EVALUATION OF BREWERS' DRIED GRAIN ON THE PERFORMANCE OF BUNAJI YEARLING BULLS RAISED UNDER INTENSIVE SYSTEM

By

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DECLARATION

I hereby declare that the work in this thesis entitled “Evaluation of Brewers’ dried grain on the performance of Bunaji yearling bulls raised under intensive system’’ was carried out by me at the Experimental Unit of Beef Research Programme, National Animal Production Research Institute, Ahmadu Bello University, Zaria under the supervision of Prof. O.S Lamidi and Dr D.D. Dung. The information derived from the literature has been duly acknowledged in the text and a list of references provided.

No part of this thesis was previously presented for another degree or diploma at any University.

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Date

CERTIFICATION

This thesis entitled EVALUATION OF BREWERS' DRIED GRAIN ON THE PERFORMANCE OF BUNAJI YEARLING BULLS RAISED UNDER INTENSIVE SYSTEM by Yusuf Mustapha meets the regulation governing the award of the degree of Masters of Science (Animal Science) of the Ahmadu Bello University, Zaria. It is approved for its literary presentation and contribution to scientific knowledge.

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DEDICATION

This work is dedicated to Almighty God, my parents and all those who have supported me in one way or the other.

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ABREVIATIONS/ACRONYMS

% Percentage

^{o}C Degree Celsius

A B U Ahmadu Bello University

ADF Acid Detergent Fibre

AFO Animal feeding operation

AOAC Association of American Analytical Chemists

ARC Agricultural Research Council

BDG Brewers' dried grain

BSR Brewers'sorghum residue

CAFOs Concentrated animal feeding operation

CBPP Contagious Bovine Pleuro-Pneumonia

CF Crude Fibre

CFO Confined feeding operation

CP Crude Protein

CSC Cotton Seed Cake

DAD-IS Domestic Animal Diversity Information System

DAGRIS Domestic Animal Genetic Resources Information System

EE Ether extract

FAO Food and Agriculture Organization

GNC Groundnut cake

h Hour

ILO Intensive livestock operation

Kcal Kilocalories

Kg Kilogram

L Litre

ME Metabolizable Energy

MJ Megajoule

Ml militres

Mmol/L Milimoles per litre

MO Maize offal

NAPRI National Animal Production Research Institute

NDF Neutral Detergent Fibre

NEg Net energy for gain

NEl Net energy for lactation

NEm Net energy for maintenance

NFE Nitrogen Free Extract

NH_3-N Ammonia-Nitrogen

NRC National Research Council

OM Organic Matter

PKC Palm kernel cake

PKM Palm kernel meal

RAN Rumen Ammonia Nitrogen

SAS Statistical Analysis System

SDW Sorghum distillers waste

SEM Standard error of the mean

TDN Total Digestible Nutrients

TVFA Total Volatile Fatty Acid

UDP Undegradable dietary protein

ABSTRACT

Two (2) trials were conducted to determine the preference, short term intake, and performance of Bunaji yearling Bulls fed concentrate diets containing brewers' dried grain (BDG). In the first experiment, the chemical composition of Brewers' dried grain procured from three breweries namely Nigerian Brewery in Kaduna State, Benue Brewery Limited in Benue State, and Nigerian Brewery, Ibadan, Oyo State were analyzed. A Preference and short term intake trial was then conducted for seven (7) days using Six (6) Bunaji yearling bulls with an average weight of 150 kg. The bulls were fed 6 kg of brewer's dried grain from each source for two (2) hours daily in a cafeteria system. In the Second experiment, a growth trial was conducted to evaluate the effect of feeding graded levels of brewer's dried grain on growth performance, apparent nutrient digestibility and nitrogen balance of Bunaji yearling bulls. A total of twenty five (25) Bunaji yearling bulls weighing 179 kg averagely were assigned to five diets containing 0, 10, 20, 30 and 40% inclusion levels of brewers' dried grain respectively in a completely randomized design. The trial lasted for 91 days. The animals were fed concentrate diets and hay at 1.5% and 2% of their body weight respectively. Rumen fluid was collected at 0, 3, 6 and 9hrs intervals to determine the rumen fluid pH, rumen ammonia nitrogen and rumen total volatile fatty acid of the bulls. Result from the preference and short term intake studies showed that the chemical composition of the BDGs' were similar irrespective of the source. It was observed that the animals preferred the BDG from Benue and Kaduna equally with a preference index of 0.99 while the BDG sourced from Ibadan was least preferred with a preference index of 0.65. The short term intake values (5.99 kg DM/2hrs) each for BDG from Kaduna and Benue were not significantly different (P>0.05) but differ significantly (P<0.05) from the value (3.92 kg DM/2hrs) recorded for BDG from Ibadan. The chemical composition of the diets showed that the dry matter content increased as the level of BDG increased in the diet up to 30% inclusion and then dropped slightly at 40% inclusion. The crude protein ranged from 15.38% to 16.18% and it increases as the level of brewers' dried grain increased in the diet while the ether extract reduced as the level of BDG increased in the diet. Average daily feed intake ranged from 6.04 to 6.47kg. There was significant difference in average weight gain recorded, the control had the lowest value (0.45 kg/day) and 30% BDG inclusion had the highest (0.61 kg/day). The effect of BDG on apparent nutrient digestibility and nitrogen balance revealed that dry matter (DM), organic matter (OM) and crude protein (CP) digestibility were significantly ($P<0.05$) affected by inclusion levels. The dry matter digestibility ranged from 54.23% to 58.93%. There was significant difference ($P<0.05$) in the digestibility of crude protein with the treatment having 30% inclusion of brewers dried grain recording the highest (56.46%) and the treatment with 0% inclusion recording the lowest (41.69%). The highest nitrogen intake was observed in 30% inclusion level of BDG and the lowest in the treatment with no BDG inclusion. Results of BDG inclusion on rumen metabolites showed that there were significant ($P<0.05$) differences between the pH of the treatments but they all fell within the range of 6.47-7.32 which are within the normal pH range reported for proper functioning of the rumen. Highest concentration of Rumen NH_3-N and TVFA was observed at 3 hours post feeding. The cost of concentrate reduced as the level of BDG inclusion increased. Feed cost to gain ratio was least in the control (₦588.67/ Kg live weight gain) and highest in 30% BDG inclusion level (₦433.26/Kg live weight gain). The net benefits were ₦466.83, ₦5825.51, ₦3425.19, ₦9,237.17 and ₦3676.26 for feeding Bunaji yearling bulls on 0, 10, 20, 30 and 40% BDG diets respectively. It was concluded that BDG can be used to replace maize offal and cotton seed cake up to 30% for growing Bunaji bulls without any deleterious effect and can therefore be recommended to farmers for better production and profit margin.

CHAPTER ONE

1.0 INTRODUCTION

Feed constitute about 70-80% of the variable cost of growing cattle (Olayiwole *et al.*, 1981). Therefore, any feeding system that will reduce feed cost will ultimately result in reduction of total cost of production and increase profit margin. Thus, the use of non-conventional feedstuffs and crop residues which have little opportunity cost in their use for other purposes on the farm can be substituted for the conventional and very expensive feedstuffs to reduce cost of production (Lamidi *et al.*, 2007).

The high growth rate of human population resulting in inadequate land available for extensive production systems has led to increased utilization of crop residues and agro-industrial by-products as animal feedstuff. Current research efforts in most developing countries are therefore aimed at identifying potential feed sources that could be cheap, available for compounding livestock ration and have little or no demand by human so as to reduce competition between man and livestock (Ulfina *et al.*, 2013).

Some of these potential feed materials that have been investigated include by-products from industries and waste from cattle ranches, abattoir and poultry houses (Alawa and Umunna, 1993; Abdulmalik *et al.*, 1994). Addressing the problem of shortage of animal protein in Nigeria calls for total exploitation of all the ways of increasing the quantity of animal protein to meet the satisfactory level of intake; one of these ways is to increase the production of animals while reducing the cost of feed using agro industrial by-products such as brewers' dried grain.

There are several by-products that evolve from the production of beer in the brewing industry such as brewers' grains (wet or dried) and brewers' dried yeast. Brewers' grains are the most extensively used brewers' by product and potential feed source for livestock keepers residing near breweries (Ulfina *et al.*, 2013). Brewers' grains are considered to be good sources of undegradable dietary protein (UDP) and water-soluble vitamins and they have been used in feeding ruminant and monogastric animals (Blezinger, 1998).

A considerable number of breweries have been established in different parts of the country, from which large quantities of brewers' waste become available as a source of energy and protein for livestock feeding. The dairy and beef cattle production survey around some Breweries in Nigeria indicated that brewers' waste is the only supplement available in the area but the form and quantity to be given to a specific type of animal was not studied (Ulfina *et al.*, 2013). With the current increasing prices of maize offal and cotton seed cake and the potential of brewers' dried grain to replace maize offal and cotton seed cake it is important to determine to what extent brewers' waste can replace both maize offal and cotton seed cake in feeding cattle since brewers' dried grain is rich in energy and protein,.

1.1 Justification

In Nigeria, research efforts have completely replaced maize with maize offal as energy source and cotton seed cake has been the major protein source in the growing and fattening ration of bulls (Lamidi, 2005). The prices of these ingredients are on the increase hence the need to evaluate other cheaper ingredients, for this reason, Brewers' dried grain comes to mind. Brewers' dried grain is a good protein and energy source and a lot of work has been reported (Mufwa *et al*., 2011; Isikwenu, 2011; Banjo *et al*, 2012, Uchegbu *et al*., 2011) on its incorporation in the diet of monogastric animals but little work has been done on its uses in ruminant diets, and the ones available are not recent (Umunna *et al.,* 1980; Ogundola, 1984)

There is a wrong perception about brewer's dried grain as a very expensive and scarce feedstuff in the country. Brewer's dried grain is cheap and readily available in most areas where there are breweries especially in the northern part of the country where swine are not commonly raised. In fact, most Breweries sell brewer's grain at a very cheap price to locals (widows and the poor) around the vicinity of the factory using a term called "evacuation" as a way of helping them. These locals then dry and bag the BDG for sale. These locals usually have tonnes of BDG waiting for available buyers. Using Kaduna breweries as a reference point, most of the sellers of BDG around the factory rely on some buyer's from Kano (called "Kanawa") for their products to be sold. Sometimes, these BDG get spoilt and wasted because there are no adequate buyers for it. This is more common in the raining season because most of the sellers rely on Sunlight to dry their product.

Brewers dried grain nutritional value and its availability makes it a very good ingredient that can be substituted for the costly maize offal and cotton seed cake. Brewers' dried grain cost N34/kg compared to maize offal and cotton seed cake that cost as high as N40-50/kg and N60-65/kg respectively. Brewer's dried grain can easily be stored and the feed ingredient is not easily attacked by insect weevils.

Also, there is no standardized commercial feed for growing or fattening cattle, therefore this study is targeted towards using a feed ingredient that is cheap, available, rich in nutrients with no competition with humans and less competition with monogastrics to compound a standard feed for growing cattle. This should be able to solve the problem of complete dependence on maize offal and cotton seed cake as a major source of energy and protein in the diet of ruminants. Hence, the need to re-evaluate the chemical composition, intake and the optimum level of incorporation of brewers' dried grain in growing Bunaji yearling bulls.

1.2 Objectives of the study

The broad objective of the study was aimed at reducing the cost of concentrate for Bunaji yearling bulls which will in turn reduce the cost of production.

Specific objectives were to:

1. Study the Nutritive value and short term intake of Brewers' dried grain sourced from three different Breweries

2. Determine the growth performance of Bunaji yearling bulls raised on diets containing brewers' dried grain.

3. Evaluate the economics of feeding Bunaji yearling bulls on diets containing brewers' dried grain.

1.3 Research hypothesis

Hypotheses

1. **Ho:** Brewers' dried grain from Kaduna, Benue and Makurdi breweries have no effect on chemical composition, preference and short term intake in Bunaji yearling bulls

Ha: Brewers' dried grain from Kaduna, Benue and Makurdi breweries have effect on chemical composition, preference and short term intake in Bunaji yearling bulls

2. **Ho:** Diets containing brewers' dried grain have no effect on growth performance of Bunaji yearling bulls.

Ha: Diets containing brewers' dried grain have effect on growth performance of Bunaji yearling bulls.

3. **Ho:** Diets containing brewers' dried grain have no effect on apparent nutrient digestibility and nitrogen balance of Bunaji yearling bulls.

Ha: Diets containing brewers' dried grain have effect on apparent nutrient digestibility and nitrogen balance of Bunaji yearling bulls.

4. **Ho:** Diets containing Brewers' dried grain have no effect on the economics of raising Bunaji yearling bulls.

Ha: Diets containing Brewers' dried grain have effect on the economics of raising Bunaji yearling bulls.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Cattle production in Nigeria

Ruminants exert a greater effect on ecosystems than other animal species. In Nigeria, ruminant livestock are numerous and provide substantial quantities of animal protein. However, cattle production systems are predominantly traditional or village systems, nomadic or pastoral systems, mixed farming, and the peri-urban and modern livestock husbandry. Aregheore (2009) opined that ruminant production and management system vary from free range in the less populated areas to year round confinement with cut and carry feeding of grasses and browse plants in densely populated areas.

Cattle population in Nigeria has been reported to be about 20 million (FAO, 2013). Data for meat and milk production, live animal imports and milk imports shows that beef and veal, sheep meat, goats and game meat production in 2009 are 280, 100.7, 147.1 and 120 metric tonnes, respectively (Aregheore, 2009).

Although, cattle are found in almost every zone of Nigeria, they are mostly found occupying about two-thirds (2/3) of the country. Aregheore (2009) noted that half of the total cattle population is permanently resident in the sub humid zone. Over 90% of the Nigerians' population of Zebu cattle is owned by agro-pastoral farmers, who adopt relatively inefficient production systems (Otchere and Nuru, 1988). The proportion of various breeds of cattle in Nigeria are 51%, 14%, 11.5%, 11.5%, 2.1%, 0.7%, 0.2% and 9% for Bunaji, Rahaji, Sokoto Gudali, Adamawa Gudali, Keteku, Muturu, N'dama and others, respectively (FAO, 1988 and Barje, 2006). Keteku, Muturu and Kuri/Chad cattle are predominantly found in the Southern-Western, Southern and North Eastern parts of Nigeria, respectively (Aregheore, 2009).

2.2 Some indigenous breeds of cattle in Nigeria

2.2.1 White Fulani

The White Fulani cattle are mainly owned by the nomadic Fulani people who occupy the belt between the Sahara and the Rainforest zones, from the west of the river Senegal to the east of Lake Chad, including parts of western Senegal, Southern Mauritania, in and around the flood plains of Niger, Chad, northern Nigeria (Kano, Zaria, Borno and Bauchi States) and Cameroon. There are two schools of thought about the origin of the White Fulani cattle breed. One is that the White Fulani are truly long-horned Zebus, and this assumption is due to appearance of a distinct hump in a newborn bull calf, and the characteristic nature of skull and thoracic vertebrae. The other one is that the breed resulted from interbreeding first between the short-horned zebu and the ancient Hamitic longhorn and/or shorthorn that results to a Sanga breed, and then interbreeding of Sanga with Thoracic humped Zebu animals could have resulted in cattle with lyre-shaped horns including the White Fulani (Tawah and Rege, 1996).

2.2.1.1 Physical characteristics: The coat colour of White Fulani is commonly white on a black skin with black ears, eyes, muzzle, hooves, horn tips and tip of tail. Their thoracic or sometimes intermediate hump and dewlap are well developed. The head is long, wide across the forehead and with a straight or concave appearance; average adult wither height is 130 cm; the neck is strong providing an upward carriage for the head; horns are slender, medium to long (81 to 107 cm), lyre shaped: curved outwards and upwards, with an outward turn at the tip (Faulkner and Epstein, 1957). The White Fulani are generally taller and narrower bodied cattle; the rump is of good length but has a marked slope from hook to pin bones. The udder is well-developed, of a good shape and strong attachment. Teats are well positioned and are of medium to reasonably large size (Tawah and Rege, 1996).

2.2.1.2 Peculiarity: The general shallowness of the body and lack of width give the breed a leggy appearance. This characteristic of the breed has been described as an adaptation to long distance trekking in the pastoral management (Tawah and Rege, 1996). The breed is of interest in that it is more tolerant to heat as compared to N'Dama and Gudali, more resistant to dermatophilosis than the Muturu and N'Dama breeds, resistant to intestinal helminth parasites, and has low mortality rate. Although it is less resistant to trypanosomosis than the N'Dama, it is more tolerant than the Gudali and other zebu types (Tawah and Rege, 1996).

2.2.1.3 Breed status: The population estimate of the Fulani cattle in Nigeria, Cameroon and the Central African Republic is about 9,645,000. The White Fulani are the most numerous and widespread of all the Nigerian cattle breeds, representing about 51% of the national cattle population; they also represent 33% of the national cattle population in Cameroon.

2.2.1.4 Utility: The White Fulani are used for milk, meat and draught although the traditional owners keep them mainly for milk. Their dairy potential is better than most zebus, and is comparable to Kenana of the Sudan. Average lactation length is around 220 days. Although the total lactation milk yield ranges from 627 to 1034 kg, the yield expressed per unit body weight would give them good milking rank. Mean butterfat percentages ranges from 4.10 to 7.50 (Tawah and Rege, 1996). Their conformation and body size make them suitable for draught. They are good beef animals, which fatten quite well in feedlots and on natural pastures. The average birth weights computed in the different regimes range from 18.2 to 24.2 kg; mature weight of bulls and cows in the improved system of management is 350-665 and 250-380 kg, respectively (Tawah and Rege, 1996). Feedlot studies indicate that these cattle can achieve growth performance of 1 kg per day. Slaughter and carcass weights of 325 and 166 kg were reported in well-finished steers. The dressing percentage is reported to be 50-60, average age at first calving 40-49 months and average calving interval 403 days (DAD-IS, 1995; Tawah and Rege 1996).

2.2.2 Sokoto Gudali

2.2.2.1 Origin and distribution: Gudali is a Hausa word for "short-horned and short-legged animals". They are also referred to as Fulbe or Peuhl zebu in West and Central Africa. Gudali, classified in the Sahelian Zebu breeds, is believed to have descended from the Indo-Pakistani Zebu, which entered the Horn of Africa by way of the Persian Gulf and south Arabia. Arabian invaders spread the zebu to the south and west over the continent from 669 BC (DAGRIS, 2005). It is among the short-horned zebu of West and Central Africa. There are about 5 strains of Gudali namely Sokoto Gudali, Adamawa Gudali, Banyo Gudali, Yola Gudali and Ngaundere Gudali. The Sokoto Gudali is the strain found in Nigeria, northern Benin, Ghana and Mali (Tawah and Rege, 1996). The Gudali are principally found in Nigeria, Cameroon and Central African Republic, but a small population also inhabits Ghana.

2.2.2.2 Physical characteristics: The Sokoto Gudali has multiple coat colours although the most common one is black and white coating with light underside. They have deeper body than the White Fulani breed and resemble East African Boran and the Sudanese Kenana (Tawah and Rege, 1996; Rege and Tawah, 1999). It is similar in conformation, size and origin to the large East African Shorthorn Zebu. The head is long and wide between the eyes and across the forehead, with a straight or slightly convex facial profile. Ears are long, large and convex, sometimes pendulous, although not to the same degree as in some of the Indo-Pakistan zebus. The hump is thoracic in position. The average height at withers ranges from 130-138 cm for males and 116-132 cm for females (Tawah and Rege, 1996).

2.2.2.3 Peculiarity: About 90% of the Sokoto Gudali are owned and managed by Fulani and Hausa pastoralists and transhumant herders (Ngere, 1985), who feed their cattle on communally owned grazing lands and browse especially in the dry season (Tawah and Rege, 1996). They are known for their hardiness to the arid northerly environments.

2.2.2.4 Breed status: Population estimate (DAD-IS, 2005) based on breed level survey in 1992 for the Sokoto Gudali in Nigeria and Ghana is 4 400 000 and 10 000, respectively. The breed is not at a risk of disappearance.

2.2.2.5 Utility: The Sokoto Gudali cattle are known for their meat and milk. Mature weights range from 495-660 kg for males and 240-355 kg for females. They are also reputed for their beef quality. Among the indigenous breeds in Ghana, the highest mean total milk yield of 1101.3 kg in a lactation length of 244.8 days was obtained from the Sokoto Gudali under direct hand and machine milking on station (Tawah and Rege, 1996). On the other hand, reproductive performance, in terms of age at first calving, which ranges from mean values of 38.6 to 49.5 months, and calving interval, ranging from 378 to 537 days, is low (Tawah and Rege, 1996). The latter is attributed to the ovarian inactivity in the postpartum period and to abortions and stillbirths, whose incidence rate were 4.7-5.9%. Their slow and sluggish nature allows them to be used for draft, including ploughing and carting.

2.2.3 Shuwa

2.2.3.1 Origin and distribution: The Shuwa cattle are also known by the names Arab Shuwa, Arab Choa or Wadara cattle. They are called Arab cattle either with reference to their home country or the traders who introduced them into the Chad region. They are known to have been brought to the region by the migrant Shuwa Arab nomads. As is evident from their wide distribution, the Shuwa cattle are influenced by the North Sudan

Zebu in the East, and by the Fulani in Cameroon. They are found throughout Chad (mainly Ouaddai, Batha and Kanem Districts, except in the southwest), in northeastern Nigeria (Bornu empire) and in the extreme north of Cameroon.

2.2.3.2 Physical characteristics: The breed is considered to have some humpless Shorthorn blood but is phenotypically zebu. Their colour is generally chestnut or dark red-and-black, less frequently reddish brown or black, with or without small white patches on the underline. The 0head is long, straight in profile, with short, moderately thick, round or flat horns with blunt tips, which commonly curve slightly outwards and upwards or downwards; occasionally the horns project laterally or lie close to the head or are loose. The ears are long but not pendulous, and are carried horizontally with the inner surface to the front. The neck is short, tending to carry the head low. The dewlap is only moderately developed; it shows some folds but is not markedly loose or pendulous. The hump is muscular in structure: small in cows, and of medium size in bulls. It is small but is well muscled, deep built on round ribs. The rump is long and sloping, the tail thin and long. The legs are short and fine-boned, with small, hard, well-formed bones. The range of wither height for males and females is 135-140 cm and 125-128 cm, resectively (Tawah and Rege, 1996).

