GROWTH AND FATTENING PERFORMANCE OF YANKASA RAMS FED COMPLETE DIET CONTAINING UREA AND LIME TREATED GROUNDNUT SHELL (*Arachis hypogaea*) SHELL

BY

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DECLARATION

I hereby declared that the work in this thesis entitled **GROWTH AND FATTENING PERFORMANCE OF YANKASA RAMS FED COMPLETE DIETS CONTAINING UREA AND LIME TREATED GROUNDNUT SHELL (*Arachis hypogaea*) SHELL**

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CERTIFICATION

This thesis entitled **GROWTH AND FATTENING PERFORMANCE OF YANKASA RAMS FED COMPLETE DIETS CONTAINING UREA AND LIME TREATED GROUNDNUT SHELL (*Arachis hypogaea*) SHELL** by Muhammad Dogon kade BELLO meets the regulation governing the award of the degree of Doctor of Philosophy in Animal Science of the Ahmadu Bello University and is approved for its contribution to knowledge and literary presentation.

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DEDICATION

This Thesis is dedicated to the Almighty Allah, my families and well wishers.

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CHAPTER FIVE

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LIST OF ABBREVIATIONS

ADF = Acid Detergent Fibre
ANOVA=Analysis Of Varience
AOAC= Association of Official Analytical Chemist
BUN=Blood Urea Nitrogen
CF=Crude Fibre
CP=Crude Protein
CRD= Completely Randomized Design
CSC=Cotton Seed Cake
DHCC= Dihydroxycholecalcifeferol
DM=Dry Matter
DP= Dressing Percentage
EE=Ether Extract
FAO= Food and Agricultural Organization
GDP=Gross Domestic Product
GIT=Gastro-Intestinal Tract
GPS= Geo-Positioning System
GNC=Groundnut Cake
HCN= Hydrogencynides
Kg=Kilogram
LTGNS=Lime Treated Groundnut Shell
NAPRI=National Animal Production Research Institute
NE=Net Energy
NDF=Neutral Detergent Fibre
NFE= Nitrogen Free Extract
NPN = Non Protein Nitrogenous
PICS =Persue Cowpea Improved Sacks
SIADH =Syndrome of Inappropriate Antidiuretic Hormone
TP=Total Protein
ULTGNS= Urea Lime Treated Groundnut Shell
UNTGNS=Un Treated Groundnut Shell
UTGNS=Urea Treated Groundnut Shell
VFA=Volatile Fatty Acid

ABSTRACT

Two studies were conducted to determine growth and fattening performance of Yankasa rams fed complete containing urea and lime treated groundnut (*Arachis hypogaea*) shell. The shell was treated with 5% urea, 5% lime and 2.5% of urea and lime for each known weight of the shell (50g/kg shell). In the first study four treatment diets were formulated containing 40% untreated groundnut shell (UNTGNS), 40% urea treated groundnut shell (UTGNS), 40% lime treated groundnut shell (LTGNS) and 40% urea plus lime treated groundnut shell (ULMTGNS). Other ingredients were maize offal, cotton seed cake, bone meal ruminants' premix and salt. 20 Yankasa ram lambs of 9-10 months were used and randomly assigned to the four treatments diets with five animals per treatment in completely randomized design (CRD). The diets were formulated to contain 15% crude protein (CP) content. The growth trial lasted for 90 days. Three ram lambs from each of the treatment groups were randomly selected and housed in individual metabolism crates for digestibility Parameters measured were daily feed intake, daily weight gain; feed conversion ratio, blood metabolites digestibility, nitrogen retention, cost and apparent profit. Second study was conducted to determine effect of the treated groundnut (*Arachis hypogaea*) shell in fattening Yankasa rams. The treatment diets were adjusted to 14% C P content. Sixteen Yankasa rams were used and randomly assigned to the four treatment diets with four animals per treatment in a completely randomized design (CRD). The fattening trial lasted for 90 days. Three rams from each of the treatment groups were randomly selected and housed in individual metabolism crates for digestibility study. Rumen liquor was collected. Carcass analysis was carried out using three rams from each of the treatment group. Measured parameters were feed intake, weight gain, digestibility, nitrogen balance, rumen microbial load, total nitrogen, ammonia nitrogen, total volatile fatty acid, carcass characteristics and cost benefit. Results of the first study indicated that ram lambs fed ULMTGNS diet had the highest daily feed intake of 88.69g/day. However highest daily weight gain (94.66g) was observed in ram lambs fed LTGNS diet with least in ram lambs on UTGNS. In feed conversion ratio ram lambs on LTGNS diet had the least mean values (8.94) and were significantly ($P<0.05$) different from those on UTGNS and ULMTGNS diets. Ram lambs on UTGNSU diet showed better digestibility coefficient among the treatment diets (49.99%). Blood urea nitrogen (BUN) was higher than normal values reported by other authors (2.8-7.1Mmol/L). Creatinine range of (123.17-150.00Mmol/L) across the treatment diets was in conformity with the normal value (106-168Mmol/L). Total protein was within the range of the normal values (60-79g/L). The result of nitrogen intake was significantly ($P<0.05$) higher in rams lambs fed ULMTGNS diet compared with the other treatment groups. Nitrogen retained as percent intake was significantly ($P<0.05$) higher in the UTGNS, LTGNS and ULMTGNS diets than the UNTGNS. Results of the economic analysis of growing ram lambs showed that ram lambs on LTGNS diet had the highest feed cost (₦5142.43) and those on ULMTGNS diet had the highest total weight gain (8.58Kg), followed by those fed LTGNS diet but a better apparent profit was realized from ram lambs fed UNTGNS diet (N1774.50). The results of the second study showed that rams fed UNTGNS diet had the highest daily dry matter intake (1027.37g) with least mean value in those on UTGNS. Rams fed UTGNS had the least daily weight gain (77.78g) rams on UNTGNS diet still had the highest daily weight gain. Feed conversion ratio was least but better in rams fed UNTGNS diet. Rams on UTGNSU diet had the highest digestibility coefficient in most of the feed components. Highest nitrogen absorbed and N retained as % intake were recorded in rams fed UNTGNS and ULMTGNS diets. Higher ammonia nitrogen and total volatile fatty acids were observed in rams fed UNTGNS diet. On rumen microbial load, more bacteria were observed in animals fed UTGNS diet followed by those on UNTGNS diet. The dressing percentage of the rams fed UNTGNS diet (53%) was higher followed by those on LTGNS diet. But the meat yield percentage was higher in rams fed LTGNS diet, with a better meat bone ratio in rams on ULMTGNS diet. Results of the studies showed that daily feed intake and weight gain were better in growing ram lambs fed LTGNS diet, but for fattening, rams on UNTGNS diet had the better daily intake and daily weight gain. However, the cost benefit analysis of both the growing and fattening rams showed that rams on UNTGNS diet had the highest apparent profit followed by those on urea treated diet. It can be concluded that ground shell of groundnut can be used in diet formulation of small ruminants. Inclusion of up to 40% is recommended.

CHAPTER ONE

1.0 INTRODUCTION

Bourn *et al*. (2002) estimated Nigerian ruminants livestock population to be about13.9 million cattle, 22.1 million of sheep and 34.5million goats. FAO (2016) reported about 15.2 million cattle, 28 million goats, 23 million sheep in Nigeria. In spite of these impressive statistics on sheep and goat, their potentials are not fully realized due to low productivity, high mortality, low growth rate, low productive performance among others (Mahadi, 2002).

Sheep are able to use marginal lands and crop residues as feed and are kept in Nigeria mainly for meat (Bello, 2008). They are ranked second after cattle in terms of meat production (FDLPCS, 1992). FAO (2016) reported sheep to contribute 16% of the total domestically produced meat in Nigeria. Of the four breeds of sheep in Nigeria, Yankasa sheep are perhaps the most widely and most numerous breed in the Northern part of the country, they are found in the Sahel, Sudan and Guinea Savannah zones of the Country (Gefu, 2002).

Increasing demand for rams and bucks as slaughter animals for meat can be satisfied through fattening. The primary objective of fattening is to increase the live weight of the animal and the quality of meat in relatively shorter period (Osuhor, 2002). Animal for fattening is confined while feeds and water are *ad-libitum* throughout the fattening period, though it can be achieved in a semi-intensive system, where they are offered more feed supplements than the rest of the flock before or after released for grazing.

Feed is one of the important factors that limit livestock production in the tropics especially during the dry season when high quality forages are scarce (Adebowale and Taiwo, 1996). The cost of livestock feeds and feed ingredients in recent years has increased tremendously. Hence, the cost of feeding has become a major problem of livestock production in the developing countries. Aduku (1993) reported cost of feed to account for about 70% of the total cost of animal production. This therefore necessitates the need and interest in exploring neglected or underutilized feedstuff materials, such as groundnut shells which are left after the groundnut was processed and are very much available in the north western zone of the country. Several researches (Abdul Hamid, 2013; Adamu, 2015) were conducted in this area, however, not much has been done in evaluating nutritive potentials of groundnut shell in the diet of sheep in attempt to reduce the cost of sheep production.

Groundnut shell is the residue of crop specie called *Arachis hypogaea*, a specie in the legume or ‘bean’ family (*Fabaceae*). The crop is known with many other names such as groundnut, peanut, monkey nut, earthnut, goober nut and pygmy nut. Groundnut (*Arachis hypogaea L.*) is among the important crops grown in Sub-Saharan Africa (Nigam *et al.*, 1991). Grown either as sole crop or mixed with other crops. It provides both high quality nuts for human consumption as well as high quality fodder for livestock. An important oil seed crop in Nigeria, grown widely in the Tropics and Sub-tropics (Ehlers and Hall, 1997). Desire *et al*. (2010) reported groundnut to have ability to grow even in sandy soils and is legume of high nutritive value as well as being a source of edible oil. The fruit is a pod with one to five seeds that develops underground within a needle-like structure called a peg. The seeds are rich in oil, 38-50 protein, calcium, potassium, phosphorous, magnesium and vitamins (Adamu, 2015)

Jumia (2012) reported groundnut shell to have dry matter content to about 90.3% of which 4.8-7.2 is crude protein, 1.0-1.1% is crude fat and 65.7-79.3% is cellulose and lignin. Carbohydrate is 10.6-21.2%, crude ash is 1.9-4.6%, calcium is 0.24%, and phosphorus is 0.08-0.09%. The dry matter per kilogram contains digestible energy of 4.605-5.108 KJ for cow, 4.438-4.898 KJ for sheep, including digestible protein as 15-17grams/Kg. The shell also contains vitamins and part of the amino acids after microbial process.

Groundnut shells were reported to contain 65.7% cellulose, 21.2% carbohydrates, 7.3% protein, 4.5% minerals and 1.2% lipids, since the processed shells from shelling machines contain bits and skins of nuts, the actual protein and lipid contents of this waste material are probably much higher (Abdur-Razak *et al.*, 2014).

1.1 Justification of the Study

Utilization of crop residues as animal feed ingredients is attracting intense research focus and interest to many researchers (Abdul Hamid, 2013; Adamu, 2015), as conventional feedstuff remained unaffordable to low income farmers because of the cost (Bello, 2008). The problem of feed cost raised the need to search for alternative feed sources that can economically supplement the conventional feed ingredients used in ration formulation without adverse effects on the health and performance of the animals. Groundnut shell is an agro-industrial by-product found in large quantities in areas where groundnut is produced and processed. Sub-Saharan region is one of the zones of groundnut production and processing, after the processing the shell is left in large quantity.

