (T_2) and 2.31 (T_1) suggesting that T_3 was superior to other diets.

Sokoto gudali heifers fed silage of elephant grass with wet brewer's grain and Gliricidia foliage had improved digestibility, better weight gain and enhanced milk yield.

Keywords: Spent grain, Tropical grass, Leguminous foliage, Zebu cattle, Silage, Milk Production

Word count: 485

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CHAPTER ONE
INTRODUCTION

1.0 Background

Shortage of livestock feeds and the low nutritional quality of available feeds are the major limitations to the productivity of livestock in Sub-Saharan Africa. Natural pastures and crop residues are the main feed of ruminants in tropical Africa (Tchinda *et al*., 1993). In the dry season, available natural pastures and crop residues are fibrous and lacking in essential nutrients (proteins, carbohydrate, minerals and vitamins) which are needed for improved performance through increased rumen microbial fermentation in the host animal (Dixon and Egan, 1987; Osuji *et al.,* 1995).The most limiting nutrient for all-year round utilization of the natural pasture and crop residues is crude protein (Sarnklong *et al*., 2010). Most of the natural pastures and crop residues are known to contain less than 6% crude protein, which is below the minimum required by rumen micro-organisms to thrive (Norton, 2003).The genetic potential of Zebu cattle for milk production still generates a number of dissenting views or opinions. Some authors (Bajwa *et al*., 2004; Zafar *et al.,* 2008 and Dongre *et al.,* 2011) reported yields of 1183 - 2585 kg per lactation for Sahiwal breed while lactation yields of 295kg to 650kg was reported for zebu cattle in Nigeria under extensive system of management (Das 1999, Boly *et al.,* 2001, Bayemi *et al.,* 2005, Yilma *et al.,* 2006, Idris *et al.,* 2011). These indicated that zebu breeds can yield more milk if properly selected, fed and managed.

A sustainable feeding system in warm climates must involve the use of diverse local biological resources (Roggero *et al*., 1996). This concept clearly makes a strong case for the utilization of fodder trees, grass species and agro-industrial by products as animal feeds. It is also pertinent to explore preservative technologies to conserve nutrients in fodders and agro-industrial by products from the period when feed is in abundance till the period of feed scarcity.

These feed resources can be preserved by ensiling them singly or in various combinations to supply good quality nutrition for the animals during the period of feed scarcity. Ensiling and hay making have been used extensively to preserve herbage all over the globe but each technology find practical application at different seasons . Hay making requires abundance of sunshine and as such is limited only to the dry season in the tropics while ensiling on the other hand can be done at all times but becomes the only choice during the rainy seasons.

Elephant grass (*Pennisetum purpureum*) is an important forage and pasture grass in the tropics, it is either cut for hay or fermented for silage in cattle feeding (FAO, 2013). Elephant grass is a choice grass for forage production in the alley cropping system of agroforestry and are also used as hedgerows for erosion prevention (Magcale-Macandog *et al*., 1998). Other uses include; as windbreak for horticultural crops and orchards, boundary mark between plots and properties (FAO, 2013). Humphreys (1994) indicated that the potential dry matter (DM) yield of elephant grass surpasses that of other tropical grasses. Wouters (1987) reported on-farm dry matter yield of about 16 tons per hectare per year with little or no fertilizer application. Schreuder *et al.,* 1993 however, reported yields varying between 10 and 40 tons dry matter per hectare depending on soil fertility, climate and management. Skerman and Riveros (1990) reported exceptionally high dry matter yields of up to 85 tons DM ha^{-1} under high rates of fertilizer application to elephant grass.

Production of cassava has been increasing in Nigeria since 1960. In 2014, Nigeria produced 54,831,600 tonnes (20% of total world production) making her the world's largest producer of cassava (FAOSTAT 48, and Ezeigbo *et al*., 2014).

Cassava peels accounts for about 22% of the raw root tubers (Nweke et al., 2002).This was corroborated by other authors (Jekayinfa and Olajide, 2007;; Kniper et al., 2007) with figures ranging between 10 – 20% of the raw cassava root. Cassava peel was considered unsuitable for feeding animal in large quantities because it contains a high amount of moisture and high concentration of cyanogenic glucosides (Ubalua, 2007). This is why the peels were sometimes dumped into the environment in order to decompose naturally. Indiscriminate dumping of cassava peels constitutes serious environmental pollution especially during the rainy season when larger quantities of the peels are produced due to increased harvesting. In recent times however, dried cassava peels have been incorporated into the diets of various livestock (Adesehinwa et al., 2016). Drying cassava peels is a means of conservation of the material, this is easily achieved during the dry season when there is adequate sunshine.

The need for the conservation of these feeding materials during the rainy season when they are produced in large quantities and at better nutritive value can not be over emphasized. Among the various methods of conservation, ensiling appears to be the most desirable because it does not require sunlight and low relative humidity conditions which are prevalent only during the dry season. Ensiling cassava peels and elephant grass with wet brewer's grain and gliricidia foliage offers a unique opportunity in ameliorating the protein deficiency in cassava peel and elephant grass, as well as removing the hydrocyanide contents of cassava peels with a view to providing high quality silage that can be fed for improved perfomance of ruminant animals in the dry season.

Evaluation of the nutritional value of our indigenous browse plants, trees, shrubs, agro and industrial by products is very important as they have great potential to contribute significantly to nutrition of ruminant animals (Cerillo and Juarez 2004, Dambe *et al*., 2015). Adequate data on the nutritional values of available biological resource is very important in the humid zones because the quality of available forage is always poor shortly after the rains (Delgado *et al.,* 1999).

1.1 JUSTIFICATION OF THE STUDY

- Current issues of farmers-herdsmen clashes in Nigeria have made intensive systems of production imperative.
- The use of elephant grass in an intensive system provides opportunity to meet nutrient demand for cattle on a year- round basis. Protein content in grass silage are however low and limits its nutritive value for growing and lactating cattle
- The short shelf life of the wet brewer's grain and the high moisture content are the critical problems of farmers utilizing the by-product. Ensiling wet brewer's grain and gliricidia foliage is a veritable means of conserving them and the prevention of environmental pollution in areas where breweries are located
- Ensiling elephant grass with high protein wet brewer's grain and gliricidia foliage may therefore enhance the nutritive value of composite elephant grass silage and improve milk production in zebu cattle.

1.2 STUDY OBJECTIVES

The general objective of this study was to assess the performance of growing and lactating Sokoto Gudali cattle fed ensiled elephant grass with wet brewer's grain and gliricidia foliage in a silage mixture.

The specific objectives were to evaluate:

- Silage characteristics and chemical composition of elephant grass ensiled with Wet brewer's grains and gliricidia foliage
- Acceptability and preference of Sokoto Gudali cattle for elephant grass ensiled with wet brewer's grains and gliricidia foliage
- Digestibility of ensiled elephant grass, wet brewer's grains and gliricidia foliage by Sokoto Gudali cattle
- Intake and growth rate of Sokoto Gudali heifers fed ensiled elephant grass, wet brewer's grains and gliricidia foliage
- Milk yield and milk quality of Sokoto Gudali cows fed ensiled elephant grass, wet brewer's grain and gliricidia foliage

1.3 General Outline of Study

The study was divided into two parts: physical and chemical evaluation of ensiled elephant grass, wet brewer's grain and gliricidia foliage and animal feeding trials. Physical and chemical evaluations involved silage characteristics, i.e., the evaluation of physical properties of different combinations of wet brewer's grain, gliricidia foliage; cassava peels and elephant grass silages and their chemical compositions. The animal feeding trial had four experiments. In the first experiment, the acceptability and coefficient of preference of different combinations of elephant grass ensiled with wet brewer's grain and gliricidia foliage by Sokoto Gudali cattle were determined. The second experiment was the determination of the digestibility of ensiled elephant grass, wet brewer's grain and gliricidia foliage by Sokoto Gudali heifers. The third experiment involved the determination of intake, Average daily Gain and feed conversion ratio of Sokoto Gudali heifers fed ensiled elephant grass, wet brewer's grain and gliricidia foliage. The fourth experiment in animal feeding trial was the milk yield and milk quality assessment of Sokoto Gudali cows fed ensiled elephant grass, wet brewer's grain and gliricidia foliage.

1.4 Hypotheses

H_{01}: There are no significant differences in the Chemical composition, silage characteristics and Acceptability of Elephant grass silage and Elephant grass ensiled with Wet Brewer's Grain and Gliricidia foliage

H_{A1}: There are significant differences in the Chemical composition, silage characteristics and Acceptability of Elephant grass silage and Elephant grass ensiled with Wet Brewer's Grain and Gliricidia foliage

H_{02}: The Digestibility, dry matter intake, Growth and milk production of Sokoto Gudali cattle fed Elephant grass silage and Elephant grass ensiled with Wet Brewer's grain and Gliricidia foliage were not significantly different.

H_{A2}: The Digestibility, dry matter intake, Growth and milk production of Sokoto Gudali cattle fed Elephant grass silage and Elephant grass ensiled with Wet Brewer's grain and Gliricidia foliage were significantly different.

CHAPTER TWO
LITERATURE REVIEW

2.1 Conservation of Fodder for Feeding Ruminants

Conserved forages can be used to feed livestock during periods of fresh forage scarcity. Forage scarcity may be caused by poor pasture growth or inadequate pasture conditions. Conserved forages can also be fed as a supplement (Romero, *et al.,* 2015). Conserved forages can be hay, haylage or silage. Several methods of conservation and storage of forages have been developed. The nutritive value of conserved forage are usually not the same with the fresh forage, a moderate to high reduction in nutrients is usually experienced. The reduction in the nutritive values of conserved forage is due to the fact that some nutrients are unavoidably lost during the process of conservation. The aim of forage conservation is to minimize losses. Nutrient loss starts immediately after cutting through the biochemical processes of respiration. The choice of conservation method is a function of the suitability of the forage material for that method, the weather conditions, storage capability and what the conserved forage is to be used for. The method chosen should be one that conserves nutrient at minimum cost.

2.2 Importance of Forage Trees and Shrubs

A wide gap exists between supply and demand of livestock feeds. Trees and shrubs are capable of bridging this gap (Makkar, 2003). Browse species (trees and shrubs) supplements the quality and quantity of pasture and are effective insurance against seasonal feed shortage in the dry season (Sanon, 2007). Browses are perennials thus allowing the provision of fodder throughout the year. Herbaceous species on the other hand diminishes quickly in quantity and quality when rainfall ceases. Browse plants have deep root system, they are able to penetrate deep into the soil to obtain water and nutrients which helps them to remain green all-year-round (Sanon, 2007). Browse plants have high protein and mineral contents (Paterson *et al.*, 1998), this is why they are considered as having high feeding quality. The use of browses as supplement to natural grasses or crop residues is well documented in literature. Enhanced productivity of ruminant animals have been reported (Norton, 1998). Inclusion of browse plants in established pastures also increase the stocking rates (Leng, 1997). Additionally, forage trees and shrubs can easily be cultivated to improve the sustainability of the farming systems. They also find use in erosion prevention on sloping lands due to their deep root system and are sources of timber and firewood for industrial and domestic uses respectively. Some by-products, like fruits and vegetables are also obtained from these trees for human consumption (Rachie, 1983; Atta-krah and Sumberg, 1988; Makkar, 2003).

Browses, however, usually contain some components like phenolics, saponins, alkaloids, free amino acids, steroids, essential oils, glycosides, oxalates, cyanogenic Glycosides, nitrates, mimosine, various sterols, terpenes and resins. These compounds are generally referred to as anti-nutritional factors. Anti-nutritional factors in plants do not play any role in basic metabolism but are rather involved in plant protection against disease or animal attack. They are sometimes toxic or mimic hormone actions. (Acamovic and Brooker, 2005). Tannins are the most common anti-nutritional components found in plants (Leng, 1997). However, tannins become significant nutritionally only when tannin containing plants forms a large portion of the diet. Usually, the effect of high protein in the tannin containing plants override the effects of the tannin when the forage is used as a supplement (Sanon, 2007). Browse utilization by ruminants is also limited by their usually high lignin contents (Sanon, 2007).

The tropics and the sub-tropical areas of the world are home to a wide varieties of multipurpose trees, shrubs and legumes. Brewbaker, (1986) listed about 30 species commonly used for feeding animals. West Africa has humid and sub-humid regions which serve as natural habitat for a good number of multi-purpose tree species and shrubs. These trees and shrubs play important roles in the agro-forestry systems of the regions in that they generate very large amounts of biomass (Oji and Kalio, 2004). Many of these browse plants are usually resistant or tolerant to drought, heat, salinity, alkalinity, grazing and continuous cuttings. They also live long and does not require maintenance (Fagg and Stewart, 1994). These multi-purpose trees and browse plants readily get established without appreciable agronomic inputs. They are the main source of supplementary feeds to small scale and medium scale livestock farmers for the improvement of the productivity of their ruminant livestock (Smith and van Houtert, 1987). Other properties of these plants include high digestible protein content in leaves, high foliage yield, and high tolerance for pruning and very good rooting system among others (Sanchez *et al*., 2005). What makes the foliage of these trees a good potential source of energy and protein supplement in the dry season is their ever green nature (D'Mello, 1992; Reed *et al*., 1990). Their availability in the dry season improve the uptake of roughage by ruminants during this period (Rachie, 1983; Atta-Krah and Sumberg, 1988).

2.3 Description, ecology and distribution of Gliricidia

Gliricidia (*Gliricidia Sepium*) is typically a semi-deciduous, medium size, tree of about ten metres and sometimes fifteen metres in height with a broad canopy. Gliricidia is considered a valuable component of many agroforestry systems because it is a multipurpose tree. This plant is usually one of the pioneer species that are established on sites in many tropical countries of the world. It serves many purposes among which is : as shade and support tree, as a green manure and forage crop in plantations, for establishment of living fences etc (Elevitch and Francis, 2006).

