EFFECT OF FEEDING CONCENTRATE DIETS CONTAINING GRADED LEVELS OF GROUNDNUT HAULMS ON THE PERFORMANCE OF FRIESIAN X BUNAJI CATTLE

BY

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DECLARATION

I hereby declare that this thesis has been written by me and that it is my own research work carried out in the Dairy Research Programme Farm of the National Animal Production Research Institute (NAPRI), A .B .U Shika, Zaria; under the supervision of Prof. O.W Ehoche, Dr. G.E. Jokthan and Dr. P.P Barje. I wish to state that no part of this thesis has been presented in any previous application for a higher degree. All quotations are indicated and sources of information are duly acknowledged by means of references.

……....
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……....
Date

CERTIFICATION

This thesis entitled "**EFFECT OF FEEDING CONCENTRATE DIETS CONTAINING GRADED LEVELS OF GROUNDNUT HAULMS ON PERFORMANCE OF FRIESIAN X BUNAJI CATTLE**" by Hosea Istifanus Finangwai meets the regulation governing the award of Doctor of Philosophy Degree of Ahmadu Bello University, Zaria, and is approved for its contribution to scientific knowledge and literary presentation.

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DEDICATION

This work is dedicated to GOD ALMIGHTY and also to my dearly beloved wife Nansat and children; Boy Favour, Lady Pangyirai Divine, and Lady Pyoktomi Love.

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ABSTRACT

A study was conducted to determine the effect of feeding concentrate diets containing graded levels of groundnut haulms on performance of Friesian x Bunaji cattle. In the first experiment twenty Friesian x Bunaji prepubertal heifers aged 14-16 months weighing 160-180kg were randomly divided into four groups and the groups were allotted four dietary treatments in a completely randomized design. The dietary treatments consisted of iso-nitrogenous concentrate mixtures in which groundnut haulms was included at 0, 25, 50 and 75% levels. The heifers were fed weighed quantity of concentrate mixture *ad libitum* and *Andropogun gayanus* (gamba) hay for 112 days. Prior to the commencement of the first experiment, a digestibility trial and nitrogen balance was carried out using sixteen bulls aged 12-18 months. The result showed that the digestibility of dry matter, organic matter, crude protein, crude fibre, ether extract, Neutral detergent fibre and Acid detergent fibre were significantly ($P<0.05$) higher in diets with 75% level of groundnut haulms. Increasing groundnut haulms level in concentrate diet up to 75% significantly ($P<0.05$) depressed both dry matter intake and gain of heifers. The result also showed that dry matter intake (DMI) was not significantly different ($P>0.05$) between heifers fed diet with 0, 25 and 50% groundnut haulms, but declined significantly ($P<0.05$) when groundnut haulms level reached 75%. The body weight and average daily gain of heifers fed concentrate diets containing 0 and 25% groundnut haulms were not significantly different ($P>0.05$); although they were higher ($P<0.05$) than for those in 50 and 75% groundnut levels. The result showed that rumen pH and Nitrogen were significantly($P<0.05$) increased with the inclusion of groundnut haulms in concentrate diets. Feeding graded levels of groundnut haulms in concentrate diets of Friesian x Bunaji heifers significantly increased ($P<0.05$) serum glucose at 25 and 50% groundnut haulm. Concentrations of serum urea, creatinine

and protein in heifers fed varying levels of groundnut haulms in concentrate diets slightly reduced, with increase in groundnut haulm levels in diet. There was a significant ($P<0.05$) increase in Red Blood Cell (RBC) with increase in the level of groundnut haulms in diet which was higher at 75% groundnut haulms level. The percentages of animals that attained puberty over the experimental period were 0, 40, 60 and 40% for 0, 25, 50 and 75% groundnut haulm levels respectively. The cost of concentrate diet both in Naira and in Naira per kilogram were reduced with increase in groundnut haulm levels in concentrate diet with Net benefit remaining positive across the treatments. In the second experiment, the effect of feeding concentrate diets containing varying levels of groundnut haulms on milk yield, milk compositions and cost- benefit analysis were examined. The animals were made of twenty Friesian x Bunaji cows at their first lactation periods. They were divided into four groups of five animals each, consisting of three postpartum and two prepartum each; and were randomly assigned to one each of the experimental diets in a completely randomized design. Results also show that there was significant difference ($P<0.05$) in dry matter intake (DMI) metabolic body weight, weight gain and average milk yield of lactating cows fed varying levels of groundnut haulms. At 25 and 75% levels of groundnut haulms in concentrate diets ADG were similar ($P>0.05$) but significantly ($P<0.05$) higher than their counterparts at 0 and 50% groundnut haulms levels. There was significant difference ($P<0.05$) in the total milk yield with those at 0% recording 557.9 litres, which were similar to cows fed 50% (538.8L) groundnut haulms in concentrate diets, but were however, significantly ($P<0.05$) higher than those at 25 (337.1L) and 75% (346.4L) groundnut haulms. Milk fat, lactose, Total solid and solid-not-fat differed significantly ($P<0.05$). Milk fat and Total solid decreased linearly with increase in groundnut haulms in concentrates diets of cows. Cost benefit analysis indicated that cows fed 50% groundnut

haulms had better net benefit. It is concluded that, inclusion of groundnut haulms up to 50% in concentrate diet can improve reproductive performance of heifers, milk production and profit margins of lactating crossbred cows.

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ABREVIATIONS/ACRONYMS

A B U	Ahmadu Bello University
ADF	Acid Detergent Fibre
ADG	Average Daily Gain
ANOVA	Analysis of Variance
AOAC	Association of American Analytical Chemists
ARC	Agricultural Research Council
ARC	Agriculture Research Council
BQ	Black Quarter
CBN	Central Bank of Nigeria
CBPP	Contagious Bovine Pleuro-Pneumonia
CF	Crude Fibre
CP	Crude Protein
CSC	Cotton Seed Cake
DIM	Day in Milk
DMI	Dry matter intake
DMI	Dry matter Intake
EDTA	Ethylene- di -amino- tetra acetic acid
EE	Ether extract
FAO	Food and Agriculture Organization
g	**g**ram
GDP	Gross Domestic Products
GH	Groundnut Haulms
GLM	General Linear Model
GNC	Groundnut cake
h	Hour
IAR	**Institute of Agriculture Research**
IU	International unit
Kcal	Kilocalories
Kg	Kilogram
kgw$^{0.75}$	Dry matter intake per metabolic body weight
L	Litre
LCFA	Long chain fatty acid
LH	Luteinizing Hormone
LOS	Level of significant difference
LU	Tropical Livestock Unit
ME	Metabolizable Energy
ME	Metabolizable Energy
MJ	Megajoule

mJ	Milijoule
Ml	militres
Mmol/L	Milimoles per litre
Mn	Manganese
N_2	Nitrogen
NAPRI	National Animal Production Research Institute
NDF	Neutral Detergent Fibre
NFE	Nitrogen Free Extract
ng/ml	nanogram/militres
NH_3-N	Ammonia-Nitrogen
NPN	Non-Protein Nitrogen
NRC	National Research Council
OM	Organic Matter
p	Phosphorus
P:E	Protein Energy Ratio
P_4	Progesterone
PER	Protein Energy Ration
PKC	Palm kernel cake
ppm	parts per million
RAN	Rumen Ammonia Nitrogen
RDN	Rumen degradable Nitrogen
RMRDC	Raw materials Research and Development Council
RUP	Rumen undegradable protein
SAS	Statistical Analysis System
SEM	Standard error of the mean
SNF	Milk Solid - Non - Fat
SRL	Strained Rumen Liquor
TDN	Total Digestible Nutrients
TN	Total Nitrogen
TVFA	Total Volatile Fatty Acid
UDP	Undegradable protein
UK	United Kingdom
VFA	Volatile fatty acids
%	Percentage
^{0}c	Degree Celsius

CHAPTER ONE

1.0 INTRODUCTION

Livestock play a significant role in Nigeriaits agriculture, contributing about 12.7% of the total agricultural Gross Domestic Products (GDP). According to Cental Bank of Nigeria (1999), cattle are found throughout Nigeria, but are most common in the northern two-thirds of the country, with almost half of the total cattle population permanently resident in the sub humid zone. Cattle in Nigeria are numerous and provide substantial quantities of animal protein in the form of meat and milk, in addition to role they play in influencing the ecosystem. Their production is based on an age-old husbandry system which needs to be gradually upgraded in order to meet the needs of ever increasing human populace.

The unorganised dairy industry in Nigeria, still represents an important component of the animal subsector of the economy

with great economic, nutritional and social implication. It provides a means of livelihood for a significant proportion of rural pastoral farmers. Food and Agriculture Organisation (1988) reported that 183 thousand rural households derived income from the dairy industry in 1986; with 96% of all cattle in Nigeria in the hands of the pastoral Fulanis, who are the most important suppliers of domestic milk. Although, a few private commercial and experimental dairy farms exist as organised dairy farms, they produce an insignificant proportion of the domestic milk (Yahuza, 2001).

Dairy cattle consume a lot of feed to remain productive, most especially during growth and early part of lactation. However, the marked seasonal fluctuations in feed supply and pasture quality experienced by dairy cattle in the tropics result in a seasonal

pattern of milk yield and other performances such as liveweight and reproduction. Cereal crop residues such as sorghum, maize and millet stovers and rice straws are produced in large quantities annually and are often used as a low cost forage option for ruminant nutrition in Nigeria. However, these cereal crop residues are low in crude protein, readily fermentable energy, essential minerals and are high in lignocellulosic compounds (Ehoche *et al.*,2002). Protein is usually the first limiting nutrient for cattle fed low-quality forages and is required by rumen microbes to digest fibre and other components necessary for growth and replacement of broken down body tissues. Low nitrogen intake makes energy utilization less efficient and consequently protein catabolism often occur internally to meet energy requirements. Under these conditions, the animals may well be more susceptible to infections or parasitic diseases, insufficient dietary protein as well as metabolic intake and productive disorders, lower body condition scores, higher feed costs, reduced conception rates, weak calves, lighter calves, poor health and reduced milking ability (Duguma et al., 2012).

Supplementation to provide essential nutrients has been found to be the most feasible, economic and preferred method of improving the utilization of poor quality forage materials by ruminant animals in the tropics (Preston and Leng, 1984; Poppi and McLennan, 1995). A practical approach to supplementing low quality forages is to correct the nitrogen and mineral deficiency for the rumen microbes (Preston and Leng, 1984). This may be achieved through supplemention with urea-molasses mineral block or poultry litter. For high production, it is necessary to supplement with high quality proteins such as oil seed cakes, cereal grains and cereal brans. However, these supplements are often not used by the smallholder farmers as they are constrained by scarcity and high cost.

In recent years, the use of forage legumes in livestock production systems for ruminants in the tropics as alternative to oil seed cakes has increased. Forage legumes and fodder trees provide high quality proteins as well as digestible cell wall carbohydrates. There is therefore, the need to explore these alternative sources of protein for cattle production.

Groundnut (*Arachis hypogaea*) is an important legume crop grown for seed and forage in smallholder crop livestock farming systems in the sub humid zone of West Africa (Oloranju *et al.*, 1996). The seed is a major source of oil for humans and the cake after oil extraction is a good source of protein supplement for livestock. The forage (haulms) after pod harvesting is commonly fed to ruminants, especially in the dry season.

Nigeria is the leading producer of groundnut in Africa, with total output estimated to be 1,976,490.00 tons (RMRDC, 2004). Thus, vast quantities of groundnut haulms are available annually for feeding livestock in the country. In spite of the potential of groundnut haulms as a major feed resource for livestock, information on its utilization by dairy cattle is very scanty. The availability of groundnut hay among arable farmers who keep small livestock and the variation in results obtained from ruminants fed groundnut haulms underscore the need for more studies on how best its potential as animal feed can be exploited.

1.1 Objectives of the study:

1. To investigate the nutritive values of groundnut haulms, gamba hay and concentrate diets containing graded levels of groundnut haulms.

2. To determine the effect of feeding concentrate diets containing graded levels of groundnut haulms on dry matter intake, digestibility and nitrogen balance of Friesian x Bunaji Bulls

3. To determine the effect of feeding concentrate diets containing graded levels of groundnut haulms on growth and reproductive performance of Friesian x Bunaji heifers.

4. To determine the effect of feeding concentrate diets containing graded levels of groundnut haulms on rumen and serum of Friesian x Bunaji heifers.

5. To determine the effect of feeding concentrate diets on blood chemistry of Friesian x Bunaji heifers

6. To investigate the effect of feeding concentrate diets containing graded levels of groundnut haulms on performance of lactating Friesian x Bunaji cow.

1.2 Statement of Research hypotheses

This study was carried out on the basis of the following hypotheses:

Null hypothesis 1:

Inclusion of groundnut haulms in concentrate diets of Friesian x Bunaji cattle can not significantly affect their chemical composition

Alternative Hypothesis 1:

Inclusion of groundnut haulms in concentrate diets of Friesian x Bunaji cattle can significantly affect their chemical composition

Null hypothesis 2:

Feeding concentrate diets containing graded levels of groundnut haulms does not have any significant effect dry matter intake, nutrient digestibility and nitrogen balance

Alternative hypothesis 2:

Feeding concentrate diets containing graded levels of groundnut haulms have any significant effect dry matter intake, nutrient digestibility and nitrogen balance

Null hypothesis 3:

Feeding concentrate diets containing graded levels of groundnut haulms does not have any significant effect on growth and reproductive performanceof Friesian x Bunaji heifers.

Alternative hypothesis 3:

Feeding concentrate diets containing graded levels of groundnut haulms have significant effect on growth and reproductive status of Friesian x Bunaji heifers.

Null hypothesis 4:

Feeding concentrate diets containing graded levels of groundnut haulms does not have significant effect on rumen metabolites of Friesian x Bunaji heifers

Alternative hypothesis 4:

Feeding concentrate diets containing graded levels of groundnut haulms have significant effect on rumen metabolites of Friesian x Bunaji heifers

Null hypothesis 5:

Feeding concentrate diets containing graded levels of groundnut haulms have no significant effect on blood chemistry of Friesian x Bunaji heifers

Alternative hypothesis 5:

Feeding concentrate diets containing graded levels of groundnut haulms have significant effect on blood chemistry of Friesian x Bunaji heifers

Null hypothesis 6:

Feeding concentrate diets containing graded levels of groundnut haulms has no significant effect on performance of lactating Friesian x Bunaji cow.

Alternative hypothesis 6:

Feeding concentrate diets containing graded levels of groundnut haulms has significant effect on performance of lactating Friesian x Bunaji cow.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Dairy Cattle Production in the Tropics

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 less populated areas to year round confinement and cut and carry feeding of grass and browse plants in densely populated areas.

Cattle population in Nigeria have been reported to be about 15.2 million in recent study (Aregheore, 2009). Data for meat and milk production, live animal imports and milk 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. While total milk production and milk equivalent import were 432 and 739.1 metric tonnes in 2005 (Aregheore, 2009). Cattle are found throughout in Nigeria but are mostly found in the 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 Nigerian's population of zebu cattle is owned by agro-pastoral farmers who adopt relatively inefficient production systems (Otchere and Nuru, 1988). The proportion of the various breed 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 and Muturu and Kuri/Chad cattle occur in the Southern-Western, Southern

and North Eastern parts of Nigeria respectively (Aregheore, 2009). Ninety six percent of cattle in Nigeria are in the hands of the Pastoral Fulanis. This pastoral herd is the most important source of domestic milk. Only a few imported cattle breeds such as Friesian and Brown Swiss and their crosses are kept on experimental dairy farm owned by government agencies. A few private commercial dairy farms, owned by companies and individuals are known to exist. They contribute insignificant proportion of the domestic milk supply (World Bank, 1992; Yahuza, 2001; Ehoche, 2002). The traditional system of production is reported to produce 515.3 thousand metric tons of domestic milk in 2001 and 606827 tons in 2005 (Yahuza, 2001).

The activities of the Nigerian dairy industry are centered on milk production, importation, processing, marketing and consumption. The dairy industry represents an important component of the agricultural sector of the economy with great economic, nutritional and social implication (Olaloku, 1976; Food and Agriculture Organization, 1991; Yahuza 2001). The dairy industry provides a means of livelihood for a significant proportion of rural pastoral families. Food and Agriculture Organization (1988) estimated 183 thousand rural households derived some income from the dairy industry in Nigeria (Food and Agriculture Organization, 2005 in Aregheore, 2009).

Food and Agriculture Organization (2009) reported that cattle population, milking cow per head and milk production in tonnes in 2005 were 25,117,798, 4018847 and 606827 respectively. While the estimated human population and annual demand for and supply of milk from national head from 2000-2005 were; 110-124.45 million, 990,000-11,2000,5 tonnes and 49,547-60,6827 tonnes respectively (Aregheore, 2009).

The rapid increase in population and more demand for food is pushing agriculture to marginal lands in West Africa (Singh *et al.*, 2004). This coupled with little or no use of

fertilizer has led to continuous decline in soil fertility, hence low food and feed productivity in the region resulting into widespread malnutrition and hunger (Ajeigbe *et al.,* 2001).

2.2 Dairy cattle production systems

In sub-saharan Africa dairy 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. Dairy 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)

2.2.1. 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).

2.2.1.1 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 notice taken 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).

2.2.1.2 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) .

2.2.1.3 Compound dairying:

In this system, milking animals are kept in the compound to supply the family with liquid milk while the excess is processed into other dairy products for sale. This system has long been practiced among the Hausas and was first described in Kano in the nineteenth century. The transhumant Fulani pastoralists who generally take away most of their herd in the dry season will leave some animals in the homesteads to supply milk to their family. These animals are either stall-fed or grazed close to the compounds in the day and confined in the night (Tewe and Bokanga, 2001).

2.2.2 Nomadic or pastoral systems

The traditional grazing pattern is that 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 the 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 Exclusively pastoralists; transhumant pastoralists and agro-pastoralists.

2.2.2.1 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).

2.2.2.2 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).

2.2.2.3 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 finite 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).

2.2.3 Mixed farming (Integrated Crop/Livestock)

This is a system conducted 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. External factors are weather patterns, market prices, political stability, 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).

2.2.4 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 have only cattle or 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 farmers. In this type of intensive production system the use of crop residues and agricultural by-products are effectively and economically combined with grazing. Intensive dairy farms are usually stocked with exotic dairy breeds and upgraded local indigenous ones (Ehoche, 2002).

2.3 Constraints to Dairy Cattle Production in Nigeria

2.3.1 Low genetic potential of indigenous cattle for milk production

Lack of organized breeding programme in Nigeria has hampered the development of the ruminant industry. For instance, it is still not clear as to what means to categorise local breeds of cattle as dairy or beef type. They all exhibit dual or triple-purpose traits, with productivity far below the average expected (Bourn *et al*., 1994). The reproductive performance of the cows, which is an important consideration in breeding is hampered by long calving interval that is rooted in poor management and inadequate feeding. Worst still, Nigeria has no breeding policy programme for livestock (Payne,1990). Cattle breeds indigenous to most tropical countries belong to the specie *Bos indicus*. This specie is well adapted to tropical environments. It possesses a high degree of heat tolerance, is resistant to tick borne and to other diseases occurring in the tropics and has a low maintenance requirement. However, its potential for milk production is low because of their dual

nomenclature both as beef and milk animal (Aregheore, 2009). Rate of growth and milk production from cattle in developing countries are generally low and often only 10% of the genetic potential of the animals (Leng and Nolan, 1984). As a result of this, the average number of animals per family is about 45.1 with low production with an average of 45% calving rate, 110 litres of milk per cow per year and an offtake of 9% (Leng and Nolan, 1984). Domestic milk production in Nigeria is mainly from indigenous cattle breeds which are kept principally by agropastoral Fulani ethnic families. The productivity of the traditionally managed dairy cattle have been reported to be low mainly because of the poor genetic nature of our dairy breeds (Ehoche, 2002). Otchere (1986) and Ehoche *et al*. (2001) obtained an average milk off-take of between 0.75- 0.77kg per cow per day for Bunaji cows under agropastoral system.

2.3.2 Inadequate and low quality feed resources

In Nigeria, pasture has not been developed except on Government and University, experimental, teaching and demonstration farms. Consequently ruminant livestock depend on natural grasslands that are nutritionally poor. Most of the livestock population in Nigeria are under extensive systems and forage availability is an important nutritional factor.

The productivity, chemical composition and nutritive value of grasses and legumes found in Nigeria vary greatly according to species, the nature and fertility of the soil, water relations; seasons 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 (Omokaye *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 food 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* (Omokaye *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; Omokaye *et al.,* 2001).

2.3.3 Incidence of diseases and parasites

Disease is reported to pose a major threat to dairy cattle production in tropics (Payne, 1990). Duguma *et al*. (2012) identified some major endemic diseases in the dairy industries to include; mastitis 35.2%, internal parasites 14.8%, Lumpy skin disease 13% and heart water 5.6%. Mastitis is reported to be the most severe disease of high prevalence on dairy farms in the tropics, which often result into decreased milk yield, pre-mature culling of cows, milk discard and high cost of treatment (Payne, 1990). Poor hygiene of cows and shelter, shortage of space, absence of disease control measures and low level of management are the major causes of high incidence of mastitis in dairy herds. Mungube *et al*. (2005) estimated the economic losses from mastitis in the urban and peri urban areas of Africa to be about US $ 58 per cow per lactation. 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 km^{2}) 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 dairy 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 dairy 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 dairy 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). Dairy cattle diseases in whatever form cause major economic loss to farmers in form of mortality loss or milk loss.

However, farmers in tropics are reluctant in controlling diseases and vectors of cattle (Jongejan and Uilenberg, 2004).

2.4 Cattle feed resources in the tropics

2.4.1 Range forages pastures and browse plants

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 subsist on mature native forage and crop residues in the dry season. The total land area of Nigeria is 94 million hectares; seventy five (75) million hectares out of the 94 million hectares is area of savannah land, out of which only about 45 million hectares are available for livestock grazing with all range hectarage per animal ratio as 5:1 (Agishi, 1985). The available grazing lands support Nine 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 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 cylindrical, 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 practices, 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 planted 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 tall perennial specie that grows in large tufts up to 2m high. Fifty 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 a 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, apart from 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). At October level of wet season, 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 Januarys 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 ratio 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).

Gamba requires intervals of more than six weeks between cuttings and a cutting height of about 4cm to maintain productivity and a good stand (Aregheore, 2001). It cannot stand heavy grazing until it is well established; however it requires high stocking rates to maintain reasonable height. Gamba is better utilized when young because once flowering stems appear, it becomes coarse with little nutritional value and after maturity with only 1.5 percent crude proteins (Gohl, 1981). Boudet (1975) reported that crude protein content of gamba in all categories of leaf and stem rose to a maximum at ear emergence. Maximum digestible nutrients are obtained by cutting at ear emergence stage of growth (Haggar and Ahmed, 1971). Gamba has low digestibility but high nitrogen levels (WFB, 1978).

Dry matter yield is observed to increase during wet season from June to October in Nigeria, reaching a maximum of about 3800 kg/ha in October declining then until February. Haggar (1970) noted that cutting gamba in early October gave best balance of bulk and quality. Adegbola and Mecha, (2000) recorded dry matter and green matter yields of 14,800kg DM/ha per year in Lagos, Nigeria. A selection of gamba No 621 from Shika, Nigeria yielded 4,000kg DM//ha without fertilizer nitrogen, but with adequate phosphorus (WFB, 1978).

Gamba when fresh and young is palatable and ruminants eat it up to flowering (Bowden, 1963) with high yield. In Nigeria natural grassland containing 60 percent of *Andropogun gayanus* (gamba) resulted in a weight gain of 0.31kg per day when grazed by N'dama and Keteku cattle. But when consumed as silage the weight gain was 0.11kg/day (Adegbola, 1979).

2.4.2 Legume and Browse Plants

Browse in the form of trees and shrubs forms an integral part of ruminant production. Feeding browse has become an essential practice especially in the dry season when herbaceous forages are scarce (Bamikole *et al*., 2004) and low in nutritive value (Aregheore, 2001). Their relative importance in ruminant nutrition especially during the dry season cannot be over-emphasized. Improved animal agro-forestry could enhance livestock production in Nigeria through forage production. Large number of browse legumes and multipurpose trees have been tried experimentally and subsequently introduced to ruminant farmers (Mecha and Adegbola, 1980).

Although many of leguminous and browse plants are non – conventional feeds, they are widely used as protein source in ruminant diet. The efficiency of utilizing green forages are determined by the physical characteristics and inherent limitation of the feeds and the knowledge of their digestion in the gastro intestinal tract (Devendra and Burns, 1983).

Devendra and Burns (1983) and Sitorus *et al.* (1985) showed that in spite of the high content of crude protein (CP) in *Leucaena leucocephala*; it had little effect on diet digestibility. Forage quality is important in getting the high nutrient uptake required for best performance. Devendra (1983) reported the best N and mineral retention in sheep when *leucaena l*eaves, stems and pods in balanced diet were fed.

Browse legumes are shrubs and trees that are of considerable nutritional importance as livestock feed during the dry season of the year. Their leaves are green all year round and many are well known to herdsmen who frequently cut down their branches for stock feeding. Most nomads and smallholders know them and therefore use them for their livestock (Aregheore, 1996; Onwuka *et al.*, 1992; Carew *et al*., 1980). The fruits of some of

the browse plants form an important feed resource during the dry season. Many browses contain high levels of essential elements such as calcium, sodium and sulphur as well as critical micro-nutrients such as iron and zinc which have been shown to be deficient or borderline for productive purposes in many grass species (Olubajo, 1974).

Browse legumes are found all over the country. Species commonly found in the range include: *Leucaena leucocephala, Gliricidia sepium, Acacia* spp. (*A. albida, A. nilotica*), *Albizia, Ficus elasticoides, Mangifera indica, Musa* sp., *Spondias mombin, Cajanus cajan, Tamarindus indica,* and *Parkia clappertonian* (Aregheore, 2009) to mention but a few. Leucaena is widely accepted as the best browse legume and has naturalized in some parts of Nigeria (Aregheore, 1996). *Leucaena* and *Gliricidia* foliage yields are higher in the wet season (Aregheore, 1996; Balogun and Otchere, 1995). Their leaves provide protein-rich supplements to traditional village diets to increase small ruminant productivity (Jabbar *et al.,* 1997). Dry matter digestibility (DMD) of *Gliricidia* as a sole feed was found to be 54 – 57 % (Ademosun *et al.,* 1988)

Bamikole *et al*. (2004) evaluated the feeding value of *Ficus religiosa* (FR) and reported that feed intake, weight gain, digestibility and N utilization can be enhanced by feeding *Ficus religiosa* in mixture with *Panicum maximum* and it can be used in diet mixtures up to 75 % of fed. Yahaya *et al.* (2001) reported that *Acacia sieberiana, F. polita* and *F. sycomorus* can sustain sheep on a maintenance diet and could also be used as a supplementary feed during the dry season.