Information on the utilization of groundnut shell as ingredient for feeding ruminants such as sheep is very scarce. Most of the earlier researches conducted were on groundnut haulms (Malau-Aduli *et al.,* 2003 and Arslan, 2005). The residue is left in the processing area after the seed had had being removed, constituting environmental problem. It sometimes results to environmental hazard as it blocks drainage in over flooding. It takes longer period for the shell to decompose; farmers therefore do not appreciate it as compost manure. While burning it may lead to air pollution, increasing atmospheric temperature that adds to the global warming. Jumia (2012) suggested microbial fermentation, if groundnut shell is to be incorporated into feed. In fermentation the shell be crushed first and stewed, at 60^0C or so, add 1% of dry yeast powder and decomposing bacteria to fermentation pool. Utilization of groundnut shell in the diet of ruminant animals will not only reduce cost of production but also helps in reducing its negative environmental impact.

1.2 Objectives of the Study

The general objective of the study was to:

Investigate the effect of urea and lime treated groundnut shell in complete diet fed to growing and fattening Yankasa rams.

The specific objectives were to determine:

1. Nutrients digestibility and retention of growing and fattening Yankasa rams fed complete diet containing urea and lime treated groundnut shell.

2. Performance of growing and fattenineg Yankasa rams fed complete diet containing urea and lime treated groundnut shell.

3. Rumen characteristics of the fattening Yankasa rams fed complete diet containing urea and lime treated groundnut shell.

4. Carcass characteristics of fattening Yankasa rams fed complete diet containing urea and lime treated groundnut shell.

5. Determine cost benefit of using complete diet containing urea and lime treated groundnut shell of growing and fattening Yankasa rams

1.3 Hypotheses:

Ho: Urea and lime treated groundnut shell in a complete diet has no effect on growing and fattening Yankasa rams.

Ha: Urea and lime treated groundnut shell in a complete diet has effect on the growth and fattening performance of Yankasa rams.

Ho: Urea and lime treated groundnut shell in a complete diet has no effect on digestibility and carcass characteristics of fattening Yankasa rams.

Ha: Urea and lime treated groundnut shell in a complete diet has effect on digestibility and carcass characteristics of fattening Yankasa rams.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Origin, Distribution and Population of Small ruminants in Nigeria

2.1.1 Origin and distribution

Sheep belong to the class *Caprini* of the family *Bovidae* in sub order *Ruminantia* of the order *Artiodactyla*. The wild ancestors of the domestic sheep live in the mountains and upland steppes of western Asia. The moderate climate and short grass rangeland (relatively free of bush and trees) provided them with an ideal habit (Devendra and McLeroy, 1982). The earliest domestic sheep introduced into interior Africa are the long-legged hairy type. They were forced out of Egypt by the fat-tailed coarse wool sheep (Payne and Wilson, 1999). The long-tailed sheep spread to the west coast where they developed into smaller hairy sheep which were well adapted to the higher rainfall areas (Devendra and McLeroy, 1982). Another migratory way of the long-legged sheep is through Sudan, where they managed their way to the countries bordering the Sahara.

The Fat-rumpled sheep introduced from Arab countries spread to Ethiopia, Somalia, Kenya and Tanzania (Gatemby and Humbert, 1991). It has been also said that the fat-sampled sheep originated from East Africa. An example is the black-headed Persian, which probably originated from East Africa. Sheep adapted to the humid environment of the tropics are smaller in size compared to those adapted to the drier zones (Devendra and McLeroy, 1982).

2.1.2 Population

Population of small ruminants in Nigeria was estimated to be about 22.1 million sheep and 34.5 million goats (FDLPCS, 1992). FAO (2016) reported about 15.2 million cattle, 28 million goats, and 23 million sheep in Nigeria. Sheep and goats are fairly well distributed throughout Nigeria, but the areas of highest density are in Kano, Sokoto, Borno, Kaduna, Zamfara and Katsina states. Africa has a population of 206 million sheep and 172 million goats which represent approximately 19 and 29% of the world total, respectively (Bello, 2008)

2.2 Importance of Small ruminants in Nigeria

Livestock production is important in Nigeria. It is next to crop within the agricultural sectors as net producer of goods and services contributing over 5.9% of the agricultural components of the GDP (Kallah, 2004). Animal production is an important sector of the national economy and is crucial in ensuring food security. Nigeria has the largest population of livestock in West Africa, of which sheep constitutes 22.1 million (FDLPC, 1992). Sheep are widely distributed throughout Nigeria with about quarters of the population concentrated in the north (Oni, 2002).

2.2.1 Source of meat

Livestock have been for ages produced to meet the animal protein requirement of man and other benefits they provide to farmers and national economy (Bamaiyi, 2013). The potentials of small ruminants as a major source of meat hinges on their comparative advantage over cattle, due to their lower feed requirement and are found more with poor farmers being able to thrive more than cattle in wide ecological zones of the country. In Nigeria sheep are kept mainly for meat production (Bello, 2007).

FAO (2016) reported that sheep contribute 16% of the total domestically produced meat in Nigeria which, together with goats, was estimated at 813,000 tonnes per annum. Sheep also supply milk for self-consumption (Gefu and Adu, 1984). Their ability of utilizing marginal lands and converting poor fodder to high protein food, their fecundity and short generation interval, their ability to fix into all agricultural systems, and the increasing demand for mutton place sheep in a unique position. In Nigeria, sheep and goats are kept primarily for meat production. They contribute about 35 per cent to the total meat supply in Nigeria (Oni, 2002).

2.2.2 Religious, social and cultural use in festival

Kyiogwom *et al.* (1996) reported that sheep rearing in Nigeria forms an integral part of the socio-cultural life of the people, contributing significantly to the nutrition, economic as well as the socio-cultural well-being of Nigerians. They feature prominently in socio-economic life of the people such as religious festivals. The rams in particular are favorite slaughter animals during Sallah, Christmas, naming and wedding festival at which time fattened rams command very high market prices (Adu, 1982). Sheep serve as currency in which social obligations are expressed (Rege, 1992). They are used as sacrificial animals in religious and cultural festivities (FDLPCS, 1992).

2.2.3 Source of manure

It has been shown that if properly harnessed, the faecal nitrogen released from sheep could make significant contributions to the fertility of soil (Powell *et al*., 1994). These benefits make sheep one of the most useful of the domesticated animal. Nutrient recycling is an essential component of any sustainable farming system. The integration of livestock and crops allows for efficient nutrient recycling. Sheep use the crop residues, such as cereal straws, as well as maize and sorghum stovers and groundnut haulms as feed. The manure produced can be recycled directly as fertilizer. One tonne of cow dung contains about 8 kg N. 4 kg P_2O_5 and 16 kg K_2O (Angé, 1994).

2.2.4 Important source of revenue

Livestock in general and sheep in particular, contribute to the stability of farm income, because they can be bought following good crop performance and sold following crop failures. Sheep therefore help to cushion farm enterprises against unstable commodity prices during unfavorable years (Rege, 1992). Sheep are important in small holder production systems because they require low initial capital and maintenance costs, and are able to be use marginal lands and crop residues. Sheep production in Nigeria is currently a subsidiary farm enterprise which adds to the diversity and presumably the stability of the economy.

A study in northern Nigeria revealed that among farm items sold, livestock and their products accounted for 56% and they are less season dependent and can therefore represent a dependable asset for emergency (Rege, 1992).

2.2.5 An investment opportunity

Lack of alternative investment opportunities in rural areas, likely promotes investment in livestock (Mrema and Rannobe, 1994). In the rural communities, sheep are used as a source of investment and this provides capital for other businesses outside agricultural (Gefu and Adu, 1984; Ademosun, 1989). Sheep also play an important role in food security during the long dry seasons in the Sahel and Sudan Savannah zones (Wilson, 1991). In addition to sheep and goats being kept for meat production, they are valuable source of cash for emergency fund for resource -poor man. Skins obtained from sheep and goats are very popular in international markets because of the very good quality leather into which they can be processed.

2.3 Breeds of Sheep in Nigeria

A breed is a collection of individuals within species which have a certain number of morphological and physiological characters which are passed into their progeny as long as they breed among themselves (Gefu, 2002). There are many breeds of sheep, but they are generally sub classed as wool, hairy, meat and dairy classes. Dual purpose breeds are breeds for both wool and meat. The major Nigerian breeds are mainly the hairy type and are four in number. The West African Dwarf Sheep, Balami, Uda and Yankasa. Other breeds which are of less importance include the Bororo and Ara-Ara and these are found in Niger and Anambra state. ((Wilson, 1991).

2.3.1 Balami

These breeds of sheep have also been called the Bororo at different times because they are associated with Borno tribe. Balami is the features. It is big predominantly white with a convex facial profile (Gefu, 2002). Ears are large and droopy; the tail is thin and long. Males have horn while females do not have horns. Mature males have dewlap. Balami is fast growing breed with some good potentials for milk production, a weaning weight of about 18kg and a yearling weight of 35-45kg for ewe and 45-60kg for rams (FDLPCS, 1992). The breeds have peculiar characteristics of surviving under arid conditions the features that enable them to be exploited in the utilization of non-arable land.

2.3.2 Uda

They are also called the Fulani or Bali-Bali. This breed is found throughout the Sahel and Savannah zones of tropical Africa. Their coat color is black or brown in front and white behind. They are large in size with mature male measuring up to 84cm height at withers. The breed is long legged thin and long tailed with moderately long floopy ears, male carrying horns which could be large emerging sideways and slightly backward with a toast (Devendra and McLeroy, 1982). The breed appears to thrive in hot, dry environments and suffers from poor survival outside its ecological zone. Because of its long legs, it is particularly adapted to extensive grazing and is renowned for its trekking abilities. Mature rams weight 55kg while females weight 45kg.

2.3.3 Yankasa

This is perhaps the most numerous and widely distributed Nigerian breed of sheep. Yankasa is found throughout the Sahel, Sudan and Guinea savannah zones. It is intermediate between large long legged Uda and Balami and short legged West African dwarf. Yankasa is also called ‘’Hausa breed’’ because Hausa tribe owns the breed in large numbers. In the north east, a particular strain of Yankasa called ‘’Biu’’ also exists (FDLPCS, 1992).

The breed has typical white coat colour with black patches around the ears, eyes and muzzles and sometimes the feet. Ewes may have patches around the neck. Yankasa are highly fertile. Birth weight is 2-3.5kg. Mature rams may weigh 30-45kg and ewe 25-45kg (FDLPCS, 1992).

2.3.4 West African Dwarf Sheep

These breeds are also called Fouta Djallon. Djoullonke is breed found in the whole area of the forest belt. The breed strives well in its area of occurrence which is known to be infected with Tsetse flies hence the assertion that, the breed is trypo-tolerant. Mature females have tassels while males have spiral or crescent shaped horns and heavy mane. Variations of this type of also found in areas such as the ‘’Pagan’’ sheep in Jos Plateau and Ummahia’’ sheep in eastern Nigeria (Loosli *et a.*, 1999).

The West African dwarf sheep is a small, compact and hardy breed with a wide range of coat colors which may be all white, black or brown or spotted black or brown on a white coat (Adu and Ngere, 1979). The breed has a slow growth rate of maturity and cessation of growth is between 18-24 months. The breed is highly prolific and incidence of twinning is high (55-58%). Mature female weigh 20-25kg and male 20-30kg.

2.3.5 Bororo

They are large long-legged breed of sheep said to have originated from Chad. It has white posterior and pendulous, white ears. Mature weight is between 45-55kg

2.4 Small Ruminants Production Systems in Nigeria

Small ruminant production system in Nigeria can be categorized into three, intensive, extensive and semi intensive (Gefu, 2002).