Gliricidia sepium thrives very well in a wide variety of soils ranging from poor acidic (pH 4.5-6.2) and eroded soils to fertile sandy, heavy clay, calcareous limestones and alkaline soils. Gliricidia is fire tolerant and has the ability to re-sprout quickly at the onset of rains.

Gliricidia like many other Green leaf manure plants play significant roles of improving soil fertility and control of soil erosion in tropical farming systems (Prasann Kumar and Pankaj Kumar Mishra, 2013). Improvement of soil fertility is very much appreciated due to the characteristic poor nitrogen contents of most tropical soils. Decayed gliricidia foliage readily augment the nitrogen contents of the soil.

2.4 Cultivation of *Gliricidia sepium* for forage Production

Cultivation of Gliricidia can be done by using seeds or cuttings. Matured seeds from dried pods are harvested and planted on a nursery bed or in containers. The use of cuttings is also possible, stems with brownish green bark measuring 30 to 60 centimetres in length should be cut at 45º at both ends. This is the preferred and recommended method as germination rate is very high given one of its common names – quick stick (IICA Forage fact sheet, 2015). Seeds and cuttings can be transplanted at a spacing of 50-100 cm apart, row width may vary depending on the height that plants are to be maintained at.

2.4.1 Uses of Gliricidia

Leaf Vegetables

Gliricidia foliage and flowers can be cooked and eaten either boiled or fried. The leaves are also used to hasten the ripening of bananas in containers.

Honey

Gliricidia produces flowers that are rich in nectar, the nectar are attractive to bees.

Medicinal

Gliricidia foliage have been used for medicinal purposes. The fresh leaves, when crushed are applied on the body as a poultice. In Mexico, many ailments like itching, nasal congestion are treated with Gliricidia plant extract because of its antihistaminic, antipyretic, expectorant and diuretic properties. Gliricidia extracts is also known to have high anti-fungal activity (Stewart *et al*., 1996).

Animal Fodder

Gliricidia foliage (green leaves with soft green branches) are used widely as fodder for cattle, sheep and goats. The leaves hardly pose any toxicity threat or problems in ruminant animals. The benefits of using Gliricidia fodder and mineral mixtures as supplement to grass pastures have been established in several experiments. Yield of gliricidia fodder range from 2-20t/Ha/year depending on several factors, this when harnessed can make significant contribution to dry season forage supply. Gliricidia foliage and molasses silage mixtures has been documented as a good supplement (Stewart *et al.,* 1996).

2.4.2 Fodder Value of Gliricidia

Trees and shrubs are multipurpose resources for many generations in many parts of the world (Smith, 1991). As a result of very harsh conditions in the arid and semi-arid livestock farming areas, multipurpose trees or shrubs have gained popularity as animal feed resource (Osuga *et al.,* 2006). Guerin *et al*., (1988) observed that browse plants could be as much as 50% of the diet of cattle while they could constitute around 80% of the diet of small ruminants when grazing during the dry season in natural pastures. Ruminants' protein supply are usually met by leaves, flowers and fruits of browses because they have high levels of nitrogen (Le Houerou, 1980; Kone, 1987; Getachew *et al*., 2002).

Rumen degradability of many browses is very good (Smith *et al.,* 1991; Minor and Hovell, 1979 and Kabaija, 1985). The breakdown of these browses supply much needed water soluble carbohydrates and fermentable nitrogen to the rumen thereby promoting forage breakdown (Smith, 1991). Good amount of essential elements like calcium, sodium and sulphur as well as micronutrients like iron, zinc and manganese are found in most browse plants (Kabaija and Smith, 1989; Devendra, 1990). These essential elements and micro-elements are known to be deficient in many grasses of tropical origin or barely at a borderline for productive purposes (Olubajo, 1974; Kabaija and Smith, 1987).

2.4.3 Proximate Composition of Gliricidia foliage

The proximate composition of Gliricidia foliage is stated in table 1. The average value of the crude protein content indicates that gliricidia foliage is a good protein source that can readily be used to augment the protein contents of protein deficient feed.

Table 1: Chemical Composition of *Gliricidia sepium*

Parameters	Average	Minimum	Maximum
Dry matter (%)	25.3	19.6	37.0
Crude protein (%)	22.3	15.4	28.8
Crude fibre (%)	19.7	14.4	28.4
Ether extract (%)	4.2	3.0	5.5
Ash (%)	10.0	6.7	13.7
Gross energy (MJ/kg)	19.7	17.5	31.8

Adapted from http://www.feedipedia.org/node/11617

2.5 The Cassava Plant

Cassava (*Manihot esculenta*) is a root tuber, which originated from Amazonian region and is now widely cultivated in all countries with tropical climates (Ogbonna *et al.,* 2021). Cassava roots provide high quality starch that supplies the caloric requirements in the food of a number of Africans in West and Central Africa.

There are many cassava cultivars distinguished on the basis of their morphology, shape of tuber, time of maturity, yield and cyanogenic glycoside content of their roots. On the basis of cyanogenic glycoside content, two major varieties have been identified: bitter variety and the sweet variety. The bitter varieties are characterized by high level distribution of cyanogenic glycoside in all parts of the root. The sweet varieties on the other hand are characterized by localization of cyanogenic glycoside mainly in the peels. The flesh of the sweet cassava contains small quantities of cyanogenic glycoside which is usually removed in form of hydrocyanic acid (HCN) when sweet cassava is cooked (Ogunbiyi, 1998).

Cassava products that are useful in livestock feeding include roots, peels, leaves and tender stems. Cassava has a great potential to supply cheap source of energy for livestock when balanced with other required nutrients. The leaves are rich in unidentified growth factors, energy, minerals, xanthophylls that can be used in poultry nutrition (Ravindran, 1990).

The annual production of cassava in Nigeria is about 50 million metric tonnes which places the country as the world's largest producer of the commodity (FAOSTAT, 2014). Cassava is playing an increasing nutritive role in both livestock and human lives in Africa. In 2004, the continent accounted for 90% of the world production (FAO, 2005). Cassava remains a very cheap food energy source and is the major carbohydrate source in the diet of a large population of the third world countries. Cassava is the staple food of about 200 million Africans (Banjoko *et al*., 2008).

Factors such as possession of anti-nutrients (e.g. HCN, polyphenols, and phytates) and low protein contents are the constraints to the utilization of cassava products (Akpan and Ikenebomeh, 1995). The consequences of these are expressed in poor feed intakes, low digestibility and eventually poor animal performance, poor feed intake and reduced animal performance (Alawa and Amadi, 1990; Adegbola and Oduozo, 1992). In order to mitigate these constraints, a number of efforts have been made using different methods of drying (Odukwe, 1994) and treatment with chemical preparation (Adebowale, 1985; Jackson, 1997). Other methods include steeping/retting or soaking in water, cooking (Okeke *et al.,* 1985) and moistening (Bradbury, 2006). Different degrees of successes, cost reduction and suitability to local technologies were attained with these efforts. Both natural and microbial inoculums enhanced fermentations have also been used extensively to improve the nutritive values of products of cassava both for humans and livestock use.

2.6 Cassava Peels

Cassava peels are agro-processing by-products that are readily found in large quantities in countries where cassava is grown and processed for human consumption and other uses. The peels constitute about 10% to 13% of the root by weight. Proximate evaluation shows that cassava has about 5% to 5.98% crude protein and minerals (Tewe, 1996). Cassava peel is the waste obtained during cassava processing. The two outer coverings of cassava roots are mechanically removed during processing into products like gari, flour, starch or chips. According to Aro *et al.,* (2008) and Tewe (1996), peel constitutes 5% and 8% of the factory and hand processed cassava root tubers respectively. The use of the peel in monogastric is limited by its low caloric value, high content of fibre and presence of anti-nutritional factors such as cyanide, phytate and tannins (Akpan and Ikenebomeh, 1995; Iyayi *et al.,* 1997). Heaps of cassava peels are left to rot away in many cassava processing areas thereby constituting environmental pollution issues when they can be easily harnessed for feeding ruminants

Cassava peels are much richer in protein, ether extract and ash than the edible portion. The composition of cassava peel as reported in literatures is as follows: residual dry matter 86.5% -94.5% organic matter 89% - 93%, crude fibre 10% -31%, crude protein 4.2% - 6.5% (Adegbola, 1980; and Onwuka, 1983), 1.10% - 1.18% ether extract, 5.93% total ash and 61.33% - 66.63% NFE (Oyenuga, 1968, Olatunji, 1990). According to Longe *et al.* (1977), the metabolizable energy of cassava waste was 1.52Kcal/g while Tewe, (1984) reported the value of 2.16Kcal/g for peels. Sonaiya and Omole (1977) reported between 64.57% - 72.9% for NFE while crude protein ranges between 5.2% - 6.5% on dry matter basis.

The utilization of cassava products like peel has been enhanced in spite of its content of cyanogenic glycosides. The use of biotechnology is a cost effective and viable means of addressing the constraints associated with the use of cassava peels for animal feed (Olowofeso *et al*., 2003; Israelides *et al.,* 1998 and Oke, 1994). Others used several processing methods like soaking in water, sun- drying, parboiling and ensiling to improve the feed value of cassava by-products (Adegbola and Asaolu, 1986; Salami, 1999; Akinfala *et al*., 2007; Salami and Odunsi, 2003). When cassava peel was fermented with a group of micro-organisms by Oboh and Akindahunsi (2003), result of the proximate analyses and digestibility indicated an improvement in protein content and digestibility of the micro-organism treated cassava peels above the untreated cassava peels. Their results suggested that micro-organism treated fermented cassava peel can be used as a supplement in the formulation of animal feed.

Zanine *et al.,* 2010 evaluated the effects of adding cassava scrapings to four levels of elephant grass (0, 7.5, 15 and 30%) on: loss of gas and effluent, pH, dry matter recovery, ammonia nitrogen, organic acids and the biochemical composition of elephant grass silages. The results obtained clearly showed the benefits of the addition of cassava scrapings in reducing gas and effluent losses and improvement of the fermentation profile of elephant grass silages. In another experiment, where grazed cross bred cattle were supplemented with molasses and dried or ensiled cassava peel at 0.7% of their body weight for six months, Larsen and Amaning- Kwarteng (1976) recorded a weight gain of 0.07kg/day for control (no supplementation), 0.29Kg/day for the test animals (with dried peel supplement) and 0.33Kg/day (supplemented with ensiled peel).

2.7 Constraints to Widespread Utilization of Cassava Products

The major constraint to feeding cassava to ruminants is probably the problem associated with cyanide toxicity. Linamarin and lotaustralin are the two cyanogenic glycosides found in cassava plants. These cynogenic glycosides are hydrolyzed by enzymes to hydrocyanic acids (HCN), acetone and glucose. The HCN content of cassava depend on varieties, age, part of plant and growing conditions of the plant. For example, cassava root and bark contains 568- 950 mg/Kg while the fresh root pulp contains 2200mg/Kg of HCN. The concentration of HCN in cassava that can cause toxicity in animals has not been determined precisely, although concentrations below 50mg/kg are considered harmless. When weaned kids were fed fresh cassava leaves of a variety of bitter cassava with 180-240mg/kg of cyanide, 40% mortality was recorded (Devendra, 1977). Chronic hydro-cyanide concentration and low dietary nitrogen have been implicated in poor performance of ruminant animals fed cassava products. The rumen and liver helps in the detoxification of hydrogen cyanide using sulphide ions and cysteine. Blakley and Coop (1949) concluded that approximately 1.2g of sulphur was needed in the detoxification of 1.0g of hydrogen cyanide. Prevention of chronic cyanide toxicity is possible with the use of sulphur licks to ruminants (Wheeler *et al.*1975).

Cyanide toxicity as observed from literatures should not be a hindrance to the feeding of cassava products and by-products. This is because simple processing procedures like ensiling or sun drying as well as supplemental feeding of dietary sulphur has been used successfully to prevent HCN toxicity.

2.8 Nutritional Properties of Wet Brewer's Grain

Among the by-products derived from the beer industry is the wet brewer's grains (WBG). These are the spent grains, usually barley, but sometimes depending on the source, other grains like corn and rice may be included (Thomas et al., 2016). The dry matter content of Wet brewer's grains is low (20 to 32 %), it has significant protein, high total digestible nutrients (TDN) and digestible available fibre (Hersom, 2006).The malting process depletes sugars and starches in the grains. This accounts for the high fiber content of WBG, structural carbohydrates (hemicellulose and Cellulose) are therefore the main component of WBG (Westendorf and Wohlt, 2002). WBG are high in crude protein content the values range between 25 to 34% (Thomas *et al.,* 2016). The highest concentration of protein is found in the germ portion of the grain. The crude protein is partially digested in the rumen while the small intestine digests a greater portion. The concentration of protein that are degradable in the rumen ranges between 28-43% with a mean value of 35%, meaning that wet brewery grains are among the good sources of rumen un-degradable or "bypass-protein". The dry matter content also ranges between 20-32% (Thomas *et al.,* 2016). Wet brewery spent grain offers a worthwhile opportunity for dairy farmers to offer additional rumen un-degradable protein and energy to dairy cows, with equal or enhanced milk production (Zanton *et al.,* 2016).

2.9 Practical tips for Silage Making

Chemical composition and physical characteristic of grasses, legumes, crop residues and by–products vary widely. Kayouli and Lee (1999) gave the following suggestions for the production of good quality silage:

(i) Energy -rich feeds like root crops, rejected bananas and fruits can be ensiled without adding other materials.