2.4.3 Crop residues

During the dry season (November- April) the range and the large quantities of cereal residues from maize, millets and sorghum forms the bulk resources available for

feeding ruminant livestock in Nigeria (Lufedaju *et al*., 1992). In some countries, ruminant livestock are maintained mainly on pastures, forages and grains derived from arable lands, while in Nigeria and most tropical countries, ruminants receive most of their energy needs from crop-residue and natural pasture land (Ehoche, 2002).

The importance of crop residue as feed for ruminants especially during the dry season has been recognised by farmers. Faced with the constrain of inadequate range forage during the dry season and the high cost of the conventional feed ingredients to feed their livestock (Ademosun *et al.*,1988; Mgheni *et al.*, 1993), farmers thus, rely on the available crop residue. Ehoche (2002) reported that large quantities of crop residues are produced annually in the major cattle producing areas of the country. Kossila, (1985) had earlier reported more than 340 Million tons of fibrous crop residues with great proportion coming from cereal crops. Alhassan (1985) estimated crop residue production from extinction rate of 1kg seed to 8, 4, 4, 2, and 5 kg of millet, sorghum, maize, rice, groundnut and cowpea residue to be 24.6, 17.2, 2.5, 0.2, 1.3 and 3.7 million tons respectively. This is from the major production areas of Sokoto, Kano, Bauchi, Adamawa, Taraba, Kaduna, Benue, Borno states of Nigeria.

In Nigeria level of crop residue availability is ranked among the highest in Africa. 50 Million tons of dry matter (DM) of fibrous crop residue is available to 11 million cattle, 8 million sheep, 22 million goats (Kossila, 1985). Cereal and legume crop residues constitute the major field crop residues for cattle. Cereal crop residues include sorghum, millets and maize stover, and rice, wheat and 'Acha' straws. Central Bank of Nigeria (CBN) (1999) estimated crop residues output for maize, sorghum, millet, rice, cowpea and groundnut production in year 2000 to be 24,914, 35,296, 53,944, 96,820, 11, 305 and 4,780 metric tons respectively. Legume hays are those from cowpea, groundnut haulms, soybean

and lablab (Ehoche, 2002). The amount of fibrous crop residue derived from cereals and other crops considering livestock unit (LU) in metric tons, dry matter metric tons ('000) and tons dry matter per unit livestock unit of Nigeria are 10,874, 56,260 and 5.17 respectively (Kossila, 1985).

Crop residues are grazed intensively from November to February between 8.00am - 6.00pm daily and by March nothing is left in the fields. The amount of crop residue consumed by livestock in Nigeria and the extent of grazing varies considerably. The estimated crop production from which the amount of crop residue can be computed is subject to considerable variation as a result of weather effects and fluctuation in crop to residue ratio (Lufadeju *et al*., 1992). Similarly, these crop residues are subjected to trampling, soiling, termite damage, and fire. As a result, less than 50% of the crop residue is actually consumed by livestock (Alhassan *et al.*, 1986; Munthali *et al.*, 2000). In addition to these, the residues have other competitive use in areas they are produced such as being used for housing, roofing, fencing, mat-making, fuel and paper making (Olayiwole, 1976). In spite of this competitive usage if available crop residues can be properly harnessed and processed; and used to provide enough roughage for the entire cattle population of Nigeria especially at the dry season (Alhassan, 1985).

2.4.3.1 Quality of crop residues

Cereal residues (maize, rice, millet, sorghum and wheat) residues are low in nitrogen and one way of improving their nutritive value is to feed them to animals together with a variety of forage supplements that are potentially valuable to ruminants (Adebowale, 1988). Some of these forages include Siam weed (*Eupatorium odoratum*), cassava leaves (*Manihot esculenta*), *Gliricidia* leaves (*Gliricidia sepium*), *Leucaena leucocephala* and

Spondias mombin foliage. The beneficial effects of feeding these forages to ruminant animals are many such as increased metabolisable energy and nitrogen intake, improved palatability, increased available minerals and vitamins, better rumen function and a laxative influence on the alimentary system.

Adebowale (1992) reported the results of a trial in which 20 White Fulani steers were fed *ad libitum* on treated and untreated maize cobs (chopped) with fresh Siam weed (2 kg/head/day). Live-weight improved from a daily loss of 320 g, when animals were fed untreated maize cobs, to a daily gain of about 480 g, when cobs were treated and supplemented with Siam weed. When *Gliricidia* foliage was supplemented to about 15 percent of the DMI of White Fulani cows on a diet of maize husk, the milk yield increased by about 22.5 percent. However, when maize husk was ensiled with 6 percent urea for ten days, the milk yield increased by 42 percent with *Gliricidia* foliage and 29 percent without it. When maize husk and bran supplemented with *Leucaena* foliage were fed to West African Djallonke goats for 12 weeks, animals reacted better to maize bran than to maize husks. This confirms that maize bran is better degraded in the rumen than maize husks. However, these two maize residues are either expensive or cumbersome to procure, especially for feeding large animals (Adebowale, 1992).

2.4.4 Agro industrial by-products

Conventional feed resources are in high demand for human consumption. They are therefore not always available for livestock. Where and when available, they are too expensive to justify their inclusion in livestock diets. The use of agro-industrial by-products as feed ingredients has been reported to depend on the cost of the feedstuff, their safety for animal health and alternative uses (Bickel and Deboer, 1988).

2.5 Role of feed supplentation in cattle production

2.5.1 Energy supplements

Emaciated cattle and buffaloes in the herds of small farmers in developing countries have been usually diagnosed as being energy deficient. While it is evident that these animals, fed largely on poor quality roughages are deficient in nutrients and total energy intake, the low energy intake appears to be due primarily to fermentable N and/or protein deficiency in the diet (Preston and Leng, 1987). The apparent energy deficiency is a result of an inefficient (fermentable - N deficient) rumen which decreases the rate of fermentative digestion and also decreases the ratio of protein to energy in the products of rumen fermentation (microbial cells which is 65% protein and the VFAs) (Singh and Gupta, 1986). The effect of the low rumen fermentative activities is a reduced feed intake (Orskov, 1982). Correcting an N deficiency for the rumen microbes increases feed intake, digestibility and the ratio of protein to energy in absorbed products, but because the nutrients arising from digestion in the rumen are imbalanced to meet the requirements for productivity this remains fairly low.

Increasing energy intake increases milk protein content through increased yields of microbial protein in the rumen. However, providing feed in excess of requirements has little further effect (Sutton, 1990). Stockdale (1994) summarized results from 27 experiments in a wide range of feedstuffs. He reported that starch-based supplements, such as cereal grains and compounded concentrates, are the best way to improve milk protein content. This improvement is believed to be due to an increase in the proportion of propionate (glycogenic precursor) produced in the rumen and an increased microbial crude protein synthesis (Beever *et al*., 2001). An average increase in ME intake of 17.9 MJ metabolisable energy (ME) from concentrates gave a 1 g/kg improvement in milk protein content

(Beever *et al*., 2001). When the extra energy was supplied by pastures or maize silage, an average of 29.5 MJ ME was required to improve milk protein content by 1g/l. On clover pastures with a high protein content, milk protein content was not increased by extra feeding. This could have been due to the energy cost of excreting surplus dietary protein, or because metabolisable amino acid supply relative to energy was already at a maximum (NRC, 1989; De Vries and Veerkamp, 2000).

2.5.1 Sources of energy for cattle supplementation

2.5.1.1 Cereal grains

Different sources of cereal grains exhibit different rumen degradability. Grains can be classified as "rapidly and highly rumen degradable" source of energy or "slowly and poorly rumen degradable". For example wheat, barley and oats undergo rapid rumen degradation and are digested more completely than maize and sorghum grains (Nocek and Tamminga, 1991; Martin *et al*., 1999). Overall, starch from all cereal sources is degraded by 50- 94% in the rumen depending on the degree and type of processing (Jouany *et al*., 2000). Martin *et al*. (1999) reported that DMI was reduced by 2.8% for diets fed to beef steers that were supplemented with wheat compared to corn. The ruminal digestibilities were shown to be 86% and 48% for wheat and corn, respectively.

It has been shown that Processing increases the digestibility of cereal grains (Nocek, 1991; Tothi *et al*., 2003). Processing can be physical, chemical or a combination of both depending on the nature of the material and the purpose. Maize grains can be fed without processing because the pericarp of maize kernels is not resistant to mastication. However, other cereal grains need to be processed before they are used as supplement to forage based diets or as a part of total mixed ration.

Physical processing may include grinding, cracking and rolling, which all reduce the particle size of grains and increase potential exposure to bacterial and enzymatic action. Other processing methods may involve grinding or cracking in association with heat and moisture, for example steam-flaking, with the aim of achieving different degrees of starch gelatinisation (Jouany *et al*., 2000). However, chemical processing does not always increase rumen digestibility. In fact some chemical treatments (for instance formaldehyde) are used to make grains pass through the rumen so that they are digested and absorbed post ruminally (Smith *et al*., 1989; Sureshkumar *et al*., 2000; Ehoche, 2002). Processing methods that involve both physical and chemical aspects have proved to be more beneficial by increasing digestibility. The intensity and nature of grain processing and amount of rumen available starch are the most influential factors controlling voluntary DMI and milk yield (Yang *et al*., 2001). Processing grains has been shown to aid rumen escape of starch and the post rumen availability (Leng, 1990; Yang *et al*., 2001). Yang *et al*. (2001) suggested that processing grains, because it alters the availability of rumen degradable starch, could change the pattern of rumen fermentation, resulting in a different acetate to propionate ratio and changes in ruminal pH.

Yang *et al*. (2001) conducted a factorial experiment to study the effects on DMI and total tract digestibilities of flat vs. coarse rolled barley grains. The total tract digestibility of DM, starch and OM were improved by 5%, 10% and 4.4% respectively. The 10% increase in starch digestibility was the result of increased ruminal (33%) and post ruminal (15%) digestion of starch. The more intensive processing to produce flatter barley grains increased both the ruminal and post ruminal digestion of the starch. Tothi *et al.* (2003) compared the effects of expander processing of barley and maize grains with untreated/unexpanded grains and noted a 4.8% increase in DMI for the treated compared to untreated barley, with

expander treatment causing an increase in the post ruminal digestibility of starch grains. In another study, DM intake in dairy cows was reduced by 3.3% for dry-rolled barley grains compared to whole barley grains, and 5% for temper-rolled compared to whole barley grains (Yang *et al*., 2001). They reported that though, DM intake was reduced, milk yield increased.

2.5.1.2 Sugar processing by products

Apart from the conventional energy sources such as cereal grains and root crops, by-products from sugar cane processing plants also provide easily fermentable energy through digestible cell walls. These include; sugar cane tops, baggases and molasses. Molasses is rapidly and entirely fermented in the rumen. It is reported to be an excellent carrier for urea as a source of non-protein nitrogen (NPN) for ruminants. It can be more easily used as a supplement and distributed to small-scale farmers when it is part of solid multi nutrient block (Leng, 1990; Sansoucy *et al.,* 1988).

2.5.1.3 By-products from root crops and fruit cannery

Root and tuber peels such as; yams, cassava and potatoes, The root crop peels are rich in phytonutrients (Brown, 2007), carbohydrates, high in starch (8-28%) but with only about 1-4% protein. Anon (1985) reported that potato starch is a large-grained starch containing 25% amylose and 73% amylopectin and high phosphate content. A large amount of root crop peels are discarded during processing for chips by many industries. These peels constitute a potential source of livestock feed ingredient. The major limitation in the use of root crop peels for livestock feeding is its low protein content (Brown, 2007). Protein enrichment of root and tuber peels through inexpensive means is therefore desirable (Brown, 2007).

Fruit cannery are by-products coming from fruits, bakery and other food industries. They provide various kinds of nutrients for livestock feeding(Chenost and Sansoucy,1994). Citrus and sugar beet pulp cell walls are not lignified (Leng, 1990). They are digestible; and favour cellulolytic activity in the rumen with moderate fermentation and are good carriers for NPN (Leng, 1990). Chenost and Sansoucy (1994) noted that citrus and sugar beet pulp cell walls were excellent energy supplements for diets based on fibrous crop residues.

2.5.1.4 By products used as energy and protein and protein supplements

Flour milling by- products: By-products providing both energy and protein such as cereal milling by-products. These include wheat bran, rice bran, maize offal. Cereal milling by-products supply moderately fermentable energy, dietary protein and neoglucogenic nutrients. Rice polishing and wheat bran (Chenost and Sansoucy, 1994) play a remarkable role in balancing sugar cane based diets. Other by products used as energy and protein supplements in the livestock industry are brewery by- products. The common ones used are brewer's dried grain, Burukutu dried grains and distiller's grain.

2.5.2 Response of dairy cattle to energy supplements

Molasses is rapidly and entirely fermented in the rumen and is an excellent carrier for urea as a source of non-protein nitrogen (NPN) for ruminants. It can be more easily used as a supplement and distributed to small-scale farmers when it is part of solid multinutrient block (Leng, 1990; Sansoucy *et al.*, 1988). Citrus and sugar beet pulps cell walls are not lignified (Leng, 1990) thus, are digestible; and favour cellulolytic activity in the rumen with moderate fermentation. Chenost and Sansoucy (1994) noted that citrus and sugar beet pulp cell walls were excellent energy supplements for diets based on fibrous crop residues.

Various energy supplements and their effects on milk production have been investigated. (Huhtanen *et al*., 1995). The extents to which they influence milk yield depend, on their effect on rumen metabolite, and ultimately the level of metabolites available in blood for extraction for milk synthesis. Muinga *et al*. (1995) reported that when energy based diet concentrate or supplements are fed to lactating ruminants, in most cases milk yield is enhanced and this is mediated via the increased levels of molar proportion of propionate in the rumen or starch which provides post ruminal glucose after acid digestion for direct absorption by or through the small intestine.

Huhtanen *et al*. (1995) reported that compared to the control, increasing the energy density of diets during mid to late lactation increased DM intake, plasma non esterified fatty acids (NEFA) concentration, milk production and milk protein yield. Comparism between the high grain diet and high fat diet showed that milk production was similar but efficiency of milk production was higher for the fat diet than the grain diet which had higher DMI and energy intake (Drackley *et al*., 2003).

Lower DMI of fat supplemented diet in Friesian cows enhanced milk production due to lower heat increment as a result of a comparative lower heat load to dissipate (as evidenced by lower respiration rate and lower rectal temperature (Drackley *et al*., 2003). This allow for better utilization of the dietary energy under summer heat stress condition when compared with the high starch based diet concentrate (Drackley *et al*., 2003). Also apart from improving the energetic efficiency of milk production by reducing methane production and therefore, increase energy available for production (Chilliard, 1993), fat supplementation provides preformed long chain fatty acids which are energetically more efficient to be incorporated into milk fat or body fat than the *de novo* synthesis of long chain fatty acid (LCFA) from acetate (Baldwin *et al*., 1989). According to Storry *et al*.

(1973), preformed LCFAS suppress *de novo* synthesis of fatty acids in the mammary gland. Consequently, the oxidative use of glucose to provide energy for milk fat synthesis is reduced and thus, spares glucose for lacto production (Palmquist and Jenkins, 1980) leading to increased milk production. Fat supplement was observed to decrease milk protein % (Chilliard, 1993). This has been attributed to availability for uptake by mammary gland as a result of effect of fat on microbial yield or reduced mammary blood fluid and the resultant reduction in the supply of amino acids to the mammary gland (Cant *et al*., 1993). Holter *et al*. (1992) found that Cottonseedcake (CSC) supplementation increased milk yield but these benefits were not reflected in superiority of milk production of Red Sokoto goats feed supplement compared with their counter parts fed unsupplemented urea- treated straw (Djibrillou *et al*., 1998). They concluded that milk production was related truly to energy intake (Hadjipanayiotou, 1988), it was not so in low yield breeds (such as Red Sokoto goats). Energy supplements are usually more effective in enhancing milk yield in high genetic merit cows, higher yielder or dairy goats such as Damascus than it does in low genetic merit cows, low yielder or non dairy, non selected breeds such as Zaraibi goat (Gihad *et al*., 1987).

2.5.3 Energy intake for milk production and postpartum weight gain

Throughout early lactation, body weight loss is inevitable because of mobilization of body tissue as a result of inability of dietary energy to meet feed energy demand for milk production (Drackley *et al.*, 2003). This phenomenon of negative energy balance during early lactation is influenced by genetic merit for milk yield (Drackley *et al*., 2003), or energy density or quantity of feed offered (Cowan, 1982). Nutritional manipulation at this stage as demonstrated by studies of Broster *et al*. (1979) is in part to reduce weight loss,

while enhancing high milk yield. In addition, Drackley *et al*. (2003) reported that high energy density diet significantly increase DMI and milk production in dairy cows when offered immediately after calving and up to a period not later than 20 days post partum.

2.6 Protein supplements

Feeding strategies adopted to improve poor quality roughages, have been demonstrated to enhance their maximum utilization. Most of the treatments of roughage are aimed towards enhancing the activities of degradable microbe in the rumen (Topps, 1995). The rumen microbe, require a conducive rumen environment to maximally degrade fibrous feed materials (Shukla *et al*., 1985). By this, rumen bacteria require additional nitrogen for the synthesis of microbial cells as well as supplementation of dietary protein which can partly pass through the rumen undegraded into the duodenum beside the energy accruing from fermented carbohydrate and Nitrogen from treated roughages (Topps, 1995). Availability and concentration in rumen fluid of precursors such as glucose, nucleic acids, amino acids peptides, ammonia and minerals (sulphur, potassium and phosphorus) are also needed for efficient digestion (Preston and Leng, 1987).

2.6.1 Oil seed cakes

The oil seed cakes are mainly used as sources of supplementary protein. They include, palm kernel cake, linseed cake, groundnut cake, soybean cake and cotton seed cake. Oil seed cakes constitute the largest sources of supplementary protein in livestock feeds (IDRC and ICAR, 1988). Oil seed cakes are reported to be high in protein, energy and phosphorus (Ehoche, 2002). Among them, cotton seed cake was the most widely used for feeding ruminant animals in Nigeria, in form of undelinted and undecoticated cottonseed cake (CSC) with crude protein (CP) of 26%; but low content of cystine,

methionine and lysine (Ikurior and Fetuga, 1985). The decline in production of cotton in Nigeria has seriously affected the availability of CSC in the country. Lufadeju and Olorunju, (1986) have reported degradable value of 0.86 for Groundnut cake (GNC) with much higher crude protein (45%). Palm kernel meal (PKC) is cheaper than GNC and CSC, but the transportation cost to northern part of the country makes it unaffordable. Moreover, the use of oil seed cakes as ruminant feed is not economical because of their high cost (Ikurior and Fetuga, 1985).

2.6.2 Animal waste from slaughter houses

Animal wastes from slaughter houses include blood meal, bone meal, meat scraps and tankages, feather meal, poultry offal, poultry litter and rumen digesta. Rumen content has potential as protein supplement. It has crude protein content of about 16% and can be raised to 34% with addition of blood (Alhassan *et al.,* 1983). Others are by-products from fishes, pulses and single cell proteins.

2.6.3 Legume forages

Legumes have been successfully established by farmers and agro-pastoralists in grassland as "fodder banks" and in cropped areas on fallows, (Tarawali and Mohamed-Saleem, 1995) using low input techniques, developed by research institutes and extension agencies. In the savannas of northern Nigeria where the technology was developed, the productivity of *Stylosanthes* fodder banks varied from 3000 to 5000 kg/ha and the legume composition from 50 to 70% (Mohammed-Saleem and Kaufmann, 1982). *Centrosema pubescens* and *Stylosanthes gracilis* have proved very useful in improved pasture. Animals readily graze *C. pubescens* and it is one of the most used legumes in grass/legume mixtures. It is compatible with *Cynodon nlemfuensis*, *Digitaria decumbens* and *Panicum maximum*

(Ademosun, 1974). However, in the mid 80s, anthracnose (*Colletotrichum)* wiped out stylo throughout Africa and these forages were largely replaced by other species. More legumes have been identified for fodder banks in semi-arid regions. These include *Chamaecrista rotundifolia, Centrosema brasilianum, C. pascuorum, S. humilis* and *Aeschynomene histrix*. (Tarawali and Ogunbile, 1995). Synge (1981) reported improved production responses in white Fulani cattle due to supplementary feeding under traditional management. Creeping legumes, such as *Calopogonium, Centrosema, Mucuna*, and *Pueraria*, have attracted much research attention (Agboola and Fayemi 1971; Akobundu, 1993; Tarawali and Ogunbile, 1995). The use of highly productive good quality pasture grasses and legumes resulted in increased productivity in grazing animals in trials in Nigeria (Agishi, 1988)

2.6.4 Limitations of forage legumes as supplement

Comparative studies revealed that in spite of the reduced cost of feeding accruing from legume supplementation, legume supplement have been shown to be deficient in energy concentration compared with concentrate supplements (Moseley, 1976; Muia *et al.*, 2000) or their effect on growth rate Umunna *et al*., 1995), to meet the potentials of animals as much as concentrate supplements. Muia *et al*. (2000) reported that daily dry matter (DM) and milk yield decreased with increasing levels of replacement and they attributed it to the attendant low dietary energy intake. Muinga *et al*. (1995) noted that addition of 1kg of energy concentrate (Maize bran) to stall fed cows significantly increased milk yield by 1kg over and above 5.5kg milk production daily by animal fed 2kg *Leucaena* supplement.

Tropical legumes generally contain high concentrations of most nutritionally valuable minerals except sodium (Norton, 1982; Elliot, 1986). However, nutritional requirements may not always be met, since availability for absorption and function varies

with each element (Norton and Poppi, 1995). Since tropical forages (grasses and legumes) contain sufficient amounts of Mg, deficiencies in animal grazing tropical pastures are likely to be rare (Minson and Norton, 1984). There is comparatively little information available on the content and availability of trace elements in tropical legume forages, and it is likely that the values reported are more indicative of the soil types (Norton and Poppi, 1995). Although the data are limited for Mn and Zn, tropical legumes appear to be adequate sources of both elements, and deficiencies of these trace elements in grazing animals are rare.

2.6.5 Nitrogen from NPN Sources

Ruminant feeds contain Non Protein Nitrogen (NPN). The NPN factions of such feed, include amides, amines, amino acids nucleic acid, purine bases, cholines, nitrates, alkaloids, peptides, ammonia and many other compounds some of such nitrates are present in significant quantities in immature pasture (Mangan, 1981). Lufadeju *et al*. (1992) reported that NPN compounds constitute about 10% of the Nitrogen in herbage plants. It has been demonstrated that substituting NPN for both plant and animal proteins in ruminant diets reduce the cost of supplementation. Dietary NPN is useful as source of ammonia (NH_3) for ruminal bacteria, apart from serving as a base in the rumen to maintain pH in a desirable range for cellulose digestion. Owens and Bergen (1983); Ehoche, (2002) noted that NPN has potential in improving the energetic efficiency of ruminal microbes as a result of the frequency of feeding behaviour of livestock fed NPN (Preston and Leng, 1987).

Post ruminal administration of NPN is useful perhaps, because of cycling of nitrogen (N) to the rumen or large intestine (Norton, 2003). They are used without impairment to animal health (NRC, 1971; Orskov, 1982) if fed within the tolerable range or

limit. Among the many NPN sources tested for use in ruminants are; Anhydrous NH_3 which is applied as a liquid or gas to both high and low quality forages (Huber and Kung, 1981), Ammonia salts of chloride, phosphate and lactate. Other forms of NPN commonly used in ruminant nutrition are, biuret, triuret, cyauric acid and starea as well as complexes of urea mixture with formaldehyde, molasses and monosaccharide, (Huber, 1994). Preston and Leng (1987) have acknowledged the use of sulphur coating urea and poultry litter. Smith (1984) reported that slow releasing urea is developed to prevent ammonia toxicity and still improve ammonia utilization by ruminants. The aim is realised by the used of urea complex starch (Starea), biuret, certain coating material, and complexes of urea with formaldehyde, molasses or monosaccharide. These urea mixed material release NH_3 in the rumen at an attenuated rate that are closely parallel to energy available to bacteria (Jolson, 1976). However, slow releasing compound have generally demonstrated their inability to improve the realization of N noticed in the performance of cattle. Finangwai *et al*. (2010) suggested that N recycling to the rumen may have compensated for the rapid release of NH_3, by maintaining an adequate NH_3 supply within the rumen for period of time after ruminal NH_3 concentration. The benefit of urea supplementation depends on the type and amount of carbohydrate simultaneously fed (Chalupa, 1973; Finangwai *et al*., 2010).

Urea is usually the NPN source for the rumen microbe. It is often administered together with minerals and its concentration in such mixture, is control by safety concerns and the difficulty of incorporation, and therefore rarely exceeds 10-15% of such mixtures (Kennedy and Milligan, 1980). However, this is usually sufficient to allow an intake of between 50-100g of urea by cattle from a molasses –urea block, which is sufficient to balance the rumen for ammonia on a low N – Roughage diet.

Hendratno *et al*. (1991) suggested that mineral urea mixtures are better given free choice; this allows the animal some degree of selection and the animal can learn to control their intake of urea to an optimal level. In Indonesia, feeding of NPN and minerals in molasses-urea blocks has a large effect on production of ruminants fed cut and carry green tropical pastures (Hendratno *et al*.,1991).

The use of NPN to meet the rumen degradable Nitrogen (RDN) need of ruminants instead of feeding degradable feed protein is justified by its relatively cheaper cost. However, substitution of NPN for plant protein sources often reduces the availability of Carbon skeleton from degraded protein needed for maximum microbial protein synthesis (Meang and Baldwin, 1976).

Feed protein provides all the forms of nitrogen (ammonia, amino acids and peptide) via rumen protein degradation apart from the fraction of NPN in feeds. An added advantage of feed protein over NPN is that some rumen microbes utilize intact amino acid and peptides in preference to the N from NPN (Hungate, 1986). Energy is also saved by rumen microbes via direct incorporation of preformed amino acids rather than synthesis from NH_3 because energy involved in intact aas transfer across microbial cell is neutralized. Transport processes and in combination with changes in cell composition and scarcity of growth nutrients increase ATP cost for cell formation resulting in decrease of microbial cell yields up to 30%.

Both dietary protein and NPN are extensively degraded in the rumen and an average of about 60- 70% of protein fed to ruminants is degraded in the rumen (Hristov *et al*., 2004). Dietary protein reaching small intestines are normally transformed due to the degree of degradability of the dietary protein or N- Source. For instance forage proteins that are readily soluble and NPN are reported to undergo the greatest transformation (Mangan,

1981). while fishmeal (Hristov et al., 2004) and bloodmeal undergo lowest transformation to nitrogen (Hume, 1984).