2.2.3.3 Peculiarity: The breed is owned by semi-nomadic people who move to good grazing lands and water in the dry seasons. Their usefulness under stressful environment is well appreciated; the animals are considered to be good dairy animals, and are used by women for riding and as pack animals (Tawah and Rege, 1996).

2.2.3.4 Breed status: The estimated population of the Shuwa Arab was 4 092 000 in Chad, 50 000 in Cameroon indicating their abundance and not threatened (Tawah and Rege, 1996).

2.2.3.5 Utility: The Shuwa breed is used for work, meat and milk in that order of importance. They are also used for riding, as pack and draft animals. They are considered to be good dairy animals, with milk off-takes of 450-1820 kg in lactations lasting 240-370 days. They give good beef carcasses, although their size is as low as 17.9-18.8 kg at birth, and 250-300 and 350-475 kg at maturity for females and males, respectively (Tawah and Rege, 1996).

2.2.4 Muturu

2.2.4.1 Origin and distribution: \`Muturu', meaning humpless, is the Hausa name for the West African Shorthorn in Anglophone West Africa. Since the second half of the first millennium B.C. Muturu cattle were the most widespread breed of Nigeria until the Fulani invasion, which started in 1820 (Felius, 1995). The breed is a variety of West African Shorthorn. Generally, two types of Muturu cattle have been identified: a larger Savannah-type and a Dwarf-Forest type, which appears to have evolved through adaptation to the humid forest environment. Most of the Muturu cattle of Nigeria belong to the Savannah type, spread over the Benue plateau, and smaller numbers are found further to the Southwest in Oyo and Kware. This breed is also found in Southeastern coastal area of Ghana. The distinction between the strains of the breed is not yet clear, however, DAGRIS (2005) has classified the Muturu cattle breed into four separate cattle populations, namely Ghana Dwarf Muturu (also called Muturu or Forest Shorthorn), Liberia Dwarf Muturu (also called Liberian Muturu), Nigerian Forest Muturu (also called Kirdi), and Nigerian Savanna Muturu (also termed Muturu). In Ghana, they inhabit the south-eastern coastal area near Ada and Keta Lagoon. In Liberia, they are found in eastern coastal areas of Maryland and Sinoe counties of southeastern Liberia. Nigerian Forest Muturu is found along the coastline of Nigeria, from the border with Benin to the Cameroon border.

2.2.4.2 Physical characteristics: The typical coat colour of forest Muturu is black and that of the Savannah Muturu is black and white. Height at withers is 95 cm for males and 88 cm for females (Maule, 1990). It is the smallest cattle breed known.

2.2.4.3 Peculiarity: The management level where these cattle are kept is low in spite of which they maintain good body condition by grazing and browsing throughout the year. The breed is also reported to be trypanotolerant (Adeneji, 1983). The Muturu have significant cultural values.

2.2.4.4 Breed status: The number of Muturu cattle in 1990 in Nigeria was between 75 000 to 120 000: 25 000 to 40 000 for the Dwarf or Forest Muturu and 50 000 to 80 000 for the Savannah Muturu (DAD-IS, 2005). Despite their abundance they are not considered as safe. The biggest threat seems to be pressure from the numerically superior zebu, especially through crossbreeding, and the increasingly popular N'Dama, through replacement. The Muturu is found in areas heavily infested with tsetse, as a result of which this breed has adapted and naturally selected to be tolerant to trypanosomosis, ticks and tick-borne diseases although it is susceptible to rinderpest.

2.2.4.5 Utility: They are used for socio-cultural purposes. In Igboland these cattle are traditionally sacred and considered as properties of the local deities or they are dedicated to a shrine. Muturu cows are seldom milked. If milked their yield per year was reported to be 421 kg. The friendly animals are sometimes used for work. As beef cattle they perform well, dressing out at 64%. Age of first calving of the Muturu is 635 days compared to that of the N'Dama 684 days. Calving interval for N'Dama was 350 compared to 363 days for Muturu (Roberts and Gray 1973). Although the weight of the Muturu is low as compared to many zebu and sanga breeds, their high fertility, tolerance to trypanosomosis, and cultural roles make them an important breed in their traditional breeding areas.

The animals and their hides are used mainly for ritual sacrifices and ceremonies particularly funerals. They are also commonly kept as pets or, frequently, they are used for prestige or dowry purposes (Tawah and Rege, 1996).

2.2.5 N'dama

2.2.5.1 Origin and distribution: The N'Dama, also known as Boenca, Boyenca, and Faouta Longhorn, is a humpless Longhorn (*Bos taurus longifrons*). Until recently, Humpless (*Bos taurus*) Hametic Longhorn cattle breeds are believed to have descended from the first domesticated cattle populations of the Humpless Hamitic Longhorn cattle in the region's so-called the 'Fertile Crescent', possibly 9000 BC (Payne and Hodges, 1997). These were said to be the first cattle to be introduced to Africa via the land connection with Asia by nomadic people and have spread to the west and south of Egypt. Archaeological findings, however, have led to the new theory that there was an African centre of domestication in the Sahara from southern Libya and north-western Niger to southern Egypt. Further genetic studies have also suggested that the present-day humpless cattle populations are so divergent from similar cattle populations of Europe which implies that separate domestication could have occurred in Africa (Bradley *et al*., 1996).

This is supported by the genetic evidence from Hanotte *et al*. (2002), which also indicated an exogenous but minor genetic influence of non-African origin from Europe and/or Near East in the breeds of north and northeast of Africa as well as localised areas of southern Africa. These African taurine cattle were also influenced by a slow genetic introgression by the zebu cattle (*Bos indicus*) of Asian origin. There is now convincing genetic and archaeological evidences for the domestication within Africa of these African taurine cattle breeds. Presently, the Humpless Longhorn cattle are represented by two breeds; the N'Dama and the Kuri, though the two breeds are quite distinct in their morphology (Rege and Tawah, 1999). N'Dama cattle are believed to have originated from the Fouta Djallon plateau in Guinea, and are now found in the whole of coastal West and Central Africa: Senegal, The Gambia, Guinea-Bissau, Guinea, Sierra Leone, Cote d'Ivoire, western Mali, Ghana, Togo, Nigeria, Cameroon, Central African Republic, Gabon, Congo (Brazzaville), and Democratic Republic of Congo (former Zaire), particularly in the regions infested by tsetse fly (DAGRIS, 2005).

2.2.5.2 Physical characteristics: The N'Dama is compact and set on short legs of fine bone; neck is thick and deep; back is fairly broad, well-fleshed and straight from withers to tail head. They have a short and broad head, straight profile and broad muzzle; the average horn size is about 60 cm and the horns typically curve upward and outward or have a lyre-shape, although there are different horn shapes and occasional polled individuals, especially in Sierra Leone and Guinea; the dewlap and umbilical folds are poorly developed; the typical coat colour is fawn with darker extremities, lighter underside; common solid colours are light to dark fawn, grey, dun, light red, chestnut, red with black head; belly and lower part of tail may be white. The breed is of medium size, being 100 cm height at shoulder for cows and 120 cm for bulls, and with a large and strong head (Tawah and Rege, 1996).

2.2.5.3 Peculiarity: The breed is known for its tolerance to trypanosomosis (Ngamuna *et al*., 1988; Claxton and Leperre, 1991; Dwinger *et al*., 1992; Mattioli *et al*., 1993). It is also markedly resistant to tick-borne infections (Mattioli *et al*., 1995), but not to rinderpest. In addition, the breed is well adapted to stressful humid and dry tropical climates.

2.2.5.4 Breed status: Population estimates by DAD-IS (2005) totals to 6 618 713 head, distributed within the countries of West and Central Africa. For the last 65 years, large scale herds of this breed have been improved in Zaire by a private Company named as Compagne J. Van Lanckeic which owns over 40 000 head of pure N'Dama and has improved the mature weight of the breed by 30-50 kg without affecting hardiness. Large herds are exclusively kept for beef under ranching condition in Guinea; commercial herds are also kept in Zaire.

The breed has been selected and crossed with Jersey in Côte d'Ivoire since 1955; it has also been crossed with the Sokoto Gudali in Ghana, after its introduction in 1923; it has been crossed with the West African Shorthorn in Togo. Since 1986 some N'Dama has been exported from Senegal to the Virgin Islands-there they have been bred to Red Poll and a new breed, resulting to the Senepol (Maule, 1990; Rege and Tawah, 1999).

2.2.5.5 Utility: The N'Dama cattle are known for their beef conformation. Average birth weight of 19 and 22 kg was reported in two high and zero trypanosomosis risk areas, respectively (Leak *et al*., 1988), while, respective body weight for cows in the two areas were 296 and 331 kg. The average adult weights range from 320 to 360 kg and 250 to 270 kg for males and females, respectively (Payne, 1970; Starkey, 1982; 1984; Maule, 1990; Porter, 1991; Mason, 1996). The dressing percentage is around 50% and the meat has a very good flavour without much fat (Maule 1990; Rege and Tawah, 1999).

The N'Dama is a multipurpose breed with relatively low milk production, although partial milking is frequently carried out in the traditional herds of West Africa. In these circumstances the yield for humans is estimated at 70-100 kg per cow per year in most countries with a higher output of 178 kg/year being reported from Mali (FAO, 1980). The full lactation yield is considered to be about 500-600 kg (Payne, 1970; Mason, 1984; Portar, 1991). A dairy herd of N'Dama maintained in Sierra Leone from 1944-1952 averaged 540 kg during lactation period of 283 days in one five-year period, with highest yields around 1 150 kg per lactation (Touchberry, 1967). Oxen are good work animals (Starkey, 1982; Spencer and Eckert, 1988). Under the traditional system, heifers give birth at about 48 months and the interval between calvings average 20 months. Under ranching conditions involving grazing, salt licking, provision of minerals and dipping, the heifers calve at 35 to 42 months (Starkey, 1984; Maule, 1990).

2.2.6 Kuri

2.2.6.1 Origin and distribution: The Kuri is a humpless longhorn (scientific name - *Bos taurus longifrons)*, the very pure form of which is found in the island region of Lake Chad i.e. Djibadala, Koremeron, Debada and Bagdal (Malbrant *et al*., 1947). Other names of the breed at different locations are Baharie, Bare, Borrie, Boundouma, Dongole, Kouburi, Buduma, White Lake Chad, Boenca, and Boyenca. The origin of Kuri cattle breed is obscure and uncertain. One theory considers the Kuri as a pure Hamitic Longhorn, which descended from the ancient Egyptian or Hamitic Longhorn as depicted in the Egyptian drawings. The Kuri probably branched off the stream of the Hamitic Longhorn on its north-westerly passage from Egypt and migrated south-west ward through the Sahara corridor to Lake Chad.

Another theory considers the Kuri to be of the Sanga (Bos indicus x Bos taurus) type that originated from the intermixture of lateral-horned zebu and the hamitic longhorn in upper Egypt and present day Ethiopia (DAGRIS 2005). The Kuri predominates on the shores and islands of Lake Chad, which borders with Cameroon, Chad, Niger and Nigeria. Its main habitat is in southern Chad and north-eastern Nigeria but they are also found in northern Cameroon, in the N'Guigmi province of Niger and to a limited extent, in the Central African Republic. The breed was also reported from Jikawo district of Gambella region in Western Ethiopia (Alberro *et al*., 1982).

2.2.6.2 Physical characteristics: The Kuri cattle are predominantly white with pigmented mucous membranes; individuals with red, red pied, light grey, or dun, dark or black spots, reddish brown, greyish red or speckled markings are often present, white animals with occasional grey-coloured shoulders and dark spots with black or greyish black (Tawah *et al*., 1997). The Kuri cattle are tall among African breeds with long back, shallow body and a large bony rump. The body length ranges 133.7 to 144 cm in females and 152 to 165 cm in males. Heart girth in females is 172 where in males range from 183 to 211 cm. They have massive bulbous shaped horns with its length range 70 to 150 cm, the circumference of which may reach up to 100 cm (Epstein, 1971; Queval *et al*., 1972; Renard, 1972). The dewlap is inconspicuous. There is no evidence of a hump in the Kuri found in the islands or on the shores of the Lake Chad but away from the lake it is obvious that there has been some intermingling with zebu (Payne, 1970).

2.2.6.3 Peculiarity: The breed is adapted to the hot and humid climate, and in their original habitat, they are managed under traditional system feeding on grass on the small islands on the Lake Chad; they are excellent swimmers and follow their herdsmen through the water as they travel from an island to another; their bulbous horns are considered useful in floating (Rege and Tawah, 1999).

2.2.6.4 Breed status: The 1991 estimate of Kuri population was 120 000 in Chad (which is ¾ of the total Kuri) and 2 350 in Cameroon (DAD-IS, 2005). More recent estimates give a lower figure of 110 000 for the total population (Rege and Tawah, 1999). The Kuri breed is said to be rapidly declining in numbers both in Nigeria and in Chad. Possible reasons for the declining trend include drought, protracted civil conflicts in the region, the retreating waters of the Lake and extensive crossbreeding with the zebus when they graze on the shores. Due to its inability to thrive outside its lake habitat, the Kuri is threatened (Rege and Tawah, 1999). The trend is exacerbated by lack of improvement programmes for the breed and susceptibility to rinderpest. In early 1980s, a project was established to evaluate, select and distribute male animals based on milk yield performance in Chad (Adeniji, 1983). There is no conservation programme for breed (Adeniji, 1983; Tawah *et al*., 1997).

2.2.6.5 Utility: Tawah *et al*. (1997) indicated that the main use of Kuri cattle is milk and to a limited extent meat. Domestic Animals Diversity Information System (DAD-IS) puts the importance in the reverse order. Although it is said that there is milk let down problem, there is a record of 1260 kg of lactation milk yield over an average lactation period of 280 days (Epstein, 1971). On the other hand DAD-IS indicates that the lactation milk yield range between 360 and 800 litres. It is also indicated that a Kuri cow is capable of producing as much as 6 kg of milk a day after feeding her calf, and fattens well on pasture and in feedlot. Meat quality of the Kuri is considered exceptionally good (Tawah *et al*., 1997).

Age at first calving of the Kuri heifers is about 40 months, the calving interval 445 days, and the number of calves produced in a lifetime of up to 12 (Malbrant *et al*., 1947; Epstein, 1971).

The birth weight is about 25 kg. Tawah *et al*. (1997) indicated that the females have 400 kg average body weight and the bulls 475 kg though some males reach a body weight of 600 kg, with dressing percentage of 50%. On the other hand, DAD-IS (2005) indicated that the females weigh 363 kg while males weigh 499 kg.

2.3 Beef cattle production systems

In sub-saharan Africa beef cattle provide substantial quantities of animal protein. However, their production is based on age-old husbandry systems, which need to be gradually modified in order to improve their productivity, hence bridge the gap between supply and demand. Beef cattle production systems in Nigeria are predominantly grouped into; traditional or village systems, nomadic or pastoral systems, mixed farming (crop-livestock) and the peri-urban commercial dairy production system. In general, production and management systems vary from free range in less populated areas to year round confinement and cut and carry feeding of grass and browse in densely populated areas (Aregheore, 2009)

2.3.1 Traditional or extensive or Village systems

Traditionally managed stock is over 85 % for all species (Tewe and Bokanga, 2001) and animals under the extensive system rely on natural grass and forage legumes for subsistence. The traditional production systems include scavenging, cut-and-carry production systems, seasonal tethering, fattening and compound dairying. In short, the livestock sub-sector is dominated by traditional systems of production, processing and marketing (Ehoche, 2002).

2.3.2 Scavenging

It is the most extreme low-input management system used by most subsistence farmers. The animals are allowed to roam freely in the villages and their environs, scavenging food scraps and crop residues. There is no record taking of mating, pregnancy, disease or anything of relevance to the survival of the animal. In short, these animals are not subjected to any routine management practices. The subsistence farmer keeps them on a side line operation to his crops and also as a hobby (Tewe and Bokanga, 2001; Aregheore, 2001).

2.3.3 Cut-and-carry method/Seasonal tethering

With increase in human population and activities, the extensive grazing systems are now becoming disruptive to crop production and other non-agricultural activities. By-laws in the nineteen-seventies required that animals be tethered and fed by the cut-and carry method. Under this system the farmer houses his stock by seasonal tethering of individual animals in the compound or in areas where forages are available. These forages are harvested and fed to them. This system is carried out where the farmer has insufficient land and there are strict village laws against scavenging. The number of animals is usually small (Tewe and Bokanga, 2001).

2.3.4 Nomadic or pastoral systems

The traditional grazing pattern is that in which at the end of the dry season the animals are either near permanent villages feeding on dry forage and browse or far enough south to find range and water but not so far as to encounter tsetse fly (Payne, 1990). The migration to north begins and continues as long as the grass ahead is as green as the pastures at hand. When the northernmost grass and water are consumed (usually in November or December), there is a slow movement southwards to the home range, where there should be crop stubble and a full growth of grass to carry the animals through the dry season (Clyburn, 1974). Traditionally, the different clans or ethnic groups usually have their respective grazing areas, depending on their environment; they also tend to specialize in certain animals. For example, the Fulani in northern Nigeria are known for their cattle.

Herding is a monumental task for the Fulani who are always trying to get the best grazing condition for their animals. Contrary to popular belief, moving with animals is not the delight of the pastoralists. The migrant Fulani in Nigeria move because they have no choice (Otchere *et al*., 1985). In general terms the pastoral systems practiced by the Fulani herders fall into three groups exclusive pastoralists, transhumant pastoralists and agro-pastoralists.

2.3.4.1 Exclusive pastoralists

These are mainly livestock producers who do not grow crops and therefore depend on the sales of live animals and dairy products to buy grains, other food items and other necessities. Most pastoralists under this system may move very long distances every year. It is a popular assumption that they wander from place to place without any logic, however, they have set migration routes and often long-standing arrangements with farmers to make use of their crop residues (Tewe and Bokanga, 2001). It is only when there is drought, a failure of the pasture or the spread of diseases that they diverge from their existing patterns. The pastoralists in the Niger-Benue valley migrate very short distances between the wet and dry seasons. They use the same grazing areas and routes each year with the thatching on houses at each location repaired annually. Most of the pastoralists spend the dry season in the River Niger floodplains and only move to higher grounds before the flood rises during the rains (Aregheore, 2001).

2.3.4.2 Transhumant pastoralists

Transhumance pastoralists in the drier north of the country rear a very high proportion of the cattle herd. Pastoralists under this production system have permanent homestead and base (Ehoche, 2002). Their animals depend on the natural forage legumes and grasses for subsistence but these are usually unavailable in the dry season (Preston and Leng, 1987). They move in response to seasonal changes in the quality of grazing resources and the tsetse fly challenges. The travelling unit is normally made of a common herd owned by close male relatives, father and son. Grain and other basic needs are purchased from sale proceeds of live animals (surplus male sheep, goats and cattle) by the men or selling of milk and other dairy products by the women in the local markets (Aregheore, 2001). They grow crops mainly for domestic use rather than for the market. The male folk take away the majority of the herd in search of grazing, however they leave older members of the community with the nucleus of lactating women. They return in the wet season to assist with crop cultivation. They do not have traditional grazing land rights and often move to the south during the dry season to fatten their animals for sale (Aregheore, 2001). The animals move from their arid home range to the wetter southern parts where vegetation remains green and suitable for grazing (Ehoche, 2002).

2.3.4.3 Agro-pastoralists

These are semi-settled pastoralists and they are found in many parts of northern Nigeria (Payne, 1990). They cultivate areas sufficient to feed their families from their own cereal production. They hold land rights, use their own or hired labour to cultivate land and grow crops such as yams and cassava in addition to the staple cereals such as sorghum, millet and maize. In the system, the average herd of cattle is small compared to other pastoral systems, because they no longer rely solely on cattle and the grazing area around their environs that can be reached in a day will limit herd size. Most pastoralists in this system have preferences for particular breeds (Aregheore, 2001).

2.3.5 Mixed farming (Integrated Crop/Livestock)

This is a system practised by households or enterprises where crop cultivation and livestock rearing are more or less integrated components of a single farming system (Payne, 1990). Mixed farming exists in many forms, depending on external and internal factors involved. External factors are weather patterns, market prices, political stability, and technological developments. Internal factors are often related to local soil characteristics, composition of the family and farmers' ingenuity (Aregheore, 2001). Even pastoralists practice a form of mixed farming since their livelihood depends on the management of different feed resources and animal species. For example, sedentary Fulani in Futh and the Mambilia Plateau in Adamawa practice mixed farming. Furthermore, arable farming peoples like the Kanuri, Hausa, Borgu, Waja, Kibba, Chamba, Kaka and Mambilla often rear cattle and other animals and produce their own manure. With the rapid changes now taking place, ethnic groups which were traditionally arable farmers are ready to acquire cattle and pastoralists are increasing their arable farming (Aregheore, 2001).

Mixed farming is one of the more subtle qualitative changes that have taken place within local systems of Agriculture in Nigeria (Bourn *et al.,* 1994). For example, the marked reduction in pastoral nomads, the widespread sedentarisation of pastoralists and their adoption of crop cultivation in addition to keeping livestock, the uptake of animal husbandry and the utilization of crop residues by livestock farmers in exchange for dairy products which is often secondary (Ehoche, 2002), manure for improving the soil fertility and primarily for drought power (Van Raay, 1975; Bourn *et al.*, 1994 and Ehoche, 2002) are all indicative of a progressive and widespread trend towards mixed farming (FAO, 1983; and McIntyre *et al.*, 1992).

Mixed farming is firmly established in Nigeria as a production system and the further integration of livestock production within local farming systems will definitely become one of the major strategic goals of livestock development in Nigeria (Bourn *et al*., 1994). Mixed farming is practiced in almost all agro-ecological zones of Nigeria. The principal objectives of this system are three fold: (i) complementary benefit from an optimum mixture of crops and livestock (ii) spreading income and risks over both crops and livestock production, and (iii) scope to adjust crop/livestock ratio to social and economic needs and opportunities (Aregheore, 2001). Most retirees from government services embrace mixed farming and the interest is growing because it uses space more efficiently and spreads risks more uniformly (Bourn *et al*., 1994).