(ii) Protein and Energy- rich foods such as brewer's grains and tomato pulp can be ensiled on their own.

(iii) Feeds that are poor in energy and protein are better ensiled after adding energy-rich by-products.

(iv) Materials that are rich in protein but having poor energy should not be ensiled alone but in combination with one or more energy-rich feed materials.

(v) Addition of molasses to silage materials is not compulsory; however, as an additive it ensures good conservation and high quality silage.

2.10 Fermentation Process

Silage fermentation involves the activities of two types of bacteria, namely; aerobic and anaerobic bacteria (Harrison and Fransen, 1991; McDonald, 1991; Woolford, 1984). Aerobic bacteria activities predominates while the silo is being filled and also at feed out. It is desirable to minimize aerobic activities in order to reduce dry matter losses. This results from the oxidation of energy rich sugars with the generation of heat. Excess heat can damage forage protein (NRDC, 1989). Also, maximizing the activities of the anaerobic bacteria in the silo leads to the conversion of water soluble carbohydrates (WSC) into organic acids which lowers the pH below the survival zone of spoilage organisms. Heterofermentative anaerobes acts on water soluble carbohydrates to produce various fermentation end products leading to high drop in dry matter content, whereas homofermentative bacteria produce lactic acid from the breakdown of water soluble carbohydrates using relatively lower amount of energy from water soluble carbohydrates. Although both homo and heterofermentative bacteria are required for silage fermentation, efficient fermentation is however achieved by minimizing heterofermentation and maximizing homofermentation. McCullough (1984) divided silage fermentation into six phases as follows:

Phase 1

Harvesting marks the onset of phase one. Epiphytic aerobic organisms acts on water soluble carbohydrates to form carbon dioxide, water and heat. Endogenous enzymes also initiates the breakdown of starch and hemicellulose to form monosaccharides. The monosaccharides so formed are used later for lactic acid fermentation. The neutral detergent fibre content of silages usually increase slightly after ensiling due to the loss of water soluble carbohydrate by hydrolysis. The aerobic activities continues until oxygen is completely depleted or when there are no more water -soluble carbohydrates. This stage hardly lasts beyond a few hours provided the conditions of moisture, chop length, compaction and sealing are ideal.

The aerobic phase is characterized by nutrient loss. It however, creates anaerobic conditions and production of some antimycotic compounds that promotes aerobic stability during silage feed out.

Phase 2

The second phase of ensiling process starts after the depletion of trapped oxygen. It is an anaerobic process by heterofermenters (usually entrobacteria which are heat tolerant) leading to the production of several fermentation end products like carbon dioxide, ethanol and short chain fatty acids (acetic acid, lactic acid and propionic acid) from hexoses and pentoses (water soluble carbohydrates). Heterofermentative bacteria are not efficient fermenters; more nutrients are lost to produce a relatively small amount of acids. They are, however, viable within a pH range of 5 and 7. The volatile fatty acids so produced help to reduce the pH below 5, the enterobacteria become inhibited at this stage and the homofermenters become activated. This marks the end of the early anaerobic stage which usually last between 24 and 72 hours.

Phase 3

Phase three is the second stage of the anaerobic fermentation. It is a relatively transient phase that does not last more than 24 hours. In this phase, because of the reduced pH, homofermentative lactic acid bacteria population is increased. These microbes further increase the acidity of the silage by rapidly and efficiently producing lactic acid. The lactic acid producing bacteria are less heat tolerant than the heterofermenters but more heat tolerant than the anaerobes in phase 4.

As the temperature and pH of the silage reduce, the activities of phase 3 anaerobes decline and eventually inhibited. The low temperature and increased acidic environment favours the proliferation of the phase 4 lactic acid producing anaerobes.

Phase 4

This phase is a continuation of phase 3 in that water soluble carbohydrates are still being hydrolysed by a strain of homofermenters (*Lactobacillus plantarum*) to produce lactic acid. Acetate producing bacteria working in conjunction with the lactic acid producing bacteria in this phase create a faster fermentation that serves to conserve nutrient. Lactic acid being the strongest and the most efficient volatile fatty acids for rapid silage pH reduction is required to be about 60% of the total volatile fatty acids in the silage. Lactic acid in a properly balanced silage diet can be used as an energy source by ruminants.

Phase 4 ends when the silage pH is sufficiently low to the point where it inhibits the growth potential of all organisms. The time span of phases 2, 3 and 4 is a function of the buffering capacity of the ensiled materials. Buffering capacity is defined as the ability of the ensiled materials to resist reduction in pH due to the presence of organic acids (malate, citrate, and quinate), orthophosphates, sulphates, nitrates, chlorides, and non-protein nitrogen materials (McDonald, 1991). It is also defined as the amount of lactic acid (mEq) required to bring down the pH of 1g of dry matter from pH 6 to 4.

Highly buffered forages requires more water soluble carbohydrates for bacterial fermentation to bring down the pH than for low buffered forage. Corn silage has lower buffering capacity than grasses or legume silage (Manhanna, 1993). The final pH of the ensiled materials depends on the type of forage and the moisture content of forages. Corn silage terminate at pH 4 while legumes with less water soluble and higher buffering capacity terminates around pH 4.5. The silage is said to be in a preserved state when terminal pH is attained. pH measurement only give an indication that ensiled materials are preserved in the silo or not, it is not a measure of the quality of the fermentation.

Phase 5

This stage is referred to as the stable stage and should last throughout storage. However, this is not so because various changes do occur depending on a number of factors that may include; presence and type of aerobes (mold, yeast e.tc.) on the crop at harvest and oxygen penetration. Other factors that determines the changes that may occur include the amount of substrate available for fermentation and the level and types of organic acids present in the silage as well as silage face management during unloading of silo.

Phase 6

This is the final stage of the ensiling process that begins when silage in the silo is being fed out. At this stage aerobic spoilage by secondary spoilage bacteria must be prevented in order to ensure that there is no loss of dry matter. (National feed industry Association: laboratory methods compendium, 1998).When the silo is opened, the introduction of air stimulates the activities of aerobic microbes resulting in the production of heat, reduction in palatability and nutrient availability in the silage. Aerobic instability is promoted by the presence of high epiphytic populations of yeast, mold, excess water soluble carbohydrates or aerobic bacteria. Crops that nurtured with heavy manure application may be contaminated with the spores of yeasts or mold, this also reduces aerobic stability.

2.11 Silage Microflora

The roles of micro- organisms in the silage are vital in the conservation process. There are two basic groups of microflora that are involved in the ensiling process, these are the desirable and the undesirable microflora. The lactic acid producing bacteria are the desirable bacteria while undesirable ones are those that cause aerobic spoilage (yeasts, bacilli, listeria and mold) or the ones that cause anaerobic spoilage (clostridia and enterobacteria). The activity of these spoilage microbes impact negatively on the feed quality of the silage and has adverse health effects on the animals.

2.11.1 Desirable Microorganisms

The most common lactic acid producing bacteria found in silages are epiphytic microflora of plant material belonging to different genera such as *Lactococcus Lactobacillus, Pediococcus, Leoconostoc, enterococcus and Streptococcus.* The competitiveness of these bacteria flora during fermentation is a function of the characteristics of the crop like its sugar and dry matter contents as well as lactic acid bacteria properties like osmo-tolerance and substrate utilization (McDonald *et al.,* 1991). Most of these lactic acid bacteria grow at temperatures between 5^0C and 50^0C. That is why they are referred to as mesophilic bacteria, their optimum temperature range is between 25^0C and 40^0C. These bacteria are capable of decreasing the pH of the silage to pH 4.5.

Lactic acid bacteria are facultative aerobes, they however prefer conditions that are devoid of oxygen (Hammes *et al.,* 1992; Devriese *et al.,* 1992; Weiss, 1992; Teuber *et al.,* 1992). There are different classes of Lactic acid bacteria, these are obligate homofermenters, facultative and obligate heterofermenters. Metabolism of hexoses by obligate homofermenters produces more than 85% lactic acids but are unable to degrade pentoses such as xylose. The facultative heterofermenters can metabolise hexoses to produce lactic acids mainly and some amount of pentoses to produce lactic acids, acetic acids or ethanol, while obligate heterofermenters breakdown hexoses as well as pentoses to produce equimolar amounts of lactic acids, CO_2, and acetic acids and/or ethanol (Hammes *et al.,* 1992; Schleifer and Ludwig, 1995). Examples of obligate homofermenters include

Pediococcus damnosus and *Lactobacillus ruminis*. Facultative heterofermenters include *Lactobacillus plantarum, Lactobacillus pentosus* and *Enterococcus faecium.* Among the obligate heterofermenters are the genus *Leuconostoc* and some *Lactobacillus* species like *Lactobacillus brevis* and *Lactobacillus buchneri* (Devriese *et al.,* 1992, Holzapfel and Schillinger, 1992).

2.11.2 Undesirable Microorganism

Enterobacteria

Silage enterobacteria are mostly non –pathogenic facultative anaerobes that competes for available sugars with lactic acid producing bacteria and are also implicated in the degradation of protein. The growth of enterobacteria are not only undesirable in silages for the above reasons but also due to the fact that the degradation of proteins reduces the feeding value and results in the production of compounds like biogenic amines and branched fatty acids that are toxic. Biogenic amines impact palatability negatively especially in animals that are not used to the taste (McDonald *et al.,* 1991; Van Os and Dulphy, 1996). The buffering capacity of the silage are also increased by the ammonia formed during proteolysis thus countering the rapid reduction in silage pH. Enterobacteria are also known to breakdown nitrate (NO_3) to nitrite (NO_2). Nitrite can also be degraded to NO, NO_2 or ammonia under silage conditions. Gaseous NO however, damages the tissues of the lung causing a disease with a pneumonia-like symptoms called "silo fillers's disease" (Woolford, 1984). This notwithstanding, formation of little NO and nitrite are beneficial to silage in that it inhibits clostridia effectively (Woods *et al.,* 1981 and Spoelstra, 1985).

Yeasts

Yeasts belong to a group of organism that are referred to as either facultative anaerobic or heterotrophic eukaryotic microorganisms. Aerobic and anaerobic yeast activity are not desirable in silages. Under anaerobic conditions, yeasts ferment sugars to ethanol and carbon dioxide in silages (McDonald *et al.,* 1991). When ethanol is produced in silages, it reduces the amount of sugars available for lactic acid production, it also gives milk an undesirable taste (Randby *et al.,* 1988). Yeasts when subjected to aerobic conditions breakdown lactic acid into carbon dioxide and water. The breakdown of lactic acid raises the pH of the silage, this condition favours the growth and multiplication of spoilage organisms (McDonald *et al.,* 1991). In the first week of ensiling, yeast population can reach 10^7 cfu/gm but gradually reduce as storage progresses (Van Wikselaar, 1996). The availability of oxygen in silages during storage promotes the survival and growth of yeasts (Donald *et al.,* 1995) whereas formic or acetic acids in high concentration reduces the survival of yeasts (Oude Elferink *et al.,* 1999). High sugar content in crops (e.g. Sugar beets and potatoes) appears to enhance yeast activity e.g. potatoes and sugar beets. The silage produced from these crops are often high in ethanol and low in lactic acids (Van Wikselaar, 1996).

Clostridia

Clostridia are a group of anaerobic bacteria that forms endospores. Most clostridia like enterobacteria reduce the feed value of silages by breaking down carbohydrates and proteins leading to reduced feeding value and production of biogenic amines. Presence of clostridia (*Clostridium tyrobutyricum*) in silage impact negatively on milk quality. *Clostridium tyrobutyricum* can also breakdown lactic acid to butyric acid, H_2 and Co_2 (2 lactic acid → 1 butyric acid $+2H_2O$ $+2CO_2$). Butyric acid fermentation counteract lactic acid fermentation and produces significant amount of gas that causes cheese defect known as "late blowing". It occurs in hard and semi-hard cheeses like Permesan, Grana, Emmental and Gouda, (Klijn *et al.,* 1995).

There are other Clostridium species that are extremely very toxic such as *C. botulism* that causes a deadly disease called botulism in cattle. The incidences of botulism are mostly associated to contamination of silage with cadaver of mouse, birds etc. (Kehler and Scholz, 1996).

When the butyric acid content of a silage is more than 5g/kgDM that silage is typically referred to as "clostridia silage". The pH of clostridia silage is usually above 5 with high ammonia and amine content and low dry matter (Voss, 1966; McPherson and Violante, 1966). Prevention of a "Clostridia silage" can be achieved by adopting an ensiling process that rapidly cause a sufficient drop in pH because Clostridia like enterobacteria are inhibited by low pH and low moisture content faster than lactic acid bacteria (Kleter *et al.,* 1982; 1984; Huchet *et al.,* 1995). Wilting crops to reduce moisture content is a means of inhibiting clostridia selectively (Wieringa, 1958). Nitrites and NO or compounds that are degraded to produce them will also inhibit Clostridia.

Acetic Acid Bacteria

Acetobacter sp. are aerobic acid tolerant bacteria also known as acetic acid bacteria. Their activity (oxidation of acetic acid and lactic acid to carbon dioxide and water) in silage can initiate aerobic spoilage which is undesirable. Yeasts are generally the initiator of aerobic spoilage in the absence of acetic acid bacteria. However, aerobic spoilage can also be initiated by acetic acid bacteria when whole corn crop is ensiled (Spoelstra *et al.,* 1988). When yeasts are selectively inhibited, proliferation of acetic acid bacteria in the silage can occur (Driehuis and Van Wikselaar, 1996).