2.7 Significance of Energy-Protein ratio in ruminant nutrition

Low productivity in ruminants on forages results from insufficient utilization of the feed because of deficiencies of critical nutrients in the diets. The deficient nutrients are those critical to growth of rumen microbes which ferment or digest the feed or those required to balance the products of digestion that are absorbed to meet requirement (Leng, 1990). Inefficient utilization of nutrient is accompanied by an increase in metabolic heat with a lot of implication for tropical ruminants impose metabolic stress and high environmental temperature and humidity (Leng, 1989).

Cattle in the topics require less feed for maintenance as they do not have to combat cold stress (Leng *et al*., 1986). The energy spared however must be supplemented with protein to ensure an appropriate protein energy (P:E) ratio in the nutrients absorbed for optimum efficiency of feed utilization. Leng *et al*. (1986) have reported higher amino acid requirement for tropical cattle than in cattle on the same feed in temperate environment.

Preston and Leng (1987) described the supplementation as one of the feeding supplement to ruminants on low quality forage. It is meant to increase the ratio of protein (absorbed amino acids) to energy (VFA) available from digestion so that it moves closely corresponding to the animal's requirements (Barje, 2006). Adequate microbial cells and VFA enhance the efficiency of microbial growth and P:E ratio. Thus, a sub-optimal level of any nutrient required for microbial growth results in low protein to energy P/E ratio in the nutrients absorbed (Leng, 1990). The P:E ratio appears to be the primary factor that

controls the efficiency of feed utilization and the partitioning of nutrient into various component of production (Leng, 1990).

The relationship of P:E to the efficiency of feed utilization has a very large effect on growth, milk yield and reproductive performance. The levels of production achieved when P:E is increased have been reported to be superior to those predicted from feeding standards based on metabolizable energy of feed (Goday and Chicco, 1990).

Application of the basic concept of balanced nutrition is reported to improve animal growth by 2-3 folds and the efficiency of animal growth by as much as 6 fold over estimate of 2-10 folds, (Leng *et al*., 1986). Leng (1990) showed that growth rate of cattle on forage based diets were below those on grain based diets; they were however, efficient in converting feed to live weight gain. Live weight gain depend mainly on the supply of amino acid and yield in substrates delivered to the tissues up to the genetic limit for protein synthesis, which is scarcely reached for animals consuming pasture (Muia *et al*., 2002). The supply of amino acids depends on the protein content of the diet and the deposition of protein depends on the efficiency of use of absorbed protein which is known to rely on the availability of non energy yielding substrates and limiting essential ammo-acids (Poppi and McLennan, 1995).

2.8 Effect of protein supplementation on reproduction in dairy cattle.

Nutrition plays a vital role in determining the onset of puberty and conception rates in dairy cattle (Payne, 1990). It is one of the courses of pregnancy losses in heifer (Clara *et al*., 2007). Both low and high plane of nutrition has been observed to lower conception rate in heifers. Oyedipe *et al*. (1982) observed that by 90 days, the percentage of heifer that

were pregnant when fed high, medium and low protein diets were 58.8, 27.8, and 16.7% respectively.

Supplementation during the lean period reduced average age at first calving from 45 to 37.5 months apart from shortening the calving interval by approximately 52 days; with calving rate achieved at 83% (Weitze, 1984). Supplementing dietary protein reduced age at calving of N'dama heifers by about 12 months (Tanner *et al.,* 1995). Furthermore, when the supplementation extended to the rainy season, reproductive performance improved eight folds. Low dietary protein intake has been shown to significantly lower conception of cow to first Service (Canfield *et al*., 1990) regardless of their ages. The effect of high dietary crude protein intake on fertility is more critical on cows in their fourth and later lactation than their younger counterparts (Kaim *et al*., 1983) Elrod and Butler (1993) reported that first service conception rate of cows fed low protein diet were surprisingly better than their counterparts on high protein diets. The reason being that high protein diets increase the number of extended oestrus cycle from 26 to 36.

A positive relationship exists between increasing crude protein and increase degradability. This often resulted in elevated serum urea or plasma content of lactating cows. However, an inverse relationship exists between when serum urea level increased, conception rates and pregnancy rate were lowered (Ferguson *et al.*, 1988; Canfield *et al*., 1990; Butler *et al*., 1996). Meat and bone used to formulate a 16% CP diet for cows resulted in consistently worse fertility, than those cows on 10% CP (Clark *et al.*, 1985). Rusche *et al*. (1993) observed that when soybeans replaced distiller dried grains or corn glutens, no significant effect on reproductive performance of cows were noticed.

Armstrong *et al*. (1990), feeding three levels of flat rate concentrates either with or without 0.8% Fish meal inclusion, improved fertility among cows fed fish meal containing

diets. The authors noticed a significant increase in time to first post partum ovulation (34.7 with fish meal against 29.2 days for those without fishmeal). However, a significant decrease in calving to conception interval of 94.1 days to 106.6 day was noticed. Other indices noted were significant improvement in conception rate to first and all services (61.0% vs 41.5%, with a significant reduction in the number of services per each pregnancy (1.62 vs 2.31).

Laven and Drew (1999) reported that availability of high concentration of rumen undegradable protein (fish meal) is responsible for improved fertility in livestock. Fishmeal has 8% fat with long chain polyunsaturated fatty acids constituting two third. Most of them escape ruminal micro flora hydrogenation resulting in increased unsaturated fatty acids. Staples *et al.* (1998) and Thatcher (1997) reported that increased unsaturated fatty acid may affect prostaglandin metabolism and possibly affect reproductive activities.

2.9 Effect of Protein Supplementation on lactation performance

Concentrate supplementation is required to complement forage nutrient supply, to enhance nutrient intake (Muinga *et al*., 1995) and productivity in cattle. The nature of basal roughage fed determines the degree of response of livestock to concentrate supplementation. Although on general note animal performances were improved, production response is revealed to be higher with good quality roughage than with poor one. Feed intake and milk yield in goats in late lactation was significantly increased by good quality silage compared to poor quality silage when both were supplemented with the same concentrate at the same level (400g/h/d) (Hussain *et al*., 1996). They opined that with good quality roughages, low to moderate levels of concentrate is adequate for milk production in lactating ruminants. Doyle (1983) demonstrated that increased concentrate

usage elicited high total lactation milk yield but reduced profit per cow in a model study to determine the effect of different levels and patterns of concentrate feeding on milk yield of dairy cows. In Nigeria, like other developing countries, concentrate supplements are expensive and are not readily available. The use of legume forages as alternative supplements has been recommended (Preston and Leng, 1987). Legume forage supplementation to basal diets roughages of cattle in confinement in Kenya (Muinga *et al*., 1995) grazing cattle in Nigeria (Ehoche *et al*., 2001) and grazing goats in UK (Min *et al.*, 2005) and more Romero *et al*., 1994) showed that in absolute term, the supplement boost milk yield. Ehoche *et al.* (2001) offered 3kg of Groundnut haulms supplement per head per day to grazing Bunaji cattle under agro- pastoral management and observed that daily milk off take increased by 32% compared with those without supplement. Further increase of 20% was observed in addition to increased calf growth rate and reduced calf mortality. They concluded that adoption of joint forage legume supplementation and helminthes control would increase milk off take, calf growth and income of small holder dairy farmers.

2.10 Effect of supplementation on milk composition

Dietary nutrient intakes have been observed to influence both milk yield and composition. Modification of levels of some nutrients in lactating cow diet has shown to positively affect milk composition. An example is milk fat content is modified by the presence of acetate, butyrate and long chain fatty acids. Propionic acid and glucose however, reduced milk fat content. Reduced long-chain fatty acids have also been found to reduce fat content of milk (Chalupa *et al*., 1996). Supplementation of dietary fat resulted in milk yield in lactating cows (ARC, 1984). During the first phase of lactation, dairy cattle experience negative energy balance with a resultant drop in milk fat percentage. De Vries

and Veerkamp (2000) reported that the decrease in milk is positively correlated with negative energy balance. Acetone, fat, fat: Protein ratio, urea and changes in fat percentage are linked with reproductive performances of dairy cattle (Anderson *et al*., 1991, Butler *et al*., 1996; Heuer *et al*., 1999).

The relationship between milk constituents and on set of luteal function were not noticed which was experienced at later post partum among first parity cows than among second parity cows (Reksen *et al*., 2002) the authors reported that acetone and lactose values in milk from the first 4 weeks postpartum were indices of postpartum luteal function in second parity cows at a sensitivity of 0.84 and specificities of 0.86.

Barje (2006) reported no significant differences in milk composition from Friesian x Bunaji and Bunaji on similar diets supplemented with whole cotton seed. He concluded that effect of breed on milk composition is not significant; however, increasing cotton seed in diet increased milk fat. Mena *et al.* (2001) reported higher percent milk fat from cows fed diets containing whole cottonseed diets than those fed cottonseed cake diets. However, Wu *et al*. (1994), and Villela *et al*. (1996) reports contradicts this finding.

Mooney and Allen (1997) and Ariel (1998) observed no change in milk protein concentrations with feeding whole cottonseed. They concluded that milk protein depression is probably due to overall ruminal feed protein degradation and microbial protein synthesis. Wu and Huber (1994) associated depression of milk protein with increased supplemental fat feeding.

Generally, unless amino acid supply is deficient relative to dietary energy, additional protein in the diet has little effect on milk composition. While it may affect total milk and protein yields, protein content remains stable. However, there are some exceptions. Both abomasal (fourth stomach) infusions of casein and formaldehyde-

treated casein given in feeding trials have reliably increased milk protein content (Cowan, 1982). The amino acid balance in casein obviously matches that in milk protein. Methionine and lysine have been identified as the amino acids likely to be first limiting for milk protein synthesis in maize-silage fed dairy cows, and perhaps histidine in grass-fed cows. The methionine and lysine contents of rumen bacterial protein are very similar to those in milk protein, so that any dietary adjustment, which enhances the production of microbial protein, provides an ideal balance of amino acids for milk protein synthesis. Microbial protein can provide sufficient metabolisable protein for the production of over 40 litres per day of milk, provided that the diet is formulated to allow a high intake of metabolisable energy, with sufficient rumen-degradable protein and minerals for the requirements of the rumen microbes. When intake of rumen-degradable protein is insufficient, in relation to metabolisable energy intake, provision of dietary protein, which is digestible in the intestines, but undegraded in the rumen (UDP), is likely to increase both total milk protein and milk protein content. The extent to which it does so is dependent on the amino acid profile of the Undegradable protein (UDP). The balance of methionine and lysine in most supplementary protein sources differs from that in milk protein for instance, sunflower is low in lysine, and lupins are low in methionine. Canola and cottonseed meals have a better balance of amino acids than lupins. When lupins were replaced by unprotected canola meal or cottonseed meal, there was no effect on milk protein content (Christian *et al*., 1999). However, when lupins were replaced by formaldehyde-protected canola meal, milk protein content was significantly increased by 1.5g/l in cows fed a basal diet of grass silage and grain concentrate.

2.11 Mineral and Vitamin Supplements

In addition to carbohydrate, protein and fats, minerals and vitamins are also required in smaller amount for the proper functioning of dairy cattle. Of the forty (40) regularly occurring elements, only fifteen have been found to play metabolic role in cattle (Payne, 1990). They are divided into two groups on the basis of concentration present in the animal body namely macro micro minerals.

The macro elements (those required in large quantities) include; Calcium, Phosphorus, Potassium, Sodium, Chlorine, Magnesium and Sulphur with percentage concentration in the body as; 1.5, 1.0, 0.2, 0.16, 0.11, 0.014 and 0.15 respectively (Payne,1990) while the micro elements (those required in trace amount) are iron, zinc, copper, cobalt, manganese, iodine molybdenum and selenium with the range of; 20-80, 10-50, 1-5, 0.02-0.1, 0.2-05, 0.3-0.6 and 1-4ppm as concentration in animal body respectively (Payne,1990).`

Supplementation of minerals is meant to alleviate deficiency experienced by lactating cows most especially during lactation and growth when demand is critical (ARC, 1980). Tropical forages contain less minerals especially during the dry season, as such grazing cattle in the tropics are often likely to develop mineral deficiency related conditions (Mc Dowell *et al.*, 1983), thus making supplementation very essential. Preston and Leng (1987) reported that there is variability in the mineral contents of pastures which is influenced by many factors including the climate, previous stock history, fertilizer application and soil.

Grant (2002) found that milk production by grazing dairy cows was more limited by the supply of ME than by CP. Adamu *et al*. (1993) reported that grazing native pasture

during the dry and wet season along with supplementation of nitrogen, energy, common salt and Phosphorus may be beneficial for animals grazing native pastures in the northern grass Savanna zone of Nigeria.

Spears (1996) noticed growing interest in the use of mineral when studies revealed their practical roles in improving growth, reproduction and health in ruminants. Early negative balances are regard as normal since no ill effects are evident as long as subsequent replenishment of body reserve take place and daily requirements are supplemented on the basis of total production over the lactation (McDonald *et al*., 1995). Twenty six to twenty eight grammes (26-28g) of Ca and 25g of phosphorus/day have proved adequate for cows producing 4540kg of milk/annum over four lactations. McDonald *et al*. (1995) reported that dietary supply of 1.10 to 1.32 of calcium and 1.10g phosphorus per kg of milk is needed (McDonald *et al*., 1995).

Although the lactation approach a satisfactory performance in many case, considerable trouble may arise if the allowances used are too low. In such cases progressive weakening and breaking of the bones results in serious shortage. In less severe cases, a premature drying of which reduce yield and shortens the productive life of the cows occur.

Lactating cows are usually given sodium chloride supplements. The primary need is for sodium rather than chloride (ARC, 1980) which is more plentiful in normal diets. The net requirement for sodium is about 8 mg/kg/day for maintenance plus 0.60g/kg/day for milk (Mc Donald *et al*., 1995). ARC (1984) recommended 28g of NaCl per head/day be produced for lactating cow in addition to that in the food.

Ca: P ratio supplementation is 1:1 or 2:1, magnesium (mg) allowance is 0.125g/kg above 3mg/kgw for maintenance (ARC, 1980) Available dietary magnesium is very low at about 0.17 (ARC, 1980; 1984). Heifers receiving zinc-methionine complex supplement

were said to have had an 8.1% fast weight gain and 7.3% feed conversion efficiency than those not fed the supplement (Spears, 1996). Significant improvement in milk production and reduced somatic cells in milk were reported when lactating cows were supplemented with zinc –methionine complex (Kellogg, 1996). In the same vein calves fed zinc-methionine gained 10.7% faster, with morbidity rate decreased and required 5-8% less medical treatment per head than those not supplemented. Ward *et al.* (1992) supplemented manganese methionine complex in steers and reported ruminal soluble concentrations of manganese increased. Copper retention was high when copper-lysine complex was fed than copper sulphate (De Bonis and Nockels, 1992). This showed the growing interest in the supplementation of organic trace mineral complex in ruminant diets.

Vitamins are required by the lactating animal to allow proper functioning of the physiological process of milk production and as constituents of the milk itself. Vitamins have important role in the synthesis of milk constituents. For instance, biotin is important in the synthesis of milk fat. (Mc Donald *et al*., 1995). Supplementary feeding with vitamin A in excess of levels adequate for reproduction increased the efficiency of the milk by up to 20 times but had no effect on the yield or gross composition of the milk (ARC, 1984). The daily requirement for Vitamin A for lactating cow is 99 iu/kgw or 30mg/kgw (Payne, 1990). Vitamin D value of milk is largely influenced by the extent of cattle to sunlight and large dietary intakes are necessary for small increases in the concentration in the milk (ARC, 1984). Administration of the vitamin has little effect in ameliorating the negative balances of Ca and P which occur in the early lactation, but very heavy doses 20, 000, 0 iu/d for 3-5 days prepartum and one day post partum have been claimed to provide some control of milk fever. The daily requirement of the lactating cow is about 10 iu/kgw (McDonald *et al*., 1995). Supplementary dietary intakes of the B vitamin have shown no

significance in ruminants because of ruminal synthesis however, they are involved in the complicated enzyme systems responsible for the synthesis of milk (McDonald *et al*., 1995).

2.12 Use of groundnut haulms as dietary supplement

Groundnut or pea nut (*Arachis hypogeae L*.) a principal oil seed in the world crop originated in South America (Olorunju *et al*., 1996). It is a short herbaceous annual legume that produces its pod inside the soil. Developing countries account for over 95% of world ground nut area and about 94% of total production (Raw Materials Research and Development Council RMRDC, 2004). Groundnut production is concentrated in Asia and Africa with Africa accounting for 35% of global area and 21% of total output mainly in Nigeria, Senegal and Sudan (RMRDC, 2004).

2.12.1 Ground nut production in Nigeria.

Ground nut production in Nigeria has reached 1.5 million tons from the late 50s up to the early 70s. Following the oil boom of the 1970s, and becoming the major source of foreign exchange against agricultural products, groundnut production declined and currently the total annual output of groundnut in Nigeria is 1,976,490.8 tons (Raw material Research and Development Centre, 2004). It has immensely contributed to the development of Nigeria. Up to 1969, Nigeria was the third largest exporter of groundnut in the world after India and china (Raw material Research and Development Centre, 2004) and the country's most important agricultural export commodity. From 1924-1983; groundnut production declined from 1.95 million tons to 0.4 million tons. Several interrelated factors have been identified as causes of the decline in production including natural disasters such as erratic rainfall, drought and diseases. Others are competition from food crops for cash, late planting and lack of fertilizer and chemicals, unavailable improved seed, in sufficient amount and labour problems during critical stages of production such as seed preparation, weeding and harvesting (Raw material Research and Development

Centre, 2004). The recent slight increase in production is due to use of improved varieties and increase in area put to groundnut. Ground nut is considered an important crop for seed and forage production in small holder crop-livestock farming systems in Nigeria (Olorunju *et al*., 1996; Larbi *et al*., 1999).

A number of groundnut varieties have been developed in the institute for Agricultural Research (IAR) Ahmadu Bello University Zaria for the various ecological zones of Nigeria. Groundnut production in Nigeria has risen beyond 1.5 million tones with such varieties as RMP 12, RRB, RMP which are resistant to Rosette (Raw material Research and Development Centre,2004; Etela and Dung, 2011).

2.12.2 Groundnut seed production in Nigeria.

Humans use groundnut seed as a major source of oil, while the cake after extraction is use as a source of protein to livestock. Groundnut's high content of edible oil (50%) and protein (25%) makes it a popular human food. It is consumed either as a shell nut or as oil. Groundnut is a good source of mineral such as phosphorus, calcium, magnesium and potassium as well as vitamins E, K and B. It is use as an enriching ingredient in a wide range of prepared dishes.

2.12.3 Forage production of groundnut in Nigeria.

Groundnut is an important crop for forage production in small holder crop livestock farming systems in sub humid zone of West Africa (ICRISAT, 1991). The forage (haulm) after pod harvesting is extensively fed to ruminants especially in the dry season (Powell, 1985, Njie and Reed, 1995; Olorunju *et al*., 1996). For this reason smallholder crop-livestock farmers also consider feed value (forage yield and quality) apart from yield (Olorunju *et al*., 1996).

Haulms are either fed in green form or hay. Dairy farmers prefer to feed this by-product alone, because of its abundant availability (Hadjipanayiotou, 1988). Field survey reports indicated that when offered in fresh green stage, the haulms impart off flavour in milk (Hadjipanayiotou, 1988). Groundnut haulms used for livestock feed are noted to be important often equal in value to the pods in semi urban area of the Sudan Sahelian zone of Nigeria under rain fed conditions, especially where fallow has disappeared from the production system thereby providing substantial cash income for the small holder producers (Olorunju *et al*., 1996). Groundnut haulms feed value is similar to that of Lucerne. Dry matter of groundnut haulm production under irrigation could rise to between 5-10 tons/ha. Since irrigations allow excellent vegetative growth with minimum defoliation at the end of the cycle; this often results in plentiful forage crop of high yield (RMRDC, 2004). The perennial wild species *Arachis glabrata* is observed to make useful pasture thus, is often used, where specialized forage production is required than the dual purposed *Arachis hypogeae* (RMRDC, 2004).

2.12.4 Nutritive value of groundnut haulms.

Groundnut haulms are reported to be excellent source of nutrients especially crude protein. Because of this, it can serve as a supplement to low quality roughages. Groundnut haulms have relatively high apparent dry matter digestion coefficient of 0.60 (Hadjipanayiotou, 1988). Mohammed Saleem and Von Kaufmann (1989) reported values of 10.5, and 5.04 % for crude protein and calcium content in groundnut haulms after harvest and threshing. Hadjipanayiotou (1984) reported that groundnut haulms is an excellent source of crude protein, ether extract, calcium and phosphors containing 14.7, 3.6,

2.3 and 1.6% respectively. Digestible Crude protein (DCP) and Total digestible nitrogen (TDN) content of 5.7% and 55.8% respectively were found by Shukla *et al*. (1985).

2.12.5 Responses of cattle to groundnut haulms supplementation.

Groundnut haulm is a valued by-product for animal feed (Duong Thanh Lien *et al*., 1998, Bui Van Chinh *et al*., 1996). Early work on the use of forage supplements was mainly concerned with the need to improve the Nitrogen content of diets based on poor quality roughage in order to overcome a deficiency of nitrogenous substrates for the rumen micro organisms. More recent evidence indicates that with the supplementation of groundnut haulms in livestock, there was enhanced intake and digestibility of diets (Bui xuan An, 1998; Ehoche *et al*., 2002; Etela and Dung, 2011)

2.12.5.1 Effect of Groundnut haulm supplementation on feed intake

One of the biggest challenges when feeding low quality forages to ruminant is to increase their intake (Ndlovu, 1992). The effects of incremental levels of groundnut haulm as supplements to a poor quality basal diet have been investigated (Mosi and Butterworth, 1985; Agishi 1993; Ehoche, 2002; Aregheore, 2009).

Alhassan, (1985) in a comparative study of maize residues with other crop residues fed 1-1.5 year old red Sokoto goats with various cereal or legume residues found that Dry matter intake ranged from 0.7% of body weight for maize stover to 2% for sorghum leaves (5.5% CP), while leguminous crop residues intake ranged from 0.8% body weight for cowpea vines (5.9% CP) to 3.4% body weight for groundnut haulms (16.7%CP). Adebowale (1988) identified the beneficial effects of the groundnut haulms, to include increase in metabolizable energy and nitrogen intake, improved palatability, increased available minerals and vitamins, better rumen function and a laxative influence on the

alimentary system. Intake and live weight gain of the animals supplemented with both ensiled or dried groundnut haulm were higher than the live weight gains of the animals supplemented with concentrate (Bui Xuan An, 1998). Ayoade and Njewa (1983) reported higher feed intake when groundnut hay was chopped compared to ground.

2.12.5.2 Effect of feeding groundnut haulm on feed Digestibility

For appreciable microbial digestion of plant materials to occur in the rumen, a close physical association is essential between the plant tissue and the microbes responsible for the digestion (Orpin, 1984). Reports have shown that that where the supplemental forage in a straw-based diet was given to sheep, a boost to digestibility of the basal diet occurred even at relatively small levels of supplementation. Possibly, as a result of the rate of and extent of colonization of fibre and the biomass of adherent organisms (Cheng *et al*., 1990). Colonization of bacteria occurs from fibre to fibre without passing through the free-floating pool. Fibres are colonized by free- floating pool of bacteria in the rumen (Kreb *et al*., 1989).

Leng (1990) explains that the beneficial effects of the incorporation of high digestibility forage in an otherwise low digestibility forage diet could be that it exerts a large effect on digestibility by providing a highly colonized fibre source to 'seed' bacteria onto the less digestible fibre. Supplementation with groundnut haulm contributes fermentable energy to the rumen in the form of available cellulose and hemi cellulose which stimulate fibre digestion (Silva and Orskov, 1988). Bauchop (1981) opined that it is possible that offering such material prior to the daily feeding of straw may induce a greater degree of colonization of basal diet by rumen bacteria and fungi, which have been implicated in the breakdown of fibre. Manyuchi *et al.*(1994) reported that groundnut hay

did not alter the *in sacco* degradation of poor quality grass hay. It is likely that any change in the degradation of the basal diet as a result of an increase in microbial activity depend on the number of available sites for microbial attachment as observed by Cheng *et al*. (1990).

The ideal N concentration in the rumen for efficient digestion is minimum of 50-70mg/litre and maximum of 150-200 mg/litre (Satter and Slyter, 1974). Groundnut haulms are relatively good sources of degradable nitrogen and fermentable energy, so their inclusion in diets as supplement increases the rumen population of cellulolytic microbes since groundnut haulms like other forage legumes increases the total concentration of volatile fatty acids without affecting the relative proportions and the rumen pH (Topps, 1995). This is an indication that groundnut haulm are likely to maintain a stable fermentation pattern and thus, stimulate the growth of cellulolytic microorganism.

Manyuchi *et al.* (1994) found that groundnut hay increased the fractional outflow rate of rumen solids without altering the pool size of the rumen digesta. This author concluded that the increase in food intake following the supplementation of groundnut hay was largely facilitated by an increase in rate of passage of digesta. The mechanism by which this occurs is not fully understood. Ayoade and Njewa (1983) recorded higher digestibility of nutrients when groundnut hay was chopped compared to ground.

2.12.5.3 Effect of feeding ground nut haulms on growth

Groundnut haulms and shells are by products which are generally used to fatten animals in northern Nigeria. Adu and Lakpini (1983) fed chopped groundnut haulms solely, to growing Yankasa lambs and recorded live weight gains of 90.2g/day for unchopped haulms. Supplementary feeding of groundnut haulms to cows improved growth rates of suckling calves compared to the non supplemented control group which was attributed to

increased milk consumed by calves arising from the increased milk output when their dams were supplemented (Ehoche *et al.*, 2001). Nicholson (1989) observed that in partial milking system, approximately 60% of the milk produced is consumed by the calf. When feeding maize residues was compared with other cereal or legume crops, it was found that live weight gain compared favourably. Higher feed consumption was recorded for maize residue, although this was not significantly higher than the sugar cane tops. However, the high consumption did not produce better live weight gain, except with sorghum stalks when fed to Red Sokoto goats with groundnut haulms (Alhassan, 1985). Topps (1995) demonstrated that the enhanced intake due to supplementation of groundnut haulms in animals to some extent reduce weight losses.

2.12.5.4 Effect of feeding ground nut haulms on milk production

The poor performance of ruminants fed low quality roughages is mainly due to a deficiency of nitrogen which results to low digestibility and low DMI (Topps, 1972). Increase in food digestibility and intake due to groundnut haulms supplementation of the basal diet leads to a significant increase in animal performance. Muinga *et al*. (1995) recorded considerable increases in milk yield in dairy cows fed Napier grass supplemented with *Leucaena leucocephala.* Supplementation of Bunaji cows in the dry season with 3.0kg of groundnut haulms increased milk off take for human consumption. Ehoche *et al*. (2001) reported that average daily milk off take was higher in cows supplemented and dewormed than in cows fed supplement only. Otchere (1986) earlier obtained similar value of milk off take when Bunaji cows grazing natural range received supplements of cottonseed cake (CSC) and L*ablab purpureous* hay (Ehoche *et al.*, 1998).