2.3.6 Peri-urban and modern ruminant livestock husbandry

This system could be referred to as the commercial or intensive production system. Wealthy urban businessmen, wealthy Fulani and government officials practice this system.

This type of farms which were found only on the periphery of major towns in northern and central Nigeria are also found today in the southern parts of the country. Rich individuals who own these farms capitalize on the potential of animals as investment, source of milk for their families and also a status symbol (Aregheore, 2001; Ehoche, 2002). In this system, a farmer normally has only cattle or many cattle with small ruminants inclusive. Trained personnel are hired and expected routine management practices carried out in most modern ranching operations are also seen in these farms. In this type of intensive production system the use of crop residues and agricultural by-products are effectively and economically combined with grazing. Intensive livestock farms are usually stocked with exotic dairy breeds and upgraded local indigenous ones (Ehoche, 2002).

2.3.7 Intensive (Feedlot) fattening

This is a system involving complete confinement of the animal and movement is restricted. All feed is carried to the animal (Clark and Jaime, 2005). A feedlot is a type of animal feeding operation (AFO) which is used in factory farming for finishing livestock, notably beef cattle, but also swine, horses, sheep, turkeys, chickens or ducks, prior to slaughter. Large beef feedlots are called concentrated animal feeding operations (CAFOs) in the United States and intensive livestock operations (ILOs) or confined feeding operations (CFOs) in Canada (Philip and Hubbs, 2010). The system essentially involves large number of cattle for intensive feeding for a short period of time. The animals are placed in full feed of high energy and high protein diets for a period lasting for 90-120days (Price, 1981).

The feedlot is a technique or system which originated in tropical America and has gradually been adopted in such places as Ethiopia, Cote d' Voire, Kenya, Niger and Nigeria. This system of livestock production was first practiced on a small scale in Mokwa cattle ranch in Nigeria between 1964-1977 under the Nigerian-German Technical Assistance.

Performances of indigenous animal managed under this system have been very encouraging and comparable with those of animal reported in temperate regions. Essentially, these afford the animal the opportunity to exhibit the highest feed efficiency and best growth performance. Edible carcass yield under feedlot operation increased by 30-40% when compared to animals not fattened (Olayiwole *et al*., 1981). A proper system should afford the animal the opportunity to exhibit the highest feed conversion efficiency and best performance (Ikhatua and Olayiwole, 1982). Creek (1972) showed that feedlots are viable commercial enterprises in Kenya while Wardle (1972) in Niger and Jespen and Creek (1976) in Ethiopia demonstrated that feedlots are very economically effective in improving carcass quality of indigenous cattle. In Nigeria, Olayiwole *et al.* (1981) have also shown that under feedlot conditions the performance of two indigenous breeds of cattle Bunaji and Gudali compared favourably with values reported for temperate breeds of cattle. Cost and return analysis of a typical semi-intensive commercial feedlot operation at Shika, Nigeria by Olayiwole and Fulani (1980) indicated that feedlot operation is profitable and commercially viable in the country. Doubts about efficiency of feed conversion into meat by local cattle (Bunaji, Rahaji, Sokoto Gudali, Azawak, Wadara, Adamawa Gudali) are not justified, they are capable of achieving satisfactory growth rates with acceptable feed conversion efficiencies (Olayiwole *et al.*, 1981) for a profitable livestock enterprise.

Similarly, data on comparative performance and carcass analysis on the two breeds of cattle have also shown that feedlot is a good means of not only improving on the performance and carcass quality of the indigenous cattle, but an accelerated means of getting them to the market within a specified period of between 90-120 days (Buvanendran *et al.*, 1983). Feedlots are classified into types based on the feed used. The major types are grain and dry roughages, grain and silage, fresh cut forage and grain only (Ikhatua and Olayiwole, 1982).

Alawa *et al*. (2007) noted that the white Fulani breed is the most fattened by sixty-percent (60%) of small holder cattle fattening operators. This may probably be due to the fact that the breed constitutes about 51% of national herd (Adamu and Alawa, 2005). The breed has been recorded to have higher dressing percentages of 52.2% (NAPRI, 2008), 52.5% (Buvanendran *et al.*, 1983) and 50-60% (Tawah and Rege, 1996). Other breeds such as Muturu, Sokoto Gudali and Keteku have been recorded to have lower dressing percentages of 50%, 50-50.3% and 46-51% respectively (Maule, 1990; Regeh and Tawah, 1999; NAPRI, 2008; Buvanendran *et al*., 1983). Olayiwole *et al*. (1981) reported liveweight gains of 0.98, 1.34, 1.40 and 0.92 kg/head/day for Bunaji bulls fed brewer's dried grain, undelinted cotton seed cake, delinted cotton seed cake and whole cotton seed respectively.

2.4 Major constraints to Beef Cattle Production in Nigeria

2.4.1 Inadequate and low quality feed resources

In Nigeria, pasture has not been well developed except in the Federal/State Government, some faculties of Agriculture in the University, and some commercial farms. Consequently the country's ruminant livestock depend on natural grasslands that are nutritionally poor. Most of the livestock population in Nigeria are under extensive systems and forage availability especially during the dry season has been a problem.

The productivity and nutritive value of forage species found in Nigeria vary greatly according to species, the nature and fertility of the soil, water relations, season of the year, disease control and the stage of growth at which the grass species are cut or grazed. The effect of seasonality on ruminant livestock production is also very important. During the mid-wet season, forage biomass is higher in quality and quantity, with crude protein up to 9 per cent in most of the native grasses (Poppi and McLennan, 1995). Natural grasses and legumes are rich and highly digestible at this period. However, as the dry season sets in, the protein level drops and the roughage quantity increases (Omokanye *et al.*, 2001). There is an increase in lignin content and voluntary intake decrease (Aregheore, 2009). This is a poor feed resource, resulting in weight loss and decreased fertility and milk yield for up to 4-5 months of the year (Yahuza, 2001). The severity and duration of low-quality feed is common to all parts of the country due to the rapid growth of pasture grass species. In the drier northern states of Nigeria where most of the ruminant livestock are concentrated, the prolonged dry season and high temperatures accompanied by rapid deterioration in quality (mostly proteins) of available pasture affects the productivity of animals (Aregheore, 1996). Under favourable conditions, dry matter yield in the northern savannas can reach as much as 2,000 kg per hectare, enough to support one to two ruminant Livestock Units (Otchere and Nuru, 1988). However, after the rainy season the quantity of forage declines rapidly and the lack of woody vegetation means that little forage is available in the dry season. Given the short-term availability of high-quality pastures, movement of animals is eminently rational and ecologically sound during the dry season (Nuru, 1996; Aregheore, 2001).

The effect of seasonality in forage availability on ruminant livestock production is also very important. In the mid wet season, forage biomass is higher in quality and quantity, with crude protein up to 9 per cent in most of the native grasses (Lufadeju *et al.,* 1992). Natural grasses and legumes are rich and highly digestible at this period. As the dry season sets in, the protein level drops and the fibre increases. There is an increase in lignin and voluntary intake decreases which makes it a poor feed, resulting in weight loss and decreased fertility and milk yield for 4-5 months of the year. The severity and duration of low-quality feed differs from the south to the north within the states. To worsen the ecology and its available feed resources further, there is widespread annual burning of native grasslands, thereby drastically reducing the amount of forage on offer (Nuru, 1996). A combination of low-quality roughage and bush burning, which reduce the biomass available in quantity and quality have been observed to lead to weight losses ranging from 300 to 400 g per head per day for cattle (Zemmelink, 1974). For example, the crude nitrogen content of *Cenchrus biflorus*, a characteristic Sahelian grass, can drop from 16 per cent in growing plants during the rainy season to 4 per cent in straw in November and only 2.6 per cent in straw in April (Boudet, 1975). For cattle, a nitrogen content of at least 5 per cent is required to prevent weight loss. Without supplemental feed, cattle under these conditions will clearly tend to lose weight and may not survive if they must be driven long distances to market (Boudet, 1975).

Legumes are not generally common in natural grasslands therefore, the contribution of fixed nitrogen is usually low to absent. Some of the commonest grasses in the natural grassland are *Andropogon gayanus, Imperata cylindrica*, *Pennisetum pedicellatum* and *Hyparrhenia* spp. They grow rapidly during the wet season, becoming fibrous and coarse and are undergrazed because of the large amounts that become rapidly available. Their quality declines further during the dry season when they become standing hay and are subject to overgrazing (Smith, 1992).

During the period of rapid growth the nutrient content of these natural grasses average 25 % dry matter; 10 % crude protein; 6 % ash and a fibre content of 35 % or 43 % acid detergent fibre (ADF) (Smith, 1992). As the dry season advances and conditions become severe, their nutritional quality declines to the extent that crude protein could fall to as low as 2 %. Ash values also decline to about 3 – 4 % as a result of translocation to the root system, while fibre content increases in response to the process of lignification, and sometimes the crude fibre could be as high as 50 % or 60 % ADF (Smith, 1992). These grasses cannot meet the nutrient requirements of grazing livestock for most of the year. Even during the rains they can only satisfy maintenance requirements (Smith, 1992). Some of the browse species are *Adenodolichos* p*aniculatus*, *Desmodium velutinum* and *Sphenostylis schweinfurthii* (Omokanye *et al.,* 2001). During the dry season the most selected browse plants in natural grasslands by sheep and goats in subhumid Nigeria are *Khaya senegalensis, Adenodolichos paniculatus* and *Gmelina arborea* (Olayemi *et al.,* 1998; Omokanye *et al.,* 2001).

2.4.2 Incidence of diseases and parasites

Disease is reported to pose a major threat to cattle production in tropics (Payne, 1990). Duguma *et al*. (2012) identified some major endemic diseases in the cattle industries to include; internal parasites 14.8%, Lumpy skin disease 13%, mastitis 35.2%, and heart water 5.6%. Although much progress has been made in the diagnosis and control of some of these diseases, the increasing populations of vector-pests that transmit epizootic diseases constitute a major hazard and threat to farm animal production in Nigeria. Infestation of tsetse fly alone for example, covers 75% (600,000 to 700,000 km2) of the entire country rendering areas with valuable feed resource nearly inhabitable for cattle (Duguma *et al*., 2012).

Ticks are also economically the most important pests of cattle and other domestic species in tropical and subtropical countries (Radostits *et al.,* 1994). They are the vectors of a number of pathogenic microorganisms including protozoans (*Babesiosis, Theileriosis*), Rickettsiae (*Anaplasmosis, Ehrlichiosis, Typhus*), viruses, bacteria (*Pasteurella*, *Brucella*, *Listeria, Staphylococcus*) and Spirochaetes (Jongejan and Uilenberg, 2004). Ticks are voracious blood suckers; loss of blood for their rapid development impoverishes the hosts. Under heavy tick infestation, cattle must have more feed merely to meet the demands of the parasites; the growth of young animals is retarded, and they may remain thin, weak and stunted, while in dairy cows, milk production is greatly reduced (Radostits *et al.*, 1994). Although, economic losses due to ticks are mainly due to the diseases which they transmit (Garcia, 2003), financial losses associated with nagging irritation and depreciation of the value of skins and hides (up to 20- 30%) are also significant (Biswas, 2003). Other cattle diseases of importance in both temperate and tropical regions include; rinderpest, dermatophilosis, trypanosomiasis, Foot and Mouth Disease (FMD), Contagious Bovine Pleuro Pneumonia (CBPP), helminthosis, abortions, ketosis, milk fever, tuberculosis, brucellosis, and blindness (Payne, 1990). All classes of cattle are likely to be more subjected to nutrient deficiencies when not managed on natural grazing pastures without supplementation with concentrate containing balance nutrient thus, leading to nutritional diseases. Others diseases of cattle include, hardware diseases, metabolic disorder, food poison accruing from the intake of physically injurious materials, poisonous chemicals and plants that are harmful to dairy animals (Payne, 1990). Cattle diseases in whatever form cause major economic loss to farmers in form of mortality loss or weight loss. However, farmers in tropics are reluctant in controlling diseases and vectors of cattle (Jongejan and Uilenberg, 2004).

2.5 Nutrient Requirements of Beef Cattle

Nutrient requirement are the amount of nutrients the animal needs for a specific purposes (Gadberry, 2007). Owing to the unique anatomical and physiological features of the ruminant digestive system, provision of cattle with the nutrients found in appropriate and suitable material such as roughages and concentrate comprises the major factor in carrying out a viable cattle project. The kind and amount of nutrients required by an animal are determined by its physiological activities (Reddy and Krishna, 2009).

Meeting the basic nutrient requirements of beef cattle is a key component of meeting cattle herd production and profitability goals for the beef cattle enterprise. Adequate nutrition is vital for adequate cow reproduction, cow and calf health, and growth of all classes of cattle (Mertens, 1997). Nutrient requirements of cattle change throughout the year based upon stage of the production cycle, age, sex, breed, level of activity, pest load and environment (Hersom, 2010).

Each nutrient fulfils specific roles in growth, production and metabolism (Hamilton, 2007). Hersom (2010) noted that cost effective supplementation practices will be difficult to implement without the knowledge of cattle's adequate basic nutrient requirement.

2.5.1 Protein requirement of beef cattle

It is usually measured as percent Crude Protein (% CP) and is one of the main building blocks of the body (Hamilton, 2007). Crude Protein (CP) is a measure of protein content of any feedstuff and has been further characterised to indicate the amount of protein that is actually available for cattle to metabolize. Rutherglen (1995) noted that even though diet may be adequate in terms of Metabolizable Energy (ME) concentration, the desired level of production will not be achieved if protein content is inadequate. Bulls with live weight of 150-300kg require a CP of 13% (Rutherglen, 1995) or 13-15% (Aduku, 2005). Growing cattle including replacement heifers and steers require from 10.5-14% of their daily dry matter intake to be protein (Rhinehart, 2006). The requirement of protein according to Hersom (2010) depends on the age, stage and level of production. Wahlberg (2005) concluded that to maximize forage intake and digestion therefore, cattle must meet its protein requirement.

2.5.2 Energy requirement of beef cattle

Energy usually account for the largest proportion of feed cost as it is required in large amounts in cattle. Protein, carbohydrates, and fats provide energy in beef cattle diets. Energy is often referred to as digestible energy, net energy for maintenance (NEm), net energy for gain (NEg), net energy for lactation (NEl), and total digestible nutrients (TDN), (Parish and Rhinehart, 2008). The primary sources of energy are cellulose and hemicellulose from roughages and starches from grains (Hamilton, 2007). According to Rhinehart (2006) adequate energy concentration in the diets allows the cattle to utilize other nutrients such as protein, vitamins and minerals.

Cattle require energy for grazing, walking, foetal development, milk production, temperature maintenance, reproduction, digestion, and excretion of body wastes. The bulk of energy for grazing cattle comes from rumen digestion of forages and roughage products. With proper amounts of protein and minerals, the rumen is capable of getting energy from a wide range of feeds that are useless to non-ruminants (Hersom, 2010).

Because the rumen bacteria themselves require protein, just as the animal’s body does, it is impossible to discuss ruminant energy requirements separately from ruminant protein requirements. With too little protein in the diet, the bacteria will not efficiently digest roughages, while with too much protein in the diet, the protein will be deaminated (the nitrogen removed) and used as a very expensive energy source (Bodine and Purvis, 2003). Energy requirements are expressed in terms of TDN and net energy for maintenance (NEm) and (or) net energy for gain (NEg). Total digestible nutrient is the value most commonly used in simple ration balancing (Gadberry, 2007). TDN is the sum of the digestible starch, fibre, protein, and fat in a feed with a correction factor for the high energy content of fat and the amount of ash or mineral content. TDN requirements are expressed as a percent of the diet dry matter (Hersom, 2010).

In recent years, the Net Energy system of evaluating feeds have been shown (Harris, 2000; Rasby and Martin, 2007) to be more accurate than TDN for high grain diets using feedstuffs that have little variation in nutrient content. In forage based diets however, the forage nutrient concentration is variable and the supplement will affect the forage intake and digestibility. Supplement with high grain content have high TDN levels and high levels of starch. Starch and sugars are rapidly fermented, resulting in lower rumen pH. This results in lower intake and digestibility of forage when starch intake reaches critical level.

Kunkle *et al.* (2004) described the effect of energy supplements on feed intake, digestibility and nutrient utilization as “associate effect”. They also reported that using by product feeds with low level of starch and sugar showed less negative effect on forage intake and digestibility, resulting in a better response than expected from the level of TDN in these feeds.

Bulls with liveweights of 150-300 kg requires a minimum Metabolizable Energy (ME) of 10-11.6 MJ/kg DM (2388-2770kcal/kg) in their diet (Rutherglen, 1995).

2.5.3 Mineral requirement of beef cattle

These essentially are elements needed for structural integrity, metabolic function and immune function. They are classified as macro or trace minerals depending on the amounts needed (Gadberry, 2007). Wahlberg (2005) noted that deficiency of mineral in certain feeds can be remedied with supplementation. Supplementation of minerals depends on the type of feed in the ration and the animal’s requirement (Hamilton, 2007). Calcium is the most abundant mineral in the body and is an important component for bones, teeth, membrane permeability, muscle contraction, and many other metabolic functions (Hersom, 2010).

Absorption of calcium is largely determined by the balance of requirement and intake. Skeletal reserves serve as a large repository of calcium that can be utilized to maintain blood concentrations.

Phosphorus is generally discussed with calcium because the two minerals function together in bone formation. Phosphorus is predominantly associated with bones and teeth, but also functions in cell growth, energy utilization, and membrane formation (Hersom, 2010). Historically, the calcium: phosphorus ratio recommendation was 2:1; however, research has indicated that ratios between 1:1 and 7:1 result in similar performance assuming that the dietary phosphorus requirement was met (Hersom, 2010).

NRC (2000) recently revised the nutrient requirement for growing and finishing of beef cattle (including breeding bulls).

2.5.4 Water intake of beef cattle

Water is a fundamental constituent of all living cells. Its presence in adequate amount in the body tissues is an essential pre-requisite for the normal maintenance of life. It is so intimately connected with the transformation of nutrients and excretory matter between the digestive system, the cells of the different body tissues and the excretory organ. To show its significance, French (1956) reported that starving animals may lose nearly all their glycogen and fatty resources, half of their body protein and about 40% of their body weight and still remain alive while the loss of only 10% of body water causes serious disorders and further losses may quickly lead to death.

Water is an important, yet overlooked, nutrient required by cattle. Water is an important component in many body functions including temperature regulation, growth, reproduction, lactation, and many metabolic functions (Hersom, 2010). Water comes from three sources; feedstuffs, ad libitum consumption and metabolic water. The water requirement is influenced by several factors including pregnancy, lactation, activity, type of diet, level of intake, and environmental temperature. Restriction of water intake below requirement will reduce feed intake, which will lower cattle productivity (Rasby and Walz, 1996). Cattle lose water from the body through a number of routes. Sources of water loss include urine, faeces, sweat, and water vapour from the skin and lungs. Urine production depends upon activity level, air temperature, water consumption and other factors. The amount of water loss in the faeces depends upon the diet. Clean water is especially important for young growing cattle, while dirty water can decrease cattle performance and be a potential source of disease (Hersom, 2010).

2.6 Feed resources for cattle in the tropics

2.6.1 Forage resources

Range forages are the most abundant feed resources available to smallholder farmers in the tropics. Natural grasses grow on uncultivated land on which animals have access for grazing. Most farmers rely on natural grass land for their animals. It account for 38 percent of the total feed energy resource available for ruminants in the whole world (Preston and Leng, 1987; Ehoche *et al*., 2001).

Adegbola (1979) and Aregheore (2009) reported that ruminants in Nigeria mostly rely on mature native forages and crop residues in the dry season. The total land area of Nigeria is ninety-four (94) million hectares; seventy five (75) million hectares out of the ninety-four (94) million hectares is area of savannah land, out of which only about forty-five (45) million hectares are available for livestock grazing (Agishi, 1985). The available grazing lands support Nine (9) million Tropical Animal units averaging (250kg), (Aregheore, 2009). Herbage forms the most important and cheapest feed for ruminant livestock in Nigeria. Of all available feed, pasture grasses is reported to form major proportion of ruminant diet accounting for more than seventy-five (75) percent. It is more economical to use grassland as a source of meat and milk. Some of the most common grasses in the native grassland are; *Andropogon gayanus, Imperata cylindrica, Pennisetum pedicellatum, and Hyparrhenia spp.*

The Northern Guinea Savanna which consists of open woodland and the Southern Guinea Savanna, that represents a transitional zone between forests and the zones has many grass species. *Andropogon gayanus* from the tribes *Andropogoneae* and *Paniceae* is reported to constitute an average of 43 percent of the total forages classified (Onifade and Agishi, 1988). It is thus, regarded as the most dominant grass species in this zone.

During the wet season, herbages and pastures are particularly important in providing additional nutrients to animal subsisting on low quality feeds from sub-maintenance to production status (Malau-Aduli, 1992). However, during the dry season, these fodders mature and contain high levels of lignified carbohydrate and low total nitrogen (Chenost and Sansoucy, 1990) and remain the major component of the diet. Digestibility of tropical forages is observed to be lower than those of temperate ones. The maximum and minimum values of digestibility of herbage are 80% and 30% in tropical forages and 85% and 45% in temperate species.The major factors responsible for the variation in herbage digestibility are plant species, genotype, stage of maturity of the plant, fertilizer application, species of the animal, physiological state of the animal and level of feed intake (Aregheore, 2009).

The carrying capacity of the native grassland is very low compared to that of sown fertilized pasture since productivity of natural grassland is affected by factors such as soil available density of canopy and management practices of grazing (Ademosun, 1974). Legumes are not generally common in natural grassland therefore, the contribution of fixed Nitrogen is usually low or absent (Aregheore, 2009).

Andropogon gayanus (Gamba grass) is a tall perennial species that grows in large tufts up to 2m high. Fifty (50) percent of its roots are fibrous and less than 0.5mm in diameter with 40% of the root growing downward and 10% vertically to 80cm giving it drought tolerance (Bowden, 1963). It is native to tropical Africa but now distributed to many countries. Gamba grows on wide range of soil including those of low fertility from sands to black cracking clays, but is known to prefer sandy clay of medium to high fertility with minimum inputs. Gamba's excellent growth and dry matter production is in acid infertile soils with minimum inputs, exceptionally tolerant to drought stress, burning and high levels of Aluminum saturation, low phosphorus and nitrogen requirement.