Molds

Detection of mold infested silage is very easy. Many species of mold produce large filamentous structures and coloured spores. Molds usually develop in the area of silage that is exposed to oxygen. Exposure to oxygen happens mainly on the surface of the silage but the entire silage can become moldy when aerobic spoilage is intense. The most common mold species found on silage are the genera *Penicillium, Fusarium, Aspergillus, Mucor, Bysssochlamys, Absidia, Arthrinium, Geotichum, Monascus, Scopulriopsis, and Trichoderma* (Pelhate, 1977; Woolford, 1984; Jonsson *et al.,* 1990; Nout *et al.,* 1993). They are known to lower feed value, acceptability and health concerns such as lung damage and allergic reactions caused by mold spores to humans and livestock (May, 1993). Molds also produce mycotoxins which present health conditions that varies from mild to very serious base on the amount and type of toxins present. Scudamore and Livesey, 1998 reported that mycotoxins may present health conditions like digestive problems, mild fertility issues, reduced immunity to liver damage and abortions. Mycotoxin producing mold of importance are: *Aspergillus fumigatus*, *Penicillium roqueforti* and *Byssochlamys nivea.*

The most predominant specie of mold in silage is *P. roqueforti*, it is an acid tolerant mold that grows at low oxygen levels and high levels of carbon dioxide (Lacey, 1989; Nout *et al.,* 1993; 1996; Auerbach *et al.,* 1998). Uncertainty still exist on the conditions that promotes the production of mycotoxins in silages. It is however, noteworthy that a heavy infestation of mold does not necessarily confirm the presence of mycotoxins, and not all the mycotoxins that are associated with a mold are necessarily present in one silage (Nout *et al.,* 1993; Auerbach, 1996). Aflatoxin B1, produced by *Aspergillus flavus* can be transferred from animal feed to milk, unlike *Aspergillus flavus*, *P. roqueforti* and *A.*

fumigatus are not known to transfer mycotoxins from animal to products (Scudamore and Livesey, 1998).

Bacilli

Unlike Clostridia, Bacilli are obligate, rod shaped endospore forming facultative aerobic bacteria (Claus and Berkeley, 1986; Cato *et al*., 1986) The product of fermentation of a wide range of carbohydrates by facultative aerobic bacilli are organic acids (lactate, acetate and butyrate), ethanol, 2,3-butanediol and glycerol (Claus and Berkeley, 1986). Bacilli compared to the lactic acid bacteria do not efficiently produce lactic acid and acetic acid (McDonald, *et al.,* 1991) and are implicated in promoting later stage aerobic spoilage (*Lindgren et al.,* 1985). High correlation exists between number of bacillus spores in raw milk and number of spores in cow faeces (Waes, 1987; te Giffel *et al.,* 1995). The mode of transfer of bacillus and clostridia spores from silage to milk via faeces appears to be similar. For pasteurized milk, psychrotrophic *B. cereus* is the main spoilage bacillus species (te Giffel, 1997). Maintaining a low storage temperatures and minimizing air ingress reduces the growth of *psychrotrophic B. cereus.*

2.12 Digestibility of Silage Mixtures

Feed cost accounts for up to 60% of livestock production cost, this is much so under the intensive concentrate feeding systems of ruminant production in developed economies where forages are the single most important feed resource (Jung and Allen, 1995). Forage quality varies, so are other factors: species, variety, physiological maturity, re-growth, season, time of harvest, cutting height and fertilization. (Adesogan, 2002). This therefore make feed analysis important in order to nutritionally characterize forages and determine the supplemental nutrients required for ration formulation to effectively optimize animal productivity. Feed analysis and evaluation are equally important for quality assurance by feed manufacturing companies and for determining the presence and concentrations of undesirable substances that can adversely affect animal health and productivity. Therefore, feed analysis has been described (Adesogan, 2002) as compulsory if efficient resource use and profitability in livestock production are desired. Feed evaluation help the farmers to decide which feeds to buy, it also help livestock planners to assess prospective production levels in planning food import and export strategies (Ørskov , 2000).

The nutritive value of a feed is a function of its ability to meet the nutrients requirement of an animal for maintenance, growth and reproduction (Norton, 2003).

2.13 SILAGE EVALUATION

Silage evaluation is done in the field and in the laboratory. Field assessment is however not a substitute for laboratory analysis but a good starting point for identifying problems in the silage making process.

Physical Evaluation

Physical evaluation of colour, texture and odour of the silage gives a general idea of the expected nutritive quality of the silage. Colour, similar to the natural colour of the constituent ingredients, firm texture and a youghurt-like smell suggests that the silage is of a good nutritional quality (Olorunnisomo, 2010).

Chemical Analysis

Feed testing laboratories generally analyze for dry matter, pH, crude protein, fibre, calcium, phosphorus and other analyses. An over-heated silage has a tobacco-like odour and its protein and dry matter digestibility is low. It is always good to perform an acid detergent insoluble nitrogen test on silages. An ADIN value of more than 0.3 percent of dry matter or 15% of total nitrogen in forage suggests that the silage is overheated.

Silage pH as an indicator of Quality

In high moisture silages, pH is the most effective indicator of quality. Generally, low pH is desired as it suggests that lactic acid type of fermentation took place. However, for silages with moisture levels below 65%, pH is not a good indicator of quality.

Estimating Moisture content of Silage

The moisture content of materials to be ensiled can be determined before being placed in the silo. The methods include hand or squeeze for chopped forage, and the use of microwave oven.

Determination of Silage Quality using Titration Method

Moisio and Heikonen (1989), developed a fast acid-base titration method for determining the quality of farm silages. A 5ml sample of pressed silage juice is taken in a conical flask and the pH is determined using a pH meter. 1N hydrochloric acid was added until the pH dropped below 2. The resulting solution was then titrated with 1N Sodium hydroxide until pH 12 is exceeded. At short intervals, the volume of base added and the pH values obtained were stored on a computer. A titration curve is generated from these data and the content of organic acids, reducing sugars, amino acids, carboxylic groups and the products of protein catabolism (---NH_2 and ---NH—) in the silage can be estimated. From the computer generated curve, the amount of saliva required to neutralize one kilogramme of silage and raise the pH to 6.5 can be calculated. pH 6.5 is the optimum pH for rumen function. This analytical model provides diverse information which are very accurate for use in feed advisory work and other research purposed.

2.14 Sokoto Gudali breed

There are many strains of Gudali cattle in Nigeria but the most prominent is the Sokoto Gudali. This strain is also found in countries like Ghana, Cameroon, Mali and central Africa. Sokoto Gudali like other gudalis are zebu breed believed to have originated from the indo Pakistani and moved to West Africa through the Persian Gulf and South Arabia (DAGRIS, 2005). Essentially Sokoto Gudali is a short horned and short legged animal with a deeper body than the white Fulani cattle. The name Gudali is a Hausa word that describes the features of short legs and horns. The breed has multiple colours but white and black are predominant. Sokoto Gudali shared strong similarities with their zebu relations like the East African Boran and the Sudanese kenana (Rege and Tawah, 1999).

At Maturity, a male Sokoto Gudali weighs between 495 and 660Kg while the female weighs about 340 to 355Kg. Male Sokoto Gudali measures 130 to 138cm at the withers while the female measures 116 to 132cm (Tawah and Rege, 1996). This breed is reared for milk and meat and has become the cattle of choice in the south western parts of Nigeria due to its docility and ability convert waste to meat. Other strains of Gudali are Adamawa Gudali, Yola Gudali Banyo Gudali and Ngaundere Gudali.

2.15 Importance of Nutrition in Animal Production

Dry season forage in the tropics are naturally low in crude protein, minerals, and digestibility; their intake are also poor (Rihirahe, 2001). Poor nutrient contents leads to reduced rumen efficiency, reduced rumen microbial population and consequently poor milk production. The effect of these is more pronounced in lactating cows in the form of weight and body condition as a result of high nutrient demand for milk production. Three approaches have been used in order to improve the productivity of livestock. Due attention has been given to the genetic improvement which contributes about 30% to production.

The other two are nutrition and management that contribute about 70% (Sethumadhavan, 2004).Indigenous cattle are regarded as poor milk producers when compared to their temperate counterparts. However, the low milk production is not only due to the poor genetic potential for milk production but the problem of under nutrition also plays a significant part. Improving nutrition may increase milk production of indigenous cattle by about 20% to 25% (Sethumadhavan, 2004). Another consequence of poor nutrition is that it also increases the animal's susceptibility to diseases and subsequently mortality. The production and composition of milk are functions of inherent traits of the cow and the external environments (O'Connor, 1994). For a dairy enterprise to be profitable, milk yield and milk quality must be high. Milk composition may vary for many reasons among which is breed, species, stage of lactation, stress, parity and change in feed. This variation has direct impact on the availability and nutritive value of milk. Successful dairy enterprises have leveraged on the possibility to alter the factors that influences milk yield and quality to maximize profit.

2.16 Factors Affecting Milk Composition

Breed

The milk yield and milk composition differ among breeds of cattle. According to O'Connor, (1994) the difference is more pronounced among breeds than within the breed due to genetic and environmental factors. Compared to the Friesian cattle, Jersey breed produces milk with higher fat content (O' Mahony, 1988).The indigenous zebu breeds in Nigeria and other tropical areas are known to have milk of higher fat contents and solid-not-fat content than their European counterparts (Cunningham and Syrstad, 1987)

Nutrition

Nutrition also plays vital role in milk yield and composition. Under feeding reduces milk yield, Milk fat and the solid non –fat (SNF) content of milk (O' Connor, 1993). As a rule of thumb, any feed or ration that increase milk yield will reduce milk fat content while solid non- fat content will fall if ration of low energy is fed (O'Connor, 1994).

Stage of Lactation

One of the factors that affects milk composition is the stage of lactation. In temperate breeds, fat, lactose and SNF values are high during the first week of lactation and declines about three months later when the peak of yield is attained. When milk yield declines during the last stage of lactation, the values rise again (O' Manhony, 1988).

Age of the Cow

Older cow's milk are lower in fat and solids non –fat (SNF) compared to their younger counterparts (O'Connor, 1994). As the cows grow old there is a decline in the casein content of the milk. This might explain the decrease in the SNF values. Another factor that affects milk composition is the milking intervals. When milking is done at longer interval the fat content of the milk is lower than when the milking interval is short. For example, the fat content of the evening milk is slightly higher than the morning milk due to the fact that the time between morning and evening milking is shorter than the time between the evening and the morning milking. The yield in the morning is however higher than the evening yield (Rai, 1985).

Importance of Nutrition In Animal Production

Dry season forage in the tropics are inherently low in crude protein, minerals, and digestibility and have poor intake (Rehrahie, 2001). Lower nutrient contents leads to reduced rumen efficiency, reduced rumen microbial population and milk production. The effect of these is more pronounced in lactating cows being unable to meet their nutritional requirements i.e. they lose weight and body condition as a result of high nutrient demand for milk production. Three approaches have been used in order to improve the productivity of livestock. Due attention has been given to the genetic improvement which contributes about 30% to production. The other two are nutrition and management that contribute about 70% (Sethumadhavan, 2004). Indigenous cattle are regarded as poor milk producers when compared to their temperate counterparts. However, the low milk production is not only due to the poor genetic potential for milk production but the problem of under nutrition also plays a significant part. Improving nutrition may increase milk production of indigenous cattle by about 20% to 25% (Sethumadhavan, 2004). Another consequence of poor nutrition apart from causing low rates of production and reproduction is that it also increases the animal's susceptibility to diseases and subsequently mortality.

CHAPTER THREE
MATERIALS AND METHODS

Physical and Chemical Evaluation of Silages

3.1 Locationstudy of Study

The experiment was conducted at the Teaching and Research Farm (Dairy Unit) of the University of Ibadan. University of Ibadan falls within latitude 7° 15' N and 7° 30' N, and longitudes 3°45' E and 4° 0' E. Annual rainfall ranges from 1150 - 1500mm

3.2 Collection of Silage Materials and Silage Preparation

Fresh cassava peels were collected from Gari processing unit in Mokola area of Ibadan. Wet Brewer's grain was obtained from the Nigerian Breweries in Ibadan. Elephant grass and gliricidia foliage were harvested from established plots behind Abadina College, University of Ibadan after 8 weeks and 12 weeks of regrowth respectively. The materials were chopped with an automated forage chopper to a particle size of about 2-3cm to enhance compaction. The forages were weighed accurately and mixed with chopped cassava peel, wet brewer's grain and Urea according to the treatments below. Silage materials were mixed properly and ensiled in replicate inside 20-litre plastic buckets for laboratory analysis, while a bunker type concrete silo was used to ensile the materials for other studies. The bunker silos were manually filled, compacted and sealed with polythene sheets. Stones were placed on the compacted silos to exclude air in the silage. The silages were opened after six weeks (42 days).

Four experimental silages were made which correspond to four treatments/diets:

- EG-Control (Elephant Grass 60 % Cassava peels 38% Urea 2%)
- EG-WBG (Elephant Grass 40 % Cassava peels 19% Wet Brewer's Grain 40% Urea 1%)
- EG-GL (Elephant Grass 40 % Cassava peels 19% Gliricidia foliage 40% Urea 1%)

- EG-WBG/GL (Elephant Grass 40% Cassava peels 19% Wet Brewer's Grain 20% Gliricidia foliage 20%Urea 1%). Ensiling process was as depicted in figure 3.1.