2.4.1 Extensive

It is the most predominant system practiced in the rural areas of Nigeria where animals are left to fend on themselves through scavenging and browsing available feeds in their areas. In those days the animals are not herded in the grazing areas during the day time, yet they return to their owners' home at the end of the day. Occasionally, they are supplemented with household wastes such as grain bran and other non-conventional feed-stuff. Housing is not provided especially when the animal's number is large. The system is characterized with poor management, feeding, record keeping and exposure to danger of transmissible diseases, but is less expensive and not laborious (Aribido, 2011).

2.4.2 Semi-Intensive

The system involves provision of housing and improved feeding where animals are served with feed after grazing in the day time. It combines the elements of extensive and intensive, so management system is better than extensive but less than intensive (Youdeowei *et al.*, 1999).

2.4.3 Intensive

In this system animals are confined and restricted from moving, but are housed, with provision of feed and water. The system is characterized with good management, feeding, record keeping and animal are not exposed to danger of transmissible diseases, but it is expensive and laborious (Payne and Wilson, 1999).

2 .5 Nutrients Requirements of Sheep

2.5.1 Energy

Energy makes up the largest portion of the diet and is usually the most limiting nutrient in sheep diets. Carbohydrates, fat, and excess protein in the diet all contribute towards fulfilling the energy requirements of sheep. Carbohydrates are the major sources of energy and concentrates may be of high protein. Forages contain fiber or cellulose, which is not as rich in energy as starch. Pasture, browse, hay, silage, and grains are the major sources of energy in a sheep's diet.

Energy requirement of sheep is mainly sourced from cereal carbohydrates, fats and to some extent protein. Other sources are pasture, browses and hay (Khan and Scott, 2005). The energy is utilized for maintenance and for production (Ledin, 2004 and Rhanjan, 2004). Energy shortage in the diets of sheep results in decreased production, reproductive failure, increased mortality and increased susceptibility to diseases and parasites.

Taylor (2004) has indicated that the low energy intake decreases fertility of ewes; lowers milk production and shortens lactation period; reduces wool production and increases vulnerability to parasitism. Poor quality pastures and roughages or inadequate amounts of feeds are the primary causes of energy deficiency (Diego, 1994). Chestworth (2006) noted that in order to survive, animals require a constant supply of energy to satisfy their needs for maintaining body functions and production. One of the main needs in sheep nutrition is to ensure the supply of energy to the animals is sufficient for its needs at all times. Other factors that affect energy requirement of sheep are climatic such as air temperature, wind velocity, humidity, wool length, stress and distance travelled during grazing (Banerjee, 2007).

The minimum energy requirement which does not permit any productive function is usually assumed to be constant, and is called the fasting heat production (or fasting metabolic rate) and it depends upon the size of the animal (McDonald *et al.*, 2002). The maintenance requirement for energy represents the sum of its fasting heat production (Gatemby and Humbert, 1991).

Energy for production is the amount of energy which exceeds the requirements for maintenance, and which leads to the process of production. The most obvious use of this extra energy is in growth, fattening, milk production and physical work (NRC, 1985; Diego, 1994; McDonald *et al.*, 2002; Khan and Scott, 2005 and Chestworth, 2006).

Net energy (NE) is the Metabolizable energy after removal of heat increment. NE is used for maintenance and production (McDonald *et al.*, 1995; Rhanjan, 2004) and represents 82% of the digestible energy (Khan and Scott, 2005). Sheep fed very low energy diets over extended periods of time can adapt by reducing their fasting heat production but they are likely to lose weight and condition (Chestworth, 2006).

The efficiency of using metabolizable energy varies with species and types of production (i.e mechanical work, meat, milk and reproduction). It also varies with the quality of the diet. High quality diets yield more metabolizable energy and hence net energy. With poor quality feeds, a large proportion of the metabolizable energy is released as heat. The efficiency of use of metabolizable energy for maintenance is about 65% for roughages and 75% for concentrates (Rhanjan, 2004; Chestworth, 2006).

The amount of energy required depends on the type of animal and the product required (Chestworth, 2006). For example, production of one litre of milk requires 0.71 kcals of energy; one kg of carcass from fat adult sheep requires about 5.74 kcals and one kg fleece needs 5.74 kcals of net energy. On the other hand, excess energy consumption can cause many problems in sheep. Extra energy is stored as fat (adipose tissue) and gross excesses in adipose tissue impair reproductive function in rams and ewes. During late gestation, fat ewes are more prone to ketosis (pregnancy toxemia).

2.5.2 Protein

Protein is usually the most expensive component of the diet. Since the rumen microbes manufacture protein from amino acids, the quantity of protein is more important than the quality of protein in a sheep's diet. Protein requirements are highest for young, growing lambs that are building muscle and lactating ewes that are producing milk proteins.

The most common protein supplement for sheep is soybean meal. Other less common sources include sunflower meal, cottonseed meal, whole cottonseed, whole soybeans, peanut meal, canola meal, fish meal, and alfalfa pellets. Proteins are used for cellular and tissue repair (Taylor and Field, 2004). The interstitial (between cells) fluid, blood and lymph require amino acid to regulate body water and to transport oxygen and carbon dioxide. All enzymes are proteins, so amino acids are also required for enzyme production (Taylor and Field, 2004). Chestworth (2006) reported that protein is very important because it is the proteins of the muscle that provide the power for work. Banerjee (1007) noted that insufficient protein results in reduced appetite lowered feed intake, poor food conversion efficiency and weight loss. Reproductive efficiency and wool growth are also affected.

Ruminants lose body proteins in secretions such as sweat and also lost from the skin in the form of scout and hair. Deficiency of protein in the diet results in mobilization of tissue protein. Growth results from increase in weight of the tissues (Cheeke, 1991; Gatemby and Humbert, 1991). In young animals, much of the weight that is added to the body is in the form of protein and water, with small amounts of fats and minerals (for bone growth)

(Chestworth, 2006). For growth to occur, the amount of protein that is being deposited in the tissues must be greater than the amount which is broken down. On the other hand, when animals lose weight, proteins are broken faster than they are being replaced by synthesis (Gatemby and Humbert, 1991). Adult sheep have a much greater tendency to put on fat. This means while young animals grow by deposing large amount of protein and water, adults deposit more fat and less of water (McDonald *et al*., 1995).

The quantity of nitrogen to protein in diet is more important than the quality (ARC, 1990; Rhanjan, 2004), apparently because, the amino acid composition of the microbial protein relatively remain constant (McDonald *et al.,* 2002). In addition, both essential and nonessential amino acids composition of the microbial protein relatively remain constant irrespective of the type of protein that is fed to the animal (McDonald *et al.,* 2002) In addition, both essential and nonessential amino acids can be synthesized by rumen micro-organisms. Although, amino acids are synthesized by rumen microbes from Non Protein Nitrogenous (NPN) sources or from feed protein, certain amino acids like methionine, lysine and threonine are still limiting, since protein or amino acids experimentally administered post-ruminally had shown increased growth markedly (Benerjee, 1007). Methionine appears to be the most limiting in microbial protein for both wool production and body gain but cysteine has been found to replace methionine for wool growth.

The requirement for protein in crude terms can vary from 16% in the diet of newly weaned lambs of 4-6 week of age to a level of 12% in the ram weighing at noted 40-50 kg (Rhanjan, 2004). Chestworth (2006) noted that the largest demand for proteins in sheep occur during lactation. Urea is the most inexpensive source of protein or dietary nitrogen. It has an equivalent crude protein value of 28 percent. Urea is converted to protein in the rumen. It needs to be carefully incorporated into sheep rations and should not be included in creep rations. Excess protein is an expensive and inefficient source of energy (Osuhur, 2002).

2.5.3 Minerals

16 minerals have been classified as nutritionally essential in sheep diets. They were divided into macro and micro depending on the amount required. Macro-minerals are required in large amounts and made up of sodium (Na), chloride (Cl), calcium (Ca), phosphorus (P), magnesium (Mg), Potassium (K), and Sulfur (S). Microminerals are required in small amounts. They include iodine (I), copper (Cu), iron (Fe), manganese (Mn), zinc (Zn), molybdenum (Mo), cobalt (Co), selenium (Se), and fluoride (Fl), are required in small amounts.(Babington, 2006).

2.5.3.1. *Calcium and phosphorus*

Calcium and phosphorus are best considered as a pair of element as they occur together in majority of situations. The hard parts of bones and teeth are largely made of calcium and phosphorus (Taylor and Field 2004; Chestworth, 2006). About 1% is in soft tissues, and is equally essential to life. Calcium has essential roles in some bio-chemical reactions such as transmission of nerve impulses. Calcium is thrombin from prothrombin involved in normal blood clotting as it must be present for the formation of muscle contraction, myocardial function, normal muscular excitability, activation of several enzymes and secretion of several hormones and hormone releasing factors (Jurgens, 2002).

Phosphorus plays important roles, in body energy metabolism. The calcium and phosphorus contained in hard tissues can be re-used by the animal to meet some of the biochemical needs in soft tissues (Gatemby and Humbert, 1991). Long term deprivation of calcium leads to formation of bones that are extremely brittle (weakened and misshaped). Joints formation is also damaged and could lead to lameness (McDonald *et al.,* 1988; Babington, 2006) and other irritability, which could lead to collapse and development of a characteristic tetany where animals lie down and are unable to stand and finally, death may occur.

2.5.3.2. *Potassium*

Potassium plays a significant role in maintaining the conceptualization of dissolve materials in milk (Perry, 1994). Most feeds, especially forages, contain some potassium. Severe deficiency therefore is not seen in practice, but where it occurs, it could lead to slow growth, weakness, nervous disorder and problems of maintaining electrolyte balance. Sheep require 1.5g/day of potassium per 20kg body weight (Jurgens, 2002)

2.5.3.3. *Sodium and Chlorine*

Sodium and chlorine stimulate salivary secretions and promote action of diastolic enzymes (Maynard *et al.,* 1979). They also play a great role in maintaining acid-base balance of body fluids. The dietary source of both sodium and chorine is common salt. The commonest method of satisfying the need for salt is to supply it either as block which the animal can lick or as a solution with other minerals in molasses (Payne and Wilson, 1999). McDonald *et al.* (1995) and Chestworth (2006) indicated that raising the sodium levels in the diet to abnormal levels can increase water consumption and urinary output.

Under normal circumstances, sodium and chlorine deficiencies do occur. The first sign of deficiency of sodium and chlorine is that animals demonstrate a craving for salt: they may lick stones, posts and trees and sometimes eat sand (Ensminger, 1996), a situation usually described as pica in trying to lick sweat from other animals and from humans (Chestworth, 2006). After a period, there is reduced feed intake which leads to loss of weight and decreased milk production. Sheep weighting 20kg and gaining 100g/day need a dietary supply of 0.3g/day of sodium chloride.

2.5.3.4. *Sulphur*

Sulphur is among the seven major minerals the body requires and can be supplied by sulphur containing amino acids (Ledin, 2004). The amount of sulphur present in the diet may be the liming factor for the synthesis of cysteine, and methionine. Addition of sulphur is of vital importance especially when non protein nitrogenous substances (such as urea) are incorporated in the diet of ruminants (McDonald *et al.*, 1995). Sulphur can only be supplied in mineral form to livestock with active rumen microbes (Cheeke, 1991). During fermentation, the microbes can incorporate sulphur into the amino acids that form the microbial protein. Thus the need for sulphur is related to the rate at which proteins are synthesized from simple nitrogenous compounds in the rumen (Bawa, 2014). Sulphur deficiency in sheep may result in reduced feed intake and reduced cellulose digestion. It is frequency recommended that the nitrogen: sulphur ratio of ruminant diets should be approximately 10:1 (Gatemby and Humbert, 1991).