The major attribute of Gamba is that no toxicity has been reported (Everist, 1976) when grazed by ruminants. Haggar (1966) also reported that no known diseases or major insect attacks aside possessing excellent seed producing ability of 21-86kg/ha. Gamba is compatible with Legumes (WFB, 1978 in Aregheore, 2009). It combines naturally with *Stylosanthes, fruticosa, Desmodium ovalifolium* and other legumes. Gamba is adaptable to low-cost pasture establishment.

The pattern of growth of Gamba grass is well defined. At the beginning of wet season (June-July) the grass is in its vegetative phase of growth, at this time, the proportion of leaf to stem is very high (Haggar, 1970, Zemmelink, 1974; Mani, 1984). In August (mid wet season), there is a distinct increase in ratio of stem due to elongation (Nuru, 1996). In October, stem and fresh leaves reach their maximum growth. In November (early dry season) inflorescence reaches it advanced stage (Haggar, 1970). At this stage, the vegetative development of gamba is completed. As with progression of dry season between January to February, the grass gradually reduces to a tall straw-like material (Lufadeju *et al*., 1992; Aregheore, 2001).

The proportion of nitrogen, phosphorous and digestible energy of the straw-like hairy grass become low, but the proportion of cell-wall material becomes high. Under the natural grassland, gamba standing hay is available throughout the dry season thus, constituting a pivotal role as feed for grazing ruminants in most of the tropical developing countries (Goodchild and Mcmeniman, 1994).

2.6.2 Feed resources of Ruminants in Nigeria

Nigeria is an agricultural country with diverse vegetation, varying from rainforest to the Sahel. The savanna zone is home to about 80% of ruminant livestock population. Availability and quality of feed stuff are major constraints in the development of the livestock industry in Nigeria. The situation is worst during the dry season when livestock depend mainly on range and cereal crop residue.

2.6.2.1 Rangeland forage resources

One of the major factors limiting the productivity of animals in sub-Saharan Africa is poor nutrition; especially in the dry season (Walshe *et al*., 1991). In Nigeria ruminants depend on range for most of their feed requirements especially in the Sahel and Sudan zones, where most of the ruminants are concentrated (Yayock *et al*., 1987). There is wide variation in the quality and quantity of pasture available from one time of the year to another. The potential yield of grasses could be as high as 6 tonnes, DM per hectare, as in *Cynodon dactylon* (Jahnke, 1982) or even higher as in *Panicum maximum* (10-18 tonnes DM/ha and 30 tonnes DM/ha, under good management and appropriate fertilizer regimes (Adegbola, 1982). Kallah (1982) observed that in Nigeria, over 98% of the dry matter (DM) needed to produce beef is derived from grasses and browses growing on native rangelands. Adamu *et al*. (1995) noted that native forages of the savannah zones of the country can meet requirement of the animals for maintenance and low levels of production for only about two to three months of the year.

Davies and Onwuka (1992) reported crude protein (CP) and crude fibre (CF) values of 5.9% and 37%, respectively for *Pennisetum purpureum*, while Bosman *et al*. (1996) and Nuru (1985) reported that crude protein value of *Panicum maximum* hay is 5.3 and 4.2%, respectively. Nuru (1985) reported the crude protein content of some roughage as follows: chloris gayana 2.6%, *Andropogon gayanus* 2.75%, *Digitaria smutsii* 5.0%, Bracharia decumbens: 3.1%. Feeds with less than 8% Crude protein values are considered deficient as livestock feeds, as they cannot provide the minimum ammonia levels (150-250mg/litre of rumen fluid) required by rumen microbes for optimum activity (Leng,1990). These grasses exhibit growth characteristics which affect their quality. Their rapid growth and early maturity during the wet season results in a rapidly increasing lignifications and declining nitrogen and soluble carbohydrate content (Haggar, 1971; Ademosun *et al.,* 1989). Crude protein (CP) content ranging from 7 to 10% has been reported for the native grass in early wet season (Smith, 1992). Also during the wet season some minimum level of animal production can be supported by these grasses without supplementation.

However, because of the energy content that may be low during the wet season (Smith, 1992) provision of energy supplements will enhance utilization of native grass at this period of the year. Performance of animals grazing tropical pasture during the dry season without supplementation shows that they lose weight and body condition (Adu, 1982). The weight loss may be about 40g per head per day for cattle, sheep or goat (Deleeuw, 1978). During the dry season, the CP of native pasture falls to about 1.5 and 3% (Adamu *et al*., 1993). The importance of supplementing poor quality forages for improved intake and animal performance has been reported (leng, 1991; Alawa and Ummuna, 1993). *Digitaria smutsii* is a good roughage and was used in this experiment.

2.6.2.2 Digitaria smutsii

Digitaria smutsii (D. smutsii) belongs to the family *Poecea* and is commonly referred to as Digitaria grass or Crab grass. It is said to be native to Southern Africa. *Digitaria* is a genus of about 300 species of grass family poaceae native to tropical and warm temperature regions. Common names include crabgrass, finger grass and fonio. They are slender monocotyledonous annual and perennial lawn, pasture and forage plants; some are often considered lawn pest. Digitus is the latin word for finger and they are distinguished by the long finger-like inflorescence they produce (Hacker *et. al.,* 1993). *Digitaria smutsii* is indigenous to Africa and grows well in the dry part of tropical and sub-tropical climates. The grass was first introduced into Nigeria from South Africa in 1956. Digitaria performs well in areas with annual rainfall ranging from 600-1800mm, but best rainfall optimum is 900mm/year. Well-drained sandy-1oam soil is preferable for the successful establishment of D. smutsii, which is by means of stem cuttings or stolons because no viable seeds are produced.

D. smutsii is tolerant to acidic or alkaline soils and withstands limited-water logging. The genus Digitaria has world-wide distribution in tropical areas (Henrard, 1950). It is found in area characterized by fertile soil, seasonal rainfall and generally high temperature (Osbourn, 1969). It is easily established, and is vigorous and adaptable. It persists under intensive grazing and is palatable to livestock (Osbourn, 1969). Its stoloniferous habits make vegetative propagation relatively easy in that both stolons and mature stems will produce. The plants cover the ground within 6-8 weeks, even when only 3 plants take root per square yard (Ronney, 1961).

2.6.2.2.1 Propagation and planting: Digitaria is usually sown at the beginning of the rainy season. Soil preparation is minimal; the fallow vegetation is burnt and the ashes spread, and the soil may be loosened by superficial cultivation. Digitaria is normally grown as a sole crop, but sometimes intercropped with sorghum or pearl millet. Farmers in Guinea Savannah commonly sow various digitari types together and later fill in any gaps with guinea millet (Hilu *et al*., 1997).

2.6.2.2.2 Cultivation: In Africa, digitaria is known as a savannah plant, which does not prosper in soils with salinity problems that has low water demands and survives strong drought (Harlan, 1993; Hilu *et al*., 1997). Propagation can be achieved by transplanting young plants. Organic fertilization has been used to increased plant biomass and grain yield. Attempts to improve grain yield with chemical fertilizers have been successful, although not necessary economical. There appears to be low response to chemical fertilizers especially Nitrogen. When digitaria grows in association with legumes (possibly due to Nitrogen fixation by the legumes) other agrochemical input appears to be very limited.

2.6.2.2.3 Chemical composition: Digitaria grass comprises a number of different species (*D. Eriantha, D. Umfolozi, D. Smutsii, D. setivalva, D. Peitzii, D. Polevansii, and D. Decumbens*) and they differ in their chemical composition. Minson (1984) attributed such differences to the genetic make-up of the plant which controls morphological characteristics such as proportion of leaf to stem, and also to different management practices during growth or harvest of the crop. Minson (1990) reported the dry matter content of six species to ranged from 56.1-70.9% , neutral detergent fibre content 13-34% and hemicelluloses 26.5-38.2% on DM basis.

2.6.2.3 Agro-industrial by-products

Agro-industrial by-products are waste products arising from the processing of crops or animal products usually by an agricultural firm. The resultant products from these industries are considered as waste since they are of little or no nutritional importance to humans.

The use of these by-products for livestock feeding is justified when the forage supply is inadequate for the animals' needs, either in terms of quantity or quality. Agro-industrial by-products in Nigeria vary from primary processing of farm produce wastes to wastes from agro allied industries. Some of these wastes are left unutilized, often causing environmental pollution and hazard. Those that are utilized do not have their full potentials harnessed. Inadequate supply and poor quality feeds are the most limiting factors to increase ruminant productivity in tropical Africa (Ademosun, 1994). Since the mid-80s, the use of cereal grains and oil seed cakes such as groundnut and cottonseed cake has been on the decline due to spiral inflation and increased competition from humans whose population has increased tremendously. Conventional feed ingredients still constitute the diets of monogastrics e.g. poultry.

Presently, the high cost of grains due to competing needs have generated interest in sourcing alternative feed resources to match animal production with available and relatively cheap feedstuffs (Jokhtan, 2006). Agro-industrial by product is used as energy or protein sources depending on the nutrient composition. Ruminants were found to exhibit good response in feeding trials involving agro-industrial products. For instance, peels of tuber crops, cereal and legume residues and browse plant have received increased attention. Cassava, yam and sweet potato peels are fermentable energy sources (Smith, 1993) that might be used in place of molasses or maize bran. Alawa and Umunna (1993) reviewed the utilization of agro-industrial by-products and other farm level residues by ruminants. The authors concluded that inclusion of low quality feedstuff to replace conventional energy source in production rations should not exceed 25-30%, whereas for maintenance rations in ruminants, these levels may be exceeded.

2.6.2.3.1 Oil seed by-products (Cakes and meals)

Oil seeds cakes and meals are the residues remaining after removal of the greater part of the oil from oil seeds. The residues are rich in protein and most are valuable feeds for farm animals. They often serve as protein supplements. Most oil seeds are of tropical origin. They include groundnut, cottonseed, soya beans and palm kernel. Other plant protein sources that are less frequently used include coconut meal, rapeseed meal, rubber seed meal, sesame (Beniseed) cake (Smith, 1993).

2.6.2.3.1.1 Cotton seed cake (CSC): Cotton seed cake (CSC) is obtained from cotton after the removal of the lint, followed by oil extraction from the seed. It has a protein content of 41- 45% depending on the efficiency of oil extraction. It is high in fibre containing about 10 - 13%. It is deficient in lysine, methionine, leucine and isoleucine (Onwuka *et al*., 2014). CSC also contains several anti-nutritional factors including gossypol. The nutritional value of CSC can be improved by; decorticating and dehulling, removal of gossypol by extracting the meal with a mixture of hexane, acetone and water, and treatment of the cake with phytase enzyme produced by *Aspergillus ficcum*.

In Nigeria, most of the CSC is used in the feeding of ruminants and the animals can utilize the CSC without dehulling. The most widely used oil seed cake for feeding ruminant animals in Nigeria is undelinted, undecorticated cotton seed cake. This is because of its availability and cost in relation to that of its closest competitor, groundnut cake. The crude protein content of delinted decorticated cotton seed cake (CSC) is about 26%. It is however low in cystine, methionine and lysine (Ikurior and Fetuga, 1984). The decline in production of cotton in Nigeria has seriously affected the availability of CSC in the country. The use of CSC as ruminant feed is also constrained by its popularity in monogastric diets, which makes the cake to be over priced and very uneconomical for ruminants.

2.6.2.3.1.2 Cotton seed: This is a by-product of the ginnery industry which is common in the Guinea and part of Sudan Savannah Zone i.e. around Funtua and Malumfashi in Katsina State. Whole cottonseed is commonly used as a source of protein, energy and fibre. The CP content of whole cottonseed is about 22.1%, but it is low in methionine and lysine. Whole cottonseed can be fed without any form of processing, however, the lint on the seed makes it difficult to handle mechanically (Lamidi *et al.,* 2008).

2.6.2.3.1.3 Groundnut cake (GNC): Groundnut cake (GNC) is the major plant protein supplement used in Nigeria. The availability of which depends on the production level of groundnut. The unextracted groundnut has about 26 - 30% protein and it mainly consumed by humans. The residue remaining from extraction of oil from groundnut either by solvent or hydraulic method is the groundnut cake. This has a protein content of about 38 - 47% depending on the efficiency of oil extraction. GNC is palatable. It is however, deficient in lysine, methionine and threonine (Onwuka *et al*., 2014). This is much higher in crude protein (45%) than CSC but it is more expensive and scarce. GNC is highly degradable in the rumen with nitrogen degradable value range of between 0.71 and 0.90 (ARC, 1980). Lufadeju and Olorunju (1986) also reported degradable value of 0.86 for GNC. However, the use of GNC as ruminant feed is not economical because of its high cost.

2.6.2.3.1.4 Soybean cake: Soya beans are by far the most widely used oil seed protein and as such is assigned the standard against which other plant proteins are compared. The commonest form in which soybean is fed is as soya bean meal after oil extraction by solvent or hydraulic method. Soya bean meal has about 40 - 48% protein depending on the efficiency of oil extraction and whether or not the beans were dehulled (Onwuka *et al*., 2014). The crude protein content of soybean meal is about 50%. The cake is considered to be one of the best protein sources because it contains all the essential amino acids, although the quantity of cystine and methionine are sub-optimal. Ruminants generally are not affected by some inhibitory and toxic factors (Trypsin inhibitor) present in soybean. In addition, the lack of Vitamin B12 associated with feeding soybean cake does not affect cattle. However, soybean cake is highly priced making it uneconomical for feeding ruminants (Lamidi *et al*., 2008).

2.6.2.3.1.5 Palm Kernel cake: Palm kernel cake (PKC) is a product of oil palm processing. It is obtained after oil extraction from Palm kernel. PKC is deficient in lysine, methionine, histidine and threonine. PKC is gritty and high in fibre content (at least 9%).The crude protein content of palm kernel cake (PKC) ranges between14 and 16% (ARC, 1980). The cake is dry and gritty and high in oil content. It is not readily acceptable by all classes of livestock. The solvent extracted cake is unpalatable and should be increased gradually when fed to livestock. Adult cattle can be fed up to 2-3kg/head/day. The degradation of protein in PKC is low (ARC, 1980). Although, PKC is cheaper than GNC and CSC, the cost of transporting it to the northern parts of the country from the south or the middle belt where it is produced makes it slightly expensive.

Nigeria has been and probably still a leading producer of palm kernel, over 75% of which used to be exported before the installation of processing mills as such a considerable amount of work has been done on palm kernel meal as feed supplement in Nigeria. PKC is an agro- industrial by- product that is being produced locally; it is easily available and affordable. Its potentials should therefore be exploited fully for sustainable livestock production in Nigeria (Oluwafemi, 2009). According to Sundu *et al*. (2006), palm kernel meal (also called palm kernel cake) is aflatoxin free, palatable and has considerable potential as carbohydrate and protein sources. Umunna *et al*. (1980) studied the utilization of dietary levels of palm kernel meal (PKM) varying up to 65% by Yankasa sheep in the growth phase (22.0 to 34.0kg and in the fattening phase (31.0 to 38.4kg).

2.6.2.3.1.6 Sunflower meal: Sunflower meal is produced from sunflower seed following oil extraction by either solvent or mechanical methods. The protein content ranges from 41-47%. It is highly deficient in lysine, tyrosine, methionine and cystine. It is high in fibre (11 - 13%). While decorticated sunflower meal can be fed to all classes of livestock, the use of undecorticated meal should be restricted to ruminants. Sunflower meal is high in calcium and phosphorus (Onwuka *et al*., 2014).

2.6.2.3.2 By-products from sugar industry

2.6.2.3.2.1 Molasses: Molasses is an important by-product of the sugar industry. The production of molasses is dependent on the production of cane or beet sugar. Molasses has been used for many years as a cheap source of energy in the ration of farm animals. Molasses contain about 3.25% crude protein. Molasses has been used in animal feeding at 5- 10%. These levels are mostly used as: a carrier for urea impregnation of poor quality roughages, a binder for commercial pelleted feeds for convenient and economic feeding of livestock and as a sweetener for increasing the voluntary intake of compounded feeds (Onwuka *et al*., 2008).

Sugarcane molasses has become an important component of diets for virtually all classes and types of farm livestock. It may be mixed or sprayed unto unpalatable rations to increase palatability and consequently consumption. Molasses is by far the most important by-product of sugarcane because of its high minerals content, energy value and palatability.

Ani (1980) reported a decrease in DM digestibility of roughage-based diets by cattle as the level of sugar cane molasses increased while Osuji (1993) in a review on sheep feed intake data, showed that DM intake generally decreases when molasses contributes more than 50% of the dietary DM. In another study by Alhassan *et al*. (1987) in which molasses was added to millet straw fed to sheep and goats maximum straw intake was reported at 25% level of molasses addition with corresponding marked improvement in rate of gain. The best feed efficiency was also reported at the 25% molasses level

2.6.2.3.2.2 Bagasse: Bagasse is another by-product from sugar cane processing. Sugar cane is processed for its sugar which leaves two by-products, molasses and a fibrous residue termed bagasse. Bagasse is a high fibre, low protein product of very low digestibility which is sometimes mixed with the cane molasses for cattle feeding (Onwuka *et al*., 2014). Bagasse is a good source of cellulose but is poor in protein (1.3%) and high in lignin (16%). It has been used successfully as roughage for ruminants. High pressure treatment improves the palatability and digestibility of bagasse (Morrison and Brice, 1984). However digestibility of unprocessed bagasse is low because it contains high lignin content (Bhatti and khan, 1996) Tomato pomace contains 14.3% DCP and 65%TDN. After drying and grinding, it can be used as a part of animal feed up to 35% level (Verma, 1997). It can replace satisfactory wheat bran on eqi-weight bases up to one third portion of a concentrate mixture (Ranjhan, 1993)

2.6.2.3.3 Animal wastes

The most important animal waste used in ruminant diets is poultry litter. The CP content of Poultry litter varies depending on the type of feed offered to the birds (Calvert, 1979). Usually a bird will defecate about ¼ of the quantity of feed consumed as faeces. Various authors have reported various values of CP for poultry litter. Adegbola *et al*. (1990)

reported 16.5% CP for layer litter while Lamidi (1995) reported 17.00 CP %. Broiler litter has higher CP content than layer litter (Lamidi, 1995). Devendra (1978), Adu and Lakpini (1983) and Lamidi (1995) all reported 25% CP for broiler litter. Poultry litter is an excellent nitrogen source for rumen microbes and it has been used as a source of nitrogen in ruminant diets containing moderate to high energy levels (El-Sabban *et al*., 1970; Smith and Calvert, 1976). Poultry litter is also a source of minerals and vitamins.

Utilization of poultry litter in ruminant diets will serve as a means of disposing the huge quantities of the litter produced across the nation. The greatest advantage associated with poultry litter is its low cost, making it very economical to incorporate in ruminant diets. However, because of its low palatability, especially for the layer litter, maximum inclusion rate of 30% has been recommended by Devendra (1978). Adu and Lakpini (1983) suggested 10% optimum level of inclusion in molasses based diets for sheep.

2.6.2.3.4 Crop residues

By-products from roots and tubers are wide spread in Nigeria. These include yam, cassava, potato, beets and carrots. Most of the tubers are produced for human consumption. However, the processing of some of these crops produces substantial quantities of by-products which go into livestock feeding.

The most common of these tubers is cassava. Cassava when dried contains less than 3% crude protein, 1.3% fat, 85% NFE, ME of about 3,500 - 3,700 kcal/kg. Cassava peels are richer in crude protein (5 - 6%) and fat (6%) than the tubers. The major problem with cassava is that the raw tubers contain linamarin, a cyanogenic glycoside and prussic acid. In the presence of enzyme linase, the glycoside is converted to β-glucose, acetone and hydrogen cyanide. This makes raw cassava poisonous. There is greater concentration of the glycoside in the peels than in the tuber. Processing methods such as soaking in water, fermentation, sun-drying or moist cooking destroys the glycoside in cassava (Abdu, 2011).

2.6.2.3.4.1 Cassava peels: Cassava peels from garri processing are richer than the cassava pulp in protein, ether extract and ash (Oyenuga, 1968). The waste produced from cassava starch or tapioca factories may be used for feeding livestock known as tapioca meals in United States of America, the waste is fed to horses, cattle and pigs substitute for the grain portion of diets (Oyenuga, 1968). Onyuka (1983) suggested 25% inclusion of cassava peels to be best for goats in terms of feed intake and dry matter digestibility. Adebowale (1981) fed fermented cassava peels at levels of 0, 20, 40 or 60% in the diet over 6 month period. The 40 and 60% cassava peel rations had lower digestibility of dry matter, crude fibre and TDN, feed intake, body weight gain and feed efficiency, but had no effects on weights of liver and hides.

2.6.2.3.4.2 Sugar Cane Wastes: Sugarcane top consists of 3 distinct parts; the green leaves blade, the leaf sheath bundle and a variable amount of immature cane. It accounts for 16-18% of the total biomass production or about 28% of the weight of the stalk (Ngyuyen Thi Mui *et al*., 1996). Cane tops can be converted into good quality silage or hay for feeding during scarcity of fodder. Sugar canes tops with or without leaves have good feeding value and are readily accepted by ruminants either fresh, dried or ensiled (Tariq, 1988; Bhatti and Khan, 1996).

Sugarcane tops have been used as fodder for livestock, mainly ruminants that are better able to utilize fibrous feed stuffs (Alawa and Umunna, 1993). It should however be noted that supplemented tops are palatable and cattle can be maintained entirely on them with a little supplement of concentrate mixture or leguminous feeds.