2.13 Pubertal development

Puberty is said to occur when the gonads begin to secrete steroid. These steroids speed up the growth of the genital organs and the development of secondary sexual features. Puberty is defined in *Bos indicus* heifer as the age at which plasma progesterone level reach 1.0 ng /ml. The major factors regulating the onset of puberty are body weight and growth rather than age (Sorensen *et al*., 1959; McDonald *et al.,* 1971); until heifers reach a targeted weight, oestrus is unlikely to occur. Short and Bellows (1971) observed high pregnancy losses and low milk production in heifer that were fed poorly prior to puberty. Poor nutrition delays puberty, reduces conception rate and increase pregnancy losses in heifer (Short and Bellows, 1971; Lemenager *et al.,* 1980).

Wiltbank *et al.,* (1966) referred to a critical age to weight ratio which must be reached before heifer attains puberty. Age at puberty is an important determinant of reproductive efficiency (Payne, 1990). Many heifers reach puberty and breed fairly satisfactory at one year old (Lemenager *et al.,* 1980). However, the cost of achieving this varies among heifers within the same breed. Heifers with inborn ability to reach puberty early attain puberty at less cost than those with inherent age at puberty. The estimated age at puberty in *Bos indicus* cattle in the tropics and subtropics range between 16-40 months. *Bos indicus* cattle were observed to reach puberty later than *Bos taurus* x *Bos indicus* crossbreds or pure breed taurine cattle (Wiltbank *et al*., 1966).

2.13.1 Genetic factors affecting puberty of cattle.

Age at puberty varies among species, breeds and even strains and families on the average. Temperate *Bos taurine* breeds of dairy cattle reach puberty at 30-40% of their adult body weight, compared to 45-55% for beef cattle (Hafez, 1980) while Boran reached

puberty at 60% of their adult body weight. Zebu heifers raised under traditional system are noted to attain puberty at an even higher percentage of adult weight. Knudsen and Sohael (1970) estimated age at puberty for white Fulani in Nigeria to be 40.2 months. Estimated ages of some breeds are zebu 22.6 months, ¾ Friesian x ¼ Zebu 19 months (Duckworth, 1949); Pure Friesian in Nigeria 19.5 months, ½ Friesian x ½ Bunaji in Nigeria 21.2 (Knudsen and Sohael, 1970). ¾ Friesian ¼ (Nigerian) 20.0 (Knudsen and Sohael, 1970) Crossbreeds (Africa) 24.5 months, (Aria and Cristotori, 1980).

Estimates of the heritability, of age at puberty range from 0.20 to 0.67 (Werre, 1980; Lunstra, 1982; King, 1983). Heritability of weight at puberty ranged from 0.30 to 0. 40 (Clara *et al*., 2007). Several studies, most especially the taurine cattle, show a positive correlation between age at puberty and other production traits. Were (1980) found strong negative genetic correlations between age at puberty and measures of growth. Faster growing heifers reached puberty earlier. Genetic relationships with average daily gain to weaning at puberty and yearling weight (0.31± 082, -0.44 ± 0.41 and 0.25± 0.70, respectively) were stronger than the phenotypic correlations (-0.13, 0.07 and -0.03, respectively).

It was found that heifers growing faster are likely to be younger and heavier at puberty (Arije and Wiltbank, 1971; Steffan., 1983). Wiltbank *et al*. (1969) observed that the breed of sire and dam and their interaction can affect age and weight at both *heterocyst* and *material* effect such as lactation and mothering ability affects age but have no effect on live mass at puberty. Reynolds *et al.* (1963) estimated the average age at puberty in Brahman heifers in Lousiana, USA, to be 27.2 months compared with Angus heifer 14.4 months. Oyedipe *et al*. (1982) showed the relationships between Age and weight of

puberty and conception among Nigerian zebu heifers on high, medium and low levels of dietary protein intake.

2.13.2 Effect of nutrition on onset of puberty in heifers

Drought was reported to have delayed the onset of puberty in heifers of 10 breed groups and stopped ovarian activity in half of those that had already reached puberty (Post and Reich, 1980). Bartha (1971) found that feeding concentrates to Azaouak Zebu cow enhanced puberty and first conception by 4 to 18 months. Penzhorn (1975) however, found that puberty was delayed by 7 months in Africander heifers on a restricted diet. Although all heifers attained puberty at about the same body weight (279-295kg) but at different ages. Conception rates after a 3 month breeding period were 80, 93, 87 and 40% for heifers on high, medium, low and restricted level of nutrition respectively.

Penzhorn (1975) indicated that overfeeding reduces reproductive performance in livestock. They demonstrated that heifer reared on a high level of nutrition had more breeding problems afterward than those on moderate feed. Although, heifers on a high protein diet were often younger and heavier at puberty than those on low protein diet (Sorensen *et al.*, 1959) and are more fertile after puberty. The author reported that very high levels of feeding do not result in earlier puberty than adequate level.

Oyedipe *et al.* (1982) reported that information on how much energy or protein heifers need daily to achieve a given weight and puberty are required. It was demonstrated that supplementation need not be continuous, when they supplemented Bornu heifers with 1.5 kg of concentrate. (1/3 oil seed cake, 2/3 wheat bran) for 90 days during the dry season preceding puberty. Result showed that heifers reached puberty earlier (596.4 Vs 633.5

days), were heavier at puberty (230.7 Vs 202. 4kg) and had larger ovaries than unsupplemented heifers.

The proportion of supplemented heifers bred in the subsequent breeding season (61.9%) was nearly twice that of unsupplemented heifer (33.3%). Studies in Boran x Friesian heifer, and Brahman heifers had similar trend (Olivares *et al.*, 1981). Cohen *et al.* (1980) found a direct relationship between body weight and incidence of Oestrus in 603 heifers ago 17.2 to 19.2 months and weighing between 130kg and 376kg. Cohen *et al.* (1980) estimated that 5% of the heifers would show Oestrus when weighing 187kg or less 50% will show estrus when weighing 231kg or less, and 95% would show Oestrus when or before they weight 280kg.

Heifers on a higher protein diet were noticed to be often younger and heavier at puberty than those on a low – protein diet (Sorensen *et al*., 1959; Wiltbank *et al*., 1966 and Garcia and Calderon, 1978) and seem to be more fertile after puberty. Although it showed that poor nutrition delay puberty, very high levels of feeding do not necessarily translates into early puberty than adequate levels.

Supplementation with undegradable proteinhas been reported to enhance reproductive performance in beef female by minimizing body weight changes, hastening the onset of puberty, decreasing postpartum anestrous, and increasing pregnancy rates in cattle consuming dormant forage (Kane *et al*., 2004) for 30-32 days. Their result reveals that high levels of undegradable protein have also been associated with impaired fertility in both beef and dairy cattle.

2.14 Lactation Performance of Dairy Cattle

2.14.1 Effect of age and Parity on lactation

Tekerli *et al*. (2000) observed a positive relationship exist between age, parity and milk production in cows at certain point before an inverse relation set in. This is because at first calving heifers are still growing thus; their anatomy and physiological structures for milk synthesis are underdeveloped. Researchers have demonstrated that temperate cows in their native environment attain peak milk production one year earlier than their tropical counterparts which coincides with the third or fourth parity. Licitra *et al*. (1990) noted that Holstein cows milk production increased with parity with its peak at third lactation.

Sing and Tomar (1991) showed that milk yield of Koran Friesian cows increased from the first to the fifth lactation. Kafidi *et al*. (1991) observed Black pied cow's milk peaked at in the third lactation. The age and parity effect on milk production in tropics showed that as parity increased from 1 to 3, milk yield in Friesian and Bunaji cows also increased but gradually decline thereafter.

Study revealed that the rate of increase in milk yield from first lactation to maturity is lower in the tropics than in the temperate breed. Milk yield of white Bunaji increased at the rate of about 10% of the first lactation yield until maximum age. Holstein in temperate increased by 20-25% of the first lactation. Those difference is due to differences in the age at first calving and lactation length (Licitra *et al*., 1990). Zebu cows attain maximum production at about seven years of age which is commensurate with their peak time of production. In the case of temperate cows their fifth lactation is at the seventh year. (Mahadevan, 1968).

2.14.2 Role of body mass and season on lactation

Body condition score is been recommended in evaluating nutritional management. A changing pattern in the body condition of the cow at calving with changes in milk yield is observed. Cows paired and fed in such a way that their diets produce within pair difference in body weights, higher body condition was associated with higher milk yield to twenty week lactation. Markusfield *et al*. (1997) observed that cows calving in a higher body condition score produced more milk, fat, and protein in the first 90 days of lactation, the effect being most pronounced on milk fat content. Gearhart *et al*. (1990) report disagrees on effects of body condition score at calving on milk solids; in their studies, cows with higher body condition scores at calving yielded more milk fat and less protein. Holter *et al*. (1990) reported cows with lower body condition scores yielded milk with a much lower fat contents. Selection of dairy cattle for milk production has led to increases in body growth of heifers and milk yield of cows due to the direct correlation between milk yield and body weight at calving (Hoffman, 1997; Barje, 2006). Mantysaari *et al.* (2002) observed that milk yield Vs body size, good, condition vs conformation of dairy cattle were correlated due to their genotype and phenotype.

The relationship between body size and milk yield appears to be affected by the nutrient composition of the animal milking. Ruegg *et al*. (1991) opined that if cows are fed well after calving, total milk yield should be independent of body condition score.

Alhassan *et al.* (1985) reported that the effect of season on daily milk yield was not much; however, yield were higher during peak rainy season on daily milk yield than the pre and post raining seasons (8.4 kg/cow/day vs 7.9kg /cow/day respectively). They observed the lactation curve of cow calving during the rainy season had marked hump in the late lactation at peak raining season. Jat *et al.* (1996) revealed a significant difference in

dairy production traits with years, seasons or parity except for milk yield/day of lactation length and dry period. The overall milk yield was (1157 ± 36.02kg), lactation length (264.68 ± 4.75d), the dry period (185.9 ± 7.37d) and milk yield/day (5.87 ± 0.096 kg). Oni *et al.* (2001) showed that season of calving had significant effect on milk production. Thakur and Singh (2001) reported a highly significant effect of year of calving on milk yield, lactation length and average daily milk yield per lactation and for lactation milk yield.

Animals that calved in the winter or monsoon periods produced more milk than those that calved in summer. Probably due to the effect of the high summer temperature of up to 48^{0c}. Shatter and Govindorah (1999) showed that milk and lactation duration were lower in the summer than in the Winter and Moonsoon season. Alhassan *et al*. (1985) opined that where supplementation feed is administered, seasoned feed variation on milk yield might likely be overturned.

2.14.3 Effect of supplementation on lactation Length

The period between when cow calves and is milked and when it is dried is regarded as the lactation length (ARC, 1984; Barje 2006). The normal lactation period is 305 if cow calve once a year and dries 60 days before next calving. This means that a cow can remain in milk for 305 days in a year especially in temperate dairy cows.

Lactation length is an indicator for determining the lactation performance of dairy cattle. Upgrading tropical breeds improve both lactation length and yield. NAPRI (1985) reported that crossing Friesian and Bunaji increased lactation length from 254 to 285 days while over a period of 9 years lactation length range between 161 to 206 days (Malau-Aduli, 1992).

The benefits of extending the lactation length have been studied. Grossman *et al.* (1999) reported that the expected benefits as calving every 18 months to include reduction in; number of excess progenies, insemination cost, and the number of dry days within a cow's productive life.

2.14.4 Effect of legume forage supplementation on serum progesterone concentration in prepubertal heifers

El-Tayeb and Gaber (1987) demonstrated that supplementing a combination of forages with concentrates improves performance and reproductive traits of Sudanese crossbred dairy heifers. However, during much of the year only one forage may be available. Their work examined the performances and sexual development of dairy heifers fed low-quality forage (*Sorghum bicolor*) supplemented with a concentrate mixture for the period of 130 days. (Forage only; forage plus 1 kg concentrate mixture; and forage plus 2 kg concentrate mixture). The concentrate mixture comprised 35% sorghum grain, 35% sunflower cake, 27% wheat bran, 2% limestone flour and 1% common salt. Serum progesterone was not detected in the unsupplemented heifers, and in two heifers in supplemented heifers. Donaldson *et al*. (1970) found that, plasma progesterone concentrations of heifers ranged from 0.3 to 3.9 ng/ml when the first sample was obtained.

Ovary surface examination by rectal palpation showed that high concentrations of progesterone were accompanied by the presence of corpus luteum. Rakha *et al.* (1970) have shown heifers with visible signs of oestrus before detection of progesterone in their peripheral blood. Heifers fed high level of concentrate reached puberty (first onset of oestrus) at a significantly younger age (20.5 months) and heavier live weight (248 kg) than heifers fed low level of concentrate (23.9 months and 231 kg, respectively). Improved

nutrition affected the onset of puberty in cattle (Rakha *et al.*, 1970; Short and Bellows, 1971; El-Tayeb and Gaber, 1987).

El-Tayeb et al. (1992) concluded from their work that the relationship between age and liveweight at puberty (r = 0.33) was positive, but not significant, indicating that animals reached puberty at a given live weight rather than at a given age. Their work demonstrated that supplementing poor quality forage improves the performance and reproductive traits of crossbred dairy heifers.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Location

The study was carried out in the Dairy Research Programme Farm of the National Animal Production Research Institute, Ahmadu Bello University, Shika- Zaria. Shika is located in the Northern Guinea Savannah on latitude 11^0 12'N, longitude 7^0 33'E, altitude 610m. Mean annual rainfall is 1100mm lasting from May to October with peak rainfall between July and September with relative average humidity is about 72% at this period, The mean temperature is about 24.4^0C (14.5 – 39.3^0C) with the lowest temperature occurring during early dry season (November to January). Higher temperatures are experienced during the late dry season (February – April) with mean relative humidity between 20-37% (Google Maps, 2013).

3.2 Experiment One: Effect of feeding concentrate diets containing graded levels of Groundnut haulms on growth and reproductive performance of Friesian x Bunaji heifers.

3.2.1 Experimental Animals

Twenty Friesian x Bunaji crossbred heifers aged 14-16 months and weighing 160-180 ± 2.11kg were used for the study. The heifers were randomly divided into four (4) groups of 5 animals each. The four groups were balanced for weight.

3.2.1.1 Animal Management

The heifers were dewormed with Albendazole® 2500mg boli (Eagle Chemicals Co. Limited. Chungchongnamdo, Korea) at the rate of 5mg/Kg body weight, before the

commencement of the growth trial. They were treated against ticks and other ectoparasites by weekly dipping in a long-walk dip containing acaricide Steladone (Novartis Inc. Basle, Switzerland). The animals were vaccinated against Contagious Bovine Pleuro-Pneumonia (CBPP), Black Quarter (BQ) and Foot and mouth disease (FMD). The experimental animals were housed in individual pens and fed their respective diets for 112 days. The animals were allowed an adjustment period of 14 days during which they were fed respective diets at 1.0% body weight per head per day. The feed allowance was adjusted to the feeding levels of 1.5% body weight per head/day. This was adjusted fortnightly after weighing.

3.2.2 Experimental Feeds

3.2.2.1 Source of Feed

Dried groundnut haulms (GH) was procured from markets in Zaria and its environs. Gamba (*Andropogon gayanus*) hay was obtained from the Forage Production Unit of Nationa Animal Production Reseearch Institute, Ahmadu Bello University, Zaria. Groundnut haulms was crushed manually and bagged. Molasses was procured from L and Z Farms in Kano.

3.2.3 Treatments and Experimental Design

Concentrate mixture was formulated consisting of maize grain, wheat offal, cottonseedcake, bonemeal, common salt and vitamin-mineral premix which formed the treatment diets (Table 1). The dietary treatments consisted of four iso-nitrogenous, isocaloric concentrate diet (14.6%CP) in which groundnut haulms was included at 0, 25, 50 and 75% levels. The low metabolizable energy content in concentrate mixtures containing groundnut haulms(GH) was compensated by daily mixing of molasses. The four groups of

animals balanced for weight were randomly allotted the four dietary treatments in a completely randomized design.

Table 1: Ingredient composition of concentrate containing varying levels of groundnut haulms (experiments 1).

	Levels of groundnut haulms in concentrate diets (%)			
Ingredients	**0**	**25**	**50**	**75**
Maize grain	35.00	25.00	15.00	6.00
Cotton seedcake	20.00	17.00	14.00	12.00
Wheat offal	42.00	30.00	18.00	4.00
Bone meal	2.00	2.00	2.00	2.00
Common salt	0.75	0.75	0.75	0.75
Vit-min premix	0.25	0.25	0.25	0.25
Molasses	0.00	2.00	4.00	5.00
Total	100.00	100.00	100.00	100.00
Calculated composition				
% CP	14.65	14.64	14.63	14.65
ME (Kcal/Kg)	2133	2133	2121	2117

Nagge mix® dairy cattle: High potency vitamins and Trace minerals premix for dairy cattle at recommended rate of 2.5kg/ ton of feed contains= Vitamins A 6250000IU, D3 875000IU, E 6250mg, K3 625mg, B1 625mg, B2 625mg, Niacin 25000mg, B6 625mg, Choline chloride 12500mg, Calcium 172500, Cobalt 75mg, Copper 7600mg, Iodine 107mg, Iron 23750, Zinc 396000, Magnesium 375000mg, Mn 63000mg, Phosphorus 135000mg, Selenium 80mg, Antioxidants 3750mg

3.2.4 Digestibility trial

Prior to the commencement of the first experiment, sixteen young Friesian x Bunaji bulls aged 12-18 months and averaging 200 ±2.44kg, were fed the experimental diets in a metabolic trial to determine nutrient digestibility and nitrogen balance. The animals were housed in individual metabolic crates, ideal for easy collection of faeces and urine as described by Osuji *et al*. (1993). During trial, the bulls were fed gamba hay a*d libitum* and test concentrate diets at 40% of estimated DM intake.

Each diet was fed during a 10 day adaptation period followed by a 7 day measurement, period of faeces and urine collection. After the adjustment period, animals were fed concentrate diets at feeding level of 1.5% of body weight, while Gamba hay was fed *ad libitum*. All the animals were weighed for 3 consecutive days before and after completion of the metabolic trial.

Leftover feed was weighed and recorded daily before the morning feeding.

Faecal samples collected were bulked, mixed thoroughly, and 10% of the mixed sample taken and oven dried at 60^0C for 2 days. The oven dried faecal samples were ground and 10% of the mixed samples taken for chemical analysis.

Daily urine output from each bull was collected in a plastic container (sample bottles) containing 100ml 0.1N H_2SO_4 placed under the metabolism crates. Daily, 10% of the urine was collected from each bull and stored in a refrigerator. The urine samples were bulked and 10% taken for keeping in refrigerator until required for analysis.

3.2.5 Data collection

3.2.5.1 Records of feeds and live body changes

Records of feed offered and leftovers were taken daily, while the body weight of heifers was recorded every fortnight before feeding. The amount of concentrate offered was adjusted fortnightly after the animals have been weighed.

3.2.5.2 Feeds samples

Samples of the experimental feed were taken daily, bulked, mixed thoroughly and sub samples taken for chemical analysis. The samples were then milled to pass through a 1 mm-mesh sieve and stored in an airtight bottle until required for analysis

3.2.5.3 Rumen liquor sample collection

Rumen liquor was collected for two consecutive days midway into the feeding trial, using a stomach tube at 0, 2, 4 and 8 hours post feeding. The stomach tube has a probe attached at posterior end which was inserted gently into the rumen through the oesophogus and the pump was pressured to collect the rumen liquor. The rumen liquor was collected in 100ml plastic sample bottles into which 5 drops of saturated mercuric chloride has been put in and was strained through 4 layered muslin cloths and pH determined (digital pH meter) immediately after collection. The strained rumen liquor were bulked and stored at -4^0C till analyzed. The strained rumen liquor samples were analysed for total nitrogen (AOAC, 1990), ammonia nitrogen (Conway, 1957) and total volatile fatty acids (Barnett and Reid, 1957).

3.2.5.4 Blood sample collection

Blood samples were taken from the heifers by jugular puncture of each animal into 10-ml sample tubes at 0, 2, 4 and 8h post feeding. Blood samples were analyzed for glucose (Folin and Wu, 1920), serum protein (Lowry *et al*., 1951) serum urea and creatinine (Brod and Sirota, 1948). Blood samples were also taken separately for determination of haematological parameters. Ethylene –di-amino tetra acetic acid (EDTA) was used as anti-coagulant (5mg/tube). The blood samples were used to determine packed cell volume, total erythrocyte count and haemoglobin. All collected blood samples were processed within 2 hours of collection.

3.2.5.5. Blood sampling for progesterone (P_4)

Blood samples were harvested fortnightly from the 20 heifers throughout the period of experiment and were placed immediately in ice and allowed to clot at 4^0C for 24 hours. Serum was separated by centrifugation and stored at -20^0C until concentrations of P_4 were determined by radioimmunoassay.

3.2.5.1 Radioimmunoassay

Serum P_4 concentrations were determined by solid phase ^{125} I radioimmunoassay 4 no-extraction technique. The sensitivity of the assay, defined as twice-the-standard deviation away from the zero standards, was 0.09 ng/ml. The within- and between-assay coefficients of variation were 8.8% and 9.7%, respectively. The potencies of the samples were estimated using a linear logit–log dose response curve. A serum P_4 concentration of 1 ng/ml and above was taken to indicate the presence of functional luteal tissue (Oyedipe *et al*., 1986).

3.2.6 Cost- benefit Analysis

Cost-benefit analysis was carried out to determine the profitability of varying the levels of groundnut haulms in concentrate diets fed to Friesian x Bunaji heifers. Parameters considered in the cost analysis are; quantity of concentrate intake, quantity of gamba intake cost of concentrate intake, cost of Gamba intake, live weight gains, values of weight gain,. Feed cost analysis was considered as the greatest input cost throughout the experimental period. All calculations of feed cost and output were based on averages per head, and at prevailing prices. Thus, inputs such as capital required for construction of feeding pens, labour were considered as invariable factors and were not included in the calculation.

3.2.7 Laboratory analysis

Sample of feeds and Faeces were collected and oven- dried at 60^{0}**c** for 48 hours. The samples were analysed for proximate composition according to methods approved by AOAC, (1990) and cell wall constituents (Goering and Van Soest, 1970). The proximate compositions determined were dry matter, Crude protein, Crude fibre ether extract, Nitrogen free extract and ash, while the cell constituents include Neutral detergent fibre and Acid detergent fibre.

3.3 Experiment Two: Effect of feeding concentrate diets containing graded levels of Groundnut haulms on feed intake and lactation performance of Friesian x Bunaji cows.

3.3.1 Experiment Animals.

Twenty Friesian x Bunaji cows in early lactation were used in the study. The animals were randomly divided into four groups of five each (consisting of two first parity and three multiparous cows) as in experiment one.

3.3.1.1 Animal Management

The animals were grazed on unimproved range predominated with *Andropogun gayanus, Digiteria smutsii, Bracheria documben, Cynodon dactylon, Panicum maximum* and *Chloris gayanus*. This was supplemented with Gamba hay in the evening after returning from grazing. In addition, they were fed concentrate diets at 1.5% of body weight. The animals were allowed a 14 day adjustment period, during which they were fed with the treatment diets corresponding to their groups. During adjustment period animals were passed through the milking parlour to acquaint them with milking procedures such as, udder washing, massaging, and restraining. At the end of the adjustment period, the animals were weighed and the quantity of diets adjusted to the experimental feeding level (1.5% of body weight). Amount of concentrate offered was adjusted fortnightly. The animals were fed for a period of 107 days.

3.3.2 Experimental Feeds

3.3.2.1 Source of Feed

Dried groundnut haulms (GH) and Urea were procured from markets in Zaria and its environs. Gamba (*Andropogon gayanus*) hay was obtained from the Forage Production Unit of National Animal Production Research Institute Ahmadu Bello University Zaria. Groundnut haulms was crushed manually and bagged. Molasses was procured from L and Z Farms in Kano.

3.3.3 Treatments and Experimental Design

Concentrate mixture was formulated consisting of maize grain, wheat offal, cottonseedcake, bonemeal, common salt, Urea and vitamin-mineral premix which formed

the treatment diets (Table 2). The dietary treatments consisted of four iso-nitrogenous, isocaloric concentrate diet (17.24%CP) in which groundnut haulms was included at 0, 25, 50 and 75% levels. The low metabolizable energy content in concentrate mixtures containing groundnut haulms (GH) was compensated by daily mixing of molasses. The concetrate diet was formulated to meet daily ration recommendation of 16-19% CP protein intake, 9-12MJ NE/kg energy intake and 3% undegradedabl protein (UDP) (NRC, 1990).The four groups of animals were randomly allotted the four dietary treatments in a completely randomized design as in Experiment one.

Table 2 Ingredient composition of concentrate diets containing graded levels of groundnut haulms (experiment 2)

	Levels of groundnut haulms in diets (%)			
Ingredients	0	25	50	75
Maize grain	35.31	22.00	7.00	6.00
Cotton seedcake	48.02	42.00	34.00	10.00
Wheat offal	13.68	8.00	6.00	5.00
Bone meal	2.00	2.00	2.00	2.00
Common salt	0.75	0.75	0.75	0.75
Vit-min premix	0.25	0.25	0.25	0.25
Urea	0.00	0.00	0.00	1.00
Molasses	0.00	2.00	6.00	5.00
Total	100	100	100	100
Calculated composition				
% CP	17.24	17.22	17.20	17.25
ME (Kcal/Kg)	2382	2355	2322	2332

Nagge mix® dairy cattle: High potency vitamins and Trace minerals premix for dairy cattle at recommended rate of 2.5kg/ ton of feed contains= Vitamins A 6250000IU, D3 875000IU, E 6250mg, K3 625mg, B1 625mg, B2 625mg, Niacin 25000mg, B6 625mg, Choline chloride 12500mg, Calcium 172500, Cobalt 75mg, Copper 7600mg, Iodine 107mg, Iron 23750, Zinc 396000, Magnesium 375000mg, Mn 63000mg, Phosphorus 135000mg, Selenium 80mg, Antioxidants 3750mg

3.3.4 Cost- benefit Analysis

Cost-benefit analysis was carried out to determine the profitability of varying the levels of groundnut haulms in concentrate diets fed to Friesian x Bunaji Cows. Parameters considered in the cost analysis are; quantity of concentrate intake, cost of concentrate intake, live weight gains, values of weight gain, total milk yield, and value of milk produced during the period of study. Feed cost analysis was considered as the greatest input cost throughout the experimental period. All calculations of feed cost and output were based on averages per head, and at prevailing prices. Thus, inputs such as capital required for construction of feeding pens, labour were considered as invariable factors and were not included in the calculation.