2.5.3.5 *Magnesium*

Magnesium is present in a range of forages and concentrate feeds. Thus it is rarely provided as supplement. Sheep of 20kg gaining 100g/day need 0.6g /day of magnesium (Cheeke, 1991).

2.5.3.6 *Iron*

Iron is involved in the use of oxygen in cells and with its transport in blood. The classical symptom of iron deficiency is an animal, is expressed by low level of red blood cells. As a result animals do not grow well and may have respiratory problems (Babington, 2006). The problem of anaemia due to iron deficiency may be common in very young sheep, but is rare in adults (Gatemby and Humbert, 1991). The circumstances in which iron deficiencies are seen in grazing animals are nearly all associated with parasitic diseases in which there is bleeding in the gut. Therefore, any attempt to cure iron deficiency without reducing the parasite burden is doomed to fail. The recommended allowances of iron lie between 30 and 40 mg/kg of food matter (Payne and Wilson, 1999).

2.5.3.7. *Manganese*

Manganese is also important in the nutrition of sheep. Manganese is needed to assists in the action of a number of very important enzymes that catalyzes chemical reactions in cells. It is also involved in activating a number of phosphate transfer and decarboxylases. Fertility of sheep can also be improved with manganese's supplementation. Plants are the major sources of manganese in ruminant diet (McDonald *et al*,. 2002; Taylor and Field, 2004).

Manganese deficiency leads to poor growth of soft tissues and bones, weakened and deformed bones, general weakness and impaired muscular movement (Maynard *et al.*, 1979). Deficiency of manganese in ruminants has also been shown to delay sexual maturity; degenerate germinal epithelium; cause irregular ovulation and re-absorption of fetus or birth of small weak offspring; impairment of glucose tolerance; defective blood clotting; ataxia and skeletal deformities (Ensminger, 1996). Not less than 20mg/kg of food dry matter should be supplied as manganese for sheep (Jurgens, 2002).

2.5.3.8. *Copper*

Copper is associated with proteins. It is involved in the production of haemoglobin and acts as an essential part of a number of reactions which assist in the oxidation of food in cells. It is also responsible for the uptake and transport of iron. Copper, is also involved in the formation of collagen, a protein found in the joints (Pond, 1995). Maynard *et al.* (1979) reported that copper is essential for the utilization of iron in haemoglobin synthesis and it plays a role in red cell maturation. It also forms an integral part of many metalloenzymes. It is also essential for osteoplastic activity and for normal collagen and elastin formation.

Copper deficiency in sheep may lead to non-specific symptoms such as severe diarrhoea, depressed growth, infertility, abnormal hair colouring and texture as well as development of lesions in the brain leading to muscular in coordination (Maynard *et al.*, 1979). The presence of high levels of molybdenum of sulphur in the diet could lead to difficulties in the uptake of copper form the gut. Ensminger *et al.* (1996) and Gatemby and Humbert (1991) reported that at high levels (15-20mg/kg of dry foods). Copper could cause chronic toxicity in sheep, and in more acute cases it can cause convulsions, paralysis and terminal heart failure. Generally, formulated diets for sheep should contain 2-6mg of copper/kg of dry feeds.

2.5.3.9 *Molybdenum*

Molybdenum is a micro nutrient involved in a number of biochemical reactions in the body. It stimulates the activities of microorganisms in the rumen (Pond, 1995). Molybdenum also forms an important constituent of the enzyme xanthine oxidase, a metalloflavo protein which plays essential role in purine metabolism (Ladin, 2004). Chestworth (2006) noted that molybdenum is available in most feeds and that its level should be maintained as low as possible.

2.5.3.10 *Cobalt*

Cobalt is associated with the metabolism of Vitamins E and B_{12}. Thus ruminants have high requirement for cobalt as it is required for synthesis of vitamin B_{12} by rumen microorganisms (Chestwoorth, 2006). Symptoms of cobalt deficiency are not specific, but they include anaemia, poor appetite, low growth rate and decreased resistance to infection.

Less than 0.1mg/kg of dry matter will meet the daily requirement of sheep (McDonald *et al.*, 1995).

2.5.3.11 *Zinc*

Zinc is an important constituent of several enzymes. It also plays a role in the effective utilization of vitamin A. Deficiency involves reduced appetite and poor growth leading to poor condition (Chestworth, 2006). Other deficiency symptoms in sheep include inflamed skin around the nose and mouth; stiffness of the joints; breaks in the skin around the hoofs; rough scaly skin on the rear legs, ears and neck and retarded growth (Perry, 1994). In long term deficiencies, reproduction is impaired in sheep. Not more than 9-14 mg of Zn should be provided per Kg of dry feed (Chestworth, 1992).

2.5.3.12 *Selenium*

Selenium is a co-factor of a number of biochemical systems that destroy potentially toxic compounds in the body (Gatemby and Humbert, 1991). Addition of selenium in the diets of sheep has been shown to prevent liver necrosis and white muscle disease in young lambs (Babington,). High levels of selenium could lead to poor appetite and development of lesions on the liver and kidney (Pond, 1995). Other symptoms of toxicity are blindness, abdominal pain, paralysis and respiratory failure. Levels of 0.1-4mg/kg of dry matter could promote good health in sheep (Chestworth, 1992).

2.5.3.13 *Iodine*

Iodine forms an integral part of the structure of several hormones produced by the thyroid gland. It regulates the overall rate of metabolic activity in sheep. Iodine is an intermediary in the biosynthesis of hormones from the amino acid tyrosine. The thyroid hormones accelerate reactions in most organs and tissues in the body, leading to increased basal metabolic rate, accelerated growth and increased oxygen consumption of the animal (Pond 1995; McDonald *et al*., 2002).

Deficiency of iodine includes enlarged thyroid gland (goiter) leading to general weakness in young sheep. Infected mothers of newly born animals may be blind or hairless. In adult sheep, deficiency symptoms include retardation of growth, slow wool growth, poor quality fleece and reduction in the fertility of both rams and ewes. Sheep require not less than 0.1mg/kg DM iodine (Maynard *el al.*, 1979).

2.5.3.14 *Other trace minerals*

Other trace minerals required by sheep include fluorine, chromium, silicon, tin, lead, nickel and vanadium. These trace minerals are available in natural feeds, hence deficiencies do not normally arise (Cheeke 1991; Babington,).

2.5.4 Vitamins

Vitamins take part in a number of chemical reactions in the body. They serve as co-enzymes. They are usually complex and cannot be synthesized by animal cells. They are essential for normal metabolism even though they are required in small amounts (Sizer and

Whitney, 2000). Adult ruminants can synthesize some of these vitamins and do not need a dietary supply (Taylor and Filed, 2004).

Sheep require vitamins A, D, and E. Vitamin A is absent in plant material, but is synthesized from beta-carotene. Vitamin D is required to prevent rickets in young animals and osteomalacia in older animals. B-vitamins are not required in the diets of ruminants because they are synthesized in the rumen. Vitamin K is essential for blood clotting. Dietary supplementation is usually not necessary.

Vitamins are classified as water soluble on the basis of their solubility either in water or in ether. The water soluble vitamins include vitamin B_1 (thiamine), B_2 (riboflavin), B_6 (pyridoxine), B_{12} (Cyanocobalmin), nicotinamide (niacin), pantothenic acid, folic acid, choline and ascorbic acid. Fat soluble vitamins include vitamins A (retinol), D_2 (ergocalciferol), D_3 (cholecalciferol), E (tocopherol) and vitamin K (phylloquinone).

2.5.4.1. *Water soluble vitamins*

Microbes of the rumen probably produce sufficient quantity of B complex vitamins to meet the daily needs (Ckeeke, 1991; Gatemby and Humbert, 1991). However, thiamine deficiency has been occasionally reported in sheep that are fed diets containing high concentration of grains (Ledin, 2004). Khan and Scott (2005) reported that under tropical conditions, supplementing B_1 deficiency include development of lesions in the nerves of the brain which could lead to blindness often referred to as bright blindness (ARC, 1990). Deficiency of vitamin B_2 can occur in young ruminants but is rare in milk fed animals. As soon as the rumen starts functioning, there will be an adequate supply from rumen microbial activity (Pond, 1995).

Vitamin B_6 is abundant in normal foods. It is also adequately synthesized by ruminants; therefore, its deficiency is unlikely to occur (Khan and Scott, 2005). Cobalt is however necessary for the synthesis of vitamin B_{12}.

Niacin (nicotinic acid and niconamide) deficiency can occur in young ruminants whose rumen is not fully developed. Symptoms of deficiency include ulceration and inflammation of the mouth and lack of appetite. The risk of deficiency recedes once the rumen starts to function (McDonald *et al.* 2002). Biotin and pantothenic acid deficiencies are unlike to occur as they are abundant in most diets.

Folic acid functions in the synthesis of pigment such as haemoglobin. Deficiency results in a characteristic form anaemia in which immature red blood cells are found within the bone marrow. Deficiency of folic acid rarely occurs in adult sheep (Sizer and Whiteney, 2000; Rhanjan, 2004).

Vitamin C or ascorbic acid is synthesized rapidly enough in the diet of muscle sheep as the rumen micro floras synthesize this in adequate amounts. Vitamin C is important to nursing lambs as its deficiency could cause white muscle disease in lambs of 2-8 weeks of age, in ruminant animals, all of the water soluble vitamins are synthesized by micro organisms in the rumen (Taylor and Field, 2004).

2.5.4.2. *Water soluble vitamins*

Vitamin A

Sheep need a dietary source of vitamin A or one of its precursors. Vitamin A plays major role in the development of cells of the skin, gut, kidney and bones. It is also intimately involved in the chemical changes which are responsible for vision (Sizer and Whitney, 2000). Vitamin A helps to maintain proper repair of internal and external body linings (Taylor and Filed, 2004). Vitamin A is abundant in green forages.

The main symptom of deficiency is a very slow and partial adaptation to vision in dim light (night blindness). In young ruminants' blindness may result from impairment leading to constriction of the canal by which the optic nerve passes through the skull (Gatemby and Humbert, 1991; Sizer and Whitney, 2000). Infertility in sheep is sometimes associated with Vitamin A deficiency, especially in circumstances of poor availability of green forage (Chestworth, 1992).

Vitamin E

Vitamin is an excellent anti-oxidant and has a role in preventing the breakdown of cell membranes. Combined metabolic and nutritional roles of vitamin E and selenium have been reported (Jurgens, 2002; Taylor and Field, 2004). Both of them act as antioxidants. Vitamin E helps to neutralize or detoxify radicals that are involved in peroxides formation (Sizer and Whitney, 2002).

Deficiency of vitamin E and selenium lead to reproductive failure. Formation of lesions in the testes of rams due to lack of vitamin E has been reported (Gatemby and Humbert, 1991). In pregnant ewes, vitamin E deficiency may lead to death of the embryo (Payne and Wilson, 1999). Deficiency of vitamin E also affects the structure of striated and sometimes smooth muscle (Chestworth, 1992). Cases of muscular dystrophy or white muscle disease (muscles lacking in pigment resulting in meat that is unusually pale) have been reported in young lambs (McDonald *et al.*, 1995). Vitamin E is not stable; therefore, storage under moist conditions or in the presence of unsaturated fatty acids leads to its destruction. For this reason, vitamin E deficiency can easily arise and its supplementation is therefore necessary, supplementation can be provision of synthetic tocopherol in the diet, while selenium is administration by injection.

It has been indicated that dietary supplementation of vitamins A and E in the diet of sheep of is vital important since they cannot be adequately synthesized by rumen micro-organisms (Taylor and Field, 2004; Khan and Scott, 2005). Supplementation is also important for pigment and lactating ewes (Taylor and Field, (2004).