Harvesting of Grasses/ Gathering of Materials

↓

Wilting for moisture reduction

↓

Chopping to reduce particle size

↓

Loading into Silo

↓

Addition of Silage Additives

↓

Compaction to exclude Air

↓

Sealing

↓

Feeding Out

Fig. 3.1: Flow Chart for Silage Making

3.3 Experiment 1: Determination of Silage Quality

The Preparation of the silages was as stated above. After 21 days of ensiling, silages inside mini silos were opened for quality assessment. The quality parameters were colour, smell, texture and pH. Sub samples were taken from different points and depths in the container. These were mixed together to give a representative sample of each silage. Each representative samples were then assessed for texture by squeezing to see if moisture easily seep out from the silage. Seepage is an indication that the materials ensiled were low in dry matter content and could have lost nutrients. Assessment for colour was determined by direct observation by comparing the colour of the silage to the original colour of the fresh material that was ensiled. The closer the colour of the silage to the original material the better. The smell or aroma of the silage was determined by directly sniffing the silage. A smell of sour milk or yoghurt was used to determine if the silage underwent proper lactic acid fermentation. The pH was determined by the use of a pH meter (model: PHS-25). 5g of the silage was weighed into a 100ml beaker and 45ml of distilled water was added. The beaker was left in a shaker for 30 minutes after which the probe of the pH meter was dipped into the beaker. The pH of the silage was read of the meter.

3.4 Experiment 2: Chemical Composition of Experimental Silages

Crude protein, ether extract and ash contents of the silage samples were determined by the AOAC methods (1990). Dry matter was determined in an oven at 105^0C until a constant weight was obtained. The determination of nitrogen was done using the micro Kjedhal method, while ether extract was determined using the soxhlet extraction procedure. The neutral detergent fibre, acid detergent fibre and lignin (detergent fibre fractions) were determined using the method of Van Soest *et al*. (1991).

3.5 Statistical Analysis

All data obtained were subjected to analysis of variance (ANOVA) and significant means were separated by Duncan's multiple range tests using the SAS (2001) procedures.

Animal Feeding Experiment

Experiment 1: Acceptability and Preference of Elephant Grass Ensiled with Wet Brewer's Grain and Gliricidia foliage by Sokoto Gudali Cattle

3.6 Location of study

The study was conducted at the Teaching and Research Farm (Dairy Unit) using the paddock near Abadina College fence.

3.7 Management of Experimental Animals

The animals were selected from the University herd already adapted and in good condition of health. The animals were held in an open paddock fenced with barbed wire devoid of grass or other sources of feed. The animals were moved into the dried paddock every morning and released after data collection. Fresh water was supplied all through the duration of the experiment.

3.8 Experimental Design

Six Sokoto Gudali heifers weighing 100- 120kg and about 4 years old were used to assess the free choice intake of the silages. 20kg each of the silages were divided into two feeding troughs measuring 2m x 6m and placed strategically in the paddock. Location of the feeding troughs were changed daily so that animals do not associate a particular diet with one location. Cattle were allowed access to feed between the hours of 10.00am to 11.00am daily in a 14 day trial. Feed intake was measured by the difference between quantity offered and remnants. The coefficient of preference (CoP) of the silages was estimated as the ratio of intake of each silage to the average intake of all silages (Olorunnisomo *et al.,* 2012). For the silage to be considered acceptable the Coefficient of Preference must be greater than unity. Silage preference on the other hand was determined by dividing individual intake by total intake multiplied by 100.

3.9 Statistical Analysis

Analysis of variance was used to analyze data and significant means were separated by Duncan's multiple range test using SAS (1995) procedures.

Experiment 2: Digestibility of Elephant Grass Ensiled with Wet Brewer's Grain and Gliricidia foliage by Sokoto Gudali Heifers

3.10 Location of Study

The experiment was conducted at the Dairy unit of the Teaching and Research Farm, University of Ibadan.

3.11 Management of Experimental Animals

Twelve Sokoto Gudali heifers with weight ranging between 164 and 171kg were used for this experiment. The animals were randomly allotted into four dietary treatments (EG-Control, EG-WBG, EG-GL and EG-WBG-GL) with three replicates per treatment. The heifers were housed in individual pens that were adapted for total faecal collection. Weighed amount of experimental diets (silage) were offered to the animals and fresh water was given *ad libitum* for 21 days. In the first 7 days, Animals were adapted to pens and fed without data collection. Data on feed intake, feed refused and total faeces voided were collected for the remaining days of the experiment. During the last 7 days, ten percent of daily faecal collection for individual animal was oven dried at 65^0C for 72 hours. The seven day faecal samples for each animal was then pooled, milled and mixed thoroughly for proximate and detergent fibre analyses. Proximate composition of the feed offered, feed refused and faeces were determined using the methods of AOAC (1995) while detergent fibre analysis were determined as described by Van Soest *et al*., (1991).

3.12 Statistical analysis

The experimental design was the completely randomized design while data obtained were analyzed using analysis of variance. Significant means were separated by Duncan's multiple range tests using the procedures of SAS (1995)

Experiment 3: Intake and Growth Rate of Sokoto Gudali Heifers Fed Ensiled Elephant Grass, Wet Brewer's Grain and Gliricidia foliage

3.13 Location of Study

The experiment was conducted at the Dairy unit of the Teaching and Research Farm, University of Ibadan.

3.14 Management of Experimental Animals

Twenty Sokoto Gudali heifers of about 12 months old with weight ranging between 100 to 120 kg were sourced from the University herd. The animals were allotted to four different feed treatments as in study one and the amount of feed offered and refused every day were recorded in a 84 day (12 weeks) feeding trial. The weight of the animals were taken at the beginning of the experiment and forthnightly thereafter. Data on the Feed Intake, Average Daily Gain (ADG) and Feed Conversion Ratio (FCR) were calculated.

3.15 Experimental Design

The experimental design used for this experiment was completely randomized design. Treatments means were compared using analysis of variance.

Experiment 4: Milk Production and Feed Conversion Ratio of Sokoto Gudali Cows Fed Elephant Grass Ensiled with Wet Brewer's Grain and Gliricidia foliage

3.16 Location of study

The experiment was conducted at the Dairy unit of the Teaching and Research Farm, University of Ibadan.

3.17 Management of Experimental Animals

Sixteen multi-parous Sokoto Gudali cows were used for milk production and milk quality study. All the cows calved within one week of each other and were between 290 and 345 kg live weight. This study was a 120-day feeding trial where the animals were housed singly and fed one of the four silages. Data on feed intake were obtained by difference between feed offered and feed refused. Daily exercise was carried out as the cows walk from the pen to the milking area which was about 100 metres apart. Weighed amount of silages were served morning and afternoon in equal amounts to ensure freshness and all-day feed availability. Fresh water was served daily without restriction.

Hand milking was adopted for this study two times per day. Morning milking was done at 7:00am while evening milking was carried out at 4:00pm in the presence of the calf. The calves were allowed to suckle the dam for 2 minutes to stimulate milk let down by the cow, the cows were then hand milked. Milk yield was determined by the addition of milk intake by the calf and milk off-take. After milking, the calves were removed from the dams and fed 10% of the calf's body weight of the milk off take with a nippled bottle. FCR was calculated and compared among the treatments using analysis of variance.

3.12 Experimental design

This study was carried out using completely randomized block design. Data obtained were subjected to analysis of variance and means, when significant, were separated by Duncan's multiple range tests using the procedures of SAS (1995).

CHAPTER FOUR

RESULTS

4.1. Crude Protein Content of Experimental Diets

The crude protein content of the experimental diets are shown in Table 4.1. The crude protein content (%) of the four diets were similar (were 24. 12% to 25.10%) and were far above the 7% minimum requirement for ruminants.

Table 4.1: Crude Protein Content of Experimental Diets

Diets		Crude Protein (%)
EG	EG60% : CSP38% : Urea 2%	24.12
EG-WBG	EG40% : WBG40% : CSP19% : Urea 1%	24.30
EG-GL	EG40% : GL40% : CSP19%: Urea 1%	25.10
EG-WBG/GL	EG40% :WBG20% :GL 20% : CSP19% : Urea1%	24.70

EG-control: 60%EG + 38%CSP + 2%Urea

EG-WBG: 40%EG + 19%CSP + 1%Urea + 40%WBG

EG-GL: 40%EG + 19%CSP + 1%Urea + 40%GL

4.2 Chemical Composition of Elephant grass, Wet Brewer’s grain, Gliricidia foliage and Cassava peels

The composition of elephant grass, wet brewer’s grain, gliricidia foliage, and cassava peels are presented in Table 4.2. The result shows that Dry matter content of materials were highest in cassava peel and least in gliricidia foliage. It was also observed that forages used in this study (elephant grass and gliricidia foliage) had lower dry matter content than the agro-industrial by products (cassava peel and wet brewer’s grain).

For the crude protein content, gliricidia foliage and wet brewer’s grain had similar protein content of 24.5 and 25.1 respectively. These are higher than that of elephant grass and cassava peel which are 7.8% and 5.10% respectively.

Table 4.2: Chemical composition of elephant grass, wet brewer's grain and gliricidia foliage used in silage-making

	Silage components			
Parameters	Elephant grass	Gliricidia foliage	Wet brewer's grain	Cassava peel
DM (%)	18.6	17.0	26.8	32.2
CP (%)	7.80	24.5	25.1	5.10
NDF (%)	64.0	56.2	44.3	49.6
ADF (%)	39.4	35.5	21.4	22.8
ADL (%)	14.8	16.2	3.50	9.50

DM = Dry matter   CP = Crude Protein   NDF = Neutral Detergent Fibre   ADF = Acid Detergent Fibre
ADL = Acid Detergent Lignin

4.3 Silage characteristics of elephant grass ensiled with brewer's grain and gliricidia foliage

The pH and physical characteristics of experimental silages are presented in Table 4.3 Significant differences exist in the pH values between the ensiled mixtures. The least pH value was recorded in silage without WBG or gliricidia (EG-control) and the highest for silage with gliricidia (EG-GL). The colours were olive green for EG-control, EG-WBG and EG-WBG/GL while EG-GL was deep green. Essentially, all the silages had colours that are not too different from the initial colours before ensiling.

All the silages were firm except EG-GL that was slightly wet. The aroma was pleasant for EG-GL and EG-WBG/GL, very pleasant for EG-WBG while EG-GL had a slight gliricidia smell.

Table 4.3 Silage characteristics of elephant grass ensiled with wet brewer's grain and gliricidia foliage

	Silages				
Parameters	EG-control	EG-WBG	EG-GL	EG-WBG/GL	SEM
pH	3.90^{b}	4.20^{ab}	4.90^{a}	4.40^{ab}	0.24
Colour*	Olive green	Olive green	Deep Green	Olive green	-
Aroma	Pleasant	Very Pleasant	Pleasant with slight gliricidia smell	Pleasant	-
Texture	Firm	Firm	Firm but wet	Firm	-

ab: means with different superscripts within the same row are significantly different ($P< 0.05$)

EG-control: 60%EG + 38%CSP + 2%Urea

EG-WBG: 40%EG + 19%CSP + 1%Urea + 40%WBG

EG-GL: 40%EG + 19%CSP + 1%Urea + 40%GL

EG-WBG/GL: 40%EG +19%CSP + 1%Urea + 20%WBG + 20%GL

*Colour of elephant grass which was initially light green was used to judge the change in colour

4.4 Chemical composition of silages fed to Sokoto Gudali cattle

The chemical composition of silage mixtures fed to Sokoto Gudali cows are presented in Table 4.4. Significant differences ($p>0.05$) exist among the parameters measured. The dry matter values ranged from 25.30 (EG-GL) to 28.74 (EG-WBG). The inclusion of wet brewer's grain appears to increase the dry matter content in the grass silage while gliricidia foliage reduced it. The content of protein in the grass silage was also significantly improved by the inclusion of Wet brewer's grain and Gliricidia foliage. The Neutral Detergent Fibre varied significantly from 38.4 (EG-WBG) to 52.10 (EG), the Acid Detergent Fibre also varied significantly from 20.0 (EG-WBG) to 28.9 (EG). Significant differences were also observed in the Acid Detergent Lignin which ranged from 8.50 (EG-WBG) to 11.26 (EG-GL). The inclusion of Wet Brewer's grain and Gliricidia foliage elicited a reduction in the fibre fractions but WBG appeared to lower the fibre fractions more than the Gliricidia foliage. The gross energy of the silages were similar, there existed no statistical difference among the silages.

Table 4.4: Chemical composition of the experimental diets fed Sokoto Gudali cattle

	Silages				
Parameters	EG-control	EG-WBG	EG-GL	EG-WBG/GL	SEM
DM (%)	26.4^{ab}	28.7^{a}	25.3^{b}	26.9^{ab}	1.20
CP (%)	24.1	25.1	24.3	24.7	0.92
NDF (%)	52.1^{a}	38.4^{c}	48.7^{ab}	42.0^{b}	0.87
ADF (%)	28.9^{a}	20.0^{b}	23.9^{b}	21.8^{b}	1.15
ADL (%)	10.0^{ab}	8.50^{b}	11.0^{a}	9.10^{b}	1.20
GE (Kcal/g)	2.96	2.99	2.91	2.94	0.20

abc: means with different superscripts within the same row are significantly different (P< 0.05)

EG-control: 60%EG + 38%CSP + 2%Urea

EG-WBG: 40%EG + 19%CSP + 1%Urea + 40%WBG

EG-GL: 40%EG + 19%CSP + 1%Urea + 40%GL

EG-WBG/GL: 40%EG +19%CSP + 1%Urea + 20%WBG + 20%GL
DM = Dry matter
CP = Crude Protein
NDF = Neutral Detergent Fibre
ADF = Acid Detergent Fibre
ADL = Acid Detergent Lignin

4.5 Acceptability of Elephant grass ensiled with wet brewer's grain and Gliricidia foliage by Sokoto Gudali cows

The intake and preference of Sokoto Gudali cows for elephant grass ensiled with wet brewer's grain or gliricidia foliage after 1 hour of offer is presented in Table 4.5. Acceptability and preference of the animals for the silages were estimated using the coefficient of preference (CoP) and percent preference. There are significant differences ($P < 0.05$) in the intake and preference for the silages by the cattle. Animals showed a greater preference for silages containing wet brewer's grain than silage with gliricidia. The coefficient of preference (CoP) varied from 0.65 to 1.38 while preference varied from 16.4 to 34.6%. Elephant grass ensiled with wet brewer's grain (EG-WBG) was the most preferred by cattle while elephant grass ensiled with gliricidia foliage (EG-GL) was least preferred.