3.4.5 Data collection

3.4.5.1 Records of feeds and live body changes

During the experiment, data taken include; feed intake, body weight changes, milk yield, milk composition and cost of milk production.

3.4.5.2 Sample collection and Laboratory analysis

Samples of the experimental feed were taken daily, bulked, mixed thoroughly and sub samples taken for chemical analysis. The samples were then milled to pass through a 1 mm-mesh sieve and stored in an airtight bottle until required for analysis. The sample of feed were oven- dried at 60^{0}**c** for 48 hours. The samples were analysed for proximate composition (AOAC, 1990) and cell wall constituents (Goering and Van Soest, 1970) as in experiment one.

Cows were milked by hand twice daily (08.00 and 16.00 hours) in the milking parlour twice/day morning and evening. Milk yield was recorded daily. Milk samples were collected once/fortnight, preserved with potassium dichromate stored at 4^0c and were analysed for fat, protein, total solids and solid-not-fat and lactose, using AOAC (1990) procedures. Fat content was determined using the Gerber Milk test procedure as described by Ling (1963), while Total solid was calculated using the formular TS = Lc/4 + (1.22 x % Fat) +0.72, where Lc = lactometer reading (O'Connor, 1994). Solid-not-fat was determined by subtracting % fat from Total solids. Ash content was determined by oven drying the samples at 550^oC for 2 days.

The metabolizable energy was calculated from the proximate analysis result as shown below

ME(kcal/kg)= 37x %CP + 81.8 x %EE +35 X % NFE (Payne,1990).

3.5 Statistical Analysis

Statistical analysis of the data collected was done using the GLM Procedures of SAS (1998). The model used considered herd, treatment, weekly milk offtake, body weight changes of both cows and calves, and body condition scores of dams. All statistical tests were done at 1 and 5% probability levels. The differences between means were separated using the Duncan Multiple Range Test Method (Steel and Torrie, 1980). The model used is as shown below:

$Y_{ijk} = \mu+\alpha_i +e_{ijk}$

Where Y = dependent variable (BWt, intake,digistbility, milk yield)

α_i = effect of i^{th} treatment (i =1 ... 4)

e_{ijk} = random error

CHAPTER FOUR

4.0 Results

4.1 Experiment One: Effect of feeding concentrate diets containing varying levels of Groundnut Haulms on feed intake, growth and reproductive status of Friesian x Bunaji heifers

4.1.1 Chemical composition of diets fed in experiment 1

Chemical composition and ME content of Gamba (*Andropogun gayana*), groundnut haulms and concentrate diets containing graded levels of groundnut haulms are shown in Table 3. The results showed that gamba hay and groundnut haulms used in the study had crude protein contents of 2.63 and 14.41 and NDF contents of 83.64 and 53.78% respectively. Organic matter and NFE tended to decrease with increase in the levels of groundnut haulms in the concentrate diets. Crude fibre ADF and NDF contents increased as levels of groundnut haulms in the diets were increased with the highest values recorded at 75% level of groundnut haulm. Crude protein values were similar across treatments averaging between 14.5 and 14.7%. The Metabolizable energy content expressed in Kcal/kg of diets decreased with increase in groundnut haulms level from 0-75%.

Table 3: Chemical composition of concentrate diets (experiments 1), gamba hay groundnut haulms on % DM basis.

	Levels of Groundnut haulms in concentrate diets (%)					
Nutrients	**0**	**25**	**50**	**75**	**GB hay**	**GH**
OM	78.51	84.53	79.82	75.49	89.93	72.88
CP	14.65	14.48	14.63	14.45	2.63	14.41
ASH	7.28	9.28	11.16	16.82	4.30	12.28
EE	11.89	10.10	6.70	11.78	9.49	8.73
CF	18.99	18.81	21.63	19.24	50.04	48.66
NFE	47.19	47.42	45.88	37.71	34.92	16.51
NDF	41.48	45.58	47.09	48.01	83.64	53.78
ADF	30.11	29.8	30.58	33.02	61.61	47.09
ME(kcal/Kg)	3166	3022	2695	2619	2095	1825

GB Hay= Gamba hay; GH=Groundnut haulms; ME= Metabolizable energy

4.1.2 Nutrient digestibility and Nitrogen balance

Digestibility and nitrogen (N) balance results are shown in Table 4. The digestibility of DM, OM and CP was significantly higher ($P<0.05$) in bulls fed concentrate diets containing groundnut haulm as compared to the control or the bulls fed concentrate diet without groundnut haulms. The DM digestibility was higher ($P<0.05$) in bulls fed 75% than those fed 25 and 50% levels of groundnut haulms in the diet. The digestibility of OM and CP was highest in 75 and 50% levels of groundnut haulm in concentrate diets. CF digestibility was highest in diet with 25% groundnut haulms followed by diets with 0, 50 and 75% levels of groundnut haulm inclusion. Ether extract digestibility was higher ($P<0.05$) in treatment with 75% level of groundnut haulm as compared to the other treatments. The digestibility of NFE was statistically comparable among the different treatment groups. NDF digestibility was higher ($P<0.05$) in diet with 75% groundnut haulms, followed by diets with 25, 50 and 75% groundnut haulms. The ADF digestibility was higher ($P<0.05$) in treatments with 25, 50 and 75% groundnut haulms as compared to treatment with 0% groundnut haulms in concentrate diet.

There was a significant difference ($P<0.05$) in Nitrogen intake across treatments, with animal fed the control diet (0% groundnut haulm) having the highest Nitrogen intake, while those fed the groundnut haulm diets having slightly different but not significantly different Nitrogen intake. Faecal N declined, though not significant ($P>0.05$) with increase in the levels of groundnut haulms in the diet. Slightly higher urinary nitrogen were recorded in animals fed 0 and 75% groundnut haulm diets, than in those fed 25 and 50% diets, however, the differences were not statistically significant ($P> 0.05$). Nitrogen balance had higher values recorded in animals fed 0 and 75% compared to 50 and 25% levels of

groundnut haulm inclusion. However, the difference was not significantly different ($P>0.05$).

Table 4: Digestibility of nutrients and Nitrogen balance in young bulls as influenced by levels of groundnut haulm inclusion

	Levels of Groundnut haulms in concentrate diets (%)					
Parameters	**0**	**25**	**50**	**75**	**SEM**	**LOS**
Nutrient Digestibility (%)						
Dry Matter	44.83^{c}	50.04^{b}	49.51^{b}	54.05^{a}	1.65	*
Organic Matter	61.08^{c}	72.77^{b}	75.07^{a}	76.97^{a}	1.93	*
Crude Protein	60.55^{c}	64.90^{b}	66.94^{ab}	70.64^{a}	1.89	*
Crude Fibre	51.16^{b}	55.93^{a}	50.97^{b}	46.14^{c}	0.29	*
Ether Extract	63.14^{b}	61.17^{b}	59.09^{b}	75.75^{a}	3.92	*
Nitrogen Free Extract	65.20	66.75	64.08	61.88	2.72	ns
Neutral Detergent Fibre	54.15^{b}	57.35^{ab}	54.55^{b}	59.47^{a}	2.07	*
Acid Detergent Fibre	53.00^{b}	63.23^{a}	60.62^{a}	60.16^{a}	1.91	*
Nitrogen balance (g/d)						
Nitrogen Intake	84.90^{a}	74.36^{ab}	64.46^{b}	7 6.32^{ab}	0.19	*
Faecal N_2	27.16	27.02	23.16	22.66	3.49	ns
Urinary N_2	5.23	3.86	4.97	5.49	2.09	ns
N_2 Balance	52.51	43.49	36.33	48.17	9.72	ns
N_2 Balance (%)	61.84	58.49	56.36	63.12	6.78	ns

Means within the same row bearing different superscripts differ significantly. LOS=Level of significance * =P<0.05; ns = No Significance.
DM= Dry matter; OM =Organic matter; CP= Crude protein; CF= Crude fibre; EE= Ether extract; NFE= Nitrogen free extract; NDF= Neutral detergent fibre; ADF= Acid detergent fibre; H/Cell= Hemicellulose
;

4.1.3 Dry Matter intake (DMI) and body weight changes

Table 5 shows the effect of feeding Friesian x Bunaji heifers with diets containing varying levels of groundnut haulms on dry matter intake and body weight changes. The result shows that dry matter intake expressed in kg/d and g/kg $w^{0.75}$ (metabolic weight), decreased significantly ($P<0.05$) with increase in the level of groundnut haulms in the diet, although there was no significant difference ($P>0.05$) at 0, 25 and 50% levels of groundnut haulm inclusion.

Final body weights of heifers fed concentrate diets containing 0 and 25% was similar but significantly higher ($P<0.05$) than heifers on 50 and 75% levels of groundnut haulms. Both total weight gain and average daily weight gain were higher ($P<0.05$) in concentrate diets with 0 and 25% groundnut haulm compared to the other treatments. The value for animals on 50 and 75% groundnut haulms were similar but lower ($P<0.05$) than those in 25% groundnut haulms.

Feed to gain ratio was significantly higher ($P<0.05$) in animals fed 50 and 75% groundnut haulm diets than in those fed 0 and 25% groundnut diets which were not significantly different from each other ($P>0.05$).

Table 5: Effect of groundnut haulms supplementation on feed intake and weight gain of Friesian × Bunaji Heifers

	Levels of Groundnut haulms in concentrate diets (%)					
Parameter	**0**	**25**	**50**	**75**	**SEM**	**LOS**
DMI (kg/d)	4.99[a]	5.09[a]	4.54[ab]	4.42[b]	0.08	*
DMI (g/kg W $^{0.75}$)	88.61[ab]	90.35[a]	85.39[ab]	83.82[b]	0.82	*
Initial Weight (kg)	160.20	164.80	165.80	163.80	3.00	ns
Final Weight (kg)	216.60[a]	211.40[a]	200.00[b]	197.20[b]	3.53	*
Total weight Gain (kg)	56.40[a]	46.60[b]	33.80[c]	33.80[c]	2.98	*
A DG (kg/day)	0.51[a]	0.42[b]	0.30[c]	0.30[c]	0.03	*
Feed: gain ratio	14.42[b]	13.46[b]	18.84[a]	19.01[a]	1.26	*

Means within the same row bearing different superscripts differ significantly. LOS= Level of significance * =P<0.05; ns = No Significance

4.1.4 Cost - Benefit analysis

Cost -benefit analysis of feeding concentrate diets containing groundnut haulms at varying levels to Friesian x Bunaji heifers is shown in Table 6. The result showed that Feed cost in Naira per kg and Total cost of feed intake in naira declined with increase in groundnut haulms levels from ₦ 31.35/kg - ₦ 27.01/kg and ₦ 102195.28 - ₦ 72441.88 respectively. The feed cost to gain ratio was higher at 50% groundnut haulms level in concentrate (₦ 475.03) and lowest at 0% groundnut haulms (₦ 362.39/Kg live weight gain). The net benefits were ₦ 179804.72, ₦ 142419.82, ₦ 88720 and ₦ 96558.12 for feeding crossbred heifers on 0, 25, 50 and 75% groundnut haulm diets respectively. Net benefit declined across treatments with increased levels of groundnut haulms in concentrate diet up to 50%. The net benefit of feeding groundnut haulms at 0% groundnut haulms (control) over 25% is ₦ 37384.9; 0% over 50% is ₦ 91084 and over 75% is ₦ 83246.60.

Table 6: Costs benefits of graded levels of groundnut haulms in concentrate diets fed to Friesian × Bunaji heifers.

	Levels of groundnut haulms in concentratediets (%)					
Parameters	**0**	**25**	**50**	**75**	**SEM**	**LOS**
Concentrate intake (kg)	1,597[a]	1,596.20[a]	1,419.96[b]	1,382.84[c]	0.56	*
Gamba intake (kg)	1,663[a]	1,440.8[b]	1,374.24[c]	1,299.16[d]	8.54	*
Total feed intake (kg)	3260[a]	3037[ab]	2794.20[bc]	2682[c]	1.40	*
Cost of Feed/kg (₦/kg)	31.35	29.83	28.73	27.01		
Cost of Concentrate intake (₦)	49,281.25	44,736.54	36,554	31,104.97		
Cost of Gamba intake (₦)	52913.64	45843.64	43725.82	41336.91		
Total Cost of feed intake (kg)	102195.28	90580.18	80279.82	72441.88		
Total gain (kg)	282[a]	233[b]	169[c]	169[c]	11.9	
Value of gain (₦)	282,000	233,000	169,000	169,000		
Cost of feed/kg gain (₦/kg)	362.39	388.75	475.03	428.65		
Net Benefit (₦)	179804.72	142419.82	88720	96558.12		

Means within the same row bearing different superscripts differ significantly. LOS= Level of significance * =P<0.05; ns = No Significance.
Lwt= Liveweight , ₦ =Naira; kg=kilogram

NB: Cost of feedstuff (₦/ton): Groundnut Haulms = 15,000; Gamba Hay = 31,818.18;Cotton Seed Cake = 40,000; Wheat Bran = 25,000; Maize grain = 40,000; Bone meal = 13,000; Common salt = 25,000; Premix=750,000; Molasses 125,000.00; Cost of liveweight/kg (₦/kg) = 1,000.00

4.1.5 Rumen metabolites

Rumen pH

Rumen fermentation pattern in Friesian x Bunaji heifers fed varying levels of groundnut haulms in concentrate diets are shown in Table 7. Rumen pH differed significantly among the treatments. It was higher ($P<0.05$) at 75% than at 0, 25 and 50% levels of groundnut haulms. However, there were no significant difference ($P>0.05$) in rumen pH at different sampling period post feeding (Figure 1). Rumen pH at 2 hours post feeding recorded slightly higher values (7.11) than those at 0, 4 and 8 hours post feeding.

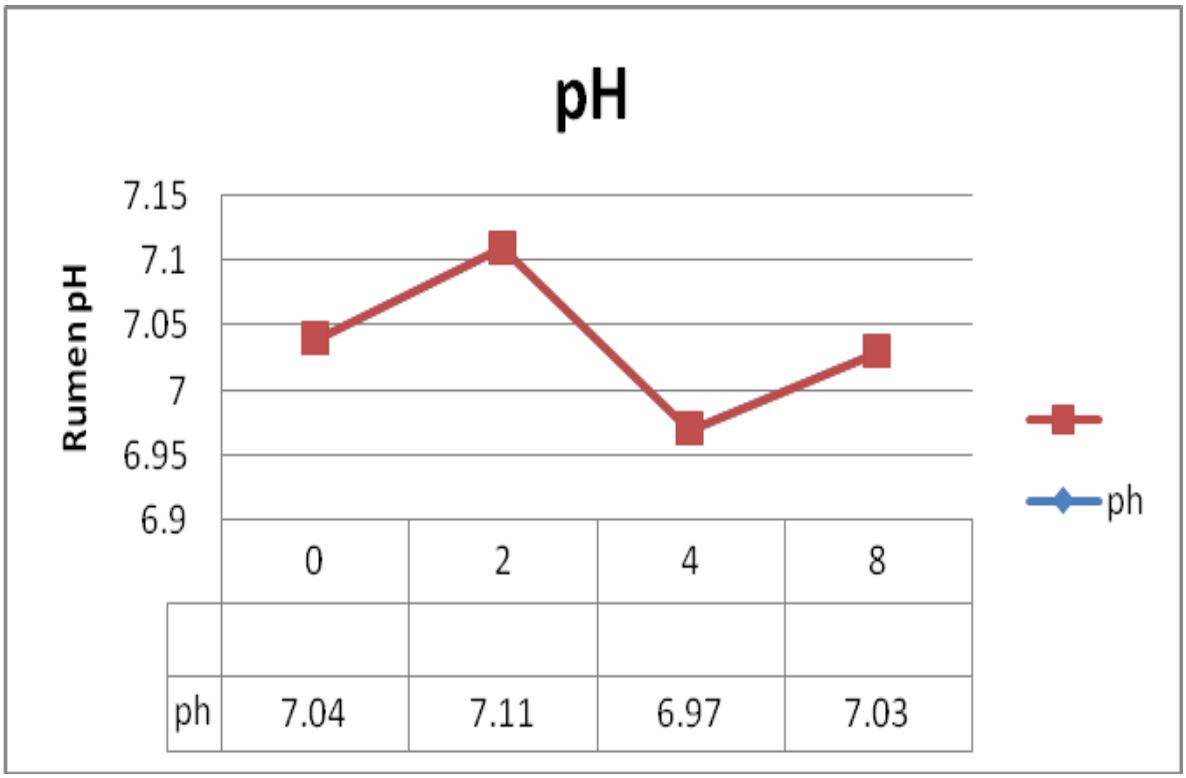


Figure 1: Effect of sampling time on rumen pH

Rumen total nitrogen

Total nitrogen concentration was significantly ($P< 0.05$) higher in heifers fed diets with 50% level of groundnut haulms than in those fed 0, 25 and 75% groundnut haulm which had values of 50mg/100 ml. The concentration of total nitrogen (TN) was significantly higher ($P < 0.05$) at 2 hours post feeding than at 0, 4 and 8 hours post feeding (Figure 2). However, total nitrogen concentrations at 0, 4, 8 hours post feeding were not significantly different ($P > 0.05$).

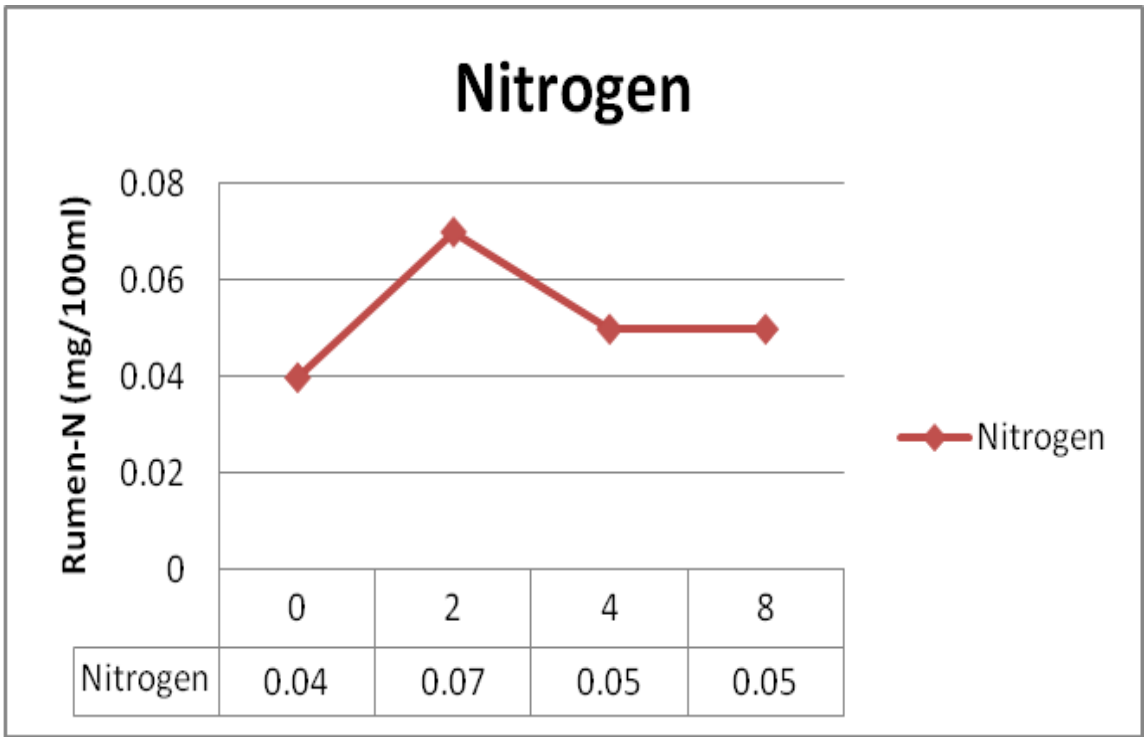


Figure 2: Effect of sampling time on rumen Nitrogen (mg/100ml)

Rumen ammonia nitrogen (NH_3 - N)

Table 7 shows that rumen ammonia (NH_3 – N) concentrations were not significantly different ($P > 0.05$) both across the treatment and over time of sampling period post feeding. The NH_3 – N concentration was slightly high at 0% level of groundnut haulms and lowest at 25%. However, NH_3 – N increased linearly with time recording its lowest value at 0 hour and peak value at 2 hours post feeding, although values were not significantly different (Figure 3).

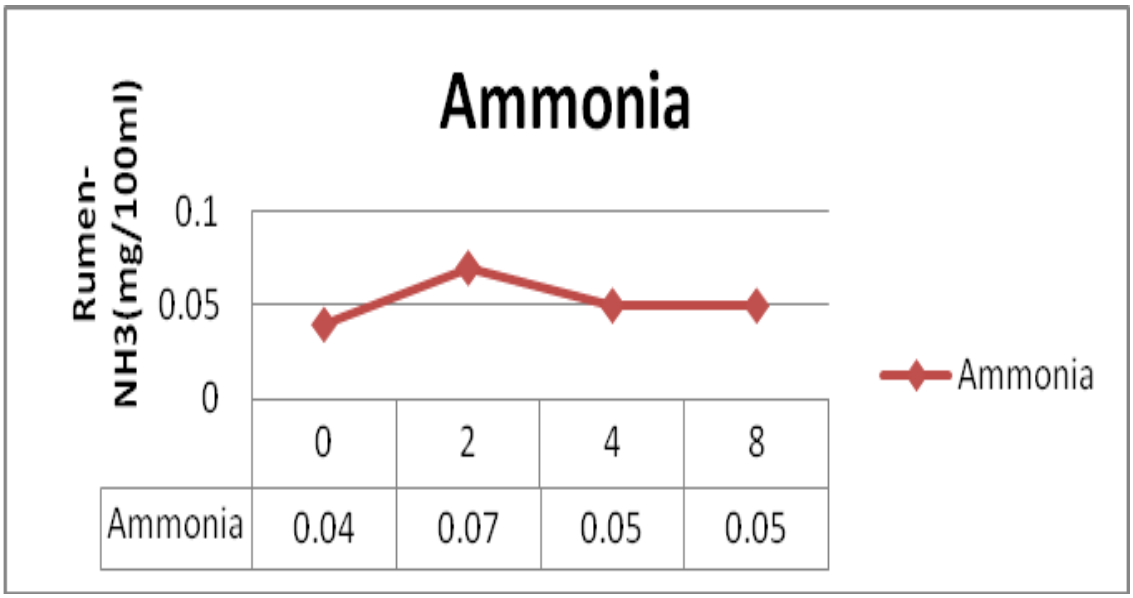


Figure 3: Effect of sampling time on rumen Ammonia (mg/100ml)

Total volatile fatty acid (TVFA)

There was no significant difference ($P > 0.05$) in rumen Total volatile fatty acids (TVFA) across treatment, although animals fed 50% levels of groundnut haulms in the concentrate diets had a higher Total volatile fatty acids concentration (Table 7). There was no significant effect ($P>0.05$) of sampling time on Total volatile fatty acids of heifers fed concentrate diets containing varying levels of groundnut haulms. Total volatile fatty acids concentration in rumen increased with increase in groundnut haulms until it reached it peak at 4 hours post feeding (Figure 4).

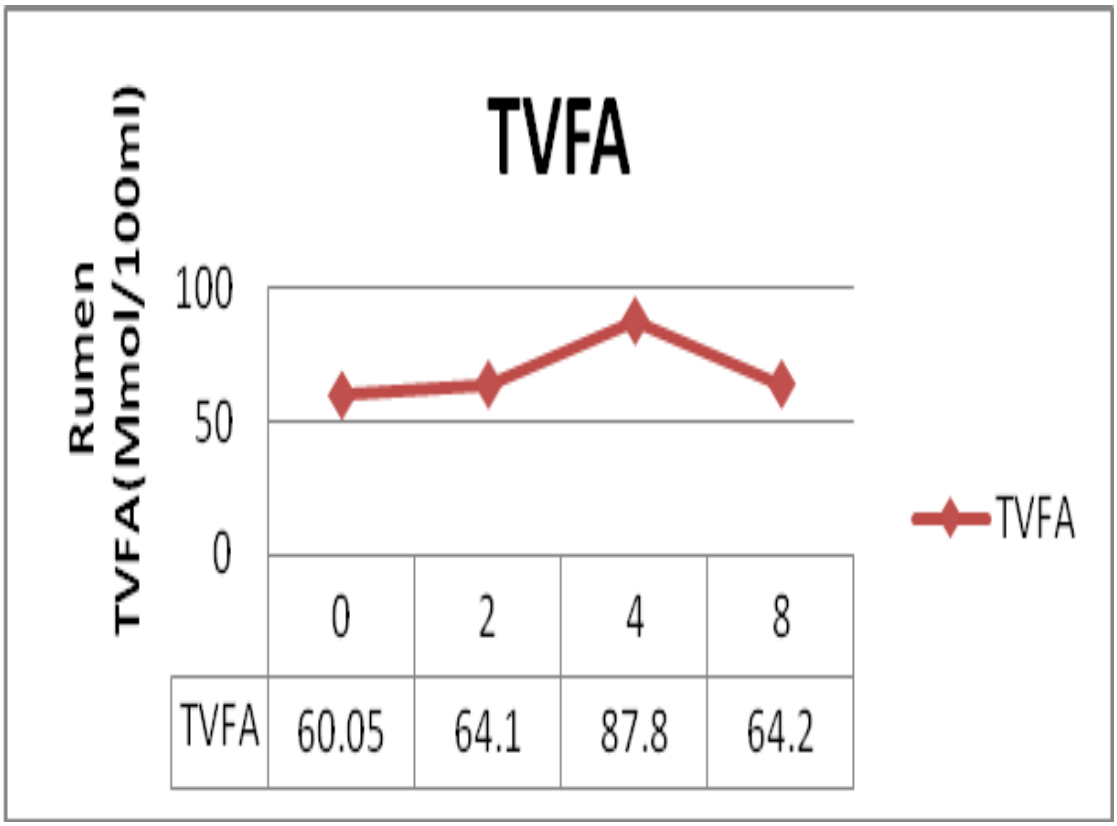


Figure 4: Effect of sampling time on rumen Total volatile fatty acids (TVFA) (Mmol/100ml)

Table 7: Effect of levels of groundnut haulms inclusion on rumen metabolites in Friesian x Bunaji heifers

	Levels of groundnut haulms in concentrate diets (%)					
Parameters	**0**	**25**	**50**	**75**	**SEM**	**LOS**
pH	7.04^{b}	7.01^{bc}	6.98^{c}	7.13^{a}	0.02	*
Total- N (mg/100ml)	50^{b}	50^{b}	70^{a}	50^{b}	0.11	*
Ammonia-N (mg/100ml)	18.34	16.35	17.90	16.52	15.95	ns
TVFA (Mmol/100ml)	60.05	64.10	87.80	64.20	16.89	ns

Means within the same row bearing different superscripts differ significantly. LOS= Level of significance * =P<0.05; ns = No Significance; N = Nitrogen; TVFA=Total volatile fatty acid.