Vitamin D

Vitamin D regulates the uptake and metabolism of calcium, and to more limited extent phosphorus (Jurgens, 2002). The most active form of the vitamin involved in this physiological function is 1.25-dihydroxycholecalcifeferol (DHCC). There are two principal source of DHCC: one from plant tissue and the other from animals. The natural illumination of the skin with sunlight will produce sufficient vitamin D from its precursor in most species of animals. Vitamin D is therefore obtained through irradiation on exposure to sunlight. Ruminant animals raised in dry areas of the tropic receive abundant supply of vitamin D (Rhanjan, 2004). Sheep with white skin or wool absorb more rays from sunlight than animals with black skin or long wool (Payne and Wilson, 1999). The major function of vitamin D is to regulate the absorption of calcium and phosphorus form the intestine. Therefore, it is required for calcium and phosphorus metabolism.

Deficiency of vitamin D reduces calcium uptake and deposition in the bone. In young growing sheep, vitamin D deficiency leads to characteristic weakening and deformation of bone called rickets. In adults, it results in Osteomalacia. Ruminants kept out of sunlight and on vitamin D deficient diets rapidly develop hypocalcaemia (Gatemby and Humbert, 1991; Chestworth, 2006). Vitamin D has an exaggerated role whenever there is an increased demand for calcium and phosphorus and such circumstance arise during parturition and lactation. Sun dried forages are the best sources of vitamin D. Fish meal from oily fish and particularly fish oils are extremely rich sources.

Vitamin K

Vitamin K is required for the synthesis of blood clotting protein (Sizer and Whitney, 2000). It has been indicated that neither vitamin K_1 nor K_2 needs to be fed to sheep, as K_1 occurs in all green leafy materials (fresh or dry) and vitamin K_2 is synthesized in the rumen, situations where deficiency occurs, symptoms would include reduction in feed intake and unusual appetite such as pica. In advance cases, haemorrhage and anaemia are common (Khan and Scott, 2005). Chestworth (2006) noted that sheep deficient in vitamin K have prolonged bleeding times and are very internal bleeding or bruising.

Even though deficiency of vitamin K rarely occurs in adult sheep, secondary deficiency can occur due to presence of some toxic compound in some forage species which might contain the anti-vitamin “caumarin”. Such deficiency can be corrected by administering large quantities of vitamin K in the diet (Gatemby and Humbert 1991; Taylor and field, 2004).

2.5.5 Water

A clean, fresh, easily accessible source of water should be available at all times. As a minimum requirement in temperate environments, the usual recommendations are approximately 1 gal. (3.8 l) of water/day for ewes on dry feed in winter, 1½ gal./day for ewes nursing lambs, and ½ gal./day for finishing lambs (Babington,2006). In many range areas, water is the limiting nutrient; even when present; it may be unpotable because of filth or high mineral content. For best production, all sheep should have their water availability monitored daily during all weather conditions.

2.5.6 Ruminant premix

This is a prepared Bio-organic animal feed supplement. Is a supplement of all the vitamins, some minerals of both macro and micro and antioxidants. It has a recommended inclusion rate of 2.5kg per ton of a feed.

2.6 Factors Affecting Small Ruminants Production in Nigeria

Despite the significant roles play by animal production in the Nigerian economy, the sector is faced with a lot of constraints that are crucial to the industry some of which are feeds, diseases and climate.

2.6.1 Feed supply

The provision of feed that is adequate both in quality and quantity and accessible to animals all year round is the most outstanding problem of livestock production in Nigeria. The natural range resources that form the primary source of nutrients have been observed to rapidly increase in nutritive value at the onset of rains and decline shortly thereafter. The state of poor quality of feed often lasts longer during the year than the period of forage abundance and high nutritive quality (Aribido, 2011). Supplementation with crop residues from cropped farmlands scarcely meets the requirements for animal growth. The unavailability of grazing feedstuff year-round is aggravated by the widespread bushfire and imbalance between the stocking rate and carrying capacity of the range (Aribido, 2011; Iro, 2012). The consequence of overstocking is simply high, incidence of erosion and a reduction in the carrying capacity of vast land area with the potential for high cattle production as in the Jos and Mambilla Plateau, Sahel and Sudan ecological zones is posing a great threat (Aribido, 2011).

2.6.2 Diseases

Livestock production does not only face the problems of feed inadequacy, but also that of disease and parasite infestation, which are equally a major problem that constrains the development of profitable livestock industries in Nigeria.

The tropical environment is for various reasons eminently suitable for the development of parasitic diseases. In the first place, many of the parasites encountered in the temperate regions are also found in the tropics together with the numerous species that are peculiar to warmer parts of the world (Payne and Wilson, 1999).

Parasites are the major health problem affecting small ruminants, particularly sheep and goats, which are more susceptible to internal parasites compared to other ruminants, due to their grazing behavior and poor immunity (Schoenian, 2001). Parasites or worms affecting digestive system cause severe health problem in ruminant production. Grotelueschen *et al.* (2001) reported that economic losses from parasitism can be extensive, ranging from mortality or death to weight loss, reduced weight gain, reduced wool production, decreased milk yield resulting in lower lamb weight, poor reproductive performance and additional cost of medications and handling. Infestations by pest is of significant importance, among are tsetse fly, flukes, roundworm and hookworms as well as ectoparasites like ticks, mange, mites and lice. They cause diarrhoea, loss of appetite, slow growth rate, unthrithfulness, damages to skin and most often debilitating mortality among stock leading to grave economic losses (Ago, 2013).

All sheep are susceptible to internal parasites, but younger animals' ages between 2 -12 months have a higher incidence. The older animals develop a measure of resistance to some species of worms from previous infestations. Since young animals are more likely to carry a worm burden, they are also more likely to be heavy shedders of worms' eggs into environment. For these reasons preventive measures are important for all sheep and critically for young ones (Grotelueschen *et al.,* 2001). Animal showing signs of severe parasitism generally will be quiet and unthrifty in appearance. They may be off feed, suffer severe weight loss, have diarrhea, and be severely anaemic. Animals with severe blood protein loss can develop "bottle jaw" a soft swelling in the jaw and throat area.

Less severely affected or chronically parasitized sheep show intermittent diarrhea, weight loss and poor reproductive performance. Whitter *et al.* (2003) stressed that internal parasites cause economic and production losses to sheep producers. Schoenian (2001) identified stomach worms like round worms (nematodes) as major parasites of concern in small ruminants. The two groups of worms of much importance in sheep are *Haemonchus contortus* (Barber pole worm) and *Tricostrongylus* (Hair worm) families of nematodes. Both types are blood suckers and lives in the stomach and small intestine of the affected animals (Neary, 2000).

2.6.3 Climate

Certain climatic factors are natural and some are man-made due to human activities but affect animal production (Yatoo *et al.,* 2012). In the northern part of Nigeria desert encroachment is already a major environmental problem (Akinbami *et al.*, 2013) Livestock production in all tropical countries is affected by the climate in two different ways. First is by the direct influence on the livestock and second is by the indirect effects on the livestock environment. The major climatic variables that directly affect domestic livestock are temperature, humidity, air movements and solar radiation. Photoperiodic also affects some livestock species as is important in some aspects of reproduction and other biological functions. Combinations of these climatic variables create climates in which maximum productivity can be achieved by specific types of livestock (Payne and Wilson, 1999) and the combination will certainly vary accordingly as to whether optimal productivity is sought in growth, milk production, or reproductive processes.

Climate directly affects feed and water intake, growth, reproduction and milk production. It has been established that high ambient temperature depress feed intake (Payne and Wilson, 1999; Loosi *et al.*, 1999; Taylor and Field, 2004). In sheep, feed consumption and rumination practically cease when ambient temperature rise above 40^0C (Payne and Wilson, 1999). Increasing relative humidity at ambient temperature above 23.9^0 also depresses feed intake (Rodriquez *et al.*, 1985). Humidity also affects water intake, and ambient temperature above 24^0C, increasing humidity decreases water consumption by sheep, but increases the frequency of drinking by cattle (Rodriguez, *et al.*, 1985). The direct effect of climate on water intake of sheep is very complex, as an essential nutrient and component of the body.

2.6.4 Other factors

2.6.4.1 Capital: The slow rate of growth of the livestock industry in Nigeria denotes a long gestation period from investment to maturity. Livestock projects are scarcely attractive which makes collaterals and guarantee of substantial value not easily available for livestock producers to secure sufficient loans to improve production even in few instances where financial institution may be willing to do so (Aribido, 2011; Ago, 2013).

*2.6.4.1 Policies***:** Lack of genuine institutional support and political will to muster required efforts to improve livestock production cannot be diverted from problems confronting the industry. (LOGBABY, 2013). In Nigeria such planned programmes are tested only within a limited area and frustrated by undue rivalry and competition for position, profession or financial benefits as well as poor implementation strategies. Policies are written and are never implemented before abrupt changes are introduced (Aribido, 2011).

*2.6.4.1 Breeding Programme***:** Adoption of haphazard breeding programme in which indigenous cows are crossbred with bulls by natural or artificial insemination at one time and massive importation of exotic breeds into Nigeria at another, have failed to make any tangible impact (Aribido, 2011; Ago, 2013). The consequence of this is the proliferation of local breeds of small ruminants in their numbers not responding to improvement in quantitative traits. It is still not clear as to what means to categorize local breeds to be for meat or milk (Oni, 2002). They all exhibit dual or triple-purpose traits, with productivity far below the average expected.

2.7 Available Feed Resources for Ruminants

2.7.1 Crop residues

About 22 species of plant are cultivated for human consumption. A large quantity of crop residues is available in Nigeria for livestock feeding (Makkar, 2002) with an estimated annual quantity of 3.2 million and 1.1 million tonnes for maize and rice respectively (Smith, 1989). Crop residues represent a vast animal feed resource, which is as yet largely unexploited (Bunmi, 2002). Considerable researches have been, and are being, carried out on the potential of these by-products and crop residues but to date, very little effective practical application has been achieved (Nyaku, 2015).

The major crop residues are maize, sorghum and rice straw; smaller quantities of millet stover are also available. These have traditionally been used by Nigeria's pastoralists, in which cattle and sheep are being allowed to graze on the crop residues, in return for their dung as manure. A variety of crop residues are available in Nigeria some abundant and more useful, others available only in small quantities and therefore of secondary importance.

2.7.2 Feed resources from Rangeland

One of the major factors limiting the productivity of animals in sub-Saharan Africa is poor nutrition; especially in the dry season (Walshe *et al.,* 1991). In Nigeria ruminants depend on range for most of their feed requirements especially in the Sahel and Sudan zones, where most of the ruminants are concentrated (Yayock *et al.,* 1987). There is wide variation in the quality and quantity of pasture available from one time of the year to another on the range land.

Kallah (2004) observed that in Nigeria, over 98% of the dry matter (DM) needed to produce beef is derived from grasses and browses growing on native rangelands. Adamu *et al*. (2013) noted that native forages resources of the savannah zones of the country can only meet requirement of the animals for maintenance and low levels of production for only about two to three months of the year.

2.7.2.1 *Grasses*

Grasses are plants that exhibit rapid growth and early maturity characteristics during the wet season which results in a rapidly increasing lignification and declining nitrogen and soluble carbohydrate content (Ademosun *et al*., 1989). Crude protein (CP) content ranging from 7 to 10% has been reported for the native grass in early wet season (Smith, 1992). The author further reported that minimum level of animal production can be supported by these grasses without supplementation even during the wet season. Probably this is due the energy content that may be low due to high moisture during the wet season. Provision of energy supplements will enhance utilization of native grass at this period of the year.