Table 4.5: Acceptability of elephant grass ensiled with wet brewer's grain or gliricidia foliage by Sokoto Gudali cows

Parameters	Silages				SEM
	EG-control	EG-WBG	EG-GL	EG-WBG/GL	
Intake (kg, wet basis)	3.18^{b}	4.66^{a}	2.39^{c}	3.40^{b}	0.97
Coefficient of preference	0.96^{b}	1.38^{a}	0.65^{c}	1.01^{b}	0.56
Preference%	23.89^{b}	34.57^{a}	16.37^{c}	25.17^{b}	2.73
Ranking	3rd	1st	4th	2nd	

abc: means with different superscripts within the same row are significantly different ($P< 0.05$)

EG-control: 60%EG + 38%CSP + 2%Urea

EG-WBG: 40%EG + 19%CSP + 1%Urea + 40%WBG

EG-GL: 40%EG + 19%CSP + 1%Urea + 40%GL

EG-WBG/GL: 40%EG +19%CSP + 1%Urea + 20%WBG + 20%GL

4.6 Apparent digestibility of Elephant grass ensiled with wet brewer's grain and Gliricidia foliage by Sokoto Gudali heifers

The apparent digestibility of silage mixtures by Sokoto Gudali heifers is presented in Table 4.6. There were significant differences ($p<0.05$) among the silages for the parameters measured. The values for dry matter intake showed that EG-Control had the least dry matter intake of 6.05kgDM while Elephant grass ensiled with wet brewer's grain (EG-WBG) had the highest dry matter intake of 8.42kgDM followed by elephant grass ensiled with wet brewer's grain and gliricidia foliage (EG-WBG/GL) had 8.03kgDM and elephant grass ensiled with gliricidia foliage (EG-GL) had 7.06kgDM. The apparent digestibility were also significantly different. Elephant grass ensiled with wet brewer's grain had the highest apparent digestibility of 70.88% followed by elephant grass ensiled with wet brewer's grain and gliricidia foliage with 68.41% and elephant grass ensiled with gliricidia foliage with 65.78%. EG-Control had the least value of 60.40%

Table 4.6: Apparent digestibility of Elephant grass ensiled with wet Brewer's grain and Gliricidia foliage by Sokoto Gudali heifers

Parameters	Silages				
	EG-control	EG-WBG	EG-GL	EG-WBG/GL	SEM
Dry Matter Intake (kg DM)	6.05[c]	8.42[a]	7.06[b]	8.03[a]	1.03
Faecal Output (kg DM)	2.40	2.45	2.42	2.54	-
Apparent Digestibility (%)	60.40[c]	70.88[a]	65.78[b]	68.41[ab]	2.11

a, b, c, means along the same row with different superscripts are significantly (P<0.05) different

EG-control Elephant Grass 60 % Cassava peels 38% Urea 2%

EG-WBG- Elephant Grass 40 % Cassava peels 19% Wet Brewer's Grain 40% Urea 1%

EG-GL- Elephant Grass 40 % Cassava peels 19% Gliricidia foliage 40% Urea 1%

EG-WBG/GL- Elephant Grass 40% Cassava peels 19% Wet Brewer's Grain 20% Gliricidia foliage 20%Urea 1

4.7 Intake and Growth rate of Sokoto Gudali heifers fed Elephant grass ensiled with wet brewer's Grain and Gliricidia foliage

The results of intake and growth of Sokoto Gudali heifers fed silage mixtures are presented in Table 4.7. Fresh silage intake, dry matter intake and weight gain varied significantly ($p<0.05$) among the silages fed to the heifers. The values obtained for fresh silage intake ranged from 15.24 (EG) to 16.74 (EG-WBG/GL). The dry matter intake expressed as a percentage of live weight (%LW) showed that EG-WBG had the highest value of 5.49 which is similar to the value of 5.23 obtained for EG-WBG/GL. The dry matter intake of EG-Control (4.76) was the least but it was not significantly different from 4.79 obtained for EG-GL. The weight gain (kg/d) of heifers on EG-WBG, EG-WBG/GL and EG-GL silages were similar (0.62, 0.61, 0.61 respectively) and were all significantly higher than 0.49 obtained for EG-control. Feed Conversion Ratio also varied significantly ($p>0.05$), EG-GL had the best Feed Conversion Ratio of 7.85 in spite of having similarly low dry matter intake as EG-control with FCR of 9.71. The Feed Conversion Ratio of EG-WBG and EG-WBG/GL were not significantly different.

Table 4.7: Intake and Growth rate of Sokoto Gudali heifers fed Elephant grass ensiled with Wet Brewer's grain and Gliricidia foliage

Parameters	Silages				
	EG-control	**EG-WBG**	**EG-GL**	**EG-WBG/GL**	**SEM**
Dry Matter Intake (kg/d)	4.76^{b}	5.49^{a}	4.79^{b}	5.23^{a}	0.55
Dry matter intake (% LW)	2.29^{b}	3.05^{a}	2.28^{b}	2.57^{b}	0.60
Protein Intake (kg/d,DM)	0.91	1.13	0.92	1.04	0.32
Weight gain (kg/d)	0.49	0.62	0.61	0.61	0.25
FCR	9.71^{a}	8.85^{b}	7.85^{c}	8.57^{b}	0.90

a, b, c, means along the same row with different superscripts are significantly (P<0.05) different

FCR: Feed Conversion Ratio

EG-control Elephant Grass 60 % Cassava peels 38% Urea 2%

EG-WBG- Elephant Grass 40 % Cassava peels 19% Wet Brewer's Grain 40% Urea 1%

EG-GL- Elephant Grass 40 % Cassava peels 19% Gliricidia foliage 40% Urea 1%

EG-WBG/GL- Elephant Grass 40% Cassava peels 19% Wet Brewer's Grain 20% Gliricidia foliage 20%Urea 1%

4.8 Intake and milk yield of Sokoto Gudali cows fed Elephant grass ensiled with Wet brewer's grain and Gliricidia foliage

The result of intake and milk yield of Sokoto Gudali cows fed different silage mixtures is presented in Table 4.8. All the parameters measured differed significantly ($p<0.05$). The values obtained for fresh silage intake ranged from 29.26 (EG-GL) to 33.12 (EG-WBG). EG-GL had the least dry matter intake of 8.40kg which was not significantly different from 7.94kg obtained for EG-control. EG-WBG had the highest dry matter intake of 9.51kg followed by 8.72kg for EG-WBG/GL. Highest Milk yield of 5.11 litres was obtained from cows on EG-WBG followed by 4.80 litres from cows on EG-WBG/GL. Cows on EG-GL had 4.40 litres while cows on EG-control had the lowest milk yield of 3.86 litres. Cows on EG-GL however gave the best FCR of 1.91 while EG-control had the poorest FCR value of 2.31. EG-WBG and EG-WBG/GL had similar FCR values of 2.05 and 2.02 respectively. This showed that all silages had better feed conversion ratio than EG-Control.

Table 4.8: Intake and milk yield of Sokoto Gudali cows fed Elephant grass ensiled with wet brewer's grain and Gliricidia foliage

	Silages				
Parameters	EG-control	EG-WBG	EG-GL	EG-WBG/GL	SEM
Fresh Intake (Kg)	30.06[b]	33.12[a]	29.26[b]	32.45[a]	1.36
DM Intake (Kg)	7.94[c]	9.51[a]	7.40[c]	8.72[b]	0.96
DM intake (% LW)	3.08	3.05	2.90	3.04	-
Protein intake (kg/d)	2.03	2.51	2.40	2.35	-
Milk Yield(L)	3.86[c]	5.11[a]	4.40[b]	4.80[ab]	0.73
FCR	2.31	2.05	1.91	2.02	0.41

a, b, c, means along the same row with different superscripts are significantly ($P<0.05$) different

FCR: Feed Conversion Ratio.

EG-control Elephant Grass 60 % Cassava peels 38% Urea 2%

EG-WBG- Elephant Grass 40 % Cassava peels 19% Wet Brewer's Grain 40% Urea 1%

EG-GL- Elephant Grass 40 % Cassava peels 19% Gliricidia foliage 40% Urea 1%

EG-WBG/GL- Elephant Grass 40% Cassava peels 19% Wet Brewer's Grain 20% Gliricidia foliage 20%Urea 1%

4.9 Chemical composition of milk from Sokoto Gudali cows fed ensiled elephant grass with wet brewer's grain and gliricidia foliage

The result of chemical composition of Sokoto Gudali cow's milk fed with silage mixtures is presented in Table 4.9. No significant differences ($p>0.05$) exist in total solids, protein fat, lactose and ash content of milk from animals fed with the different experimental silages.

Table 4.9: Chemical Composition of Milk from Sokoto Gudali Cows Fed Ensiled Elephant Grass with Wet Brewer's Grain and Gliricidia foliage.

	Silages				
Parameters	**EG-control**	**EG-WBG**	**EG-GL**	**EG-WB/GL**	**SEM**
Total Solid (%)	12.05	12.64	12.37	12.72	0.55
Protein (%)	3.12	3.29	3.25	3.40	0.34
Fat (%)	3.87	3.88	3.66	3.98	0.37
Lactose (%)	4.6	4.86	4.52	4.85	0.42
Ash (%)	0.79	0.79	0.75	0.75	0.15

a,b,c, means along the same row with different superscripts are significantly (P<0.05) different

EG-control	Elephant Grass 60% Cassava peels 38% Urea 2%
EG-WBG	Elephant Grass 40% Cassava peels 19% Wet Brewer's Grain 40% Urea 1%
EG-GL	Elephant Grass 40% Cassava peels 19% Gliricidia foliage 40% Urea 1%
EG-WBG/GL	Elephant Grass 40% Cassava peels 19% Wet Brewer's Grain 20% Gliricidia foliage 20% Urea 1%.

4.10 The Serum Biochemistry of Sokoto Gudali heifers fed test Silages

The serum biochemistry of Sokoto Gudali heifers fed the control diet is presented in Table 4.10. The level of serum glucose of the heifers increased from 70.05mg/dL at the beginning of the treatment and increased slightly to 71.36mg/dL mid experiment and 72.54mg/dL at the end of the treatment. Total protein also increased marginally from 7.04 to 7.80 at the end of the feeding trial. Serum albumin was 2.86mg/dL at the beginning of the trial but increased to 3.46mg/dL at the end. The same trend of increment was observed for serum globulin from 4.18mg/dL to 4.34mg/dL the level of serum cholesterol was fairly constant throughout the experiment. The serum creatinine level however decreased from the initial value of 2.26 to 1.68mg/dL at the end of the study, while the value of serum urea remain fairly constant.

The serum Biochemistry values obtained for the heifers fed Elephant grass ensiled with wet brewer’s grain is presented in table 4.10. Serum glucose level of heifers in this study were 72.20 at the beginning of the experiment, and 72.36mg/dL at the end of the experiment. The serum glucose values at the beginning of the experiment was similar to the value obtained at the end of the experiment. The same trend of similar values were observed for the serum total protein 7.86 and 7.90mg/dL before and after the experiment respectively. The serum albumin values of 3.42, and 3.28mg/dL and globulin values of 4.41, and 4.62mg/dL were also similar at the beginning and at the end of the experiment. The values of cholesterol, creatinine and urea were also similar.

The values obtained for the serum biochemistry of Sokoto Gudali heifers fed elephant grass ensiled with gliricidia foliage is presented in Table 4.10. Serum glucose level was 70.25mg/dL at the beginning of the experiment, the experiment, rose to 71.98 at the end of the experiment. The total serum protein was 7.80g/dL before the commencement of the experiment but rose to 8.12g/dL at the end of the experiment. The values of serum globulin, albumin, cholesterol, creatinine and urea did not change from the beginning to the end of the experiment. There was however a reduction in the value of serum Na^+ from 120.4mEq/dL to 112.68mEq/dL at the end of the experiment. The value of Cl^- also increased from 86.74mg/dL to 87.56mg/dL.