4.1.6 Effects of feeding concentrate diets containing graded levels of groundnut haulms on serum metabolites

Serum protein

Serum protein decreased with increase in the level of groundnut haulm in concentrate diets (Table 8). It was highest ($P<0.05$) at 0% level of groundnut haulm inclusion. The values of serum protein were comparable at 25, 50 and 75% levels of groundnut supplementation. Serum protein concentration peaked at 8 hours post feeding and was lowest at 2 hours post feeding (Figure 5).

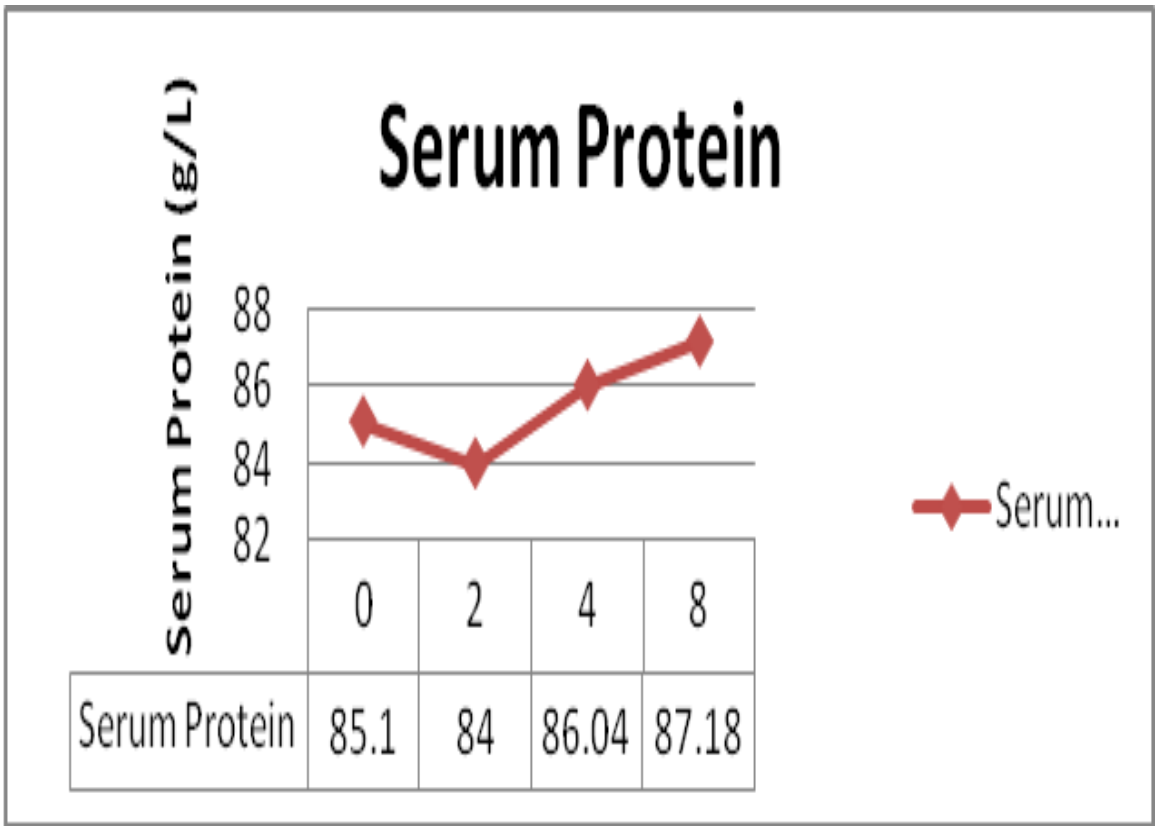


Figure 5 : Effect of supplementing groundnut haulms on serum protein (g/L)

Urea (Mmo/L)

The changes in serum metabolites are shown in Table 7. Serum urea was higher ($P < 0.05$) in heifers fed concentrate diet with 0% level of groundnut haulms in concentrate diet than at the other levels. The values of serum urea were comparable at 25, 50 and 75% levels of goroundnut haulm. Serum urea was significantly higher ($P < 0.05$) at 4 hours and least at 0 hours post feeding. Although, the effect of time of sampling on serum urea at 0, 2 and 8 hours post feeding were non- significant ($P > 0.05$) (Figure 6).

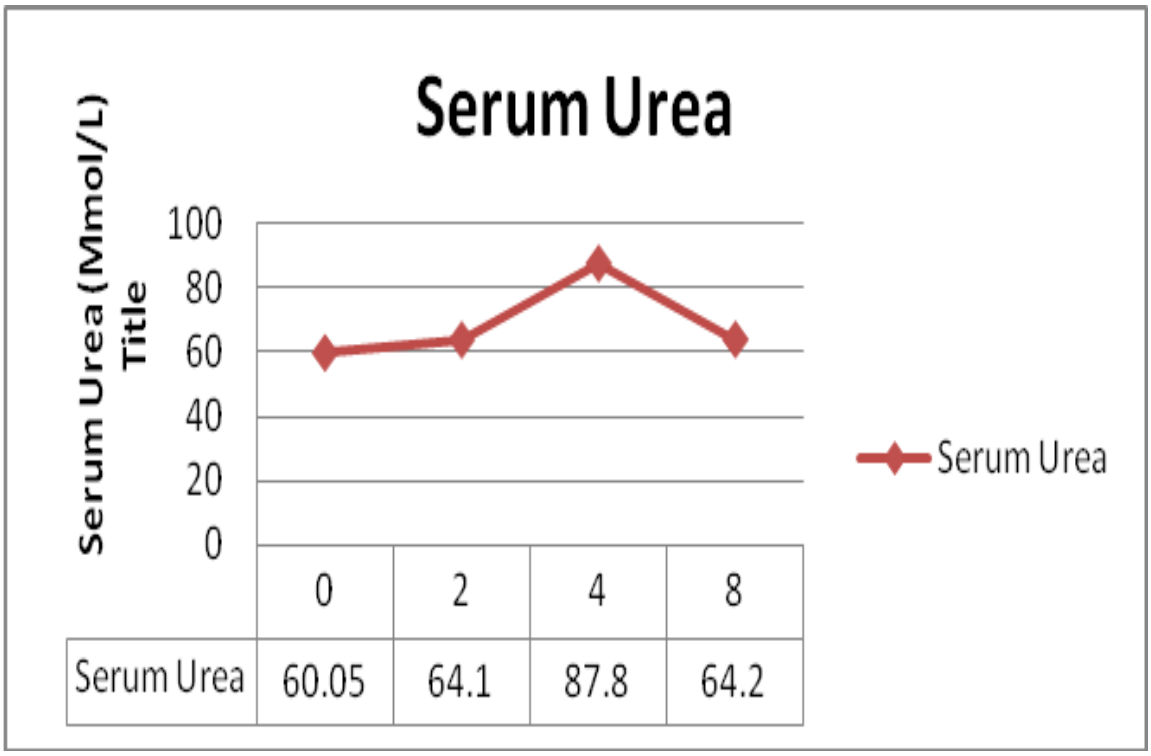


Figure 6 : Effect of supplementing groundnut haulms on serum urea (Mmol/L)

Serum creatinine (Mmol/L)

The results showed that serum creatinine was higher ($P<0.05$) in heifers fed concentrate diet with 0% compared to those with 25, 50 and 75% groundnut haulms (Table 8). There was no significant difference ($P > 0.05$) in serum creatinine concentration at sampling times of 0, 2, 4 and 8 hours post feeding (Figure 7).

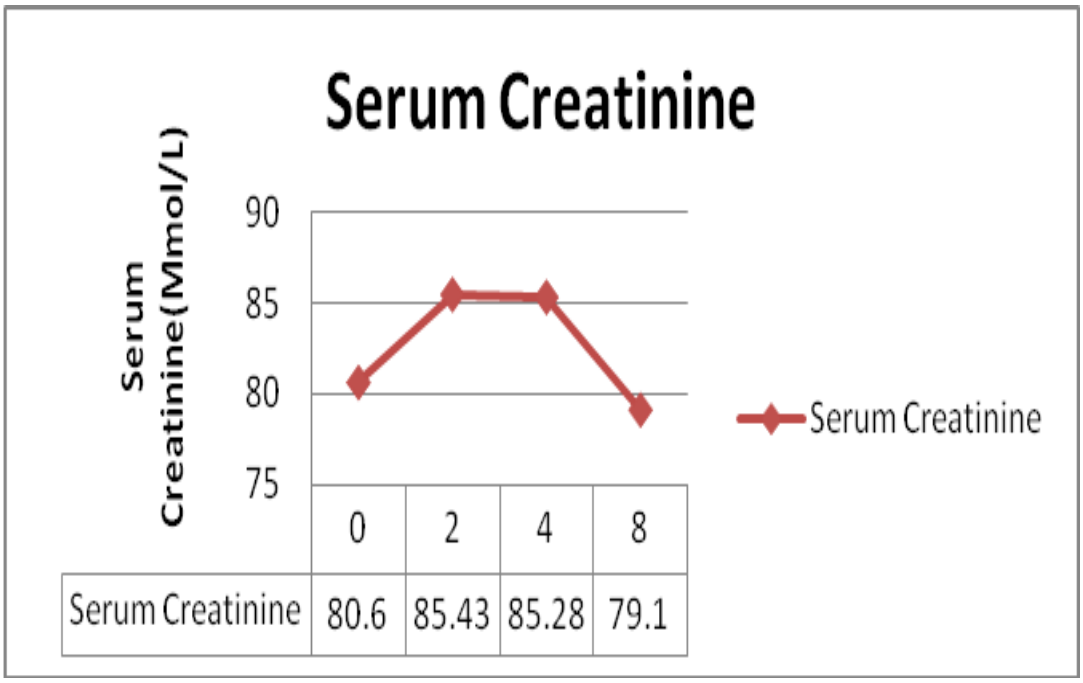


Figure 7 : Effect of supplementing groundnut nut haulms on serum Creatinine (Mmol/L)

Serum glucose (g/L)

Serum glucose was higher ($P<0.05$) at 25% level of inclusion of groundnut in concentrate diet than at 0, 50 and 75% levels (Table 8). Serum glucose was similar across sampling times (Figure 8).

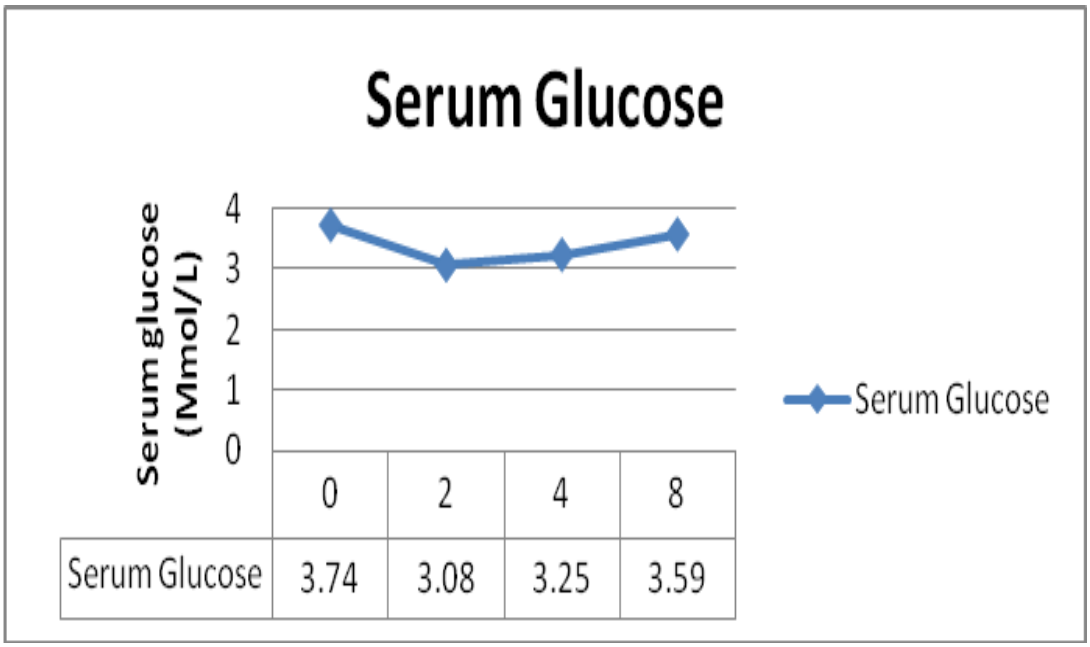


Figure 8 : Effect of supplementing groundnut haulms on serum glucose (Mmol/L)

Table 8: Serum metabolites in Friesian x Bunaji heifers as influenced by levels of groundnut haulms in concentrate diets.

	Levels of groundnut haulms in concentrate diets (%)					
Metabolites	**0**	**25**	**50**	**75**	**SEM**	**LOS**
Serum Protein (g/L)	87.97^{a}	84.99^{b}	85.7^{b}	84.52^{b}	0.49	*
Serum Urea (Mmol/L	8.05^{a}	5.50^{b}	5.65^{b}	5.67^{b}	0.35	*
Serum Creatinine (Mmol/L)	90.70^{a}	70.15^{b}	79.40^{b}	81.15^{b}	5.60	*
Serum glucose (Mmol/L)	3.38^{ab}	3.59^{a}	3.43^{ab}	3.25^{b}	0.11	*

Means within the same row bearing different superscripts differ significantly. LOS= Level of significance *
=P<0.05; ns = No Significance

4.1.7 Haematological changes

Result of changes in haematological parameters in heifers fed concentrate diets with varying levels of groundnut haulms are shown in Table 9. Heifers fed concentrate diet containing 75% groundnut haulms had significant ($P < 0.05$) increased in their red blood cells (RBC) than those fed the other diets, which had slightly different, but not significant RBC values ($P>0.05$). Similarly, there were no significant difference ($P > 0.05$) in packed cell volume (PCV) and haemoglobin (Hb) levels in of Friesian x Bunaji heifer across treatments. PCV and Hb values were however, relatively higher in heifers fed concentrate with 25% groundnut haulms.

Table 9: Haematological changes in pre-pubertal Friesian × Bunaji heifers fed varying levels of groundnut haulms in concentrate diets.

	Varying levels of GH in concentrate diets (%)					
Parameters	**0**	**25**	**50**	**75**	**SEM**	**LOS**
Packed Cell Volume (g/100ml)	28.00	28.40	24.80	27.40	3.05	ns
Haemoglobin (g/100ml)	9.12	9.36	8.16	8.94	1.00	ns
Red Blood Cell (%) ($x10^6$)	4.14^{b}	5.22^{ab}	4.92^{ab}	6.32^{a}	1.03	*

Means within the same row bearing different superscripts differ significantly. LOS= Level of significance * =P<0.05; ns = No Significance

4.1.8. Effects of feeding Friesian x Bunaji heifers concentrate diets with varying levels on groundnut haulms on Onset of puberty

The effect of feeding concentrate diets containing varying levels of groundnut haulms on onset of puberty of Friesian x Bunaji heifers is shown in Table 10. The age at first oestrus detection in Friesian x Bunaji heifers fed concentrate diets with different levels of groundnut haulms were not significantly different ($P > 0.05$). Friesian x Bunaji heifers fed diet with 25% groundnut haulms attained puberty significantly heavier ($P < 0.05$) than those at 50% and 75% groundnut haulms levels, and were similarly older. Heifers fed 50% groundnut haulms came to puberty much earlier ($P < 0.05$) with lighter weight (180.4Kg); though similar ($P > 0.05$) to those at 75% groundnut haulms (182.3Kg) when compared to those on 25% groundnut haulms (191.8Kg). None of the heifers fed concentrate diet with 0% groundnut haulms in concentrate diets came into oestrus during the period of study.

Table 10: Effect of feeding concentrate diets containing varying levels of groundnut haulms on onset of puberty in Friesian x Bunaji heifers

	Varying levels of GH in concentrate diets (%)					
Parameters	**0**	**25**	**50**	**75**	**SEM**	**LOS**
Age at First oestrus (days)	-	590	476	560	120.71	ns
Age (months) at puberty	17.06	19.6	15.09	18.06	3.00	ns
Weight at first oestrus (kg)	-	191.8^{a}	180.4^{b}	182.3^{b}	3.00	*
Initial P_4 (ng/ml)	0.42^{b}	0.44^{b}	0.59^{a}	0.38^{b}	0.10	*
Final P_4 (ng/ml)	0.41^{b}	0.92^{a}	2.00	1.76^{a}	1.54	ns
Animals reached puberty (%)	0	40	60	40	-	-

Means within the same row bearing different superscripts differ significantly. LOS= Level of significance * =P<0.05; ns = No Significance

The percentages of heifers that reached puberty were 0, 40, 60 and 40% for 0, 25, 50 and 75% groundnut haulms levels respectively. There was significant difference ($P < 0.05$) in the numbers of heifers that attained puberty across treatment in favour of heifers on 50% groundnut haulms level. Serum P_4 was significantly higher ($P < 0.05$) in heifers fed 50% groundnut haulms in concentrate diet on day 14 when compared to other treatments (Figure 9). The P_4 increased simultaneously but remained consistently low across treatment on day 28. At day 42, heifers fed 50 and 75% groundnut haulms level had their serum P_4 concentration above 1ng/ ml. However, serum P_4 concentration in heifers fed diets with 0% levels of groundnut haulms reduced to 0.38ng/ml and remained below 1ng/ml throughout the period of experiment. Serum P_4 concentration in heifers fed concentrates with 50 and 75% groundnut haulms maintained stable form, while the P_4 in heifers on 25% groundnut haulms concentrate diet remained stable from 56-100 days. The P_4 concentration peaked at day 70 with 4.54 ng/ml for heifers on 50% level; while 0% level of groundnut haulms in concentrate diets recorded the lowest value at day 84 respectively.

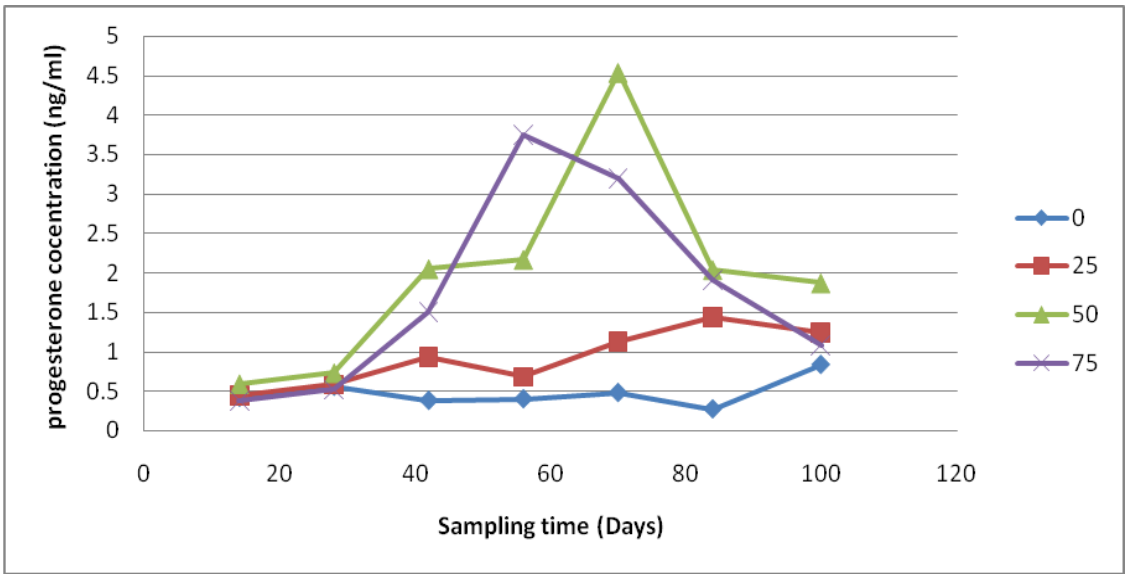


Figure 9 : Effect of varying levels of groundnut haulms in concentrate diets on serum progesterone (ng/ml).

4.2.0 Experiment Two: Effect of feeding concentrate diets containing varying levels of groundnut haulms on lactation performance of Friesian x Bunaji cows.

4.2.1 Chemical composition of diets.

The chemical composition of groundnut haulms and Concentrate diets are presented in Table 11. Organic matter contents of the concentrate diets (91.11-94.50%) and groundnut haulms (83.01-86.18%) were high. The percentage crude protein were 17.08, 16.35, 16.24 and 17.40 % for 0, 25, 50 and 75% levels of groundnut haulms in concentrate diets respectively. Inclusion of groundnut haulms in concentrate diet increased CF from 17.07% for 0% groundnut haulms to 23-26.35% for varying levels of groundnut haulms from 25 - 75%. Ether extract content decreased with increase in the level of groundnut haulms in concentrate diet, while NDF and ADF increased with increase in the level of groundnut haulms from 0-25%, but dropped when groundnut haulms in diets reached between 50-75% levels. However, the Ash content of diet increased with increase in groundnut haulms.

Table 11: Chemical composition of concentrate diets and Groundnut haulms, (% DM basis) for experiment 2.

	Levels of groundnut haulms in concentrate diets (%)				
Nutrients	**0**	**25**	**50**	**75**	**G H**
OM	83.01	83.79	85.83	86.18	83.98
ASH	8.10	8.40	7.50	8.39	9.17
EE	3.70	3.5	2.04	1.81	2.00
CP (%)	17.08	16.35	16.24	17.40	14.92
CF	17.07	26.35	24.06	23.00	23.63
NFE	54.61	48.52	52.39	56.04	50.28
NDF	56.00	69.00	64.00	61.00	64.00
ADF	27.00	36.00	38.00	29.00	27.00
ME(Kcal/kg)	2,846	2,589	2,601	2,752	1,877

GH= Groundnut haulm, ME= Metabolizable Energy

4.2.2 Dry matter intake and weight changes

The effects of feeding concentrate diets with varying levels of groundnut haulms to lactating cows on feed intake, body weight changes and lactation performance are shown in Table 12. Varying groundnut haulms levels in concentrate diets did not significantly ($P > 0.05$) affect DMI expressed in kg/day and kg/100 Body weight; while at 25% level of groundnut haulms, dry matter intake ($g/kgW^{o.75}/d$) significantly ($P<0.05$) improved above other treatments.

The changes in weights of lactating cows are shown in Table 12. The result showed that cows supplemented with groundnut haulm at 25% level had significantly higher ($P < 0.05$) total gain and ADG compared to those supplemented at 0, 50% and 75% groundnut haulms (Table 12). There were no significant differences ($P > 0.05$) in total gain and Average daily gain between cows fed concentrate diets with 0, 50 and 75% groundnut haulms.

4.2.3 Milk Yield

The lactation performance of Friesian x Bunaji cows fed varying levels of groundnut haulms in concentrate mixture is shown in Table 12. The results showed that cows fed sole concentrate diets (control) recorded slightly higher total milk yield (557.9liters) than cows supplemented at 50% groundnut haulms (538.8l). These values were similar ($P>0.05$) but higher ($P<0.05$) than the values obtained for cows fed concentrate diets containing 25 and 75% levels of groundnut haulms. Average daily milk yield followed the same pattern as the total milk yield, with animals fed 0 and 50% groundnut haulms having significantly higher average daily milk yield (5.81 and 5.61 liters

respectively) than those fed 25 and 75% groundnut haulm diets (3.43 and 3.61liters respectively).

Cows fed 0% groundnut haulms in concentrate diets recorded highest mean daily milk yield of 5.81 kg/day, though similar ($P > 0.05$) to 8.61 kg/day for cows on 50% groundnut haulms levels. However, mean milk yield per day was lowest at 25% groundnut haulms which also did not differ ($P > 0.05$) from those on 75% groundnut haulms levels. There was no significant difference ($P > 0.05$) of average yield during the first 14 days of lactation, although there were drastic drop in milk yield for all experimental cows when they reached 96th day in milk (DIM) across treatments. Cows fed 25, 50 and 75% groundnut haulms levels had similar milk yield ($P > 0.05$) but were significantly lower ($P<0.05$) than those on 0% groundnut haulms treatment.

Table 12: Feeding concentrate diets containing graded levels of groundnut haulms on performance of lactating Friesian × Bunaji cows

	Levels of groundnut haulm in concentrate diets (%)					
Parameters	**0**	**25**	**50**	**75**	**SEM**	**LOS**
Total Concentrate DMI (kg)	417.83	441.31	414.01	425.13	17.97	ns
Concentrate DMI (Kg/d)	4.35	4.60	4.31	4.42	0.19	ns
DMI g/kgW$^{0.75/d}$	4.89^{c}	6.50^{a}	4.92^{c}	5.71^{b}	0.30	*
Total gain (kg)	3.80^{b}	12.00^{a}	5.60^{b}	7.00^{b}	2.21	*
ADG (kg)	0.04^{b}	0.13^{a}	0.06^{b}	0.07^{b}	0.02	*
Total Milk Yield (litre)	557.9^{a}	337.1^{b}	538.8^{a}	346.4^{b}	51.99	*
Milk yield (L/d)	5.81^{a}	3.43^{b}	5.61^{a}	3.61^{b}	0.11	
14 DIM	76.10	66.00	79.00	78.00	8.55	**ns**
96 DIM	73.40^{a}	37.50^{b}	37.50^{b}	33.5^{b}	7.37	

Mean within the same row bearing different superscripts differ significantly. LOS= Level of significantly. LOS= Le el of significance * =P<0.05; ns = No Significance, DMI =Dry matter intake,
ADG= Average daily gain, DIM= Days in milk, LBW= Live body weight; KgW$^{0.75}$ = Metabolic weight.

4.2.3 Milk composition

Results of analysis of milk composition of Friesian x Bunaji cows fed diets with varying levels of groundnut haulms are shown in Table 14. There was no significant difference ($P > 0.05$) in milk protein across treatment. There were significant differences ($P < 0.05$) in milk fat, lactose, total solid and Solid-not-Fat (SNF). Milk fat was significantly higher ($P<0.05$) in milk from cows fed the diets with 75% groundnut haulms than in milk from those fed other diets, which were not statistically different. Lactose levels was significantly higher ($P<0.05$) in milk from cows fed the control diet (0% groundnut haulms), than in milk from cows fed groundnut haulm diets. However, milk from cows fed 50 and 75% groundnut haulms had similarly lactose levels (3.72%) which were significantly higher ($P<0.05$) than the level in the milk from cows fed 25% groundnut haulm diet. Total Solids in the milk decreased significantly ($P<0.05$) with increase in the level of groundnut haulms in the diets with milk from cows fed 0 and 75% groundnut haulm diets having the highest (13.73%) and least (13.42%) total solids respectively. Solid-not-fat concentrations varied significantly ($P<0.05$) with animals fed 25% groundnut haulms having the highest concentration of Solid -not -fat, followed by those fed 50% groundnut haulm diet. Milk from cows fed the concentrate with 75% groundnut haulms had the least Solid-not-fat concentrations followed by those fed the control diet.