2.6.2.3.4.3 Cereal Crop Residues: It is known that most of the ruminants in Nigeria are found in the Guinea savanna and Sahel zones where they are managed by pastoralists. These zones are the major cereal (sorghum, millet and maize) growing areas in Nigeria. The amount of straws and leaves left in the cereal plants after grain harvest can be estimated. For example in the case of sorghum the ratio of grains to straw is 1:4 at the time of harvest. Thus with a production of about 6 million tonnes of sorghum in Nigeria, 24 million tonnes of straw would be available for use in livestock production annually. Also with a ratio of 1.3:1 for leaves and grains in maize 5.2 million tonnes of leaves would be left behind. In addition to this, there is an estimated amount of over 400,000 tonnes of maize cobs available for livestock feeding after the necessary treatment (Reddish *et al*., 1987). More than 340 million tonnes of maize stover are produced annually in Africa (Mosi and Butterworth, 1985). The intensification of crop production as a result of population increase has over the years increased the quantity of these maize stover. Shaib *et al*. (1997) gave the production target for the year 2010 of the main cereal crops in Nigeria as million tonnes of maize, millet, sorghum and rice, respectively per annum. Generally, since the straw: grain ration of these crops is 2:1, about 256,450,000 tonnes of crop residue was made available. These maize stovers are potential sources of energy for the ruminant-livestock population.

The feeding value of cereal crop residue is, however, limited by major deficiencies of protein, metabolizable energy and minerals (Dutta *et al*., 1999). The chemical composition and digestibility of maize stover also, vary greatly depending on species, variety and agronomic practices. When fed alone, cereal straws cannot meet the maintenance requirement of cattle, sheep and goat. Alawa and Ummuna (1993) stated that an important principle in the feeding of maize stover especially the poor quality roughages is that the potential intake and digestibility can only be achieved if certain factors are not limiting. He further stated that nitrogen is often considered the first limiting nutrient to intake by ruminants on low quality roughage feeds. Kabaija and Little (1988) reported that in general, ruminants fed solely on maize stover are unlikely to have adequate sodium intake. Crop residues are also deficient in several minerals particularly calcium, phosphorus, sulphur, cobalt, copper and iodine (Verma and Jackson, 1984). These minerals play an important role in diverse metabolic functions within the body and their deficiency may affect productivity.

2.6.2.3.4.4 Wastes from Leguminous crops: Dual purpose legumes are crops that improve the soil fertility through their root nodules which fix atmospheric nitrogen, the seeds are used for human consumption while the fodder for livestock feed. Thus dual-purpose legumes appear more acceptable to the subsistence crop-livestock farmers of Nigeria, Some of such crops are cowpea, soya bean, groundnut and lablab. The parts of these crops used in livestock feeding include groundnut haulms, cowpea pod shell and leaves, lablab leaves, soybean leaves and threshing. These feed resources and cereal straw constitute the most important field crop residues for ruminants. They are higher in CP compared to the cereal residues (Alhassan *et al*., 1985), but low in ADF. The CP content of cowpea haulms range from 5.9 to10.4 per cent while that of cowpea shell ranges from 6.9-7.1 %. The use of these crop residues has led to improvement in animal performance.

2.6.2.3.5 By-products from the brewing industry

In the brewing process (McDonald *et al.,* (1998), sorghum or barley is soaked first for about six days and allowed to germinate. During this time, a complete enzyme system is developed for hydrolyzing starch to dextrin and maltose. This first stage is known as the malting process in which the conversion of starch to maltose and other sugars is said to be completed.

After germination just before mashing, the germinated grain (malt) is dried carefully so as not to in-activate the enzymes. The sprouts are removed and are sold as malt culms. The dried malt is crushed and small amount of other cereals (maize or rice) could still be added. Water is sprayed on the mixture and the temperature of the mash increased to about 65^{o}C. The mashing process provides the enzymes with suitable condition for the conversion of proteins and starch to dextrin, maltose and small amount of other sugars. At the completion of the mashing process, the sugary liquid or 'wort' is drained off, leaving brewers grains as residue, which is sold wet or dried as feedstuff for farm animal(s).

The sugary liquid (wort) is boiled with hops, which gives it a characteristic flavour and aroma. The hops are filtered off and after drying are sold as spent hops. The wort is fermented in an open vessel with yeast for a number of days, during which most of the sugars are converted to alcohol and carbondioxide. The yeast is filtered off, dried and sold as brewers' yeast. The by-products obtained from entire brewing process are malt culms, brewer's grains, spent hops and brewers' yeast.

The main by-products of brewing industries in Nigeria as reported by Bello (1984) which becomes available for livestock and poultry feeding are brewers dried grains and brewers dried yeast. However, with increasing local brewing, another by-products of considerable importance to poultry nutrition is the dried spent sorghum mash which is a residue arising from local brewing of "Burukutu" and "Pito" (Dogari, 1985).

2.6.2.3.5.1 Sorghum Brewers' Waste (SBW)

Sorghum brewers' waste/mash is a by-product of the local breweries. The residue is brownish and odorless when properly dried and has a sour taste. It arises from local brewing of “Burukutu” and “Pito” (Tyokpat, 1989). The local breweries are scattered all over Nigeria especially in parts of Kaduna, Benue, Bauchi, Borno and Gongola States (Dogari, 1985). Inhabitants of the Savannah zone of Nigeria practice the use of the residue for animal feeding.

2.6.2.3.5.1.1 Sorghum Brewer’s Waste (Burukutu waste) and its utilization in livestock diets

The locally produced beer using sole sorghum generates spent grains which depend on the system used. This by product can also be referred to as burukutu waste or BKT waste (Dogari, 1985). Though it has been fed to livestock, literature is still quite scanty on its utilization. The grain source is usually sorghum or the combination of it with maize and it is used by pig farmers singly or in combination with other feed ingredients (Tegbe *et al.*, 1995). Dairo (1990) reported high fibre content (16.9%) for sorghum distillers waste (SDW) with crude protein value of 14.98%. Results showed that there were no significant difference in feed intake, average daily weight gain and feed conversion ratio. Feed intake increased up to 10% but no difference was noticeable between 10 and 15% replacement levels. A generally low rate of growth was observed for pigs on all the treatments. Thus, SDW at 10% replacement level of maize appeared to be the optimum level of inclusion in growing pig rations and this agreed with the reports of Tegbe (1985) who fed brewers dried grains to growing pigs.

According to Dogari (1985), up to 50% burukutu waste can be included in broiler starter diets. The results showed that there was no significant difference in the weight gain of broilers fed sorghum brewers’waste and those fed with maize as the main energy source. The author also reported that increasing level of burukutu waste in the diets of broiler chickens up to 50% depressed weight gains, feed efficiency and feed cost per kilogram gain. In a feeding trial, Tegbe *et al.* (1995) fed graded levels of 10, 20, and 30% local spent grains to weaner pigs and reported a decrease in weight gain, feed intake, feed to gain and feed cost per kilogram gain as the level of BKT waste increased in the diet. The best result on the utilization of BKT waste was obtained at 10% inclusion levels in the diets of weaner pigs. Same authors in another trial fed diets of 12.5, 25 and 37.5% BKT waste to adult pigs and found that performance characteristics related to feed intake, weight gain and feed to gain were not affected by the level of the waste.

Abdulmalik (1997) carried out two studies using the weaner and the breeding rabbits. The weaner rations contained 0, 10, 20, 30 and 40% brewers'sorghum residue (BSR) while the rations for the breeding does contained 0, 7.5, 15, 22.5 and 30% of same test ingredient. Results showed that BSR was a rich source of protein having 30.16% and other nutrients for rabbit growth. Inclusion of BSR in weaner rations reduced feed intake and feed cost per kilogram of the feed. Weight gain increased up to 20% inclusion in the diets and thereafter decreased. The 20% diet gave the best result in terms of feed conversion and feed cost per kilogram live weight gain. Inclusion of BSR in the diet reduced dressing percentage, gut length and abdominal fat contents. There was no significant effect on liver weight and edible organ weights. These studies showed that without adjusting for energy, BSR can be included at a level of 15 and 20% in the diets of breeding does and weaner rabbits, respectively without adverse effects on their performance. There was also savings in the cost of feed when BSR was included in their diets.

2.6.2.3.5.2 Brewers' Dried Grain (BDG)

Bello (1984) and McDonald *et al.* (1998) defined BDG as dried extracted residue of barley malt, alone or in mixture with other cereals resulting from the manufacture of wort. The fresh brewers' grains contain about 700-760g water/ kg (Mowat, 1990) and may be given to cattle, sheep and horses in this fresh state or preserved as silage alternatively. The wet product could be dried to about 100g of water/kg and sold as dried brewers' grains. Wet Brewers' grains are reported to have an exposed storage life of about 4-5 days in warm or hot environment and up to 8 days in cold weather (Mowat, 1990). Lilly *et al.* (1990) have shown through laboratory and pilot studies that wet brewers' grains could be stabilized by incorporating 30% beet molasses and 0.3% potassium sorbate in cooled containers.

Lopez and Pascal (1991) reported that BDG could be produced by oven-drying the wet material at temperature ranges of 80-200^{o}C for 3-6 minutes with minimal losses in the dry matter of the materials. The authors however observed that oven-drying the grains beyond 3-6 minutes resulted in significant dry matter losses of 18% and therefore concluded that temperature of 100-120^{o}C and oven-drying time of 6 minutes had no adverse effects on the nutrient composition of the dried grains.

2.6.2.3.5.2.1 Nutrient composition

There is wide variability in the proximate composition of BDG depending on the brewery that produced it (Oyediji, 2001). Breweries in Nigeria presently use maize and sorghum in combinations, which vary from one brewery to another (Oluponna *et al*., 2002). This, therefore, has resulted in the production of BDG with variable physical and chemical composition (Oluponna and Balogun, 1996). BDG contains about 19-25% crude protein (Kwari *et al*., 1999; Oluponna *et al*., 2002), 10-22% crude fibre (Kwari *et al*., 1999; Oluponna *et al*., 2002), ME of 7.38 MJ/kg (Dogari, 1985) and gross energy value of 3030-3170 kcal/kg (Oluponna *et al*., 2002). The protein value can be affected by the heat applied during the brewing process, which can be beneficial to ruminants but tend to be detrimental for monogastric animals. Brewer's grain are also relatively rich in fibre (ADF 17- 26%

DM), which makes them suitable for ruminants fed concentrate-rich diets, but less suitable for pigs and poultry (Crawshaw, 2004).

Bello (1984) showed that BDG contained 18-20% crude protein, 6.0% oil, 20.0% fibre, 0.2% Ca, 0.05% P, 0.4% methionine, 50% TDN and 1960 kcal ME/kg. Lufadeju (1986) reported the chemical composition of BDG (in g/100g) as; 92.5% dry matter, 3.6% nitrogen, 33.33% acid detergent fibre and 4.6% ash. Almquist (1992) reported that BDG was fairly rich in essential amino acids, with; 0.9% lysine. 0.4% phenylalanine, 1.0% threonine and 1.6% valine. In another study, Oluokun and Olalokun (1995) reported values of 19.78% Crude fibre, 21.65% Crude protein, 7.25% Ether extract, 3.45% Ash, and 47.87% Nitrogen free extract. The nutrient composition of BDG varies from grain source to another, and method of brewing (Oluokun and Olalokun, 1995). Uchegbu and Udedibie (1998) reported the proximate composition of BDG (maize/sorghum based) as 28.25% Crude protein, 13.12% Crude fibre, 6.70% Ether extract, 7.36% Total ash, 44.57% Nitrogen free extract and 4.23 kcal/g gross energy. Church and Pond (1988) reported the composition of dehydrated BDG as 92% DM, 25.3% CP, 15% CF, 0.29% Ca, 0.52% P, and 2080 kcal/kg of ME. The authors further gave the amino acid composition as; 1.30% arginine, 0.50% histidine, 1.50% isoleucine, 2.30% leucine, 0.90% lysine, 0.40% methionine, 1.30% phenylalanine, 0.90% threonine, 0.40% tryptophan, 1.20% tyrosine and 1.60% valine. Perry (1990) reported that although the protein content of BDG was high (about 20-30%) it does not contain a good balance of amino acids. Jensen *et al.* (1996) noted that as a result of the conversion or utilization of the starch in the original cereal grains, low metabolizable energy values are associated with the use of BDG in monogastric animals. Ben-Hamed *et al.* (2011) reported BDG to have a dry matter content of 92%, Crude protein 28%, Ether extract 7.5%, Ash 4%, Crude fibre 15% and NFE 45.8%. These workers further noted that the other nutrient components were concentrated, namely: protein, fibre, vitamins, fatty acids and minerals.

2.6.2.3.5.2.2 Influence of brewers' dried grain in ruminant diets

Some studies (Adeyanju, 1977; Umunna *et al*., 1980; Ogundola, 1984) have been conducted in the past using brewers' dried grain to feed ruminants. Most of these studies however are not recent. Ummuna *et al.* (1980) evaluated brewers' dried grains and palm kernel meal as major sources of nitrogen for growing cattle. They reported that Palm kernel meal (PKM) and brewers' dried grains (BDG) were evaluated as cheaper alternatives for groundnut cake (GNC) or cottonseed cake (CSC) as a major protein source for growing cattle. Calves were fed the various diets either individually or in groups. Average daily gain, feed intake and feed conversion efficiency between calves supplemented with CSC or BDG were not significantly ($P > 0.05$) different. Both dry matter (DM) and nitrogen (N) digestibilities were not significantly ($P > 0.05$) affected by the treatments but there was a tendency towards reduced DM digestibility of the BDG treatment. Judging from the principal parameters (average daily gain, feed intake and feed conversion) BDG or PKM supported comparable growth to either GNC or CSC.

Preston *et al.* (1973) reported using One hundred and eight steer calves to study the feeding value of dried brewers' grains for growing and finishing cattle. Three levels of brewers' grains (none, 25% and 50%) were fed in the total ration with corn grain, minerals and vitamins making up the remainder of the ration. Urea was used in the ration that did not contain brewers' grains to provide an adequate level of crude protein. Additionally, one ration was evaluated which contained 25% brewers grains to which 5% brewers' yeast was added. All rations were full-fed as well as fed at a restricted level to determine the net energy value of dried brewers' grains.

The authors affirmed that feedlot performance was improved by adding brewers' grains to the ration at either the 25 or 50% level. Problems associated with rumen keratosis when the high corn ration was fed were overcome by feeding brewers grains; liver abscesses were also markedly reduced. The net energy value of brewers' grains was nearly the same as corn grain. The NE_m and NE_{gain} values for dried brewers grains determined in their experiment were near 2.3 and 1.4 kcal/g, respectively, on a dry matter basis. Their results indicated that brewers' grains have considerable potential as cattle feed.

Ogundola (1984), studied the utilization of brewers dry grains and wheat offals by calves, the author studied the growth performance of 24 calves fed concentrates consisting of 20, 40 and 60% levels of both brewers' dry grains (BDG) and wheat offals (WO) to replace maize in a 16-week trial period.

The author reported that there were no trends established between dry matter, total digestible nutrient and energy intakes and levels of BDG and WO except the digestible crude protein intake which increased with increasing levels of BDG and WO in the ration. The author reported that growth rates of 0.26, 0.27, 0.24 and 0.31 kg/day of calves on diets A, B. C and D respectively were positively but not significantly ($P>0.05$) correlated ($r = 0.99$). The N intake (av. 49.7 g/day) and N retention (av. 52.5%) were high and increased as the level of BDG and WO increased in the ration. The rumen pH in the authors' study ranged between 6.4 and 6.8 and was not different among the diets. The NH_3 -N levels were high in all the diets (av. 14.0 mg/100 ml) showing that N was not limiting and enough to support the growth of the calves. The total VFA showed no particular trend but moderate accumulation and averaged 9.8 m-equiv/litre. However, the acetic acid level (av. 73%) was high enough to furnish energy for the N utilisation.

2.7 Feed digestion and physiology in Ruminants

Many animals across a wide range of orders have a portion of their digestive tract adapted to accommodate a microbial population which aids in digestion and provides a variety of nutritional and health benefits (Broderick *et al*., 1991). Microbial populations have been described in the gut of herbivores, omnivores and carnivores and in all zoological classes. This complex, mixed, microbial culture (comprising bacteria, ciliate and flagellate protozoa, anaerobic phycomycete fungi and bacteriophage) forms a closely integrated ecological unit with each other and the host animal, as well as playing a vital role in the nutritional, physiological, immunological and protective functions of the host (Broderick *et al*., 1991).

Development of microbial populations in the digestive tract of higher animals commences soon after birth and involves a complex process of microbial succession and many microbial – host interactions which, eventually results in dense, stable microbial populations inhabiting characteristic regions of the gut (Allen, 2000). The rumen is one of the most extensively studied and well-documented gut ecosystem because of the importance of ruminants (cattle, sheep, goats, camels and yak) to human nutrition and the major role played by rumen microbes in nutrition of the ruminant animal.

The ruminant foregut or stomach has evolved into three pregastric fermentation chambers (rumen, reticulum and omasum) of which the rumen is by far the largest. Ingested plant material is hydrolysed and fermented in the rumen, and microbial cells and undigested plant particles pass into the abomasum where gastric digestion begins. The most distinctive feature of ruminants is rumination, where foregut digesta is regurgitated, rechewed and reswallowed in a frequent regular pattern repeated up to 500 times per day which enables reduction in particle size (comminution) and exposure of maximal surface area to microbial attack.

2.7.1 Role of rumen microbes in ruminant digestion.

The presence of microbes in the rumen makes it possible for ruminants to digest and metabolize feed materials that may otherwise be indigestible. The microbes are predominantly anaerobic and live in a symbiotic relationship with the animal. The rumen is a continuous anaerobic culture system in which the pH and temperature are maintained at between 5-7 and 39-40^{o}C respectively. Feed materials are fermented to volatile fatty acids, and ammonia which are either absorbed or incorporated into the microbial cells (Hungate, 1966). Small-scale farmers are increasingly relying on browse and on crop residues and by-products to supplement roadside grazing during the dry season. Some of these materials are potentially good feed resources which degrade readily in the rumen (Krishna, 1985; Odunlami, 1988). Others have shown poor degradability so that they may require some treatment before they can contribute to animal nutrition (Smith and Calvert, 1976).

Microbial cells are the main source of protein for the ruminant. Microbial cells, together with soluble nutrients and undigested feed eventually pass to the abomasum and small intestine where they are digested and absorbed. The rumen microbial populations are made up of bacteria, protozoa and fungi. The relative proportion of different microbial species present depends on the type of substrate entering the ecosystem (Orpin, 1981). Detailed classifications and descriptions of some of the microbes in the rumen have been presented by Hobson and Stewart (1997).

2.7.2 Rumen microbiology

Ruminant nutritionist and microbiologist have long been interested in manipulating the microbial ecosystem of the rumen to enhance feedstuff utilization, improve production efficiency by ruminants and alleviate problems associated with current feeding practices (Lee *et al.*, 2000).

The reticulo-rumen provides a very favourable environment for microbial survival and activity. According to Church and Pond (1988), a typical count of bacteria in the rumen approaches between 25-50 billion/ml and typical values of protozoa counts expected are in the order of 20,000-50,000/ml. Yeast was also reported to occur sometimes in large number but not with great regularity. McDonald *et al*. (1998) reported that rumen content contains 850- 930g water/kg on the average and the number of bacteria per ml of rumen content ranges between 109- 1010 with over 60 species identified. Protozoa was observed to be smaller in number (106per ml) than bacteria. The bacteria dry matter contains about 100g N/kg out of which 80% is in the form of amino acid and the remaining 20% being present as nucleic acid (McDonald *et al.*, 1998).

Feed and water enter the rumen and is partially fermented to yield principal volatile fatty acids, microbial cells and the gases (methane and carbon dioxide). Greater part (sometimes all) of the proteins reaching the small intestine is microbial proteins also called single cell proteins (Church and Pond, 1988).

Microorganism according to Tegbe (1976), have rapid growth rates and their growth is not affected by climatic fluctuations. The author affirmed that single cell protein (SCP) can be produced in large amount without climatic disturbances. The disadvantages of using SCP compared to conventional sources of proteins were identified to include; the toxicity of nucleic acid to humans, the non palatability of the SCP causes low feed intake and the limitations of the sulfur amino acids in the product (Tegbe 1976). The problems listed above however are not without solutions. According to Tegbe (1976) the availability of the enzyme Uricase in the mammals enable them overcome nucleic acid metabolism. The acceptability of SCP has been improved through blending.

2.7.3 Rumen ammonia concentrations and rumen microbial protein synthesis

Optimal ammonia concentrations required to ensure the most rapid microbial growth differ between diets (Orskov *et al.*, 1980). Orskov *et al.* (1972) showed that although, microbial protein produced per unit of substrate fermented was not altered as a result of urea supplementation of barley grain, the extent of rumen fermentation and degradability was increased. Low rumen ammonia concentration limits rates of protein degradation. This may be due to reduced cellulolysis, resulting in low microbial cell synthesis in nitrogen deficient medium.

There is no general agreement on the ruminal ammonia concentration for maximum microbial protein synthesis. Estimate of optimal ammonia concentration for microbial protein synthesis ranged from 3.5 to 29mg/100ml (Satter and Slyter, 1974; Hespell and Bryant, 1979 and Slyter *et al.*, 1979). Mehrez *et al.* (1976) reported 100mg/10ml for sheep fed whole barley. Most in vitro studies, however, showed maximum microbial growth to occur when the ammonia nitrogen concentration was 5 to 8mg/100ml (Allison, 1970; Satter and Slyter, 1974 and Annison, 1975).

Hume *et al.* (1970) observed in an in vivo experiment that maximum microbial growth was obtained when rumen ammonia nitrogen concentration reached approximately 9mg/100ml, however, Lamidi (1995) reported the rumen ammonia nitrogen in cattle fed sun-dried poultry litter to range between 9.13 to 12.51mg/100ml. Okorie *et al.* (1977) reported a much lower value of 5mg/100ml as the rumen ammonia for maximum microbial growth and 8.5mg/100ml as rumen ammonia nitrogen concentration required for optimum bacterial protein yield. These observations are consistent with what Satter and Slyter (1974) reported. Adegbola (2002) reported the rumen ammonia nitrogen to range from 6.74 to 27.7mg/100ml.

There were also differences in the rumen ammonia nitrogen due to type of diet and time of sampling. Mehrez and Orskov (1977) gave rumen ammonia nitrogen between 19 to 25mg/100ml as optimum for forage digestion. When rumen ammonia concentrations fell below 3.5mg/100ml, microbial growth decreased significantly (Satter and Slyter, 1974). Some of the differences in ruminal ammonia concentration obtained may be due to differences in sampling techniques and variation in rumen ammonia concentration post feeding (Satter and Slyter, 1974).