The serum biochemistry values of Sokoto Gudali heifers fed Elephant grass ensiled with wet brewer’s grain and Gliricidia foliage is shown in table 4.10. The serum glucose level did not change, it remained 72.81and 72.68mg/dL at the beginning and at the end of the experiment. Serum protein rose from 7.64 to 8.08g/dL. Other parameters were also not affected except for Na+ which dropped from 118.40mEq/dL to112.32mEq/dL

Table 4.10: Serum Biochemistry of Sokoto Gudali Heifers fed Experimental silages

Before Experiment

PARAMETERS	EG-Control	EG-WBG	EG-GL	EG-WBG/GL	SEM
Glucose (mg/dL)	70.05	72.20	70.25	72.81	1.188
Total Protein (g/dL)	7.04	7.86	7.80	7.64	0.61
Albumin (g/dL)	2.86	3.42	3.26	3.30	0.49
Globulin (g/dL)	4.18	4.41	4.54	4.34	0.39
Cholesterol (mg/dL)	146.84	146.78	146.50	145.20	0.88
Creatinine (mg/dL)	2.26	1.66	1.74	1.86	0.52
Urea (mg/dL)	18.72	18.74	18.88	18.96	0.34
Na+ (meq/dL)	89.50	116.82	120.40	118.40	3.82
Cl- (meq/dL)	85.95	85.93	86.74	86.22	0.61
After Experiment					
Glucose (mg/dL)	72.54	72.36	71.98	72.68	0.55
Total Protein (g/dL)	7.8	7.9	8.12	8.08	0.39
Albumin (g/dL)	3.46	3.28	3.36	3.22	0.32
Globulin (g/dL)	4.34	4.62	4.76	4.86	0.48
Cholesterol (mg/dL)	146.25	146.5	146.88	146.86	0.55
Creatinine (mg/dL)	1.68	1.78	1.72	1.8	0.23
Urea (mg/dL)	18.76	18.72	18.58	18.76	0.29
Na+ (meq/dL)	100.12	116.46	112.68	112.32	2.66
Cl- (meq/dL)	87.12	87.32	87.56	86.71	0.60

EG-control	Elephant Grass 60% Cassava peels 38% Urea 2%
EG-WBG	Elephant Grass 40% Cassava peels 19% Wet Brewer’s Grain 40% Urea 1%
EG-GL	Elephant Grass 40% Cassava peels 19% Gliricidia foliage 40% Urea 1%
EG-WBG/GL	Elephant Grass 40% Cassava peels 19% Wet Brewer’s Grain 20% Gliricidia foliage 20% Urea 1%.

CHAPTER FIVE

DISCUSSION

Urea has been used extensively to supply nitrogen to nitrogen deficient feed materials to improve their crude protein contents. Salem *et al*., (2013) reported that the observed increase in crude protein content of urea treated silages is a function of urea hydrolysis to produce ammonia. Also, Olorunnisomo (2013) also advocated that an improvement of the crude protein content of grass silages can be achieved with the inclusion of legume to the silages. Furthermore, Kang *et al.,* (2018) in their work on cassava top silage reported a dose dependent increase in protein content when urea was used to treat the cassava top. Addition of Urea to elephant grass silage in this study also increased the crude protein contents of all the silages. Similarly, the addition of wet brewer's grain and gliricidia foliage because of their relatively high crude protein contents contributed to the high protein contents of the silages. While the inclusion of urea furnishes non-protein nitrogen that are useful to the rumen microbes, wet brewer's grain and gliricidia furnishes by-pass protein that is useful directly to the animal (Senthil *et al.,* 2015). These silages as constituted is a total mixed ration (TMR) that can sustain the nitrogen need of the rumen microbiota and also the crude protein that can be digested post rumen for increased productivity of the animal.

The low dry matter observed in elephant grass (18.6%) and gliricidia (17.0%) is typical of tropical forages with dry matter ranging from 16% to 22%   Variation in dry matter content of tropical forage is mostly a reflection of climatic conditions at the time of harvest. The crude protein content was lowest for cassava peel, followed by elephant grass, gliricidia, and wet brewer's grain respectively. Cassava peel is a by-product of cassava roots which is known to be typically low in protein content (ARC, 2014). Grasses and members of the grass family are also known to accumulate low protein contents in their leaf and stem Mtui *et al*., (2009), hence the low protein content of elephant grass used in these studies. Unlike grasses, leguminous plant like gliricidia are known to accumulate high protein content in their leaves and seeds (Aremu *et al.,* 2017). This is basically due to their ability to fix atmospheric nitrogen through rhizobia present in their roots. Nitrogen thus fixed is then used to build protein in the leaf and seeds of these plants. The high crude protein content reported in wet brewer's grain is due to the brewing process to which cereal grains are subjected. The process include microbial fermentation, addition of yeast and concentration of protein through removal of carbohydrate fractions (Senthil *et al.,* 2015). The fibre fractions (NDF, ADF and ADL) are highest in wet brewer's grains and cassava peels. This is expected since fibre are required in high amounts to maintain the structural integrity of forage plants. However, for wet brewer's grain and cassava peels which are derived from cereal grains and tubers respectively, the fibre fractions is lower since original materials are known to be low in fibre.

The pH ranged from 3.9 – 4.9 which falls within the range reported for tropical forages (Meneses *et al*., 2007). This also indicates that the ensiled mixtures made acceptable silage for feeding ruminants in the tropics. This may be attributed to the inclusion of cassava peel which formed at least 19% of the total mixture. Cassava peel has a high concentration of soluble and highly fermentable carbohydrate which aided the fermentation process and formation of organic acids in the ensiled mixtures. The relatively high pH (4.4 – 4.9) in mixtures containing gliricidia foliage may be attributed to the high buffering capacity of the leaves which tend to resist pH change in the ensiled mass,, leading to high pH values. The colour of the ensiled mixtures remained green which reflects the colour of the main forage (elephant grass and gliricidia) used in the mixtures. Silage is reported to be good, if the colour of the ensiled mass is close to the original colour of the fresh material (Oduguwa *et al*., 2007; Babayemi, 2009 and Adesoji *et al*., 2012). Since all the silages maintained the green colour of the fresh forages, it can be inferred that they all made quality silages.

The aroma of the silages varied from pleasant to very pleasant, indicating well preserved silages. Although the EG-GL gave a slightly prickish smell typical of gliricidia, it was not strong enough to totally discourage intake of the mixture.

All the mixtures showed a firm texture, showing that they are all within the range of a good tropical silage. The slightly wet form EG-GL is due to the low dry matter content of gliricidia foliage and the tendency for the leaf to putrefy (Carvalho et al., 2017). All silage mixtures in this study compare well with acceptable characteristics reported for silages in tropical environments (Mugweni, 2001).

The dry matter of the silage mixtures ranged between 25.3 and 28.7% three of the silages fell within the range of 25.4 to 26.8% reported for tropical silages (Amodu *et al*., 2008) while EG-WBG had higher value of 28.7%. The dry matter content of the silages were, to a large extent, a reflection of the dry matter content of the component ingredients. The relatively high dry matter content of EG-WBG compared to other silages was due mainly to the high proportion and dry matter content of WBG in the mixtures while the lower dry matter of EG-GL was due to the lower dry matter content of gliricidia foliage.

The crude protein content of silages in this study (24.1 – 25.1) compared more favourably with crude protein content of gliricidia-cassava peel and Enterolobium- cassava peel silage reported by Olorunnisomo and Fayomi, 2012. The acceptable minimum crude protein content of ruminant livestock feed for performance according to ARC (1980) was 7%. However, Norton (1994) reported an 8% for crude protein needed by ruminant for optimal rumen function. The crude protein content of the silages used in this study were above the stated requirements as a result of the functional effect of the crude protein content of Wet brewer's grain and Gliricidia foliage as well as that of the silage additive (urea) in the silage mixtures. Furthermore, Olorunnisomo (2014) had earlier reported a higher crude protein range of 11.02 to 18.50 % while Mendieta-Araica *et al*. (2009; 2011) reported a range of 14.4 to 22.6 % for legume based silage.

The coefficient of preference (CoP) shows that only EG-WBG and EG-WBG/GL had CoP above 1. This infers that only silages containing wet brewer's grain were acceptable to the animals. Although EG-Control had CoP index (0.9) and intake level similar to EG-WBG/GL, it is considered to be unacceptable to animals in this study judging by the CoP index which should be equal to or above 1. The CoP judges acceptability of feeds to animals by comparing the specific feed intake to mean intake of all the different feeds. This method has the advantage of helping the researcher to quickly identify the most acceptable or preferred feed among others offered, it however has the disadvantage of precluding other feeds as unacceptable to the animals. This may therefore lead the researcher to reject an otherwise nutritious feed as 'unacceptable' to the animals.

Another method of judging preference for feed by animals is the percent preference index (%Preference). This method judges the acceptability of feed by animals in a relative term to other feeds offered. The main advantage of this method is that while the most preferred feed can be easily identified, it does not preclude other feeds as unacceptable to the animals. Thus a relatively less acceptable feed with high nutritional profile may still find use as feed resource for livestock under different circumstances. The percentage preference of silages used in this study shows that EG-WBG was the most preferred, followed by EG-BG/GL, EG-Control while EG-GL was the least preferred. The high preference for silages containing WBG may be related to its sweet aroma and taste. The lower preference for EG-GL may be due to the unpleasant smell of gliricidia foliage, similar depressed intake result was also recorded for gliricidia foliage by Moiforay *et al.*, 2017 and Olorunnisomo and Fayomi, (2012).

The higher digestibility associated with silages containing wet brewer's grains (EG-WBG and EG-WBG/GL may be due to the lower fibre content and the high quality of protein in the mixtures. Silage containing gliricidia also showed higher digestibility compared with the control. This is also related to the lower fibre content and higher protein quality in gliricidia compared to elephant grass and urea in the control mixtures (Rusdy *et al,* 2019). Wet brewer's grain is known to have a good complement of essential amino acids and also a high by-pass protein value. This probably assisted the animals on silage containing wet brewer's grain to utilize protein in the diet better and consequently improving the digestibility of the silage mixtures (Inthapanya *et al.* 2016).

The intake and growth performance of Sokoto Gudali heifers fed different silages have been presented. The dry matter intake (%LW) was highest for EG-WBG and least for EG-GL. This is due to the highly palatable wet brewer's grain which encourage intake while the coumarin odour of gliricidia discouraged intake Wina, *et al.,* (1998). Also the high digestibility of wet brewer's grain containing silages may have helped a passage rate and therefore encouraged the animals to eat more (Hersom, 2006). The dry matter intake of 2.28 – 3.05 %LW reported for this study compares well with the dry matter intake reported for zebu cattle by Olorunnisomo and Ibhaze, 2013.
The protein intake (Kg/dDM) did not vary significantly among the treatments. This was probably due to the iso-proteineous nature of the diets, and the tendency of animals to eat to satisfy protein needs for body development. Weight gain (kg/d) showed that animals on

silages that contain wet brewer's grain or gliricidia had similar weight gain while animals on EG-Control had slightly lowered weight gain. Since diets were iso-proteinous and iso-caloric in content, this indicates that the diets except (EG-Control) satisfied the nutrient requirements of the animals for growth. The lower weight gain recorded for EG-control may be due to the lower protein quality of the diet since a significant proportion of its protein was non-protein nitrogen. The feed conversion ratio of the silages in this study varied from 7.85 to 9.71. This is within the range reported by Coleman *et al.,* 2007 for tropically adapted breed and cross breed fed in the southern plains
The best feed conversion was observed for EG-GL and the poorest for EG-Control. This may be due to unexplained factors in gliricidia foliage that encouraged better utilization of nutrient for growth.

Ideally, the required dry matter content for silage making should range between 40 to 50%. Jianxin, (2002) also reported a range of 20 to 30% dry matter for effective silage making. This recent findings agree with this report as values obtained falls within the range. The values of crude protein of the silages were well above the recommended values for ruminants as reported by ARC (1980) and Norton (1994) who reported 7% and 8% crude protein for optimal rumen function by ruminants. The additive and legumes ensiled together with the grass also contributed to the increased crude protein of the silages. The de-lignifying ability of the feed additive (urea) could explain the reduction in the values of acid detergent lignin observed in this study. This also indicated that the silages were highly digestible.

Intake and milk yield of Sokoto Gudali cows fed different silage mixtures showed that there were no significant differences in dry matter intake of the cows fed the various silages, the figures reported in this study (2.90 – 3.08%LW) indicated that the animals' intake were comparable to the range of values reported for zebu cows fed Moringa forage ensiled with cassava peel (Olorunnisomo, 2014). Protein intake also indicated that there were no significant differences among the different treatment groups which is a reflection of the iso-proteinous nature of the diets. The milk yield of Sokoto Gudali cows used in this study varied from 3.86 – 5.11kg/d with highest yield recorded for EG-WBG and the least for EG-Control, while EG-WBG/GL and EG-GL had milk yield values of 4.80 and 4.40kg/d respectively. The higher milk yield from cattle fed silages containing wet brewer's grain and gliricidia foliage is traceable to the higher dry matter intake of these diets. It is expected that the true protein content, higher protein quality and by-pass protein value of these diets contributed to the higher milk yield from these treatments. The feed conversion ratio (Milk) of Sokoto Gudali cows fed the various silage mixtures varied slightly from 1.91 to 2.31. Although there were no significant differences in the FCR (Milk), slight variations observed showed that the EG-GL was the most efficient diet for milk production while EG-Control was the least efficient. This is mainly a reflection of the protein quality of the diets.

The composition of milk from Sokoto Gudali cows fed silages containing elephant grass, wet brewer's grain and gliricidia foliage were similar. This is probably due to the higher influence of cattle genetics on milk composition than the dietary effects (Gaunt, 1980). Since the silages used in this study were formulated to be iso-nitrogenous and iso-caloric, dietary effects on composition of the milk is expected to be minimal while genetic effects from the cows are expected to be more prominent. Since all cows used in the study are largely homogenous genotypically, little or no variations are expected in the milk composition.

The blood glucose level of all the animals on the diets were within the normal physiological range of 42 – 75mg/dL reported by Latimer *et al.* (2003) but higher than 41.55 - 59.40mg/dL reported by Ewuola *et al*. (2014). Energy need of the cells are supplied by the circulating blood glucose which is derived majorly from the breakdown of dietary carbohydrates and to some extent from a complex endogenous process of glycogenolysis and gluconeogenesis. Blood glucose level is usually a result of a delicate balance between glucose availability and utilisation. Low blood sugar is implicated in weight loss and lowered idices of performance. All the silages appear to furnish adequate amount of carbohydrates to meet the physiological and nutritional requirements of the animals for the maintenance of normal blood glucose levels and for growth as observed.