Table 13: Effect of feeding concentrate diet containing graded levels of groundnut haulms on Friesian × Bunaji Milk Composition (%).

	Levels of groundnut haulms in concentrate diets (%)					
Parameters	**0**	**25**	**50**	**75**	**SEM**	**LOS**
Milk fat	4.09^{b}	4.09^{b}	4.03^{b}	4.25^{a}	0.05	*
Milk Protein	4.31	4.34	4.27	4.29	0.04	ns
Lactose	3.80^{a}	3.59^{c}	3.72^{b}	3.72^{b}	0.03	*
Total Solids	13.73^{a}	13.72^{a}	13.69^{a}	13.42^{b}	0.02	*
SNF	9.45^{c}	9.61^{a}	9.56^{b}	9.32^{d}	0.01	*

Means within the same row bearing different superscripts differ significantly. LOS= Level of significance * =P<0.05; ns = No Significance.
SNF=Solid-Not-Fat

4.2.4 Cost- benefit analysis

The cost-benefit analysis of varying groundnut haulms in concentrate diets of Friesian x Bunaji lactating cows is shown in Table 15. The current market prices of live cows and milk, cows fed 75% levels of groundnut haulms had the significantly ($P< 0.05$) lowest cost of concentrate cost per kilogram. The net benefit was similar across treatments with higher value at 50% groundnut haulms. Concentrate cost per unit output was higher at 25% groundnut haulms and lowest at 50% groundnut haulms level. However, there was no much difference in concentrate cost /unit output between those fed varying levels of groundnut haulms at 0 and 75%. Values of gain were higher ($P< 0.05$) at 25% level of groundnut haulms but similar to those fed 75% groundnut haulms level. Those fed 0, 50 and 75% groundnut haulms levels did not differ in their value of gain. Conversely, the milk values and total value of output were higher at 25 and 75% levels of groundnut haulms in concentrate diets.

Table 14: Cost benefits of feeding concentrate diet containing graded levels of groundnut haulms of Friesian × Bunaji lactating cows.

	Levels of Groundnut haulms in concentrate diets (%).					
Parameters	**0**	**25**	**50**	**75**	**SEM**	**LOS**
Total intake (kg)	458.60	466.60	443.60	461.20	19.37	ns
Conc. cost/kg (₦ /kg)	27.34	26.09	26.20	18.95		
Cost of Conc.intake (₦)	12,797	12,212	12,262	8,868		
Total gain/head	3.80^{b}	12.00^{a}	5.60^{b}	7.00^{a}	2.21	*
Value of gain (₦)	3,800	12,000	5,600	7,000		
Milk yield/head (kg)	557.9^{a}	337.1^{b}	538.8^{a}	346.4^{b}	51.99	*
Milk Value /head (₦)	39053	23,040	37,713	24,249		
Total output/head (kg)	561.70^{a}	349.10^{b}	544.40^{a}	353.04^{b}	52.82	*
Value of output (₦)	42,853	34,240	43,299	31,251	4618.56	
Feed Cost/Unitoutput	40.09	55.14	25.13	43.97	5.41	*
Net Benefit (₦)	30,056	24,028	31,069	22,383	4353.42	

Means within the same row bearing different superscripts differ significantly. LOS= Level of significance * =P<0.05; ns = No Significance.
Conc.=Concentrate, Total output=Milk yield per head+total gain/head
NB: milk value= ₦70/kg, cost value of dairy cow = ₦1, 000/kg live weight

CHAPTER 5

5.0 Discussion

5.1 Experiment One: Effect of feeding concentrate diet containing graded levels of ground haulm on feed intake, growth and reproductive statues of Friesian x Bunaji heifers

5.1.1 Chemical composition

The 2.63% CP of gamba in this study is comparable to 2.8% reported by Zimmelink (1974) and 1.5-3.5% by Haggar (1970) when gamba was cut between October and February. The CP content of groundnut haulms is higher than reported range of 7.4 to 8.8 % (Ahmed and Pollot 1977; Ndlovu and Hove 1995) or 8.6-9.1% (Etela and Dung, 2011). It was however comparable to the values of 14.7% (Murthy *et al*., 2004); 13.5 % (Nouala *et al*., 2006) and 12.8 % (Asaolu *et al.,* 2010). The low total ash content of gamba (4.3%) as against groundnut haulms (12.28%) agrees with Jayasuriya (1980) and Lufadeju *et al*., (1992) that poor quality roughages have low ash content. However, the Metabolizable energy (ME) and Nitrogen free extract (NFE) values of gamba (2095kcal/kg and 34.92) as against groundnut haulms (1825 kcal/kg and 16.51%) respectively showed that gamba has more prospects of generating energy than groundnut haulms with proper management. The progressive reduction of ME content of diets as level of groundnut haulms increases from 0-75% is probably because of the relatively lower level of Metabolizable energy in groundnut haulms. Conversely, the continuous increased in ash content of diet with increase in groundnut haulms level of diets suggest that the high content of ash in groundnut haulms is responsible.

The crude protein content of the concentrate diets ranged from 14.45 and 14.65% indicating that the diets were isonitrogenous. The mean CP concentrations in the four concentrate diets were all higher than the minimum of 8% necessary to provide the minimum ammonia levels required by rumen microorganisms to support optimum activity (Annison and Bryden 1998; Norton 2003). The Crude fibre (CF) value of 48.66% obtained in this study for groundnut haulms was higher than the values of 39.5 % reported by Ahmed and Pollot (1977). The observed variations in groundnut haulms nutrient composition in this study could have been due to non-uniformity in their harvesting and collection methods from one source to another since the groundnut haulms used in this study, was purchased from the opened market. Leng (1990) classified groundnut hay on the basis of quality to be location-dependent.

5.1.2 Nutrient Digestibility and Nitrogen balance

The higher digestibilities of DM, OM, CP, EE, NDF, ADF and Ash at 75% groundnut haulm inclusion compared to those at 0% groundnut haulms can be attributed to lower feed intake. Higher intake often results to a faster rate of passage of ingested food from the reticulo-rumen (Swan and Lamming, 1967). This could have reduced the efficiency of degradation thus, lowering the digestibility of feed. Nouala *et al.* (2006) reported increased *in vitro* digestibility on the proportion of *Moringa oleifera* when the supplement increased. Although, type and level of diet included determined digestibility. The authors noted a higher digestibility with *Moringa oleifera* as a sole supplement compared to concentrate as sole supplement at whatever level of supplement.

Barrioas *et al.* (2000) and Fondevilla *et al.* (2002) reported negative effects of feeding diets high in carbohydrates, as they modify the environmental conditions of the

rumen towards an unfavourable condition for the fibrolytic micro organisms. However, supplementation with leguminous leaves invariably alleviate nitrogen deficiency and other mineral deficiencies, and increase the intensity of rumen microbial activity thus, increasing the digestibility (Merkel *et al.,* 1999; Hove *et al.,* 2001). The high digestibility of DM and OM in this study is an indication of the possible boost to digestibility of the gamba hay, since supplemental forage in a straw-based diet have been shown to improve the digestibility of basal diet even at relatively small levels of supplementation (Cheng *et al.,* 1990). This was probably because of the rate and extent of colonization of fibre and the biomass of adherent organisms, since fibres are rapidly colonized by free-floating pool of bacteria in the rumen (Kreb *et al.,* 1989). Groundnut haulms incorporation as high digestible forage in an otherwise low digestible gamba hay could have brought to bear a large effect on digestibility by providing a highly colonized fibre source to seed bacteria to the less digestible gamba fibre. In addition to this, the ability of groundnut haulms to contribute fermentable energy to the rumen in form of available cellulose and hemicelluloses possibly stimulated fibre digestion. Although, Manyuchi *et al*. (1994) reported that groundnut hay did not alter the *in sacco* degradation of poor quality grass hays, it is possible that the number of available sites for microbial attachment was altered thus, changing the degradation of the basal diet as a result of increased microbial activities and this could have resulted to the non significant difference in the NFE digestibility.

Murthy *et al.* (2004) reported that digestibility of nutrients was not significantly affected by inclusion of varying levels of groundnut haulms as roughage source in the ration for growing GIR calves. Hadjipanayiotou (1988) reported that groundnut haulms significantly increased apparent digestion coefficients of DM 60%, OM 65%, CP 63% and gross energy 65%

Although nitrogen (N_2) intake were significantly different across treatments, positive nitrogen balance was recorded in all the heifers fed groundnut haulms diet. The lack of significant difference in nitrogen retention across treatment indicated that the nitrogen obtained from groundnut haulms inclusion in concentrate diet was adequate for the amount of energy available from its fermentation. The values of N_2 - balance g/d were however, higher than 12.5g/d and 21.4 g/d recorded by Pham *et al.* (2007) for cattle and buffaloes fed cottonseed and *Sesbania* on paragrass basal diet, or ammoniated wheat straw based complete diets (Reddy and Reddy, 1999; Sureshkumar *et al.*, 2000). Nitrogen balance obtained in this study was within the normal range of 52.8-64.6% reported by Prakash *et al.* (2003).

5.1.3 Dry matter intake and weight changes

Dry-matter intake is an important factor in the utilization of roughages by ruminant livestock and is a critical determinant of energy intake and performance (Devendra and Burns, 1983). The non-significant differences in DM intake by animals fed the diets with 0, 25 and 50% levels of groundnut haulm could be due to the fact that the animals did not suffer a nitrogen deficiency. Each diet had a CP level above the critical level of 8% (Leng 1990). In diets with low-quality roughages, protein supplementation has been found to increase total DM intake (Church and Santos 1981). Goodchild and McMeniman (1994) reported that inclusion of 20 – 50% plants rich in protein, in the diet resulted in 10 – 45% increase in intake of fibrous forage. Adebowale (1988) reported that groundnut haulms supplementation improved palatability, increased minerals and vitamins, better rumen function and has a laxative influence on the gastrointestinal tract (GIT) of Bunaji steers. The average dry matter intake (DMI) of concentrate of 5.09 and 4.99 kg/d at 0 and 25%

level of groundnut haulms levels in this study is comparable with 5.82 and 5.12 reported by Biu Xuan An (1998) who used dried and silage groundnut haulms to replace concentrate fed crossbred heifers on poor quality diet. However, DMI expressed in gram per metabolic weight which ranged from 83.39 to 90.35 g/ $kgW^{0.75}$ in this study was higher than 67.5 to 71.4 g/ $kgW^{0.75}$ by local cattle and buffaloes (Pham *et al.*, 2007) fed *Sesbanian sesban* and cottonseed cake as supplement.

It has been shown that nature of basal roughage fed determines the degree of livestock response to concentrate supplement intake (Murthy *et al*., 2004). Thus, the sudden drop in concentrate intake when groundnut haulms level reached 75% could have been caused by increased in gut fill due to high fibre intake accruing from groundnut haulms and gamba hay. Muia *et al*. (2002) had reported that replacing concentrate with increasing levels of leguminous forage leaves decreased DMI. These was attributed to attendant low dietary energy intake. The result of the current study seeem to support the reports of these authors as shown by the sudden decline in Metabolizable energy (ME) with increase in the level of groundnut haulms (3166,3022,2695 and 2619 kcal/kg) for 0, 25, 50 and 75% grounnut haulms in diet.

There was a negetive correlation between varying groundnut haulm in concentrate diets and ADG of heifers. The significantly higher ADG of heifers fed concentrate diet at 0% of groundnut haulms was most likely due to the fact this diet had a slightly higher energy and protein content, which are critical for the growth of livestock. The ADG of 0.51, 0.42, 0.3 and 0.3kg for 0, 25, 50 and 75% level of groundnut haulms in concentrate diet in this study were higher than was reported for heifers fed concentrate, groundnut haulms silage and dried groundnut haulms (Bui Xuan An, 1998). Increasing groundnut haulms level in concentrate diets above 25% depressed total gain and ADG of heifers. The

significant decline in ADG in this study at 50-75% level of groundnut haulms inclusion could be attributed to the observed decrease in metabolizable energy and dry matter intake (DMI) of the concentrates at these levels. Insufficient energy level in diet of high protein level has been associated with wastage of protein and increase energy cost of eliminating excess urea from the body (Huber, 1994). Growth rate in ruminants is highly correlated to energy and protein intake; with energy intake being the major limiting factor affecting tissues deposition (Leng, 1990). The increased CF, NDF, ADF in the diets at 50 to 75% could have contributed to depressing both the intake and consequently live weight gains at these levels.

5.1.4 Feed to gain ratio

Heifers fed 0 and 25% groundnut haulms levels had similar feed to gain ratios (14.42 vs 13.46), but were significantly lower ($P<0.05$) than those fed 50 and 75% (18.84 vs 19.01) levels of groundnut haulms in concentrate diets. The significant improvement in feed:gain ratio at 25% level of groundnut haulm in concentrate diets meant that the ratio of absorbed amino acids to energy (VFA) available from digestion corresponded to the animal's requirements needed for efficient utilization of poor quality feed resources (Preston and Leng, 1987).

5.1.5 Cost benefit analysis

The result in this study shows that Feed cost in Naira per kg and Total cost of feed intake in naira declined with increase in groundnut haulms levels from ₦31.35/kg to ₦27.01/kg and ₦102195.28 to ₦72441.88 respectively. Supplementation to provide essential nutrients has been found to be the most feasible, economic and preferred method of improving the utilization of poor quality forage materials by ruminant animals in the

tropics (Preston and Leng, 1987; Poppi and McLennan, 1995). The feed cost to gain ratio was higher at 50% groundnut haulms level in concentrate (₦475.03) and lowest at 0% groundnut haulms (₦ 362.39/Kg live weight gain). The net benefits were ₦ 179804.72, ₦ 142419.82, ₦ 88720 and ₦ 96558.12 for feeding crossbred heifers on 0, 25, 50 and 75% groundnut haulm diets respectively. Net benefit declined across treatments with increased levels of groundnut haulms in concentrate diet up to 50%, although they remained positive indicating it was beneficial replacing concentrate diet with groundnut haulms. Ehoche *et al*. (2001) earlier reported that supplementation with either groundnut haulms or Lablab haulms improved income of smallholder dairy farmers. The net benefit of feeding groundnut haulms at 0% groundnut haulms (control) over 25% is ₦ 37384.9; 0% over 50% is ₦ 91084 and over 75% is ₦ 83246.60.

5.1.7 Effects of graded levels of groundnut on Rumen metabolites

Rumen pH

The pH values of 6.98 – 7.13 in this study were slightly lower than the pH of 7.1-7.31 obtained by Jokthan (2006) when Pigeon Pea forage and rice straw based diets was fed to sheep. The slightly alkaline rumen condition in this study is probably due to increased concentration of ammonia in the rumen during these periods (Naik and Sengar 1999). The peak mean pH values at 2 hours post-feeding agrees with the result of Adegbola (2002).

Total nitrogen

The mean total nitrogen concentration of 70 mg/100 ml at 50% level of groundnut haulms inclusion was within normal range of 48 – 118.2 mg/100 ml reported by Reddy and Reddy (1999). The 50 mg/100 ml obtained at 0, 25 and 75% levels of groundnut haulms were similar to values obtained by Finangwai *et al.*(2008) when Urea treated maize stover

complete based diet were fed to Friesian × Bunaji bulls. The total Nitrogen (TN) peak concentration at 2 hours post feeding agrees with the report of Naik and Sengar (1999) who recorded the lowest concentration time at 0 – 2 hours post feeding. This shows that protein degradation and hydrolysis of groundnut haulm was slow in the rumen.

Ammonia nitrogen

Rumen ammonia nitrogen is a measure of the extent of rumen microbial protein degradation. The rumen ammonia nitrogen (NH_3 – N) concentration of 16.35 – 18.34 mg/100 ml in this study is slightly lower than 19.24 – 23.27 mg/100 ml reported by Finangwai *et al.* (2010) when Urea treated maize stover was fed to Friesian × Bunaji Bulls. The values of NH_3 – N in this study is close to 21.5 mg/100 ml reported by Naik and Sengar (1999) and 19 – 25 mg/100 ml observed by Mehrez *et al.* (1977) as adequate for forage digestion. Satter and Slyster (1974) have reported 50 mg/100 ml as the optimum NH_3 – N concentration for microbial growth. Powel *et al.* (1981) have reported that between 3.6 – 17 mg/100 ml NH_3 – N concentration promoted microbial protein production. Ammonia -Nitrogen is an important factor in determining the utilization of nitrogen in the rumen (Jokthan, 2006).

The peak NH_3 – N concentration time at 8 hours showed that NH_3 – N concentration increased with increasing sampling time. Naik and Sengar (1990) reported a peak NH_3 – N time at 4 – 6 hours post feeding. Jonas and Vilma (2007) reported similar values of 11.42 mg/100ml at beginning of feeding and 13.79 mg/100ml at end of sampling period. The non significant difference in NH_3 – N concentration across treatments showed that groundnut haulms inclusion in concentrate diet was beneficial to rumen protein synthesis. Similarly, the non significant difference across the sampling time is an indication

that there was a stable rumen environment needed for efficient rumen fermentation. Orskov (1982) noted that the requirement for rumen degraded protein is considerably less with straw than for concentrate due to low digestibility of highly fibrous crop residues.

Total Volatile Fatty Acid (TVFA)

The non significant differences in Total volatile fatty acid (TVFA) concentration in rumen across treatment is in line with the report of Orskov (1982) which states that once the nitrogen limitation in the rumen is corrected; there may be no benefit in increasing nitrogen level. Volatile Fatty Acids are the main energy sources for ruminants feeding solely on roughages. Thus, their concentration in the experimental diets gave indication of their energy values. The TVFA value range of between 60.05 – 87.80 Mmol/L in this study is above 19.57 – 36.57 Mmol/L reported by Jokthan (2006) when pigeon pea forage was supplemented in sheep diet. Although these values were lower than 96.1 – 111.9 Mmol/L reported by Jonas and Vilma (2007) when dairy cows were fed fermented legume silages. The increase in rumen TVFA in this study could possibly be due to increased digestibility of the feed material (Orskov and Ryle, 1990).

5.1.8 Effects of feeding concentrate diets containing graded levels of groundnut haulms on Serum metabolites

Serum urea.

The serum urea levels in Friesian x Bunaji heifers fed concentrate diets with varying levels of groundnut haulms in the diet (25, 50 and 75%) were within the normal range of 2.5-6.5 Mmol/L (Woodsman and Evans, 1974; Moloney *et al*., 1994). When rumen ammonia is absorbed into the systemic blood, it is converted to urea by the liver, thus, the moderate levels of serum urea with inclusion of groundnut haulms in the diet could be a

pointer to better urea nitrogen utilization. On the other hand, the value of 8.05 Mmol/L serum urea obtained at 0% groundnut haulms level could be due to the significantly higher ruminal ammonia-N concentration in the rumen. The high levels of serum urea-N is suggestive of inability of the animal to utilize nitrogen made available by digestion (Woodman and Evans, 1974). Also the urea concentration of serum urea in animals fed the diet with 0% groundnut haulms were higher than the values obtained from animal fed with the legume *Sesbian Sesban* (Reed *et al.,* 1990).The results also suggest an increased in microbial degradation due to increased protein supplied to rumen. Since serum urea level is an indication of effective rumen degradable protein in the diet.

Serum creatinine

The creatinine concentration of between 70.15-101Mmol/L in this study were closely similar to the minimum normal value of 90-126 Mmol/L (Woodman and Evans, 1974). Thus, the moderately high ME and percentage crude protein in diets at 0% level of groundnut haulms may have resulted to the observed high serum creatinine levels. Bakshi *et al.* (1997) noticed feed low in ME significantly increased serum creatinine above normal range.

Serum glucose

The concentration of serum glucose in this study were higher (2.11-2.90 Mmol/L) than glucose concentration reported by Jonas and Vilma (2007) when fermented silage was fed to daily cows, but closely similar to 2.82-3.33 Mmol/L reported by Finangwai *et al.* (2010) when urea treated maize stover were fed to Friesian x Bunaji bulls . However, they were within the normal range of 3.0- 8.3 Mmol/L reported by Woodman and Evans (1974). Singh and Gupta (1986) observed that higher rumen TVFA concentration resulted into

increased serum glucose concentration which was attributed to the higher molar proportion of propionic acid of TVFA. Thus, the highest level of serum glucose at 25% level of inclusion groundnut haulms in concentrate diets may be a true reflection of TVFA concentration in rumen. Feeding groundnut haulms in concentrate benefited rumen microbial activities, as all were within the normal range.

Serum protein

Although serum protein levels were significantly lower in animals fed concentrate containing groundnut haulms were significantly lower than in those fed the control diet (0%). The serum protein levels were within the normal range of 60-82g/L (Singh and Gupta, 1986). Jonas and Vilma (2007) reported a normal range of 81.53-82.03 g/L. The low ME in groundnut haulms was responsible for the low serum protein obtained in animals fed concentrate diets with varying level of groundnut haulms compared to those fed the control diet (0% groundnut haulms). The peak concentration of serum protein at 8 hours post feeding showed that protein concentration, increased with sampling time. This is not in agreement with the findings of Finangwai *et al.* (2010) report with peak concentration at 0 hours and least value between 2-4 hours post feeding correspondingly. The high total protein concentration recorded in animal 0% groundnut haulms diet could have been caused by the significantly higher ruminant NH_3-N and higher serum blood urea - N observed in this study. Bakshi *et al*. (1997) reported that diets high in protein content are always responsible for higher serum ammonia nitrogen.

5.1.9 Haematological changes

The significant improvement in the Red blood cell of Friesian x Bunaji heifers fed diets with varying levels of groundnut haulms underscored the importance of plane of

nutrition on the blood metabolite profiles. Alabi (2005) reported that protein deficiency is responsible for clinical anaemia accruing from decreased Red blood cells (erythrocytes and hypo-proteinemia). Packed cell volumes range of 27.40 to 28.00 were moderately lower than the range of 39.79 to 41.42% reported by Moloney *et al.* (1994). However, these were similar to the values observed in sheep fed pigeon pea hay (Jokthan, 2006) when Pigeon pea was supplemented to Yankasa sheep and in Friesian x Bunaji heifers fed diets with varying levels of cottonseed cake (Barje, 2006). However, the values of packed cell volume (PCV) and Haemoglobin in this study were within the normal ranges in cattle (Coles, 1974 and Olaloku and Oyenuga, 1975). This suggests that groundnut haulms does not possess any detrimental factor to ruminants.

5.1.10 Serum progesterone

Puberty is defined in heifers as the age at which plasma progesterone level reach 1.0 ng/ml. Animal body weight, rather than age is known to regulate it (McDonald *et al.*, 1971). Puberty occur when the gonads begin to secrete steroid which speed up the growth of the genital organs and the development of secondary sexual features. Until heifers reach a targeted weight, oestrus is unlikely to occur. The age at first oestrus detection in Friesian x Bunaji heifers fed groundnut haulms at 25, 50 and 75% varying levels were 596, 476 and 560 days respectively and these were not significantly different. Friesian x Bunaji heifers that reached puberty around 476- 596 days (15-19 months) with an average live weight of 180.40 – 191.8 kg were above values of 12 - 13 months reported for dairy cattle (Ferguson *et al.*, 1988). However, the values in this study were lower than 21.2 months for 1/2 Friesian x 1/2 Bunaji in Nigeria (Knudsen and Sohael, 1970) and 40.2 months for most Bunaji in Nigeria. The non significant difference in age of heifers at puberty disagrees with

Sorensen and Sohael (1970) that weight and not age is responsible for puberty attainment after a targeted weight is reached. Werre (1980) found a strong negative correlation between age at puberty and measure of growth. Oyedipe *et al.* (1982) demonstrated that nutrition affects puberty; and heifers on high protein diets are often younger and heavier at puberty than those on a low- protein diet. They however, noted that though poor nutrition delays puberty, very high levels of feeding do not necessarily result to an early puberty than adequate levels. Cohen *et al.* (1980) noted that increased progesterone is an indication of a functional corpus luteum. The protein and ME content of the experimental diets probably met the heifers requirement. More so, that the nitrogen during the period of study remained positive.

In addition, a well cured legume hay have advantage of preserved bioactive substances needed to regulate metabolism and cellular functions in animals (Shukla *et al*., 1985). Vitamins especially vitamins A, D, E, C and B have been shown to have tremendous influence on reproductive functions of animals (Payne, 1990). Vitamins particularly Vitamins B6 and E posses oestrogenic properties and act synergistically with oestradial in increasing the uterine weight of ovariectomised rats (Sharaf and Gomaa, 1971).

The typical oscillating trend of the serum P4 concentration in Friesian x Bunaji heifer's activities from 42 – 100 days of experiment, indicate the classical pattern of the animals' physiological evolution related to their age. El – Tayeb and Gaber (1987) demonstrated earlier that supplementing a combination of forages with concentrate improves performance and reproductive traits of Sudanese crossbred heifers. Serum progesterone was not detected in their unsupplemented heifers. However, Donald *et al.* (1970) found that serum progesterone concentration of heifers range between 0.3 – 3.9 ng/ml. This is similar to 0.27 – 4.0 ng/ml obtained in this study.

5.2 Experiment Two: Effect of feeding concentrate diets containing varying the levels of Groundnut haulms on feed intake, milk yield and cost of milk production in Friesian x Bunaji cows

5.1.1 Chemical composition.

The use of molasses and urea to adjust for the Metabolizable energy and protein of diets kept the concentrate mixture isocaloric and isonitrogenous. Although the isonitrogenous diets analysed were slightly above the 16% CP, they were however, within the normal range recommended by NRC (1989) for lactating cows. Ash content of diets increased with increase in groundnut haulms in the concentrate possibly, because of the high contents of ash in groundnut haulms (Murthy *et al*., 2004). Conversely, the declined in ether extract (EE) and Neutral detergent fibre (NDF) with increasing level of groundnut haulms in diet in this study were possibly due to their high content in cotton seed cake which was replaced by groundnut haulms as the major source of protein (Bernard and Montgomey, 1999; Barje, 2006). The increased Crude fibre (CF), Neutral detergent fibre (NDF), Acid detergent fibre (ADF) and ash could be attributed to higher contents of fibre in groundnut haulms than in cottonseed meal. Jayasuriya (1980) classified groundnut haulms as a high fibre-high protein leguminous crop residue. The slight reduction in ME with increasing level of groundnut haulms in concentrate diets is associated with the relatively lower ME in groundnut haulms (Etela and Dung, 2011). However, ME values of all dietary treatments were within the range for lactating cows, although lower than 3600 Kcal/kg reported by Barje (2006).