The potential yield of grasses could be as high as 6 tonnes, DM per hectare, as in *Cynodon dactylon* (Jahnke, 1982) or even higher as in *Panicum maximum* (10-18 tonnes DM/ha and 30 tonnes DM/ha, under good management and appropriate fertilizer regimes (Adegbola, 1982).

Davies and Onwuka (1992) reported crude protein (CP) and crude fibre (CF) values of 5.9% and 37%, respectively for *Pennisetum purpureum*, while (1985) reported the crude protein and crude fibre values of *Panicum maximum* hay as 5.3 and 4.2%, respectively and the crude protein content of some roughage as follows: *Chloris gayana* 2.6%, *Andropogon gayanus* 2.75%, *Digitaria smutsii* 5.0%, *Bracharia decumbens:* 3.1%. Feeds with less than 8% Crude protein values are considered deficient as livestock feeds, as they cannot provide the minimum ammonia levels (150-250mg/litre of rumen fluid) required by rumen microbes for optimum activity (Leng, 1990).

Performance of animals grazing tropical pasture during the dry season without supplementation shows that they lose weight and body condition (Adu, 1982). The weight loss may be about 40g per head per day for cattle, sheep or goat. During the dry season, the CP content of native pasture falls to about 1.5 and 3% (Adamu *et al*., 2013). The importance of supplementing poor quality forages for improved intake and animal performance has been reported (Leng, 1991; Alawa and Umunna, 1993).

2.7.2.2 *Browseplants*

Browse are particularly valuable in providing additional nutrients to, and shifting the status of an animal subsisting on low quality feeds from sub-maintenance to production status (Amodu *et al.*, 2004). Browse is defined as the palatable portion like the leaves, tender twigs, shoots, flowers fruits and pods of woody forage of plants (Adediran, 2002). The illustrated heritage dictionary and information in its own, defines browse as young twigs, leaves and tender shoots of plants or shrubs that animals eat.

Browse plants are either legumes or non-legumes. They are rich in protein and minerals at a time when grasses are deficient in these constituents (Amodu *et al.*, 2004). Browse plants particularly the pod bearing species otherwise called legumes are very important source of forage for livestock in all parts of the tropical world, especially in the arid areas. This role is more importantly felt when the dry season is long and the rainfall is less. They come in to leaf early in the season before the rains come and their leaves retain the nutritive value at a moderately high level long into the dry season. The unique characteristic of browses that endeared them to livestock farmer lies in their ability to establish and grow fast, produce good leaf biomass which remains green during the dry season when feed is scarce (Adediran, 2002).

2.8 Groundnut as Feed Resources

Groundnut (*Arachis hypogaea*) is a small erect or trailing herbaceous legume, about 15 to 60 cm high. The flowers are a typical pea flower in shape, 2 to 4 cm across, yellow with reddish veining. Hypogeal means under the earth after, the pollination, the flower stalk elongates causing it to bend until the ovary touches the ground. Continued stalk growth then pushes the ovary underground where the mature fruit develops into a legume pod. The fruit is a pod with one to five seeds that develops underground within a needle-like structure called a peg. The seeds are rich in oil 38-50 protein, calcium, potassium, phosphorous, magnesium and vitamins (Adamu, 2015).

2.8.1 Groundnut hayand haulms

Groundnut (*Arachis hypogaea*) haulm is important crop residue especially in the northern part of Nigeria where some produced groundnut for the haulms annually. Arslan (2005) considered groundnut haulm as the most important of its by-products that can be used to supply feed to livestock and its hay providing extra income to smallholder farmers.

Studies have indicated that groundnut hay could meet the maintenance energy requirements of adult goats even at increasing levels of dietary inclusion (Ndlovu and Sibanda, 1995, Malau-aduli *et al.*, 2003). Results from animal fattening studies in Nigeria have indicated that animals fed chopped haulms gained more weight compared to those fed unchopped haulms (Alawa and Umunna, 1993). It has been reported that some farmers who grow groundnut for haulms only (Adamu, 2015).

Groundnut haulms is a very popular feed resource among livestock producers in th savanna ecological zone, especially area covering the humid to the dry savannas. Research results have shown that groundnut haulm gives positive results in terms of weight gain (Adu and Lakpini 1983; Ikhatua and Adu, 1984).

2.8.2 Groundnut cake as industrial by- product

Groundnut cake is one of the major plant protein supplement used in Nigeria. The availability of which depends on the production level of groundnut. The residue remaining after extraction of oil from groundnut is the groundnut cake. It has a protein content of about 38 - 47%, however, is deficient in lysine, methionine and threonine (Onwuka *et al.*, 2014). This is much higher in crude protein (45%) than CSC. Unlike cottonseed cake, it can also be used for monogatric nutrition, and thus is widely used in compounded feeds for pigs and poultry. The main constraints to its use are availability and price; other factors influencing its use are high oil content and the aflatoxin level, which can become unacceptably high, if the groundnuts are of poor quality, or badly stored.

2.8.3 Groundnut shell

Groundnut shell is a waste produced when the nut is processed for consumption by breaking the shell open manually or mechanically (Alu *et al.*, 2012) the pod or pericarp contains about 25–40% shell (Vyas *et al.*, 2005) of the total mass produced. From the production, processing and consumption of groundnut, there are a great variety of remains especially the husks, which create increasing problems of elimination (Akinfemi *et al.*, 2012).

Alawa and Umunna (1993) observed that groundnut shell may form a part of production diet if it is crushed or milled before inclusion. Sheep and goats offer an alternative to utilize feed resources which is otherwise "wasted" (Lemus and Brown, 2008) such as groundnut shell.

2.8.3.1 *Availability of groundnut shell*

In Nigeria, from extraction rates of 1kg seed to 3 kg of groundnut shells, the corresponding crop residue production has been estimated to be 1.3 million tonnes in the major production areas of Sokoto, Zamfara, Kano, Bauchi, Adamawa, Kaduna, Benue, Borno, Nasarawa and Anambra States of Nigeria (Hostville, 2013). The authors found the groundnut shell greatest utilization between December and April (during the dry season) when the available pasture is low in quantity and quality. Groundnut shells are also used as mulch, bedding, fuel, building materials or source of organic fertilizer etc. (Akinfemi *et al.*, 2012 and Vyas, *et al*., 2015). It is abundantly available from October to May in the Northern region, (Alu, *et al*., 2012) and can supply enough roughage for the ruminant population in the country if properly harnessed and processed despite its other uses (Hostville, 2013).

For now, groundnut shell could be very cheap because, being a waste, the only costs would be those of gathering, processing and transporting to points of use. Exploiting cheap feed resources for animal production would lower the market price of their products and therefore, increase the intake of animal protein by the general populace in under developed countries, such as Nigeria (Akinfemi *et al.,* 2012 and Adamafio *et al.,* 2012). This would, in turn, ameliorate the havoc caused by malnutrition and under-nutrition in such societies, the brunt of which is borne by women and children (Alu *et al.,* 2012).

2.8.3.2 *Nutritive value of groundnut shell*

From a nutritional perspective, plant material is made up of two fractions – cell contents and cell walls. The cell contents, which are usually highly digestible, constitute only a small fraction of the dry matter of groundnut shell, and hence make only a minor contribution to the feed value. The cell walls which make up the major fraction of groundnut shell is highly or poorly digestible, depending on the relative extent of its constituent parts lignin, cellulose, hemicellulose, silica, and how they are multifaceted with each other (Smith, 1989; Hostville, 2013).

Groundnut shells contain more than 60% fibre, and therefore, has low digestibility (Singh and Diwakar, 1993). Generally, palatability, seasonal variation and availability are some factors that influence feed intake by an animal (Aregheore, 2000). The high cell wall content (Neutral Detergent Fibre) in groundnut shells prevent enough consumption and makes rumination more difficult for younger animals while the high fibre content (Acid Detergent Fibre) limits its digestibility. The combination of the two above mentioned factors restrict adequate nutrient intake and digestibility for acceptable production levels without supplementary feeding (Hernandez and Sanchez, 2014).

2.8.3.3 *Groundnut shell in animal feeding*

Previous studies have shown that the use of groundnut shell in diets of monogastrics proved useful. Oke *et al.* (1995) as cited in Alu *et al*. (2012) established that 15% groundnut shell fortified with methionine in diets fed to rabbits produced weight gain equal to rabbits fed the control diet. Alu *et al.* (2012) found that rabbits fed 30% groundnut shell in diet without palm oil, gained weight similar to those fed on control diet. With addition of palm oil, (Alu *et al.*, 2012) feed intake was not affected by inclusion of up to 50% groundnut shell in the diet of rabbits. Tham *et al.* (1987) as cited in Alu *et al.* (2012) reported that when rabbits were fed groundnut shell up to 40% in the diet, Methionine decreased fibre level. In another study, there was a higher average weight gain, feed conversion ratio and daily feed consumption rate for rats fed untreated groundnut shell compared to the treated treatments (Adamofio, 2012).

Moreover, leguminous crop residues are usually better and may be used as complementary forages if quantities permit. There appears to be no toxic substances in groundnut shells except when they are mould (Aregheore, 2000). Furthermore, Growing pigs fed on a diet containing 40% groundnut shell have been observed to perform satisfactorily (Alu *et al.*,

2012) and produced leaner carcasses which indicate economy of feed conversion. Alu *et al.* *(*2012*)* found no significant difference in average daily weight gain, feed conversion efficiency or carcass characteristics when groundnut shell replaced 0-54% of maize in diets of growing – finishing pigs, although inclusion of groundnut shell at 30% in the ration was observed to depress the growth of young pigs.

2.9 Limitation of Crop Residues as Feed Resources to Small ruminants

2.9.1 Availability

The basic reason for the poor performance of livestock in developing countries is the seasonal inadequacy of feeds, both in quantity and quality (Payne and Wilson, 1999). The bulk of poor quality roughages (crop residues) available during the dry season can serve as a source of feed for ruminants, but if treated appropriately. Therefore, if diets based cereals crop residues are to be productive, the residues must be upgraded to improve their nutritive value. These crop residues can be enriched by different processes some of which can be carried out by the rural farmers themselves.

2.9.2 Nutritive value

The nutritive value of crop residues varies according to species, varieties, and environmental conditions, stage of maturity and methods of harvest, storage and feeding among other factors (Smith, 1989; Hostville, 2013). The nutritive value can be determined by their chemical composition or by a combination of chemical constituents and gas released on incubation of feeds in an *in vitro* medium or *in vivo (*Aregheore, 2000). In general, the crop residues are characterized by low levels of one or more key nutrients which limit their utilization by livestock. They are inherently low in crude protein and readily fermentable metabolizable energy (Rana, 2013 and Hostville, 2013), essential minerals and contain high levels of structural carbohydrate or fibre (Abdel Hameed *et al.*, 2013). As a result the DM intakes (DMI) are too low to permit digestibility; adequate nutrient intake for maintenance and production (Akinfemi *et al.*, 2012) total degradability; and the rate at which particles breakdown to a critical size small enough to leave the rumen, resulting in low level of performance (Hostville, 2013).

2.9.3 Nutrients digestibility

These residues are low in N and high in crude fibre, characteristics which restrict intake and digestibility, which resulted to underfeeding (Hostville, 2013). The low protein fibrous materials (crop residues and natural grazing) have a pivotal role in dry season feeding, and, therefore, a modest improvement (5–10%) in their feeding value would substantially reduce the effects of underfeeding on both survivability and production (Makkar, 2002).