The normal physiological range of total serum protein for cattle as reported by Mitruka and Rawnsley (1977) is 6.2 -8.2g/dL. The total serum protein (sum of serum Albumin and Globulin) of the animals in this study were between 7.04 -8.12g/dL and fell within normal physiological range of healthy cows indicating that the protein synthesis and utilization in the animals are good. Albumin levels may indicate if the animal is dehydrated and can provide information about the function of the liver, kidneys and the digestive systems.

Globulin levels on the other hand may reflect an underlying inflammation and or antibody production. Increased globulin levels are often associated with infectious diseases or immune mediated disease and some cancer types. The silages in this study can be adjudged adequate to furnish the animals with required amount of crude protein for the synthesis of proteins needed for physiological processes and growth. T

Cholesterol is a sterol of human health concern, it is mainly found in milk and meat consumed by man. High blood cholesterol levels have been implicated in heart failure (Hofvendahl, 1977) and medical practitioners have been pushing for the reduction in cholesterol intake (Alabdulkarim *et al*., 2012).The cholesterol values obtained in this study ranged from 145.20 – 146.88mg/dL. These values were lower than the value (196.30 - 212.00mg/dL) reported by Hansen *et al*. (2014) but were comparable to the value reported by Chladek *et al.* (2004) for cows. Serum cholesterol of dairy cow is modulated by diets. This has been demonstrated by the works of Mikula *et al.* (2011). The lower value obtained in this study for heifers was possibly because they were younger animals (heifers) as against the older cows being compared.

Blood serum urea concentration is the end product of protein metabolism. It is excreted through the kidneys in healthy animals. The urea levels in the serum of heifers in this study ranged from 18.52 – 18.96mg/dL. All the animals fed the different silages had values within the normal range (7.8 – 25.0mg/dL) reported by Mitruka and Rawnsley (1977). It was however higher than the range (12- 15mg/dL) reported by Quiroz-Rocha *et al.* (2009) for normal healthy cows. The values obtained in this study did not have observable negative effects on the animal. The addition of urea to the silages to make them iso-nitrogenous possibly informed the relatively higher values in the serum.

Creatinine level in serum is considered the best indicator of kidney function. Creatinine is a product of the metabolism of creatine in the muscle, its only means of excretion is through the kidney. Levels up to 1.5mg/dL is considered normal for healthy cattle (Smith, 2009 and Radostits *et al.,* 2008). However, values obtained in this study were slightly higher than the values reported by Smith, 2009. This slight increase observed in this study was possibly due to high crude protein (24.1 -25.1) content of the silages.

CHAPTER SIX

SUMMARY, CONCLUSION AND RECOMMENDATION

6.1 Summary

The chemical composition, silage characteristics and acceptability of Elephant grass ensiled with Wet Brewer's grains and Gliricidia forage by Sokoto Gudali cattle were assessed. The results showed that the silages had chemical compositions that meet the requirements for growth of heifers and milk production by Sokoto Gudali cows. Wet Brewer's Grain and Gliricidia forage increase the protein content of Elephant grass silage. The silages had good texture, colour, smell and pH that fell within acceptable pH range. All the silages were accepted by the animals to a varying degree indicating that the preference for the silages was highest for elephant grass ensiled with wet brewer's grain, followed by elephant grass ensiled with wet brewer's grain and gliricidia foliage, elephant grass-Control and elephant grass ensiled with gliricidia foliage respectively. There is a clear indication that the animals preferred silages with Wet Brewer's Grain to silages without Wet Brewer's Grain, since the percentage preference for elephant grass ensiled with wet brewer's grain and gliricidia foliage was still higher than the elephant grass ensiled with gliricidia foliage.

Furthermore, the digestibility of composite elephant grass silages mixtures by Sokoto Gudali cattle was evaluated. Inclusion of Wet Brewer's Grain and Gliricidia foliage improved the digestibility of Elephant grass. Wet Brewer's Grain however elicited better digestibility than the gliricidia foliage.

The Intake and growth rate of Sokoto Gudali heifers fed Wet Brewer's grains and Gliricidia forage ensiled with Elephant grass was also evaluated. Inclusion of Wet Brewer's Grain impacted positively on the dry matter intake of the heifers and the protein intake as well. Gliricidia forage however had no impact on dry matter intake. Ensiling Elephant grass with Wet Brewer's grain and Gliricidia foliage promoted the growth of Sokoto Gudali heifers equally. The feed conversion ratio of the heifers on elephant grass ensiled with gliricidia foliage silage was however superior to others on elephant grass ensiled with wet brewer's grain and elephant grass -control

Finally, the milk production and milk quality of Sokoto Gudali cows fed Elephant grass ensiled with Wet Brewer's grains and Gliricidia forage were evaluated. Cows on Elephant grass ensiled with wet brewer's grain produced more milk than the cows on other silages. The milk production by cows on elephant grass-Control was the least. Elephant grass ensiled with gliricidia foliage silage however elicited better feed conversion ratio (milk).

6.2 Conclusion

Ensiling Elephant grass with Wet Brewer's Grain and Gliricidia foliage offers the possibility of providing all-year-round supply of quality feed that can meet the nutrient requirements of growing as well as lactating Sokoto Gudali cows in Nigeria. This will go a long way in providing solution to the problem of having to herd animals over a long distance in search of forage during the dry season and the attendant farmers-herder clashes that has claimed many lives and properties. The adoption of this research findings will also increase productivity in terms of milk and meat and improve the economic returns on the cattle business. Ensiling Wet Brewer's Grain is a means of solving the problem of quality deterioration and spoilage due to its short shelve life. Finally, the values of serum biochemistry parameters of the animals fed the test silages were within acceptable range indicating that the silage had no adverse effects on health and general well -being of the animals.

6.3 Contributions to Knowledge

1. Addition of wet brewer's grain and Gliricidia foliage improved the silage characteristics and chemical composition of elephant grass.

2. Ensiling elephant grass with wet Brewer's grain increased the coefficient of preference of the silage i.e. more acceptable whereas the inclusion of Gliricidia foliage depressed the coefficient of preference.

3. Ensiling Elephant Grass with wet brewer's grain and Gliricidia foliage enhanced the digestibility of Elephant Grass.

4. The addition of Wet Brewer's grain and Gliricidia foliage to Elephant grass silage had positive effect on dry matter intake and growth.

5. Inclusion of wet brewer's grain and Gliricidia foliage in the silage mixtures significantly improved milk yield but had no effect on milk quality of Sokoto Gudali cow.`

6.4 Recommendations

- This study established the benefits of Ensiling Elephant grass with wet brewer's grain and gliricidia forage for feeding dairy cattle and other ruminants. There is a need to promote silage making using the test materials in other to make quality feed available for our cattle all year round
- On-farm studies should also be conducted using the silage compositions in this study in selected dairy farms as a means of promoting the adoption of silage technology.
- The cost benefit analysis needs to be done in order to determine which of the silages gave the highest return on investment.

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Appendix

Plate 1: Established Gliricidia Plot

Plate 2: Heap of Harvested Elephant grass and Gliricidia foliage

Plate 3: Cassava Peel

Plate 4: Particle size reduction of Forages with a Mechanical Chopper

Plate 5: Particle size reduction of cassava peels with a Mechanical Chopper

Plate 6: A Set of Bunker silos

Plate 7: Filling of silos with silage materials

Plate 8: Manual Compaction of silage Materials in the silo

Plate 9: Sealed silo

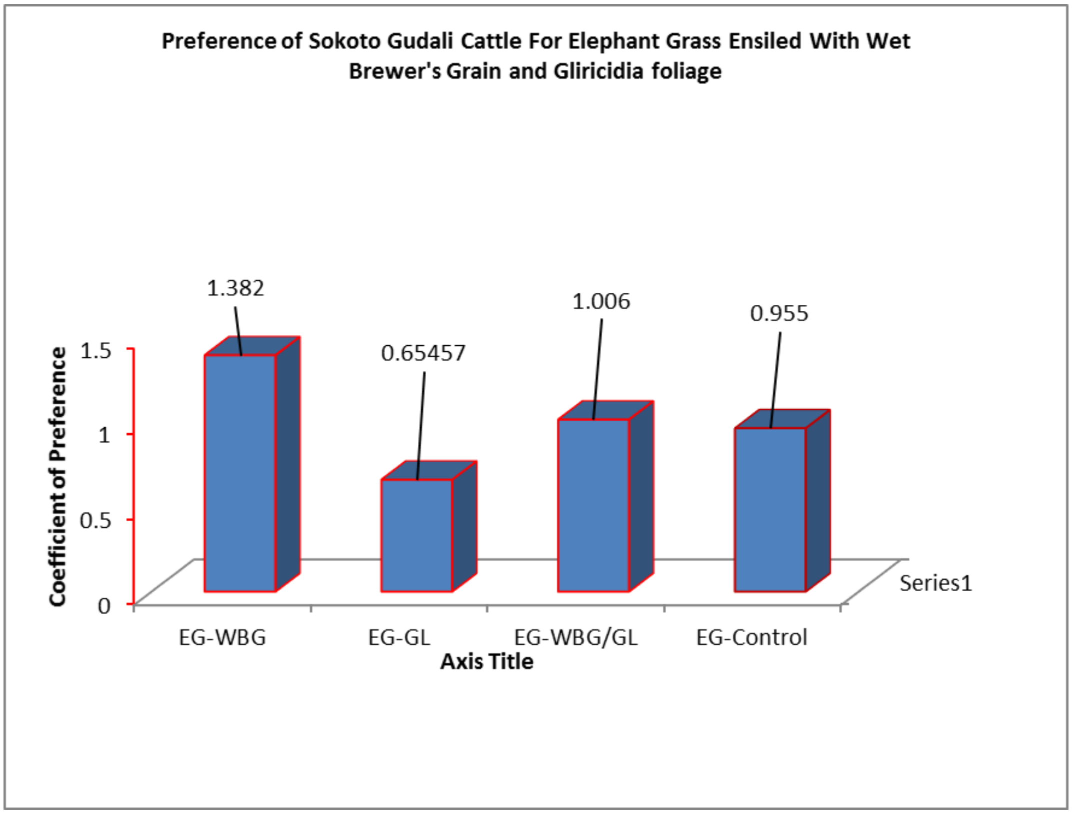

Fig. 1:Preference of Sokoto Gudali cattle for Elephant grass ensiled with Wet Brewer's Grain and Gliricidia Foliage

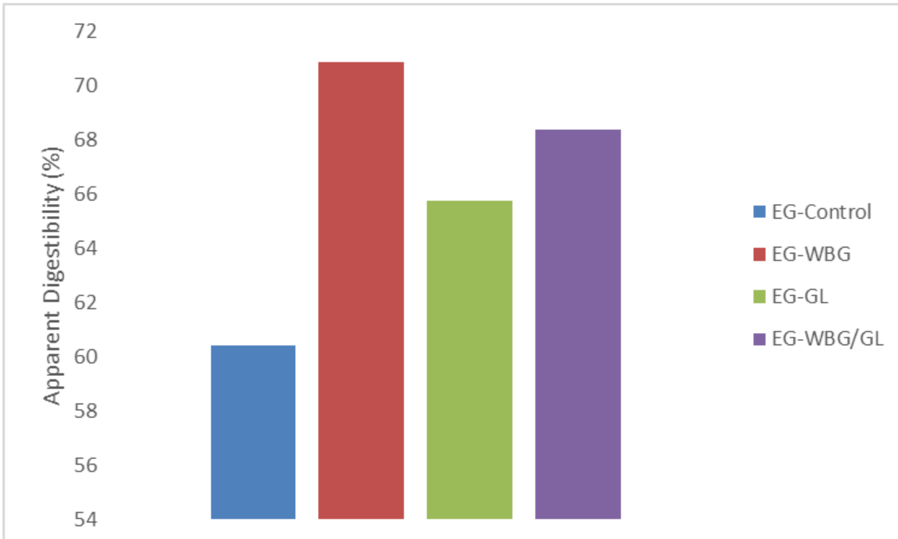

Fig.2: Apparent Digestibility of Silages

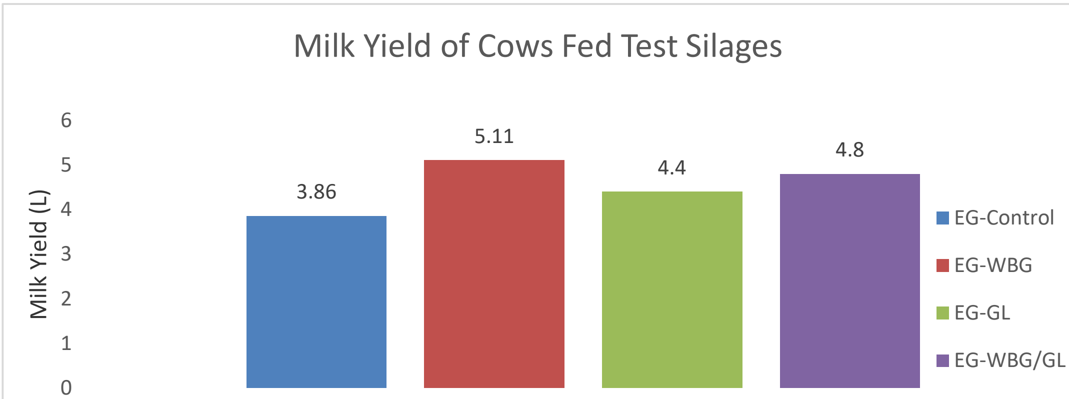

Fig. 3: Milk Yield

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