The rate of rumen fermentation has greater influence on both total and digestible feed intake (Orskov, 1982). Feed intake may be reduced if the ammonia concentration is limiting the rate of fermentation. Orskov (1982) reported an increase in intake and digestibility as the concentration of urea increased in the diet, though, the increase was not linear. Similar result was also reported by de-Faria and Huber (1984) when they fed corn silage supplemented with urea to steers.

2.8 Palatability and feeding behaviour in ruminants

To be consumed, a feed has first to be recognized as edible. The role of certain senses (ie, sight, smell, touch and taste) in the feeding behaviour of ruminants has been studied and reviewed by a number of authors (Arnold, 1970; Goatcher and Church, 1970a; Demarquilly, 1978; Church, 1979; Grovum, 1988). It is well established that the senses are used in selective grazing but they are probably less important when no choice is given to a stall-fed animal. Even in such a simple situation, however, it is impossible to describe voluntary feed intake for a wide range of feeds solely in terms of digestive and metabolic characteristics (Faverdin *et al.*, 1995). Scientists interested in feed intake in ruminants have probably paid less attention to the role of senses than to physical or energy control of intake. It is remarkable that none of the published feed intake prediction systems takes into account the sensory response to the feed. The term palatability usually designates those characteristics of a feed that invoke a sensory response in the animal (Greenhalgh and Reid, 1971).

2.8.1 Palatability

In accordance with the definition given by Greenhalgh and Reid (1971), Church (1979) palatability is defined as the dietary characteristics or conditions which stimulate a selective response by the animal, palatability being considered as an inherent characteristic of the feed (Hodgson, 1979). For Matthews (1983), the palatability of a feed is interchangeable with preference for the feed. It is determined by the taste, smell, appearance, temperature and texture of the feed. However, Forbes (1986, 1995a) claims that palatability cannot be considered solely as a quality of the feed since it depends on the experience and metabolic status of the animal in question; palatability of a feed is not absolute and depends on the state of hunger of the animal (Gallouin and Le Magnen, 1987). Palatability of the feed is the corollary of the appetite of the animal, which is the stimulation to eat aroused by the feed. Eating rate, especially at the beginning of the meal, is a good criterion of the animals' appetite. Palatability of the feed is defined as all the physical (plant bearing, spines, etc) and chemical (odour, taste, etc) characteristics of the feed that act on appetite (Jarrige, 1988). Mertens (1994) concurs with this last definition but does not mention physical characteristics of the plant; thus, it is not clear if the physical characteristics that determine ease of prehension and ease of mastication are components of palatability or not. For animals fed indoors, it is well known that the same hay in long, chopped or ground form is not eaten at the same rate and in the same amount. It is established that physical characteristics such as particle size and water content contribute to the sensory response invoked by the feed (Jarrige *et al.*, 1995).

2.8.2 Evaluating palatability

Palatability is obviously not a quantitative measure unless feed intake is measured per unit time (Church, 1979). An ideal measure of palatability will not be influenced by the consequences of previous ingestion of feeds (Matthews, 1983) nor by the postingestive consequences of intake (Grovum and Chapman, 1988). Several methods are used to evaluate palatability. They differ according to what intake or behavioural parameters are recorded and whether only one or more than one feed is offered. However, none of these methods can avoid the effects of prior learning of feed characteristics.

2.8.3 Intake measurements

Differences in voluntary intake cannot be attributed only to palatability as they result from the sensory response and the digestive, metabolic and hormonal events following meals. Recording intake during the first minutes following exposure to the feed limits confusion of palatability with postingestive factors. In dairy cows fed on the same diet, the initial eating rate reflects the increase in eating motivation or appetite with the advance of lactation (Faverdin, 1985). When sheep have finished a first meal and the same hay is offered again, initial eating rates are similar for both meals (although digestive and metabolic statuses are very different (Baumont *et al.*, 1990). Initial eating rate, which can double from one forage to another, may thus be a good criterion for evaluating the sensory response invoked by a feed and thus its palatability.

2.8.4 Main feed components of palatability

Physical characteristics: since the work of Arnold (1966) it has been recognized that the sense of touch plays a role in the response of the animal to the feed. The sense of touch is used in selective grazing to avoid thorny and sticky plants. Physical characteristics of the forage such as dry matter content, particle size and resistance to fracture or height and density of the sward at pasture are known to affect ease of prehension and thus intake rate (Jarrige *et al.*, 1995). Many measurements of voluntary intake and feeding behaviour were performed on chopped and ground-dehydrated forages by Jarrige *et al.* (1973).

Chemical characteristics factors other than physical characteristics influence palatability. Without choice, legumes are always ingested at a higher rate than grasses, irrespective of particle size (Jarrige *et al.*, 1973). The effects of the primary tastes (sweet, salty, bitter, sour) were studied with water solutions (Goatcher and Church, 1970b, c) and with sham intakes on oesophageal-fistulated sheep (Grovum and Chapman, 1988). The results varied according to the method used particularly for sweet and salty tastes. The effects of various odoriferous compounds were analysed by Arnold (1970) and Arnold *et al.* (1980) by sprinkling the chemicals onto cotton wool pads placed in the manger. The difficulty was in controlling the level of odour being tested. Odoriferous compounds were also studied with preference tests for different water solutions. The difficulty then was to separate the response through smell from the response through taste. For these reasons, anosmic and agustatory sheep were used in comparison with normal ones (Arnold *et al.*, 1980). As stated earlier, effects of odoriferous compounds can vary in amplitude and sometimes in sign according to whether the animals are in choice situations or not. Amyl acetate has a positive effect on voluntary intake in a no-choice situation and a negative one in a free choice situation (Arnold, 1970). Arnold *et al.* (1980) added to pelleted hay small quantities of several compounds recognized to decrease intake by their odour or to decrease preference for a water solution by their taste. Over a 3 day period, significant depressions in intake were obtained with coumarin, gramine, tannic acid, malonic acid and glycine.

However, sheep that were both anosmic and agustatory were affected in the same way as normal sheep.

In short-term preference studies, palatability of wheaten hay could be increased by adding a combination of butyric acid plus monosodium glutamate or decreased by magnesium oxide (Gherardi and Black, 1991). In a long- term study over 25 days (Gherardi *et al.*, 1991 the voluntary intake of hay treated with butyric acid plus monosodium glutamate was 10% higher than that of untreated hay. This increase in intake was associated with an increase in the apparent fractional rate of digestion in the rumen. The high preference for the treated hay was maintained over 25 days. Voluntary intake of hay treated with magnesium oxide was not decreased over 25 days, even though ruminal digestion was depressed and thus compensated for by an increase in rumen fill. In preference tests, however, aversion to hay treated with magnesium oxide was maintained. Long-term effects on feed preferences or on voluntary intake seem to be generally associated with modification of digestive parameters.

2.8.5 Utilization of senses in feeding behaviour

As judged from the long-term effects of modifications of feed palatability, animals seem to be able to associate the sensory characteristics of a given feed with its nutritional consequences after feeding.

2.8.6 Learning the postingestive effects of feeds

The senses that are stimulated in the presence of feed enable the animal to anticipate the postingestive effects of feed. This effect has been extensively reviewed in rats by Le Magnen (1985). Provenza *et al.* (1992) proposed a schematic representation of the processes involved in the learning of feed preferences. The affective system integrates the taste of a feed with postingestive feedback and the cognitive system integrates the odour and sight of the feed with its taste. Learned food aversions against toxic plants or feeds experimentally laced with several compounds that cause malaise have been clearly established in ruminants and in other mammals (Burrit and Provenza, 1989; du Toit *et al.*, 1991; Ralphs and Cheney, 1993). Learned preferences based on positive nutritional postingestive feedback are undoubtedly also important for ruminants. Lambs, after 10 days adaptation, developed a strong preference for non-nutritive flavours paired with glucose over the same flavours paired with saccharin (Burrit and Provenza, 1992). Thus, ruminants, like other mammals, develop preferences for feeds that provide more energy (Provenza, 1995). These results, together with those stated earlier (Arnold *et al.*, 1980; Gherardi *et al.*, 1991), must be interpreted as the consequences of learning the nutritive value of the diet. However in a free choice situation, diet selection will not always maximize energy density of the diet. Ruminants eat some straw to prevent rumen disorders even though a more concentrated feed is also on offer (Cooper *et al.*, 1995). Anticipation by the senses of postingestive effects explains to a certain extent the diurnal pattern of preference (Parsons *et al.*, 1994).

Intake is primarily a behaviour influenced by hunger, which is distressing, and by satiety, which is generally pleasurable (Read, 1992). Recently, Forbes (1995b) postulated that ruminants eat that amount of food which leaves them with the most comfortable feelings. Qualitative, quantitative and affective components can be discerned in the complex sensations perceived in humans during intake (Fantino, 1992). The first two components afford recognition of the nature and amounts of feed ingested. In a test situation, when animals have to walk to obtain good forage, the preference for the good forage depends on the amount offered the animals in reward (Dumont and Petit, 1995).

2.8.7 Palatability and control of intake

The sensory response invoked by a feed is expressed by the intake rate when no choice is offered to the animal and by the feed preferences in choice situation. It integrates the postingestive effects that the animal has learned to associate with its sensory properties and it interacts with the nutrient requirements of the animal. Meal size and diet composition are mainly controlled by anticipation of postingestive effects to avoid nutritional excesses or deficiencies. Ruminants generally develop preferences for feeds that will provide a high satiety level rapidly (Baumont *et al.*, 1994).

Feeds that can be ingested fast and that are rapidly and highly digestible are very palatable provided they do not contain toxic compounds. Nevertheless, for a given nutritive value, sensory properties of the feed per se can stimulate or depress hedonic behaviour and thus intake. Indeed, residual variation in predictive models of voluntary intake based on nutritional characteristics (i.e. energy and nitrogen values, fill effect) remains generally high. Thus, palatability measured as the sensory response invoked by a feed combines its nutritive and hedonic values. Hedonic behaviour is probably more important in low-producing animals than in high-producing ones (Baumont *et al.*, 1994). Moreover, the effect of hedonic behaviour on intake is probably more important when choice is offered to the animals. In a first approach, the hedonic value of the feed can be assessed by the difference between the observed and the predicted intake as affected by the nutritional characteristics.

Several questions remain unanswered. Is it possible to increase intake in the long term by improving hedonic perception of the feed without also increasing the nutritive value? What exactly are the physical characteristics and chemical compounds that are used by ruminants to associate the sensory properties of feed with its nutritive value? Modern analytical methods to characterize texture and aromatic compounds in feeds may help in gaining a better understanding of the components determining palatability (Baumont *et al.*, 1994).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Site description

The study was conducted at the Experimental Unit of Beef Research Programme, National Animal Production Research Institute (NAPRI) Shika, Zaria. Shika is geographically located between latitude 11^0 $12^'$N and 7^0 33' E, at an altitude of 640m above sea level (Garmin Receiver, 2015). Annual rainfall is about 1100-1200mm while, mean temperature is 24.4^0C (14.5-39.5^0C) with lower temperature occurring during the early dry season (November-January) while the higher temperatures are experienced during the late dry season (February- April).

3.2 Source of Brewers' dried grain and Experimental Animals

The Brewers' dried grain for the trial was procured from three Different Breweries namely: Nigerian Brewery in Kaduna State, Benue Brewery Limited in Benue State and Nigerian Brewery, Ibadan, Oyo State. The Brewers' dried grains from the three different sources were sampled for chemical analysis.

Bulls at the Beef Research Programme of the National Animal Production Research Institute, Shika, Zaria, were used for this experiment. Six (6) bunaji yearling bulls with an average weight of 150 kg were used for the Preference and short time intake studies, while 25 Bunaji yearling bulls with an average weight of 179 kg were used for the growth trial. The animals were within the age of 1-2 years

3.3 Preference trial and short term feed intake by Bunaji yearling Bulls fed Brewers' dried grain from three different sources

A preference and voluntary intake trial was conducted to evaluate the preference and short term intake of brewers' dried grain from the three different sources listed above. Six (6) Bunaji yearling Bulls with an average weight of 150kg were used for this study. Three (3) metal feeding troughs were used for the trial. A quantity of 6 kg brewer's dried grain from each source was put into each of the three feeding troughs placed side by side. The animals were then allowed free access to the feeds at the same time for two hours each day. The left over for each of the brewers' dried grain were recorded and this was used to determine short term feed intake. The position of the different feeds in the feeding troughs were predetermined and changed daily. The trial lasted for 7 days. The behaviour and selectivity of the animals to each of the feed ingredient was observed and the relative Preference Index (PI) was calculated using Van Dyne and Headly (1995) formular as

$$PI = \frac{\text{Amount of Feed Intake}}{\text{Amount of Feed Offered}}$$

Based on the dietary preference index calculated, the BDGs' were classified into the following five preference classes

High preference (hp)	0.77-1.00
Moderate preference (mp)	0.56-0.76
Fair preference (fp)	0.45-0.55
Poor preference (pp)	0.26-0.44
No preference (np)	<0.26

3.4 GROWTH TRIAL

A growth trial was conducted for 91 days using twenty-five (25) Bunaji yearling bulls with an average weight of 179 kg within the age range of 1-2 years. Prior to the commencement of the experiment, the animals were dipped in acaricide solution against ectoparasites and then dewormed using albendazole. The bulls were allotted to five dietary treatments in a complete randomized design with each treatment consisting of five animals to evaluate the effect of brewers' dried grain on the growth performance of Bunaji yearling bulls.

3.4.1 Experimental diets

Five (5) experimental diets were formulated to contain 0, 10, 20, 30 and 40 percent inclusion levels of Brewers' dried grain representing treatments 1, 2, 3, 4, and 5, respectively (Table 3.1). The experimental diets were Isonitrogenous and Isocaloric.

Table 3.1: Ingredient composition of experimental diets

Ingredient	BDG Inclusion				
	0	10	20	30	40
Maize Offal (%)	59	57	55	53	51
BDG (%)	0	10	20	30	40
CSC (%)	40	32	24	16	8
Salt (%)	1	1	1	1	1
Total	100.0	100.0	100.0	100.0	100.0
Calculated analysis					
Crude protein (%)	16.45	16.47	16.49	16.50	16.52
TDN (%)	72.84	72.32	71.80	71.28	70.76
ME(MJKg DM)	9.90	10.03	10.10	10.30	10.40
Feed cost (₦/Kg)	54.94.	52.24	49.55	46.85	44.15

BDG=Brewers' dried grain, CSC=Cotton seed cake, TDN=Total digestible Nutrient, ME=Metabolizable energy. Where ME = Metabolizable energy, DM = Dry matter, CP = Crude protein, EE = Ether extract, CF = Crude fibre and A = Ash.

3.4.2 Management of experimental animals

The bulls were housed in individual feeding pens and fed experimental diets and Wooly finger grass (*Digitaria smutsii*) at 1.5% and 2% of their body weight, respectively. The animals were given salt lick also. Their weights were balanced before the commencement of the experiment and all animals were weighed fortnightly. Water intake was measured and evaporative loss was taken into consideration.

3.4.3 Parameters measured

Parameters measured include: initial weight, fortnight weighing, final body weight, weight gain, voluntary feed intake and water intake, Rumen pH, Rumen ammonia nitrogen (RAN), Total volatile fatty acid (TVFA). Feed efficiency and feed cost per kilogram gain were calculated. The live weight of the animals was obtained by weighing the bulls with a Standard cattle scale (Avery) at the beginning of the experiment and then fortnightly before every morning feeding. The initial weight of the bulls was considered as their weight after adjustment period and the final weight was their weight at the end of the experiment.

3.4.4 Voluntary feed intake and water intake

Feed was offered and the leftover of the previous days' feed was collected and weighed every morning. The quantity of feed offered to each animal was adjusted every two weeks in relation to changes in their body weight throughout the period of the experiment.

Water remaining in the trough was measured in a calibrated plastic bucket and the water intake was measured by finding the difference between the water offered and the left over. Another separate water trough not used for the animals was used to determine evaporative loss.

3.5 Rumen Fluid Sampling

Rumen fluid samples were collected from the bulls at the end of the feeding trial at 0hr, 3hrs, 6hrs and 9hrs after feeding. About 50mls of the rumen fluid was drawn from all the bulls in each treatment using a stomach tube. The tube which is about 150cm with a metallic strainer attached to the end was passed through a pipe placed in the mouth of the bulls into the rumen and a suction pump which was used to draw out the rumen fluid was attached to the other end of the tube. The fluid was collected into plastic bottles containing equal quantity of 0.1N H_2SO_4 to trap ammonia. The samples were frozen until required for analysis. Rumen ammonia concentration was determined by steam distillation into boric acid and back titrated with 0.01N hydrochloric acid, according to the procedure described by Whitehead *et al.,* (1976). Rumen pH fluid was determined using Philips digital pH meter (model 9409)

3.6 Digestibility Study

At the end of the growth study, three bulls were randomly selected from each treatment and housed in metabolic crates for total faecal and urine collection. The animals were allowed for 7 days to adjust to the condition of the metabolic crates before the commencement of the collection period which lasted for another 7 days. 1.5% and 2% of the experimental diets and hay, respectively were offered daily and water intake was also measured. Daily faeces voided were weighed and 10% of each day collection was sub sampled and oven dried at 60^oC for dry matter determination. This was bulked later and taken to the laboratory for proximate analysis, neutral detergent fibre, acid detergent fibre and acid detergent lignin. Daily urine output was collected in a plastic container containing 100mls 0.1N H_2SO4 placed under metabolic crates. 10% of daily urine was taken from each bull and stored in the refrigerator. At the end of the 7 day collection period, 10% of the urine taken from each bull was sub sampled and stored in the refrigerator pending Nitrogen determination (Osuji *et al.*, 1993).

3.7 Chemical analysis

Dry matter content of brewers' dried grain, experimental diets and faecal samples was determined by drying at 60^oC for 48 hours. Nitrogen content of the feed samples and urine were determined using Kjedahl Procedure AOAC (2000). The samples were ashed by charring in muffle furnace at 500^oC for about 3 hours, Ether extract and crude fibre of the samples were also analyzed according to (AOAC, 2000) procedure. The acid detergent fibre (ADF) and Neutral Detergent Fibre (NDF) of the feed samples and faeces were analyzed according to the Procedure of Van Soest (1991). Metabolizable energy (ME) was determined by using the equation of Alderman and Cottrill (1985). ME (MJ/Kg DM) = $11.78 + 0.0064\ CP + (0.000665EE)^2 - CF\ (0.00414EE) - 0.0118A$. Where ME = Metabolizable energy, DM = Dry matter, CP = Crude protein, EE = Ether extract, CF = Crude fibre and A = Ash.

3.8 Cost benefit analysis

The current market price of the various feed ingredients was used to compute and compare the total cost of feed consumed within the growth period and feed cost per kilogram weight gain. This was used to determine how profitable or otherwise it is to raise yearling bulls with the feeds that were compounded. Net benefit was calculated by subtracting the total cost of feed and cost of water from the value of gain.

3.9 Data analysis

The data from this study were analyzed using General Linear Model procedure of SAS (2002) and significant differences among treatment means with the control were compared using Dunnet test of the SAS package. Repeated measures analysis was also used to analyze the rumen fluid samples taken over time.

The Model used is as follows:

$Y_{ij} = \mu + t_i + E_{ij}$

Where

Y_{ij}= j^{th} observation of i^{th} graded level of Brewers' dried grain inclusion.

μ=overall mean

t_i = effect of i^{th} graded level of Brewers' dried grain inclusion on performance

E_{ij} = random error

CHAPTER FOUR

4.0 RESULTS

4.1 EXPERIMENT I

4.1.1 Chemical Composition of Brewer's dried grain obtained from three breweries

The result of chemical composition of brewers' dried grain from three breweries is presented in Table 4.1. The dry matter contents were 82.63%, 82.39% and 83.06% for Kaduna, Benue and Ibadan brewery respectively. The Crude protein contents were 22.50%, 23.00% and 22.94% for Kaduna, Benue and Ibadan brewery, respectively. The crude fibre ranged from 6.61% to 6.82%, The Ether extract ranged from 2.22% to 3.92%. The ash values were 5.74%, 5.00% and 5.45% for Kaduna, Benue and Ibadan brewery respectively. The Nitrogen free extract ranged from 43.86% to 45.78 % with that of Ibadan brewery having the highest value of 45.78%. The ADF and NDF values were 22.88% and 40.29%, 21.86% and 42.36%, 23.56% and 42.28% for Kaduna, Benue and Ibadan Brewery respectively. The Metabolizable energy values were 11.76 MJ/KgDM for Benue brewery and 11.80 MJ/KgDM for Kaduna and Ibadan brewery.

4.1.2: Preference Index (PI) and Short term intake of Bunaji yearling bulls fed sole brewers' dried grain from three breweries.