2.9.4 Other limitations

Anti-nutritional factors are among the factors that limit the utilization of crop residues as feed resources. They are substances present in the diet which by themselves or their metabolic products arising in the system interfere with the feed utilization, reduce production or affects the health of the animal. Those anti-nutritive substances are often referred to as toxic factors because of deleterious effects they produce when eaten by animals (Reddy, 1996). Those substances can be generated in natural feedstuffs by the normal metabolism of species and by different mechanisms e.g. inactivation of some nutrients interference with the digestive process or metabolic utilization of feed which exert effects contrary to optimum nutrition (Aganga *et al.*, 2003).

In fact, plants contain thousands of compounds which depending upon their situation can have beneficial or deleterious effects on organisms consuming them. These compounds with exception of nutrients are referred to as allele chemicals (Jurgen, 1997). Browse species contain anti-nutritive factors which affect their utilization; such factors include nitrates and nitrites Mimosine, Hydrogencynides (HCN), Saponins, Phytate and tannins or polyphenolics.

2.10 Methods of Improving Crop Residues.

As crop residues have high fiber content, low in nitrogen and difficult to degrade, it is obvious that improving their intake and degradability is very necessary which will consequently improve the performance and production of the animals (Akter *et al.*, 2004) . Therefore, if diets based cereals crop residues are to be productive, the residues must be upgraded to improve their nutritive value. Alternatives are available for improving the intake and digestibility of fibrous residues, these include appropriate supplementation with additional nitrogen, readily available energy and minerals; physical, biological and chemical treatment of the residue to improve biodegradation; and a combination of treatment and supplementation (Warly *et al.*, 1992). The processes alter the composition of that feed by physical, chemical or biological action (Hostville, 2013; Smith, 2002).

Supplementation of a ration containing crop residue with protein, energy and/or minerals may optimize rumen function, also maximized their utilization and increased intake. Akter *et al.* (2004) emphasized that it is primarily necessary to supply the rumen microorganisms with the nutritive elements needed for self multiplication as well as for degradation of the cell walls of straw, leading to suitable conditions for maintenance of good cellulolysis.

Different supplements can be used, such as concentrates, molasses, multi-nutrient blocks, green leaves and locally available by-products to improve crop residues. In case of high-yielding dairy cows, the supplements can be the major part of the ration where fibrous feed only serves to supply the rumen with enough fiber. Warly *et al.* (1992) showed in a field trial that a ration of rice straw supplemented with soybean meal increased both degradability and intake. Because of the poor quality of untreated rice straw, supplementation can easily increase milk production, as shown for supplementation with cottonseed meal (Wanapat *et al.,* 1996) and with urea molasses- multi-nutrient block (Vu *et al.,* 1999; Wanapat *et al.,* 1999 and Akter *et al.,* 2004).

Improving the utilization of crop residues by ruminants is to overcome their inherent barriers to rumen microbial fermentation. The important factors that restrict bacterial degradation of crop residues in the rumen are its high levels of lignifications and silicification, and low contents of nitrogen, vitamins and minerals. Basically, some of the chemicals and biological organisms used in the treatment methods can be absorbed into the cell wall and chemically or biologically break down the ester bonds between lignin and hemicellulose and cellulose, and physically make the structural fibers swollen (Lam *et al.*, 2001). These processes enable the rumen microorganisms to attack more easily the structural carbohydrates, enhancing degradability and palatability of the crop residue (Prasad *et al.* 1998; Shen *et al.*, 1999 and Selim *et al.*, 2002).

2.10.1 Treatment of crop residues

The key to improving the use of crop residues for ruminants by treatment is to overcome their inherent barriers to rumen microbial fermentation. The important factors that restrict bacterial degradation of crop residues in the rumen are its high levels of lignification and silicification, and its low contents of nitrogen, vitamins and minerals. To improve the feeding value of crop residue, it can be treated with different means and methods. These methods include: physical, biological and chemical treatments.

2.10.1.1 *Physical treatment*

Physical treatment of crop residues include grinding, soaking, pelleting or chopping to reduce particle size or can be treated with steam or X-rays or pressure cooked. Physical treatments of crop residues have received an appreciable amount of research. Many of these treatments are not practical for use on small-scale farms, as they require machines or industrial processing. This made these treatments in many cases economically unprofitable for farmers as the benefits may be too low or even negative (Schiere and Ibrahim, 1989). However, small machines to grind or chop crop residue may be feasible.

It has been observed that grinding and pelleting of grass hay decreased dry matter degradability in cows from 73 to 67%, which was mainly due to a decreased in total retention time of the solids from 73 to 54 hours and decreased fermentation rate (9.4-5.1%/h) and resulting in an increased intake (Stensig *et al.*, 1994).

Liu e*t al.* (1999) reported that the use of steam treatment in a high pressure vessel at different pressures and for a range of different treatment times increased the degradation *in vitro* in rumen fluid after 24hrs and the rate of degradation, but could not enhance the potential degradability of the fibrous fractions (NDF, ADF and hemicellulose).

2.10.1.2 *Biological treatment*

Is where enzymes as catalyst, fungi, or other microbes are used to improve crop residues. Fungi and/or their enzymes that metabolize lignocelluloses are potential in biological treatment to improve the nutritional value of straw by selective delignification (Jalc, 2002). Nevertheless, it is currently too early to apply this method in developing countries due to the difficulties and lack of technology to produce large quantities of fungi or their enzymes to meet the requirements. There are also a number of serious problems to consider and overcome (Schiere and Ibrahim, 1989). For example, the fungi may produce toxic substances. It is also difficult to control the optimal conditions for fungal growth.

White-rot fungi treatment: White-rot fungi, belonging to the wood-decaying *basidiomycetes*, as lignocellulolytic microorganisms which are able to decompose and metabolize all plant cell constituents (cellulose, hemicellulose and lignin) by their enzymes (Eriksson *et al.,* 1990). Many species of white-rot fungi which are effective lignin degraders have been used to assess their ability to improve the nutritive value of fodder for ruminant nutrition (Yamakava and Okamnto, 1992 and Howard *et al.*, 2003). Their extracellular lignin-modifying enzymes consist of lignin-peroxidase (LiP), manganese-dependent peroxidase (MnP), laccase (phenol oxidase) and H_2O_2-producing oxidase (aryl-alcohol oxidase; (AAO) and glyoxaloxidase) (Arora *et al.* 2002; Novotny *et al.* 2004; Arora and Gill, 2005 and Lechner and Papinutti, 2006). Karunanandaa *et al.* (1996a) reported the effect of incubation of rice straw for 30 days with three white-rot fungi, showing that *Pleurotussajor-caju*enhanced in vitro dry matter digestibility (IVDMD), in both leaves and stems of rice.

However, entire rice straw (leaf and stem) treated with *Cyathusstercoreus*had the highest IVDMD compared to the other fungi (Karunanandaa *et al.*, 1992). Using white-rot fungi to increase the degradability of straw is often at the expense of easy assessable carbohydrates, such as cellulose and hemicellulose, resulting in less degradable feed for ruminants (Karunanandaa *et al.*, 1995; Karunanandaa and Varga, 1996a,b; Jalc, 2002). In fact, cellulose and hemicellulose losses during the initial part of incubation with fungi are rather common, but losses due to mycelial growth depend on the fungus species. After the initial period of incubation, some white-rot species preferably attack lignin, without degrading cellulose and hemicellulose. Rodrigues *et al.* (2008), were able to extract the enzymes from white rot fungi that are responsible for breaking down the bonds in lignin and within the matrix of cell wall carbohydrates, but without also extracting enzymes affecting hemicellulose and cellulose. Using these enzymes on wheat straw the *in vitro* NDF degradability (IVNDFD) increased.

Although the use of fungi to improve the feed value of crop residue is not new, progressing research and new knowledge offers new challenges and possibilities. Fungi can be selected that preferably attack lignin and not the structural carbohydrates in the cell walls. Once these species are identified, mycologists can breed even better strains. The most desirable situation would be that the mushrooms of the fungi are edible and can be harvested by farmers, after which the remaining residue can be fed to their herd . There are some edible white-rot fungi, like *Pleurotisostreatus*.

Exogenous fiber-degrading enzyme treatment: Most commercially available exogenous fiber-degrading enzyme products consist of cellulases and xylanases, as produced for non-feed applications. Commercial enzymes used in the livestock feed industry are generally of fungal (mostly *Trichoderma longibrachiatum*, *Aspergillus niger*, *A. oryzae*) or bacterial origin. 22 commercial enzyme products were examined for biochemical characteristics and for *in vitro* ruminal degradation of alfalfa hay and corn silages (Colombatto *et al.*, 2003).

Enzyme treatment alone or in combination with other treatments can increase the degradability of cereal straw by the rumen microorganisms (Liu and Ørskov, 2000; Wang *et al.*, 2004; Zhu *et al.*, 2005; Eun *et al.*, 2006; Fazaeli *et al.;* 2006 and Rodrigues *et al.*, 2008). In addition, using fibrolytic enzymes in ruminant feed have shown improvements in the average daily gain of steers (Beauchemin *et al., 2004*), fleece weight and wool production of lambs (Jafari *et al.*, 2005) and in milk yield of dairy cows (Yang *et al.*, 2000).

The use of combinations of fibrolytic enzyme with these pre-treatments is expected to have a synergistic effect on the nutritive improvement of rice straw products consist of cellulases and xylanases, as produced for non-feed applications.

Using ligninolytic fungi, including their enzymes, may be one potential alternative to provide a more practical and environmental-friendly approach for enhancing the nutritive value of crop residue. The cost of exogenous enzymes is at present too high to be applied by smallholder farms, but this may change in the future. Moreover, the application of ligninolytic fungi or their enzymes combined with chemical pre-treatments to crop residue may be an alternative way to shorten the period of the incubation times and (or) decrease the number of chemicals, effecting some synergy.

2.10.1.3 *Chemical treatment*

Chemical treatments appear to be the most practical for use on-farm, as no expensive machinery is required, the chemicals are relatively cheap and the procedures to use them are relatively simple. However, the chemicals themselves are not harmless and safety precautions are needed for their use.

Chemicals to improve the utilization of crop residue may be alkaline, acidic or oxidative agents. Among these, alkali agents have been most widely investigated and practically accepted for application on farms. Basically, these alkalis agents can be absorbed into the cell wall and chemically break down the ester bonds between lignin and hemicellulose and cellulose, and physically make the structural fibers swollen (Lam *et al.*, 2001). These processes enable the rumen microorganisms to attack more easily the structural carbohydrates, enhancing degradability and palatability of the crop residue (Prasad *et al.*, 1998; Shen *et al.*, 1999; Selim *et al.*, 2004). The most commonly used alkaline agents are urea, sodium hydroxide (NaOH), and ammonia (NH_3).

Urea treatment: Crop residue can also be treated with urea, which releases ammonia after dissolving in water. For practical use by farmers, urea is safer than anhydrous or aqueous ammonia and also provides a source of nitrogen (crude protein) in which residue is deficient (Schiere and Ibrahim, 1989). Since urea is a solid chemical, it is also easy to handle and transport (Sundstøl and Coxworth, 1984) and urea can be obtained easily in many developing countries. In addition, urea is considerably cheaper than NaOH or NH_3. Vadiveloo (2003) reported that crop varieties with a low degradability responded better to urea treatments than higher quality straw, increasing the *in vitro* dry matter degradability from 45 to 55-62%. Urea treatment may therefore be most suitable for small-scale farmers to improve the quality of straws, particularly varieties showing a low degradability.