5.2.2 Dry matter intake (DMI)

The Non-significant difference in dry matter intake per day and per body weight showed that varying the levels of groundnut haulms in concentrate diets improve

palatability in lactating cows. The slight increased in DMI of concentrate diets containing varying levels of groundnut haulms is in tandem with previous reports that showed the prospect of groundnut haulms in improving feed palatability and intake by livestock (Adebowale 1988, Etela and Dung, 2011). This tends to agree with the report of Bui Xuan An (1998) that the replacing concentrate with either ensiled or dry groundnut haulms had positive effects on intake. The high content of Rumen Degradable Nitrogen (RDN) in groundnut haulms could have elicited the greater response of cow feed intake. The increased in dry matter intake due to supplementation of groundnut haulms per unit of metabolic weight may be due to increased rate of fibre digestion which is associated with decreased gut fill and increased protein flow to the duodenum (Thomas *et al.*, 1980). Forage supplementation is geared towards increasing the Nitrogen contents of diets based on poor quality roughages, so that the deficiency of nitrogen substrates for the rumen microorganism can be overcome. This study showed that varying Groundnut haulm in concentrate diet enhanced both intake and digestibility of the diet.

5.2.3 Weight gains

The significant improvement in average daily weight changes of cows fed 25% level of groundnut haulms in concentrate diets compared to those fed sole concentrate could be due to the enhanced feed intake in lactating cows. Although it has been reported that high consumption of feed does not produce better live weight gain (Alhassan, 1985). Topps (1995) reported that enhanced feed intake due to supplementation with groundnut haulms in animal to some extent reduce weight losses while Adu and Lakpini, (1983). reported weight gain in yankasa sheep.

5.2.4 Milk production

The significantly higher average daily milk yield of cows fed concentrate with 0 and 50% levels of groundnut haulms inclusion than those fed diets 25 and 75% groundnut haulms, highlights the effect of replacing concentrate diet with groundnut haulms on on milk yield. Cows fed 0 and 50% groundnut haulms concentrate diets had significant milk yield than those fed 25 are 75% groundnut haulms diets. Markusfield *et al.* (1997) observed that cows calving in higher body condition score produced more milk. Mantyssari *et al.* (2002) observed that milk yield and body size were correlated due to their genotype and phenotype.

The average milk yield/day of 3.43-5.81litres in this study were comparable to average yield of 3.9 kg, when different forage legume were supplemented (Juma *et al.*, 2006) to lactating Jersey cows. Ehoche *et al.* (2001) have reported average milk off take of 0.76 - 1.25kg when Bunaji cows were supplemented with 3.0 kg of groundnut haulms in the dry season.

The reason for the low milk yield from cows fed 25 and 75% groundnut haulms is not clear, inspite the addition of molasses to make them isoenergetic. Although, Metabolizable energy content of diet at 25% level of goundnut haulms was least. Muia *et al.* (2002) reported when concentrate for lactating goats were replaced with legume *Flemingia (Flemingia Macrophylla* and Jack fruit (*Artocarpius heterophyllus*) at 0, 20, 40, 60, and 80%, there was a decreased milk yield with increasing levels of replacement which was attributed to the attendant low dietary energy intake. Muinga *et al.* (1995) noted that the addition of 1 kg of energy concentrate (Maize brain) to stall fed cows significantly

increased milk yield by 1kg over and above 5.5kg milk production daily by animals fed 2kg *Leucaena* supplement.

The non significant difference in milk yield at the first 14th day in milk, revealed that replacing concentrate diets with groundnut haulms up to 75% stabilied milk yield. This agrees with the findings of Otchere, (1986) and (Ehoche *et al*. 2001). However, the steep fall in milk production at the 96th DIM generally showed that milk yield is higher at early stage. This suggests that nutrient utilization is likely shifted from milk production to fat deposition and tissues growth at mid and late lactation stage.

5.2.5 Milk composition

The non significant difference in milk protein concentrate is in conformity with the report of Mooney and Allen (1997); Ariel (1998) and Barje (2007), when whole cotton seed were fed to lactating cows. The milk protein concentration of 4.31, 4.34, 4.27 and 4.29% for 0, 25, 50, and 75% groundnut haulms levels were higher than 3.5 - 3.7% reported by Ehoche *et al.* (2001) when 3.0kg of groundnut haulms was supplemented to Bunaji cows, but slightly lower than 5.1- 6.8% reported by Barje (2006) when whole cottonseed were fed at varying levels to Friesian x Bunaji and Bunaji heifer. This is probably due to the overall ruminal feed protein degradation and microbial protein synthesis as reported by Ariel (1998). The declined of milk fat in the experimental diets with increasing groundnut haulms level did not depress milk protein.

Milk fat significantly increased with increase in the levels of groundnut haulms and recorded a higher value (4.25%) at 75% compared with 4.09% for 0% groundnut haulms level. This was opposite of the dietary fat which decreased with increasing level of groundnut haulms in concentrate diets. Although the values obtained were similar to values

reported by Barje (2006) and Ehoche *et al*. (2001) of between (4.0 – 4.8%) in cotton seed and groundnut haulms supplemented to Friesian x Bunaji and Bunaji cows respectively. Modification of milk fat could have been due to the presence of acetate, butyrate long - chain fatty acids accrued from high fibre of groundnut haulms and gamba intake. During the first phase of lactation, the animal had low fat averaged 3.6-3.7% across treatment. However, at the 96^{th} day, milk fat increased to 4.73 - 4.78% when milk yield dropped across treatments. The low fat at first stage of lactation is expected due to the normal negative energy balance experienced by lactating animals at the early stage of lactation (De Vries and Veerkamp, 2000).

The significantly higher lactose concentration at 0% groundnut haulms in relation to other dietary treatments was a reflection of the energy content of the concentrate diets. Although the metabolizable energy content of diets were isocaloric, the slightly higher ME at 0% groundnut haulms was enough to cause a significant difference in lactose concentration. In the same way, the significantly low metabolizable energy observed at 25% groundnut haulms resulted to a significantly lower lactose concentration in milk yield. The lactose concentrations of 3.59 - 3.80% in this study, were similar to 3.8% lactose in goats (Payne 1990), but lower than 4.6 - 4.9% for cows reported by Wilson (1984)

The significant difference in lactose, Total solids and Solid-not-fat disagree with the report of Mooney and Allen (1997) and Barje (2006) when cottonseed was offered to Friesian x Bunaji cows. They concluded from their studies that effect of breed on milk composition is not significant. The average value of total solids (13.42-13.73%) and Solid - not- fat (9.32-9.61%) were higher than (9.3-10.6%) and (5.2-6.6%) reported by Barje (2007) in cotton seed supplemented Friesian x Bunaji cows, but slightly higher than 12.4-

13.1% for total solids and 8.1-12.4-8.8% for Solid-not-fat respectively reported by Ehoche *et al*. (2001) when 3.0kg groundnut haulms was supplemented to lactating Bunaji cows.

5.2.6 Cost- benefit analysis

The concentrate cost both in Naira and Naira per kilogram had an inverse trend which reduced with increasing levels of groundnut haulms in concentrate diet. This indicated that cost of feed is reduced with increasing level of groundnut haulms in concentrate diet. Agyemang *et al*. (1998) reported 5 to 8 fold margin of milk yield over feed cost when some ground forage legumes were used to supplement Bunaji cows. Ehoche *et al*. (2001) reported a higher net economic benefit in animals dewormed and supplemented with groundnut haulms. Feed cost per unit output in this study significantly favoured cows fed 50% groundnut haulms in concentrate. This is attributed to its ability to improve both milk yield and gain respectively when compared with those at 0, 25 and 75% levels of groundnut haulms. Concentrate cost per unit output was higher in animals with 25% groundnut haulms in their diets and lowest when 50% groundnut haulms level was fed. Values of gain were higher at 25% level of groundnut haulms but similar to the animals fed 75% level of groundnut haulms in diet. Conversely the milk values and total value of output were higher for animals fed 25 and 75% levels of groundnut haulms in concentrate diets.

The cost-benefit analysis result showed a positive profit when groundnut haulms was fed in concentrate diet to Friesian x Bunaji at varying levels based on the current market price. Cows fed 75% levels of groundnut haulms had the lowest concentrate cost per kilogram. The slightly higher net benefit value at 50% groundnut haulms is most likely a reflection of the total value of output accruing from total gain and milk yield in animals.

High yielding animals lost weight, similarly, low yielding cows were compensated with gains. Animals fed 25 and 75% groundnut haulms had lower net benefit perhaps due to the significantly reduced milk recorded in these groups of animals.

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

- Inclusion of groundnut haulms in concentrate diets up to 75% could influence dry matter, organic matter, Neutral detergent fibre and Acid detergent fibre digestibility.
- Feeding concentrate diet containing groundnut haulms at 25% improved dry matter intake and efficiency of concentrate utilization in Friesian x Bunaji heifers by 9.65%.
- Feeding concentrate diets containing groundnut haulms up to 75% could not promote growth of Friesian x Buanaji heifers although, liveweight of lactating was improved at 25% by 225%.
- Replacing concentrate diets with groundnut haulms up to 75% boosted Red blood cells of Friesian x Bunaji heifers by 2.18% ($x10^6$).
- Feeding concentrate diet containing graded levels of groundnut haulm at 50% in Friesian x Bunaji heifers promoted onset of puberty of Frisian x Bunaji heifers at much more younger ages by 3 months.
- Inclusion of groundnut haulms at 50% in the concentrate diets of Friesian x Bunaji lactating cows grazing on gamba dry forage could improve average daily milk yield by 2.0 -2.18L/day over those at 25 and 75%.
- Feeding concentrate diet containing graded levels of groundnut haulm up to 75% in lactating Friesian x Bunaji cows may increase milk fat and Total Solids; on the

contrary, Total solid (TS), milk protein and Solid-not-fat declined when groundnut haulms level in concentrate diets reached 75%.

- Inclusion of groundnut haulms in concentrate diets of Friesian x Bunaji heifers and lactating cows reduced their Feed cost/kg and Total feed cost by ₦ 4.34/kg, ₦ 29,753.4 and ₦ 4.34/kg, ₦ 3929 respectively, with prospect of increasing the income of smallholder dairy farmers at 50% by ₦ 1013.

6.1 Recommendations

- To enhance onset of puberty, reduce cost of cattle feeds, improve milk yield of lactating cows as well as increase the income of smallholder farmers, groundnut haulms could replace concentrate diets up to 50%.

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APPENDICES

APPENDIX I: Effect of sampling time on rumen metabolites in Friesian x Bunaji heifers

	Sampling time of rumen metabolites in hours					
Parameter	**0**	**2**	**4**	**8**	**SEM**	**LOS**
pH	7.04	7.11	6.97	7.03	0.06	Ns
Total Nitrogen (mg/100ml)	0.04^{b}	0.07^{a}	0.05^{ab}	0.05^{ab}	0.01	*
Ammonia (mg/100ml)	10.23	16.96	16.18	25.74	15.95	Ns
TVFA (Mmol/100ml)	48.64	64.45	75.30	65.03	15.92	Ns

Means within the same row bearing different superscripts differ significantly. LOS= Level of significance * =P<0.05; ns = No Significance

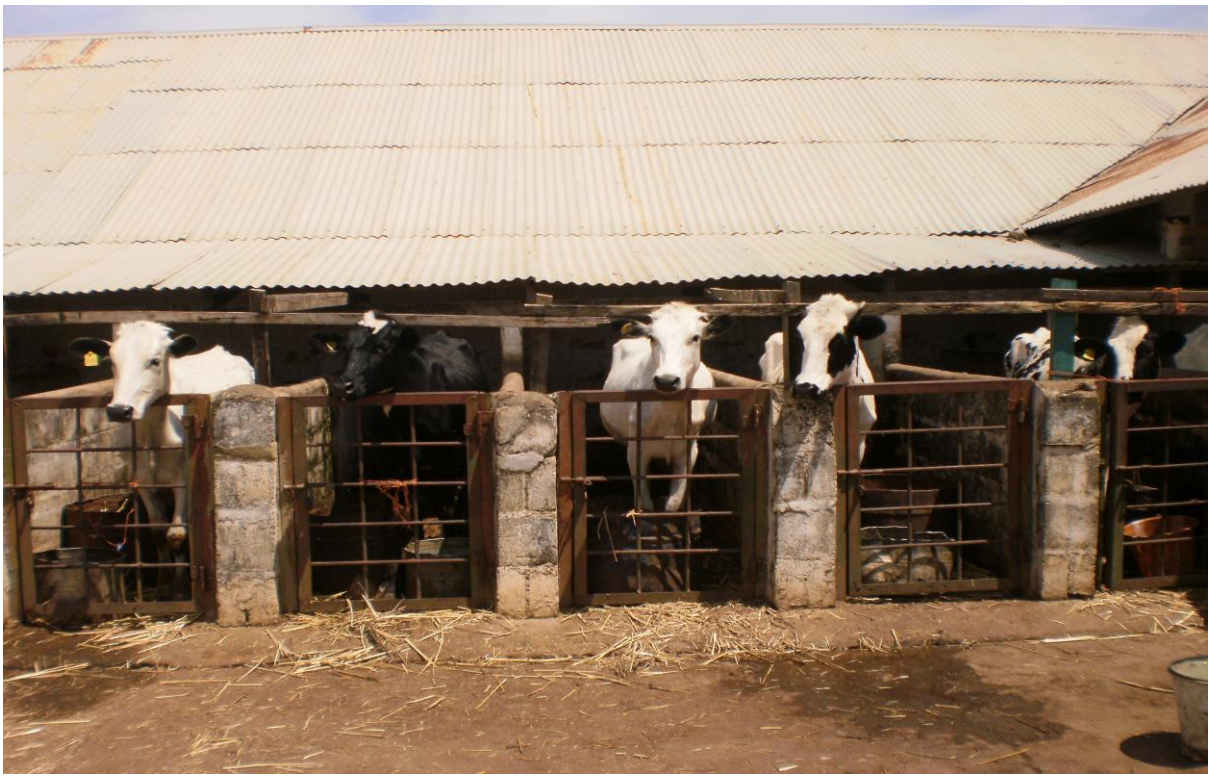
APPENDIX II: Effect sampling time on serum metabolites in Friesian × Bunaji heifers

	Sampling time on serum metabolites in hours					
Parameters	**0**	**2**	**4**	**8**	**SEM**	**LOS**
Serum Urea (Mmol/L)	4.41^{b}	7.20^{b}	7.28^{a}	5.97^{b}	1.40	*
Serum Creatinine (Mmol/L)	80.6	85.43	85.28	79.1	22.4	Ns
Serum glucose (Mmol/L)	3.74	3.08	3.25	3.59	0.44	Ns
Serum Protein (g/L)	85.1^{b}	84.0^{b}	86.04^{ab}	87.18^{a}	1.96	*

Means within the same row bearing different superscripts differ significantly. LOS= Level of significance *=P<0.05; ns = No Significance



Blood sample collection from the jugular vein



Friesian x Bunaji heifers fed concentrate diets containing varying levels of GH



Collecting the rumen fluid of heifers using the rumen liquor tube!

Rumen liquor, what is your pH?



Any difference in this lactating cow fed concentrate diet containing groundnut haulm?

APPENDIX III: Summary ANOVA for Effect of GH Supplementation on Nutrient Intake Digestibility And Nitrogen Balance in Friesian × Bunaji Heifers

SOURCE	DF	ErrDF	SS	ErrSS	MS
ErrDF	F.Value	Pr>F	LOS		
DMD	3	12	171.04	522.38	57.01
43.53	1.31	0.32	*		
DMD	3	12	220.48	711.77	73.49
59.31	1.24	0.34	*		
CPD	3	12	212.57	687.40	70.86
57.28	1.24	0.34	NS		
CFD	3	12			
NFED	3	12	50.77	1,421.08	16.79
118.42	0.14	0.93	*		
EED	3	12	633.71	2,951.51	224.57
245.96	0.91	0.46	*		
NDFD	3	12	136.68	825.23	45.56
68.77	0.66	0.59	*		
ADFD	3	12	230.58	701.18	76.86
58.43	1.32	0.315	*		
H/CD	3	12	710.94	1,502.50	236.98
125.21	1.89	0.18	*		
ASHD	3	12	777.16	1,623.25	259.05
135.27	1.92	0.181	*		
N_2 intake	3	12	845.36	1,245.87	281.79
103.82	2.71	0.09	*		
N_2 Absorbed	3	12	624.21	1,386.28	208.07
115.52	1.80	0.20	NS		
N_2 Balance (g/d)	3	12	575.51	1,132.94	191.84
94.41	2.03	0.16	NS		

N_2 Balance (%)	3	12		124.39	551.71	41.46
45.98	0.90		0.47	NS		

DF=Degree of freedom, SS=Sum of Square, MS=Mean sum of square, Err=Error, Pr>F=Probability Level, NS=Non significant (P<0.05), ***= Significant = (P<0.01)

APPENDIX IV: Summary ANOVA for the effect of GH supplementation on intake gain and cost analysis on Friesian × Bunaji heifers

SOURCE	**DF**	**ErrDF**		**SS**	**ErrSS**	**MS**
ErrDF	**F.Value**		**Pr>F**	**LOS**		
DMI (kg/d)	3	16		1.64	2.51	0.346
0.157	3.48		0.05	*		
DMI (kg/100kg)	3	16		2.03	3.17	0.68
0.20	3.41		0.04	*		
DMI (2/kg$W^{0.75}$)	3	16		132.56	266.28	44.19
16.64	2.65		0.08	*		
Initial weight	3	16		89.35	3,601.20	29.78
225.08	0.13		0.94	NS		
Final weight	3	16		127.30	5,109.20	424.33
319.33	1.33		0.030	*		
ADG	3	16		0.145	0.291	0.048
0.018	2.65		0.08	*		
FCE	3	16		126.58	632.15	42.19
39.51	1.07		0.39	*		
FEED COST	3	16		758.57	0.00	253.86
0.00	INFTY		<0.0001	*		
Total Feed Cost/kg	3	16		4.32×10^{8}	2.1×10^{8}	1.44×10^{8}
1.3×10^{6}	109.76		<0.0001	*		
FEED COST GAIN	3	16		58.108.76	216,518.99	19,369.59
13,532.44	1.43		0.27	*		

NET BENEFIT	3	16

DF=Degree of freedom, SS=Sum of Square, MS=Mean sum of square, Err=Error, Pr>F=Probability Level, NS=Non significant (P<0.05), ***= Significant = (P<0.01)

APPENDIX V: Summary ANOVA for the effect of GH supplementation on rumen parameters

SOURCE	DF	ErrDF	SS	ErrSS	MS
ErrDF	F Value	Pr>F	LOS		
pH					
0	3	16	0.213	1.173	0.071
0.073	0.97	0.43	NS		
2	3	16	0.564	0.820	0.188
0.051	3.67	0.035	*		
4	3	16	0.251	1.396	0.08
0.087	0.96	0.435	NS		
8	3	16	0.270	0.878	0.09
0.05	1.64	0.22	*		
Total N_2					
0	3	16	0.0003	0.001	0.0001
0.0000	1.74	0.198	NS		
2	3	16	0.027	0.130	0.009
0.008	1.10	0.379	NS		
4	3	16	0.001	0.002	0.0002
0.0001	1.69	0.209	NS		
8	3	16	0.0000	0.0003	0.00003
0.00002	1.56	0.2373	*		
NH_3-N_2					
0	3	16	13.224	67.912	4.408
4.245	1.04	0.402	NS		
2	3	16	53.248	652.03	17.749
40.75	0.44	0.731	NS		
4	3	16	90.79	528.44	30.26
33.03	0.92	0.455	NS		
8	3	16	257.55	2,835.70	85.85
177.23	0.48	0.698	NS		
TVFA					
0	3	16	586.14	1,434.80	195.38
89.675	2.18	0.13	*		
2	3	16	50,288.15	285,499.3	16,762.72
17,843.71	0.94	0.44	NS		

4		3	16	401.85	2023.60	133.95	
	126.48	1.06	0.394	NS			
8		3	16	414.54	3312.7 1	38.18	
	207.04	0.67	0.584	NS			

DF=Degree of freedom, SS=Sum of Square, MS=Mean sum of square, Err=Error, Pr>F=Probability Level, NS=Non significant (P<0.05),

***= Significant (P<0.01)

APPENDIX VI: Summary ANOVA for the effect of GH supplementation on serum metabolites of Friesian×Bunaji heifers

SOURCE	DF	ErrDF	SS	ErrSS	MS
ErrDF	F.Value	Pr>F	LOS		
UREA					
0	3	16	33.82	40.68	11.27
2.54	4.43	0.02	*		
2	3	16	21.66	263.17	7.22
16.45	0.44	0.73	NS		
4	3	16	19.68	171.14	6.54
10.70	0.61	0.62	NS		
8	3	16	26.6	267.88	8.87
16.74	0.53	0.66	NS		
CREATININE					
0	3	16	496.00	3,025.8	165.33
189.11	0.87	0.48	NS		
2	3	16	1,897.43	9,303.7	632.17
581.48	1.09	0.383	NS		
4	3	16	579.54	4,669.2	193.18
291.83	0.66	0.59	NS		
8	3	16	1,440.20	7,975.60	480.07
498.47	0.96	0.43	NS		
GLUCOSE					
0	3	16	2.30	2.01	0.83
0.18	4.69	0.02	*		
2	3	16	1.47	1.66	0.49
0.10	4.72	0.02	*		
4	3	16	78.72	180.27	26.24
11.27	2.33	0.11	NS		
8	3	16	67.84	166.21	22.61
10.39	2.18	0.13	NS		
PROTEIN					
0	3	16	8.095	214.47	2.698
14.298	0.19	0.902	NS		
2	3	16	137.27	282.59	45.76
17.66	2.59	0.089	NS		

4		3	16		78.72		180.27	26.24
	11.27	2.27		0.11		NS		
8		3	16		67.84		166.21	22.61
	10.39	2.18		0.13		NS		

DF=Degree of freedom, SS=Sum of Square, MS=Mean sum of square, Err=Error, Pr>F=Probability Level, NS=Non significant, (P<0.05)= Significant, ***Significant at (P<0.01)

APPENDIX VII: Summary ANOVA for the effect of GH supplementation on haematological changes and progesterone in Friesian × Bunajiheifers

SOURCE	DF	ErrDF	SS	ErrSS	MS	ErrDF	F.Value	Pr>F	LOS
RBC	3	16	12.23	17.06	4.08	1.07	3.83	0.031	*
PVC	3	16	39.35	149.20	13.12	9.83	1.41	0.28	NS
Hb	3	16	4.05	16.12	1.35	1.01	1.34	0.30	NS
D14 P4	3	16	3.09	22.47	1.03	1.40	0.73	0.55	*
D28 P4	3	16	7.78	44.15	2.59	2.76	0.94	0.44	NS
D42 P4	3	16	35.72	199.57	11.91	12.47	0.95	0.49	NS
D36 P4	3	16	52.44	338.12	17.48	21.13	0.83	0.49	NS
D70 P4	3	16	9.76	47.22	3.25	2.95	1.10	0.38	NS
D84 P4	3	16	5.90	38.03	1.97	2.38	0.83	0.50	NS

DF=Degree of freedom, SS=Sum of Square, MS=Mean sum of square, Err=Error, Pr>F=Probability Level, NS=Non significant (P<0.05), ***= Significant (P<0.01)

APPENDIX VIII: Summary ANOVA for the effect of groundnut haulmssupplementation on milk yield and milk composition ofFriesian× Bunaji cows

SOURCE	DF	ErrDF	SS	ErrSS	MS
ErrDF	**F.Value**	**Pr>F**	**LOS**		
GAIN	3	16	185.80	1,954.00	61.93
122.13	0.51	0.68	*		
MILK YEILD	3	16	214,445.66	1,081,194.87	71,481.89
67,574.68	0.51	0.68	*		
TOTAL OUTPUT	3	16	145,135.08	1,116,179.10	48,378.36
69,761.19	0.69	0.57	*		
VAL.OUTPUT	3	16	5,564,519.48	85,324,634.13	1,854,839.83
5,332,789.63	0.35	0.79	NS		
FEED COST	3	16	221.01	0.00	73.67
0.00	infinity	<0.0001	*		
NET BENEFIT	3	16	186,627,712	7,580,932,500	622,092,237
473,808,281	0.13	0.94	NS		
F.COST OUTPUT	3	16	2,306.45	11,727.69	768.82
732.98	1.05	0.40	*		

DF=Degree of freedom, SS=Sum of Square, MS=Mean sum of square, Err=Error, Pr>F=Probability Level, NS=Non significant (P<0.05), ***= Significant (P<0.01)

APPENDIX IX: Summary ANOVA for the effect of GH supplementation on milk yield and milk composition of Friesian × Bunaji cows

SOURCE	DF	ErrDF	SS	ErrSS	MS
ErrDF	F.Value	Pr>F	LOS		
MILK COMPOSITION					
LIPID	3	16	0.22	7.73	0.07
0.21	0.35	0.74	*		
N PROTEIN	3	16	0.27	12.84	0.09
0.36	0.25	0.51	ns		
LACTOSE	3	16	4.16	2.81	1.39
0.08	4.47	0.79	*		
TOTAL SOLID	3	16	1.52	1.94	0.51
0.05	9.38	0.47	*		
SOLID NOT FAT	3	16	37.54	45.06	12.51
1.25	10.00	1.87	*		
SERUM METABOLITE					
LACTOSE	3	16	0.23	2.16	0.08
0.18	0.43	0.11	NS		
PROTEIN	3	16	26.38	45.95	8.79
3.83	2.30	0.49	NS		
UREA	3	16	17.98	23.97	5.99
1.99	3.00	0.35	NS		
CREATINE	3	16	851.18	602.30	283.73
501.93	0.505	5.60	NS		
SERUM P4	3	16	11.47	20.23	3.82
0.84	4.55	0.12	*		
F.COST OUTPUT	3	16	2,306.45	11,727.69	768.82
732.98	1.05	0.40	*		
MILK COMPOSITION					
LIPID	3	16	0.22	7.73	0.07
0.21	0.35	0.74	*		
N PROTEIN	3	16	0.27	12.84	0.09
0.36	0.25	0.51	NS		
LACTOSE	3	16	4.16	2.81	1.39
0.08	4.47	0.79	*		
TOTAL SOLID	3	16	1.52	1.94	0.51
0.05	9.38	0.47	*		
SOLID NOT FAT	3	16	37.54	45.06	12.51
1.25	10.00	0.87	*		

SERUM METABOLITES

LACTOSE	3	16	0.23	2.16	0.08	
0.18	0.43	0.11	NS			
PROTEIN	3	16	26.38	45.95	8.79	
3.83	2.30	0.49	NS			
UREA	3	16	17.98	23.97	5.99	
1.99	3.00	0.35	NS			
Creatinine	3	16	851.18	60.23	283.73	
501.93	0.57	5.60	NS			
SERUM P_4	3	16	11.47	20.23	3.82	
0.84	4.55	0.12	*			

DF=Degree of freedom, SS=Sum of Square, MS=Mean sum of square, Err=Error, Pr>F=Probability Level, NS=Non significant (P<0.05), ***= Significant (P<0.01)