Table 4.2 shows the Preference Index (PI) and Short term feed intake by Bunaji yearling bulls fed brewers' dried grain from three breweries. The preference index for Kaduna and Benue breweries were 0.99 each while that of Ibadan brewery was 0.65.The Short term intake of brewers' dried grain from three breweries is also shown in Table 4.2. The average daily intake was 5.99 Kg/DM/2hrs for Kaduna and Benue Breweries each while that of Ibadan Brewery was 3.92 kg/DM/2hrs

Table 4.1: Chemical composition of brewers' dried grain from three breweries

	Source				
Parameters	Kaduna	Benue	Ibadan	SEM	
Dry matter (%)	82.63	82.39	83.06	0.40	NS
Crude protein (%)	22.50	23.00	22.94	0.32	NS
Crude fibre (%)	6.82	6.61	6.67	0.12	NS
Ether extract (%)	2.27	3.92	2.22	1.12	NS
Ash (%)	5.74	5.00	5.45	0.44	NS
Nitrogen free extract (%)	45.30	43.86	45.78	1.16	NS
Acid detergent fibre (%)	22.88	21.86	23.56	0.98	NS
Neutral detergent fibre (%)	40.29	42.36	42.28	1.36	NS
Acid detergent lignin (%)	10.44	11.72	10.61	0.8	NS
Metabolizable energy(MJ/KgDM)	11.80	11.76	11.80	0.02	NS

Table 4.2: Preference index (PI) and Short term feed intake by Bunaji yearling Bulls fed sole brewers' dried grain from three breweries

	Trial	
Brewery	Preference	STI (Kg DM/2hrs)
Kaduna	0.99(hp)	5.99^{a}
Benue	0.99(hp)	5.99^{a}
Ibadan	0.65(mp)	3.92^{b}
SEM		0.47

^{a,b} means with different superscripts differ significantly (P<0.05). SEM = Standard error of mean
STI=Short term intake

4.2 EXPERIMENT II

4.2.1 Chemical Composition of individual feed ingredient and hay used for growth trial

The Chemical Composition of individual feed ingredients and hay used for growth trial is shown in Table 4.3. The dry matter content for *Digitaria smutsii* was 94.29% while the crude protein, crude fibre, ether extract, nitrogen free extract , ash, ADF, NDF, and ADL were 9.63%, 42.62%, 5.29%, 24.45%, 8.30% 43.26%, 67.26% and 2.66%, respectively. The dry matter of maize offal and cotton seed cake were 94.08% and 94.82%, respectively. The crude protein content was 9.44% and 26.56% for Maize offal and cotton seed cake, respectively. The Crude fibre, ether extract, nitrogen free extract, ash, ADF, NDF, and ADL for Maize offal were 9.64%, 15.40%, 56.46%, 3.14%, 21.95%, 28.55% and 6.60% respectively. For Cotton seed cake, the crude fibre, ether extract, Nitrogen free extract, ash, ADF, NDF and ADL values were 30.68%, 12.11%, 20.12%, 5.35%, 34.17%, 42.71% and 8.64%, respectively.

Table 4.3: Chemical composition of individual feed ingredient and hay

Parameters	Ingredient		
	D. smutsii	MO	CSC
Dry matter (%)	94.29	94.08	94.82
Crude protein (%)	9.63	9.44	26.56
Crude fibre (%)	42.62	9.64	30.68
Ether extract (%)	5.29	15.40	12.11
Nitrogen Free extract (%)	26.45	56.46	20.12
Ash (%)	8.30	3.14	5.35
Acid detergent fibre (%)	48.26	21.95	34.17
Neutral detergent fibre (%)	67.26	28.55	42.71
Acid detergent lignin (%)	2.66	6.60	8.64
ME (MJ/KgDM)	10.81	11.19	10.35

CSC = Cotton Seed Cake, MO = Maize offal, D.*smutsii* = *Digitaria smutsii*. ME=Metabolizable Energy. ME for the feed ingredients will be determined by equation of Alderman and Cottrill, 1985. ME (MJ/Kg DM) = 11.78 + 0.0064 CP + $(0.000665EE)^2$ - CF (0.00414EE) - 0.0118A. Where ME = Metabolizable energy, DM = Dry matter, CP = Crude protein, EE = Ether Extract, CF = Crude fibre and A = Ash.

4.2.2 Chemical composition of concentrate diets containing graded levels of brewers’ dried grain fed to growing Bunaji yearling bulls

Table 4.4 shows the chemical composition of concentrate diets containing graded levels of brewers’ dried grain fed to growing Bunaji yearling bulls. The dry matter values ranged from 83.36 to 90.41% with 0% BDG inclusion having the lowest (83.36%) and 30% BDG inclusion having the highest (90.36%). The Crude protein ranged from 15.38 to 16.18%, the crude fibre values ranged from 5.83 to 7.00% with 0% BDG inclusion having the highest crude fibre. The ether extract ranged from 3.33- 3.85% while ash ranged from 4.80 - 5.47%. The ADF and NDF ranged from 24.18-29.44% and 43.61-52.36% respectively. The ADL values ranged from 11.19- 12.59% while Metabolizable energy ranged from 11.71- 11.75 MJ/KgDM.

Table 4.4: Chemical compositions of concentrate diets containing graded levels of Brewers' dried grain fed to growing Bunaji yearling bulls.

	Level of BDG inclusion (%)				
Parameters	0	10	20	30	40
Dry matter (%)	83.36	85.12	89.70	90.41	90.36
Crude protein (%)	15.38	15.75	15.81	16.05	16.18
Crude fibre (%)	7.00	6.48	5.69	5.65	5.83
Ether extract (%)	3.85	3.57	3.57	3.39	3. 33
Ash (%)	5.26	5.47	5.21	5.26	4.80
Nitrogen free extract (%)	68.51	68.73	69.78	69.65	69.86
Acid detergent fibre (ADF) (%)	24.18	29.44	28.79	28.88	25.36
Neutral detergent fibre (NDF) (%)	43.61	49.66	51.38	52.36	48.77
Acid detergent lignin (%)	12.10	11.80	12.52	12.59	11.19
Metabolizable energy(MJ/KgDM)	11.71	11.72	11.74	11.74	11.75

BDG=Brewers' dried grain

4.2.3 Effect of feeding diets containing graded levels of brewers' dried grain on the growth performance of Bunaji yearling bulls

The effect of feeding diets containing graded levels of brewers' dried grain on growth performance of Bunaji yearling bulls is shown on Table 4.5. There was significant difference (P<0.05) in the final weight gain (kg) with 30% inclusion level recording the highest final weight (234.80kg) and treatment without brewer's dried grain had the lowest final weight (220.60kg). Average water intake ranged from 15.58-17.49 litres/day, and there was no significant difference (P>0.05) between treatments. The average dry matter intake was observed to be higher for all other treatments except the 40% inclusion level. There was also significant difference (P<0.05) in average weight gain between the treatments. Animals fed 10% and 30% inclusion levels of BDG had higher average weight gain than other treatments.

Table 4.5: Effect of feeding diets containing varying levels of Brewers' dried grain on the growth performance of Bunaji yearling bulls

	Level of BDG inclusion (%)					
Parameters	0	10	20	30	40	SEM
Initial weight (Kg)	179.40	179.20	179.00	179.40	179.20	4.30
Final weight (Kg)	220.60^{b}	229.80^{a}	223.80^{a}	234.80^{a}	221.80^{b}	5.96
Average concentrate intake (Kg/day)	2.56	2.65	2.57	2.67	2.55	0.07
Average hay intake (Kg/day)	3.61^{a}	3.71^{a}	3.63^{a}	3.80^{a}	3.49^{b}	0.10
Average total feed intake (Kg/day)	6.17^{a}	6.36^{a}	6.20^{a}	6.47^{a}	6.04^{b}	0.17
Average water intake (l/day)	17.21	17.46	16.88	17.49	15.58	1.92
Average DM intake (Kg/day)	5.85^{a}	6.01^{a}	5.88^{a}	6.13^{a}	5.75^{b}	0.16
Average weight gain (Kg/day)	0.45^{b}	0.56^{a}	0.49^{b}	0.61^{a}	0.47^{b}	0.03
Feed Efficiency(kg feed/kg gain)	13.71^{a}	11.36^{c}	12.65^{b}	10.60^{d}	12.85^{b}	0.23

^{abcd} means within the same row with different superscripts are significantly different (P<0.05) SEM=Standard Error of mean, l=litre

4.2.4 Effects of feeding diets containing graded levels of brewers' dried grain on Rumen metabolites of Bunaji yearling bulls.

Figure 1 shows the effect of feeding diets containing graded levels of brewers' dried grain on the rumen pH of Bunaji yearling bulls at different sampling hours. The lowest rumen pH recorded in this study is 6.47 at 3 hours post feeding and the highest was 7.36 at 9 hours post feeding.

Figure 2 shows the effect of feeding diets containing graded levels of brewers' dried grain on rumen ammonia nitrogen production of Bunaji yearling bulls at different sampling hours. Rumen ammonia nitrogen recorded in this study ranged from 8.24-9.81, 11.17-12.83, 7.10-10.96 and 7.23-8.24 for 0, 3, 6 and 9 hours, respectively.

Figure 3 shows the effect of feeding diets containing graded levels of brewers' dried grain on total volatile fatty acid (TVFA) production in Bunaji yearling bulls at different sampling hours. TVFA in this study ranged from 36.67-40.67, 39.67-75.00, 35.33-39.00 and 39.67-45.00 for 0, 3, 6 and 9 hours respectively.

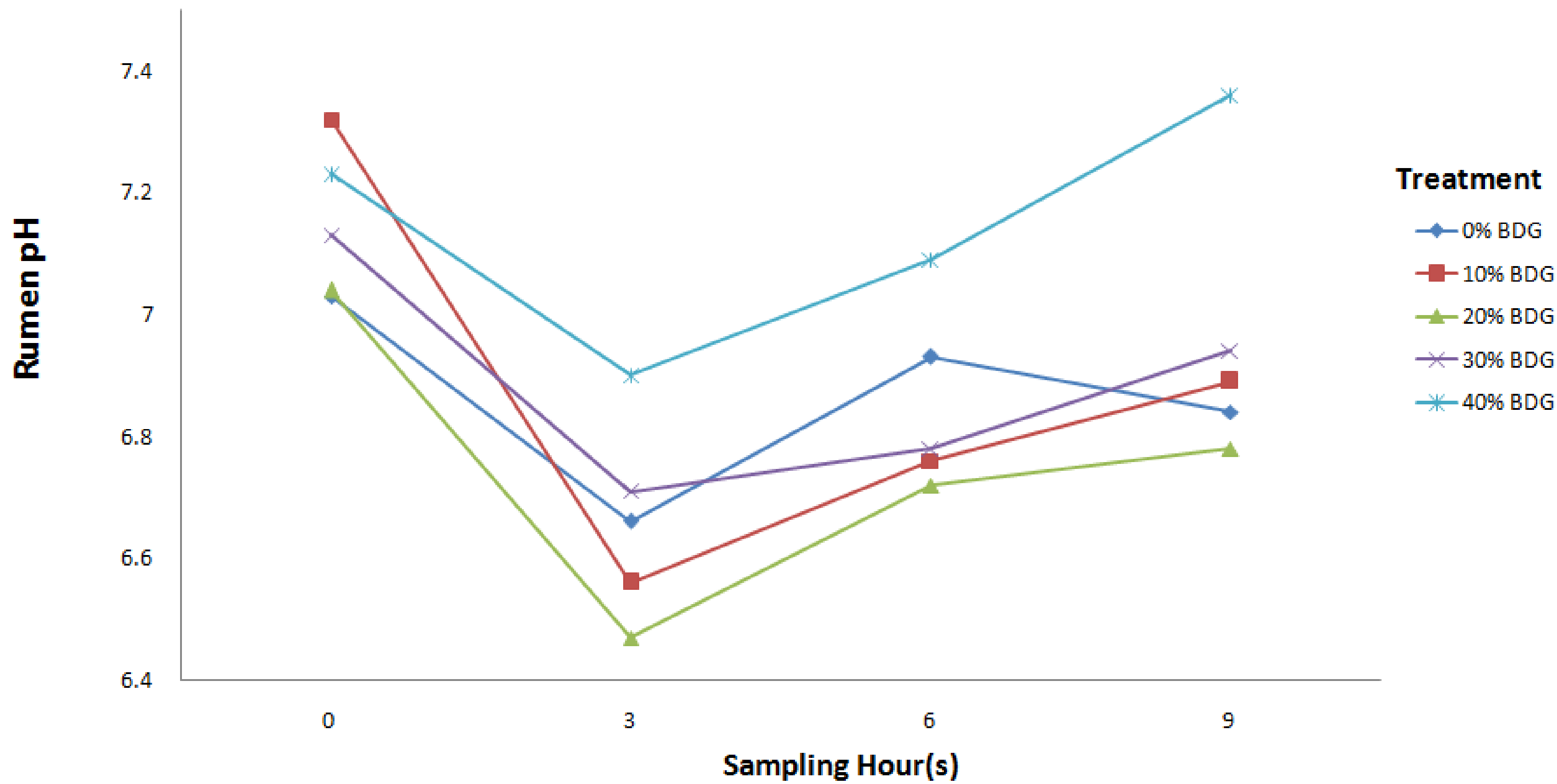

Figure 1: Effect of feeding diets containing varying levels of brewers' dried grain on the Rumen pH of Bunaji yearling bulls at different sampling hours.

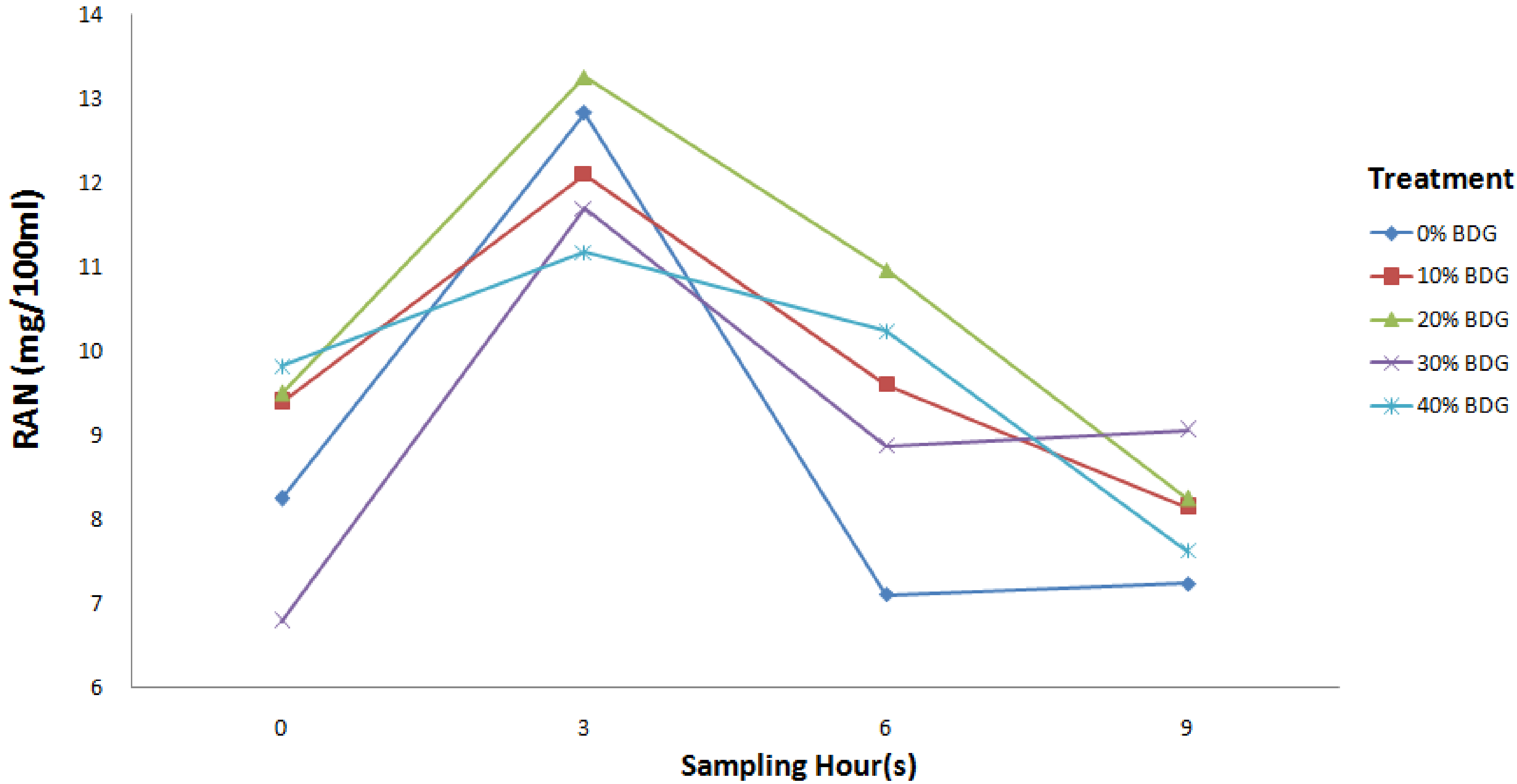

Figure 2: Effect of feeding diets containing varying levels of brewers' dried grain on rumen ammonia nitrogen production of Bunaji yearling bulls at different sampling hours

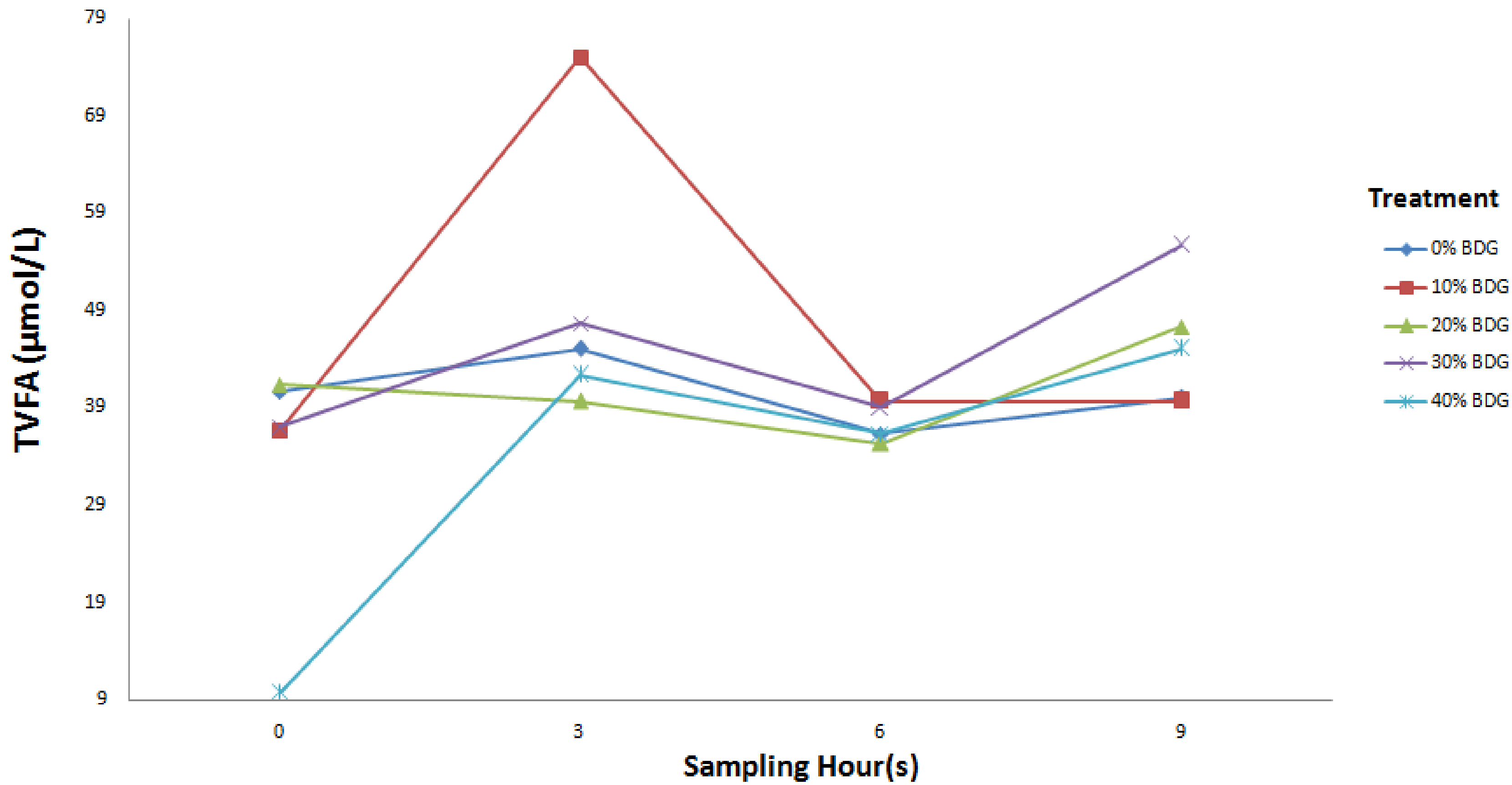

Figure 3: Effect of feeding diets containing varying levels of brewers' dried grain on total volatile fatty acid (TVFA) production in Bunaji yearling bulls at different sampling hours

4.2.5 Apparent nutrient digestibility of diets containing graded levels of Brewers' dried grain fed to Bunaji yearling bulls.

The apparent nutrient digestibility of diets containing graded levels of Brewers' dried grain fed to Bunaji yearling bulls is shown in Table 4.6. The dry matter digestibility ranged from 54.23% to 58.93%. There was significant difference (P<0.05) in crude protein digestibility and it ranged from 41.69% -56.46%. Crude fibre digestibility ranged from 38.99% to 45.62%. Ether extract digestibility was highest in animals fed 10% inclusion of brewers' dried grain and lowest in animals with no inclusion of brewers' dried grain in their diet. There was significant difference (P<0.05) in ADF and NDF digestibility in diets containing brewers' dried grain compared to the control, however, treatment with 40% inclusion level of BDG had the highest digestibility values of these parameters

Table 4.6: Apparent nutrient digestibility of diets containing graded levels of Brewers' dried grain fed to Bunaji yearling bulls.

	Level of BDG inclusion (%)					
Apparent Nutrient Digestibility (%)	0	10	20	30	40	SEM
Dry matter	54.23[c]	58.93[a]	56.90[b]	56.04[b]	58.14[a]	0.56
Organic matter	55.94[c]	60.24[a]	58.79[b]	59.32[ab]	61.05[a]	0.58
Crude protein	41.69[c]	45.33[bc]	48.94[b]	56.46[a]	48.62[b]	1.99
Crude fibre	38.99[b]	45.31[a]	44.28[a]	45.62[a]	45.12[a]	1.07
Ash	33.75[b]	43.37[a]	33.38[b]	15.11[d]	20.16[c]	1.62
Ether extract	16.73[b]	40.43[a]	32.03[a]	25.57[ab]	21.48[b]	4.89
Nitrogen free extract	79.00[c]	83.05[a]	78.90[c]	81.56[b]	83.82[a]	0.91
Acid detergent fibre	44.58[d]	53.35[b]	46.70[c]	47.74[c]	57.33[a]	1.28
Neutral detergent fibre	63.67[d]	69.90[b]	65.18[c]	66.10[c]	72.90[a]	1.03
Acid detergent lignin	16.29[c]	28.45[b]	18.49[c]	24.44[b]	45.76[a]	2.94

[abcd] means within the same row with different superscripts are significantly different (P<0.05) SEM = Standard Error of mean, BDG=Brewers' dried grain

4.2.6 Nitrogen balance of Bunaji yearling bulls fed graded levels of brewers' dried grain

The result of nitrogen balance study is presented in Table 4.7. Total Nitrogen intake was significantly affected by inclusion level of brewers' dried grain. The highest nitrogen intake was observed in bulls consuming diet containing 30% inclusion level of brewer's dried grain and the lowest in the control. The result showed an increase in Urinary nitrogen loss as the level of BDG increased in the diets. Also the faecal nitrogen loss was higher in the treatments with BDG than the control. Nitrogen retained ranged from 72.01-79.48 g/day. The bulls fed diets containing 30% BDG had the highest nitrogen retention (79.48 g/day) compared to other treatments

Table 4.7: Nitrogen balance of Bunaji yearling bulls fed diets containing graded levels of Brewers' dried grain

	Level of BDG inclusion (%)					
Parameters	0	10	20	30	40	SEM
Nitrogen intake (g/day)	145.68^{c}	158.72^{a}	151.64^{b}	164.42^{a}	153.41^{b}	3.71
Urinary Nitrogen (g/day)	2.97^{e}	3.44^{d}	3.63^{c}	4.10^{b}	4.22^{a}	0.04
Faecal Nitrogen (g/day)	64.87^{b}	79.12^{a}	77.62^{a}	80.84^{a}	77.17^{a}	3.44
Total Nitrogen Output (g/day)	67.84^{b}	82.57^{a}	81.24^{a}	84.94^{a}	81.39^{a}	3.43
Nitrogen Retained (g/day)	77.84^{a}	76.15^{a}	70.40^{b}	79.48^{a}	72.01^{b}	3.57
Nitrogen Retained (%N-intake)	54.40^{a}	48.06^{b}	46.54^{b}	48.34^{b}	45.85^{b}	2.02

^{abcde} means within the same row with different superscripts are significantly different (P<0.05) SEM=Standard Error of mean, BDG=Brewers' dried grain.

4.2.7 Cost benefit analysis of Bunaji yearling bulls raised on diets containing graded levels of Brewers dried grain.

Table 9 shows the cost benefit analysis of Bunaji yearling bulls raised on diets containing graded levels of Brewers dried grain. There were significant differences (P<0.05) among most of the parameters evaluated. The value of gain ranged from ₦24,720 – ₦33,240; the total cost of feed ranged from ₦20,809.60 to ₦23,263.72. The cost/kg gain values ranged from 433.26 to 588.67 with 30% inclusion having the lowest and 0% inclusion having the highest cost/kg gain. The Net benefit ranged from ₦466.83 to 9237.17. Return to investment were 0.05, 0.26, 0.17, 0.42 and 0.20 for 0, 10, 20, 30 and 40 % inclusion levels of brewers dried grain, respectively.

Table 4.8: Cost benefit analysis of Bunaji yearling bulls raised on diets containing varying levels of Brewers' dried grain.

	Level of BDG inclusion (%)					
Parameters	0	10	20	30	40	SEM
Total weight gain (Kg)	41.20[e]	50.60[b]	44.80[c]	55.40[a]	42.70[d]	1.08
Daily weight gain (Kg)	0.45[d]	0.56[b]	0.49[c]	0.61[a]	0.47[c]	0.01
Value of gain (₦)	24720.00[d]	30360.00[b]	26880.00[c]	33240.00[a]	25620.00[c]	649.17
Concentrate intake (Kg)	233.00	241.10	233.66	243.06	232.41	5.90
Hay intake (Kg)(*D. smutsii)*	328.68[a]	337.84[a]	330.66[a]	345.90[a]	317.35[b]	9.18
Total feed intake (Kg)	561.68[a]	578.94[a]	564.32[a]	588.96[a]	549.76[b]	14.43
Total water intake (Litres)	1565.90[a]	1588.46[a]	1536.50[a]	1586.46[a]	1417.68[b]	34.86
Total cost of concentrate consumed (₦)	10951.18[a]	10878.43[a]	10103.46[b]	10052.96[b]	91755.47[c]	287.41
Cost of hay consumed (₦)	12049.26[a]	12385.29[a]	12122.14[a]	12680.69[a]	11634.05[b]	336.37
Total cost of feed consumed (₦)	23000.45[a]	23263.72[a]	22225.60[a]	22733.66[a]	20809.60[b]	587.80
Cost of water consumed(₦)	1252.72[a]	1270.77[a]	1229.20[b]	1269.17[a]	1134.14[c]	10.37
Cost of concentrate/Kg (₦)	47.00	45.12	443.24	41.36	39.48	
Cost/ Kg gain (₦/Kg gain)	588.67	484.87	523.54	433.26	513.90	
Net Benefit (₦)	466.83[d]	5825.51[b]	3425.19[c]	9237.17[a]	3676.26[c]	816.38
Return to investment on feed (RIF)	0.05[d]	0.26[b]	0.17[c]	0.42[a]	0.20[c]	0.03

[abcde] means within the same row with different superscripts are significantly different (P<0.05) SEM=Standard Error of mean, BDG=Brewers' dried grain. , Priceof yearling bull/liveweight=N600/kg Price of maize offal=₦ 40.00/kg, Cotton seed cake=₦ 56.00/kg, Brewers' dried grain=₦ 34.00/kg, *Digitaria smutsii* hay=₦ 36.66/kg , price of water= ₦ 0.8/l, yearling bull/liveweight=600/kg. value of gain= total weight gain×N600

CHAPTER FIVE

5.0 DISCUSSION

5.1 Chemical analysis, Preference Index (PI) and short term intake.

5.1.1 Chemical composition of brewers' dried grain from different breweries.

The dry matter contents are 82.63%, 82.39% and 83.06% for Kaduna, Benue and Ibadan brewery respectively. The dry matter content (82.39-83.06%) of brewers' dried grains obtained from this study is very close to the value (84.20%) obtained by Uchegbu *et al*. (2011) but lower than the values of 92%, 91.8%, and 89.56% obtained by Church and Pond (1998), Anigbogu (2003) and Ironkwe and Bamgbose (2012), respectively. The Crude protein (22.50-23.00%) is similar to the values (9-25%) reported by Kwari *et al*. (1999), Oluponna *et al*. (2002) however, the value reported in this study is higher than the values (18-20%) obtained by Bello (1984). The Crude fibre ranged from 6.61 - 6.82%, this value is however close to the value (8.11%) reported by Ironkwe and Bamgbose (2012) but lower than the value (13.12%) reported by Uchegbu and Udedibie (1998). The Metabolizable energy values are 11.76 MJ/KgDM for Benue brewery and 11.80 MJ/KgDM for Kaduna and Ibadan brewery. This result compared favorably with that of Ironkwe and Bamgbose (2012). The difference in the nutrient composition of the BDG from these breweries with the report of some other workers could be as a result of variation from grain source and method of brewing as established by Oluokun and Olalokun (1995).

5.1.2 Preference index (PI) and short term intake

In this study, the brewer's dried grain from Benue brewery and Nigerian breweries in Kaduna were most preferred with a preference index of 0.99 while the least preferred was the BDG sourced from Nigerian breweries in Ibadan with a preference index of 0.65. The high preference for BDG sourced from Benue and Kaduna could be as a result of lack of any smell that could repel the animals that was observed in the BDG from Ibadan. The smell observed in the BDG in Ibadan was as a result of improper drying which was compounded by transportation to the location of the experiment, therefore making it have a pungent smell. Also, the Physical characteristics of the diet such as dry matter content and particle size could have affected the preference as stated by Jarrige *et al*. (1995). The different processing method undergone by each brewery might have affected the physical and chemical composition of the BDGs'.

The Short term intake of brewers' dried grain from three breweries is also shown in Table 3. The average daily intake of 5.99 kg DM/2hrs was recorded for the BDGs' sourced from Benue and Kaduna compared to 3.92 kg DM/2hrs for the BDG sourced from Ibadan. The difference in preference might have been what brought about this significant difference ($P < 0.05$) in the average daily intake. This is in line with the report by Jarrige *et al*. (1995) that physical characteristics of a diet such as dry matter content and particle size could affects intake. Also Baumont (1996) stated that certain senses (i.e. sight, smell, touch and taste) in the feeding behaviour of ruminants affects intake, therefore the lower Intake of BDG sourced from Ibadan might have been as a result of the smell which puts the animals off.

5.1.3 Chemical Composition of individual feed ingredient and hay used for growth trial

The dry matter (94.29%) of *Digitaria smutsii* in this study is similar to the value (94.42%) reported by Abu (2014) and (93.10%) obtained by Sani (2014). However it is higher than the value (90.04%) reported by Yashim (2014) and lower than the value (97.00%) reported by Hassan (2007). The crude protein (9.63%) in this study is similar to the value (8.06%)

obtained by Sani (2014) but higher than the value (5.36%) and (7.88%) reported by Yashim (2014) and Abu (2014), respectively.

The dry matter value (94.08%) of maize offal obtained in this study is similar to the value (92.32%) reported by Lamidi (2005) but higher than the value (89.46%) reported by Sani (2014). Crude protein value (9.44%) is similar to the 9.88% reported by Adesote (2013) but lower than 11.88% reported by Sani (2014) and 10.93-11.98% reported by Lamidi (2005).

Crude fibre value (9.64%) is lower than 12.38% and 12.07% reported by Olorunnisomo *et al.* (2006) and Ezieshi *et al.* (2011) respectively. The ME (11.19 MJ/Kg) obtained in this study is close to the value (11.37 MJ/Kg) reported by Sani (2014) but lower than the ME range (14.52-16.69 MJ/Kg) obtained by lamidi (2005). The NDF value 28.55% in this study is higher than 21.64% reported by Lamidi *et al.* (2008) but lower than 55.15%, 33% and 53.92% reported by Idowu, (2011), Olorunnisomo *et al.* (2006) and Madziga *et al.* (2013) respectively.

The DM value (94.82%), CP (26.56%) and ME (10.35 MJ/Kg) of cotton seed cake obtained in this study are slightly higher than the value DM (89.94%), CP (23.69%) and ME (9.14 MJ/Kg) reported by Sani (2014). However the value of CP and ME (26.56%, 10.35 MJ/Kg) in this study are lower than the value (30.88% and 11.51 MJ/Kg) respectively reported by Madziga *et al.* (2013). The values of CF, EE, ADF and ADF (30.68%, 12.11%, 34.17% and 42.71%) respectively obtained in this study are lower than the values (38.49%, 17.84%, 47.31 and 55.37%) reported by Sani (2014). However the values of CF, EE, and NDF from this study are higher than the values (14.75-38.02%), EE (7.0-8.38%), NDF (50.31-54.28%) reported by Lamidi (2005). These variations could be as a result of difference in processing, storage and varietal differences. In general, the differences observed in the proximate composition of these individual feed ingredients (MO, and CSC) was in line with the view of Oyediji (2001) who reported that, the protein, fibre and energy of these by-products differ within themselves according to source and variety as well as processing methods. The nutritional value of cotton seed cake might have been affected by plant variety, geographical source, weather, processing conditions and level of endogenous substances (Adegun and Aye, 2013). The Difference in the proximate composition of the hay (*Digitaria smutsii)* could be as a result of the variation in the nutrient quality of the soil, stage and method of harvesting, and also storage.

5.1.4 Chemical composition of concentrate diets containing graded levels of brewers' dried grain fed to growing Bunaji yearling bulls

The CP of the diets ranged from 15.38-16.18%, which falls within the range of 13-16% reported by Aduku (2005) and 16% CP recommended by NRC (1989) for growing bulls. However it is higher than the value reported by Rutherglen (1995) and lower than the value (19.63%) reported by Madziga *et al.* (2013) and 19.00 to 22.91% reported by Lamidi *et al.* (2007) for bulls. The CF ranged from 7.00% for the control diet to 5.83 for the treatment with 40% inclusion level of BDG which are lower than the minimum level of 17% required for beef cattle (NRC, 2000). The decrease in crude fibre as the level of BDG increases could be as a result of low fibre content in BDG compared with CSC. The ether extract also reduced as the level of BDG increased which might have been as a result of the low quantity of oil in BDG in relation to CSC which has higher oil content. The EE of all the diets were not higher than the Maximum recommended level of 6% for matured cattle (Parish and Rhinehart, 2008). Differences in the grains used could have been why the chemical composition of concentrate diets used in this study differed from other authors

5.2 Effect of feeding diets containing graded levels of brewers' dried grain on the growth performance of Bunaji yearling bulls

There was significant difference on the performance of animals fed diets containing graded levels of brewers' dried grain in all the parameters measured. The average dry matter was observed to be higher for all other treatments except in the 40% inclusion level. There was also significant difference in average weight gain between the treatments fed 10% and 30% inclusion level and other treatments. The treatments with 10% and 30% inclusion of BDG had a higher average weight gain than other treatments, this could be attributed to the higher feed intake observed in those treatments compared to others. The average daily weight gain (0.45-0.61 kg/day) in the present study is higher than the values (0.24-0.31 kg/day) and (0.25 kg/day) reported by Ogundola (1984) and Ummuna *et al.* (1980) who fed brewers dried grain to Bunaji yearlings and brewers' dried grain to Bunaji yearlings steers respectively. The differences could be due to differences in the season the experiment was carried out, concentrate fed, temperature differences, and individual differences of the bulls used.

5.3 Effect of feeding diets containing varying levels of brewers' dried grain on Rumen metabolites of Bunaji yearling bulls.

5.3.1 Rumen pH

The pH of rumen fluid obtained in this study showed significant difference among the treatments. At 0hr, the pH of the rumen fluid was slightly above 7. This could be due to a kind of conditioned reflex displayed by much salivation into the buccal cavity in expectation of the morning feeding regime. At 3hrs, 6hrs and 9hrs post feeding, the pH of the rumen fluid dropped a little because the rumen microbes have degraded the diets thereby releasing TVFA's which drops the pH of the rumen, although the pH still fell within the normal range of 6-7 (Mould and Orskov, 1984) and 6.2 – 6.9 (Reddy and Reddy 1999). This implies that the pH in this study is adequate for normal rumen function.

5.3.2 Rumen Ammonia nitrogen (NH_3-N) concentration

Rumen ammonia nitrogen recorded in this study ranged from 8.24-9.81, 11.17-12.83, 7.10-10.96 and 7.23-8.24 for 0, 3, 6 and 9 hours respectively. Rumen ammonia nitrogen is a measure of the extent of rumen microbial protein degradation. In this study, the highest concentration of rumen NH_3-N observed at 3 hours post feeding indicated that there was high degradation of nitrogen in the rumen. The highest NH_3-N values was observed in 20% inclusion while the lowest was observed in 0% BDG. The rumen NH_3-N values observed in this study is higher than 5mg/100ml reported by Satter and Slyter (1974) for optimum microbial production in vitro and 8mg/100ml reported by Leng *et al.* (1984). The rumen NH_3-N values in this study were also higher than the value of 2-8 mg/100ml reported for high producing ruminant livestock (Drewnoski and Poore, 2012). The differences observed in the present study and other workers may be due to differences in the protein contents of the diets fed and the animals involved.

5.3.3 Total volatile fatty acid (TVFA) production

The TVFA values obtained in this study were higher than the values (10.5- 12.8mm/l) reported by Kandil *et al.* (1996). The highest TVFA was observed in 10% BDG inclusion while the lowest was observed in the treatment with no BDG inclusion. The result showed increase in the level of total volatile fatty acids to 3 hours post feeding. The increase in volatile fatty acids at 3 hours post feeding could be associated with the digestibility of the feed material (Orskov and Ryle, 1990; Khampa and Wanapat, 2007), since the volatile fatty acids are products of degradation of feed in the rumen. The slight decline in TVFA values at 6 hours post feeding across inclusion levels agrees with the work of Orskov (1982), who reported that the concentration of rumen volatile fatty acids decline with time, since volatile fatty acids are the major source of energy and are always absorbed through the walls of the rumen. This gave a positive indication of the energy value of the experimental diets and signifies better utilization by the animals.

5.4 Apparent nutrient digestibility

Dry matter digestibility (DMD) and Organic matter Digestibility (OMD) of the treatments with inclusion of brewers' dried grain were significantly higher than the control. The significant difference in organic matter digestibility observed in the present study is in accordance with the report of Rotger *et al.* (2006) who stated that a change in feed ingredients alters the amount of OM and N and their fermentation rate in the rumen. There was significant difference in crude protein digestibility. The treatment with 30% inclusion of brewers dried grain recorded the highest (56.46%) digestibility of crude protein and the treatment with 0% inclusion level recorded the lowest (41.69%). The high crude protein digestibility might have been what resulted to a higher weight gain observed in the bulls fed 30% BDG in their diets. The high digestibility of DM, OM, and CP of diets containing BDG are in line with the report of Ogundola (1984) that fed brewers dried grain to Bunaji yearlings. There was also significant difference in ADF and NDF digestibility in diets containing brewers' dried grain compared to the control, however, treatment with 40% inclusion level of BDG had the highest digestibility values of these parameters. This can be attributed to the lower intake recorded and low intake is often known to result in slower rate of passage of ingested feed from the reticulo-rumen (Swan and Lamming, 1967), this could have increased the efficiency of degradation thus, increasing the digestibility of the feed as reported by previous workers like Herrera-Saldana *et al*. (1990), Huhtanen (1991), Pettersson and Martinsson (1994).

5.5 Nitrogen Balance

The result showed an increase in Urinary nitrogen loss as the level of BDG increased in the diets. Also the faecal nitrogen loss was higher in the treatments with BDG than the control. The observed result on faecal and urinary nitrogen output does agree with the findings of Al-Asfoor, (2010) who reported that the nitrogen concentration of faeces strongly depends on the N concentration of the diet. Nitrogen retained ranged from 72.01-79.48 g/day

All the bulls had positive nitrogen balance irrespective of the level of BDG in their diet. This is an indication that the nitrogen was well metabolized and utilized by the bulls. This is also an indication that there was no detrimental effect on feeding BDG up to 40% inclusion level.The bulls fed diets containing 30% BDG had the highest nitrogen retention (79.48 g/day) compared to other treatments. This is in agreement with the report of Sarwar *et al*. (2003) who stated that nitrogen depends on good digestibility of nutrients and or utilization. In some cases this effect is sufficient to maintain an adequate N balance (Woodward and Reed, 1997). Performance was similar for most of the parameters measured irrespective of the inclusion levels of BDG. Hence BDG can be utilized for growing bulls without any adverse effect because Nitrogen retention is a major indicator used to assess the protein nutrition status of ruminant livestock (Abdu *et al.*, 2012).

5.6 Cost benefit Analysis

Feed account for 70-80% of the total cost of fattening bulls (Powell, 1975, Olayiwole *et al.*, 1981); and since feed cost was the major cost monitored during the study; the economic returns were based on this. The calculations of other cost such as capital required for pens, depreciation and purchase of stock and labour were not considered.

The result of this study shows that feed cost (concentrate) in Naira per kg declined with increase in BDG levels from ₦47.00/kg to ₦39.48/kg. The feed cost to gain ratio was higher in the control (₦ 588.67/ Kg live weight gain) and lowest at 30% BDG inclusion level (N 433.26/Kg live weight gain) which implies that the 30% inclusion was economically better than the control. The net benefits were ₦466.83, ₦5,825.51, ₦3,425.19, ₦9,237.17 and ₦3,676.26 for feeding Bunaji yearling bulls on 0, 10, 20, 30 and 40% BDG diets respectively. Net benefit was higher in the diets with inclusion levels of BDG compared with the control (0% inclusion) but the highest was recorded in diet with 30% inclusion level. This result is in agreement with the report of Ogundola (1984) who also observed a similar trend of reduced cost of feed as the quantity of BDG increased in the diet of Bunaji yearlings.

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATION

6.1 Conclusion

From the result of this study, it can be concluded that:

- Bunaji yearling bulls preferred Brewers' dried grain from Nigerian brewery Kaduna, and Benue brewery limited equally while that of Nigerian brewery, Ibadan was least preferred.
- Best weight gain and net benefit were recorded in 30% inclusion level which is optimum, therefore, brewers' dried grain can be incorporated in the diets of Bunaji yearling bulls up to 30% inclusion level.

6.2 Recommendations

From the results of this study, the following recommendations were made:

Small holder farmers and large scale farmers in Nigeria could include brewers' dried grain up to 30% in the diets of Bunaji yearling bulls for improved performance.

Research can be carried out to see how unfavourable olfactory properties of brewers' dried grain can be eliminated by processing and treatment.

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APPENDICES

Appendix I: Bags of brewers' dried grain and experimental feed used during preference, growth and digestibility trial.

Appendix II: Bunaji yearling bulls feeding during preference and short term intake studies.

Appendix III: Bunaji yearling bulls in their individual pens during growth trial.

Appendix IV: Left: Feeding of Bunaji yearling bulls during growth trial. Right: Feeding of Bunaji yearling bulls during digestibility trial.

Appendix V: Weighing of Bunaji yearling bulls during growth trial.

Appendix VI: Rumen fluid collection after the growth trial.

Appendix VII: Bunaji yearling bulls in Metabolic crates during digestibility studies

Appendix VIII: Faecal sample collection from Bunaji yearling bulls during digestibility studies

Appendix VII: Urine sample measurement after collection from Bunaji yearling bulls

Appendix X: Local women on the field drying Brewers' grain at Kudenda area in Kaduna State.

Appendix XI: Mean values of Rumen metabolites of Bunaji yearling bulls fed diets containing varying levels of Brewers dried grain

	Level of BDG inclusion (%)					
Parameters	0	10	20	30	40	SEM
pH	6.87^{b}	6.88^{b}	6.75^{c}	6.89^{b}	7.14^{a}	0.05
Rumen NH_3-N (mg/100ml)	8.85^{b}	9.81^{a}	10.49^{a}	9.10^{ab}	9.71^{a}	0.43
TVFA (μmol)	40.50^{b}	47.75^{a}	40.92^{b}	44.84^{a}	41.08^{ab}	2.01

^{abcde} means within the same row with different superscripts are significantly different (P<0.05) SEM=Standard Error of mean, BDG=Brewers' dried grain, TVFA= Total volatile fatty acids