Numerous investigations involving urea treatment of rice straw, with or without additional supplementation, have been carried out in the laboratory (Reddy, 1996 and Shen *et al.* 1998) and in the field (Prasad *et al.,* 1998; Vu *et al.,* 1999; Vadiveloo, 2003 and Akter *et al.,* 2004). Pradhan *et al.* (1997) showed that addition of $Ca(OH)_2$ to urea improved the IVDMD. Using urea is regarded as a practical and available method in livestock production, especially in developing countries, as it is relatively cheap, adds nitrogen to the ration and is relatively safe to work with.

Lime ($CaO/Ca(OH)_2$): is a weak alkali agent with a low solubility in water. It has been reported that lime can be used to improve the utilization of straw and also can be used to supplement the ration with calcium, which has been found to be in a negative balance in cattle fed only rice straw (Pradhan *et al.,* 1997; Chaudhry, 1998). Soaking and ensiling are two methods of treating crop residue with lime. Although lime treatments increase the degradability of the residue, the dry matter intake decreases, due to a reduced acceptability of the treated feed by animals. Pradhan, *et al.,* (1997) reported that ensiling rice straw with 4 or 6% $Ca(OH)_2$ showed a higher IVDMD than using 4 or 6% urea. However, mould growth was noticed in the $Ca(OH)_2$ treated straw. It was suggested that a combination of lime and urea would give better results than urea or lime alone. This combination has the advantage of increased degradability and increased content of both calcium and nitrogen. Additive effects of lime and the other alkali agents have been demonstrated (Saadulah *et al.,* 1981). The use of lime may be safer and more cost effective to use than NaOH.

NaOH treatment: Several NaOH treatment methods to improve the use of crop residues for ruminant feeding have been developed as reviewed by Berger *et al.* (1994) and Arieli, (1997). The principal advantages of the different NaOH treatment methods are increased degradability and palatability of treated straw, compared to untreated straw (Chaudhry and Miller, 1996; Vadiveloo, 2003). However, NaOH is not widely available as a resource for small-scale farmers and may be too expensive to use. In addition, the application of NaOH can be a cause of environmental pollution, resulting in a high content of sodium in the environment (Sundstøl and Coxworth, 1984).

Ammonia treatment: Treatment of crop residue with anhydrous and aqueous ammonia, urea or other ammonia-releasing compounds has been widely investigated to improve degradability (Abou-EL-Enin *et al. 1999;* Selim *et al.* 2002; Fadel-Elseed *et al.* 2003). The principle of ammonia treatment is supposed to be similar to that of NaOH treatment. Ammonia treatment not only increases the degradability of the crop residue, but also adds nitrogen (Abou-EL-Eninn, *et al.*, 1999) and preserves the residue by inhibiting mould growth (Calzado and Rolz, 1990). Besides, improvement in degradability of structural carbohydrates, ammonia treatment is an effective means of reducing the amount of supplemental nitrogen, reducing the costs of purchasing protein-rich feedstuffs, and enhancing acceptability and voluntary intake of the treated residue by ruminants. Although comparative studies in improving the energy value of rice straw have shown that ammonia treatment is less efficient than NaOH (Liu *et al.*, 2002), its use may be more profitable for farmers as the added ammonia serves as a source of nitrogen. In a previous study using sheep, Selim *et al.* (2002) treated rice straw packed in polyethylene bags for 4 weeks with gaseous ammonia (3 g NH_3 per 100 g dry matter). The excess ammonia was removed before offering the straw to animals.

Ammonia treatment increased the N content in the rice straw from 8.16 to 18.4 g kg-$_1$ (CP content increased from 51 to 115 g kg-$_1$). The ammonia treatment slightly decreased the NDF content from 571 to 551 g kg-$_1$, because of dilution with the additional N, but increased the ADF content from 303 to 327 g kg-$_1$, indicating that the cell wall properties were changed.

Moreover, the physical strength of ammoniated rice straw was significantly lower than that of the untreated straw. In addition, the proportion of small feed particles tended to be higher and stimulated more attachment and growth of the rumen bacteria (Selim *et al.*, 2002). The reduced particle size and the increased attachment sites could lead to subsequent increased microbial colonization and digestion. Ammonia treatment therefore increases feed value by making the cell wall more available for the rumen microorganisms and also the increased N content improves microbial growth.

Urine treatment: As urine contains urea, urine can be used as a source of urea and ammonia to improve the quality of rice straw. Urine can be sprayed on the straw in a similar way as is done with urea solutions (Dias da Silva, 1993) and can provide a nearly equal improvement of the degradability and nitrogen content as other methods of ammonia treatment (Dias da Silva, 1993; Schubert and Flachowsky, 1994). However, research on this subject has been quite limited and there is currently inadequate information available to define clearly the conditions to optimize urine treatment (Dias da Silva, 1993).The use of urine is hampered by the difficulty of separation of urine from feces in ruminant husbandry. This also makes the use of urine rather unhygienic and therefore not advisable to use, although its use is without costs for farmers and urine is normally available in excess.

2.10.1.4 *Physio-chemical treatment*

The methods involve are particle size/chemicals, NaOH/pelleting, urea/pelleting, lime/pelleting, chemicals/steaming, etc (Sarnlong *et al.,* 2010). There is evidence that combining physical treatments such as milling, grinding and steaming, which decrease particle size, with chemical treatments, increase the effectiveness of the chemicals, although the effects may not always be additive. In any case, such severe physico-chemical treatments may be out of reach of village farmers in humid West Africa (Smith, 1989).

2.10.2 Supplementation

Supply of deficient nutrients in diet containing crop residue improves intake, digestibility and optimize the utilization of the residues. Chemical or other treatments may improve intake and digestibility, but unless adequate supplementation of deficient nutrients is made, much of the additional energy released will be inefficiently used (Rasambainarivo *et al.*, 2002). Smith (1988) have suggested that to optimize the utilization of crop residues, nutritional supplements should be provided.

2.10.2.1 *Supplementation with agro-based product*

Performance of animals grazing tropical pasture during the dry season without supplementation shows that they lose weight and body condition (Adu, 1982) in Adamu *et al.* (2013). The weight loss may be about 40g per head per day for cattle, sheep or goat. During the dry season, the CP of native pasture falls to about 1.5 and 3% (Adamu *et al*., 2013). The importance of supplementing poor quality forages for improved intake and animal performance using agro-based products has been reported (Alawa and Umunna, 1993).

Agro-industrial by-products are waste products arising from the processing of crops or animal products usually by an agricultural firm. The resultant products from these industries are considered as waste since they are of little or no nutritional importance to humans (Adamu, 2015). These by-products in Nigeria vary from primary processing of farm produce wastes to wastes from agro allied industries. Some of these wastes are left unutilized, often causing environmental pollution and hazard. Those that are utilized do not have their full potentials harnessed. They may be of plants or animal origin like bagasse, molasses, bran or offal, cotton seed, cotton seed cake, groundnut cake, groundnut shell, palm kernel cake, soybean cake, sunflower meal, cassava meal all of plant origin. Those of animal origin include blood meal, bone meal, fish meal, feather meal, etc. The use of agro-based products for livestock feeding is justified when the forage supply is inadequate for the animals' needs, either in terms of quantity or quality.

Agro-industrial by product is used as energy or protein sources depending on the nutrient composition. Small ruminants were found to exhibit good response in feeding trials involving agro-industrial products. For instance, peels of tuber crops, cereal and legume residues and browse plant have received increased attention. Cassava, yam and sweet potato peels are fermentable energy sources (Smith, 1993) that might be used in place of molasses or maize bran.

Cotton seed cake (CSC):

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

In Nigeria, most of the CSC is used in the feeding of ruminants and ruminants can utilize the CSC without dehulling. The most widely used oil seed cake for feeding ruminant animals in Nigeria is undelinted, undecorticated cotton seed cake. Alhassan *et al.* (1985) observed an influence of cotton seed cake supplementation on intake and nutritive value of untreated cereals of sorghum, millet and maize. This is may be attributed to its availability and cost in relation to that of its closest competitor, groundnut cake. The crude protein content of delinted decorticated cotton seed cake (CSC) is about 26%. It is however low in cystine, methionine and lysine. The decline in production of cotton in Nigeria has seriously affected the availability of CSC in the country. The use of CSC as ruminant feed is also constrained by its popularity in monogastric diets, which makes the cake to be over priced and very uneconomical for ruminants.

2.10.2.2 *Supplementation with leguminous crop residues*

Legumes are crops that improve the soil fertility through their root nodules which fix atmospheric nitrogen, the seeds are used for human consumption while the fodder for livestock feed. Thus dual-purpose legumes appear more acceptable to the subsistence crop-livestock farmers of Nigeria, some of such crops are cowpea, soya bean, groundnut and lablab.

The parts of these crops used in livestock feeding include groundnut haulms, cowpea pod shell and hay, lablab hay, soybean hay and threshing. These feed resources and cereal straw constitute the most important field crop residues for ruminants. The legume residues are higher in CP compared to the cereal residues (Alhassan *et al.,* 1985), but low in ADF. The CP content of cowpea haulms range from 5.9 to10.4 % while that of cowpea shell ranges from 6.9 – 7.1 %. The use of these crop residues has led to improvement in animal performance.

Cowpea *(Vignesis sinensis)* vines:

The main by-product from cowpea is the remnants of cowpea harvest; include cowpea vines, leaves and husk. Alhassan *et al.* (1984) stall-fed cowpea vines, cowpea leaves and cowpea-shells to cattle, sheep and goats in experiments intended to determine the voluntary intake and digestibility of these residues. Sheep and cattle consumed in excess of 1.2% of their body weights of cowpea vines with DM digestibility of 48.8 and 78%, respectively.

Labla (*Lablab purpureus*) vines:

Lablab purpureus is a dual purpose legume crop that is rapidly gaining acceptance by agro-pastoral farmers and has been widely used for feeding ruminants in the tropics (Tanko *et al.,* 1992). Amodu *et al.* (2004) reported the crop to have high forage yielding potential compared to other commonly grown legume crops.

Lablab has been reported to be one of the most popular leguminous forage species in various parts of the world. There are many varieties of lablab that are currently utilized for different purpose, ranging from green manuring to grazing of livestock. *Lablab* has been known to acclimatize in many tropical and subtropical countries of the world (Purseglove, 1968) in Adamu, (2015). The lifespan of *lablab* has been found to extend into early dry season in Nigeria (Nworgu and Ajayi, 2005). It is a legume which produces high quality conserved feed (Agishi, 1985; Amodu *et al.,* 2004).

In a study where *lablab* was used as a supplement to oat hay, average daily gain in sheep fed the supplement was almost double than that of sheep fed oat hay solely as the basal diet (Umunna *et al.,* 1995). Ndlovu and Sibanda (1996) had similar results when sheep fed lablab as a supplement to Zimbabwe scrub land herbage gained a total of 3.1 kg in two months while unsupplemented sheep only gained 1.0 kg. Results from a goat study by Makembe and Ndlovu (1996), showed that maize stover diets supplemented with *lablab* resulted in better body weight changes of the does, higher kid birth weights, faster growth rates and more milk as compared to traditional small holder practices in which no supplementation was used. Hassan (2014) reported blood urea nitrogen (BUN) of (5.26-7.50Mmol/L) after feeding Red Sokoto Bucks with graded levels of Lablab (*Lablab purpureus* L. sweet) hay as supplement to a basal diet of maize (*Zea mays*) stover.

Though *lablab* is known in many countries and has the capability of being an outstanding resource for agricultural systems in the tropics, it is not being used to its full potential (Agishi, 1985; Amodu *et al.,* 2004). In many areas where *lablab* could be beneficial, ability to buy seed is restricted by economic constraints and producers' willingness to take the risk in trying a new practice is guarded by traditional paradigms. *Lablab* forage haulms gathered after harvesting the seeds are not as popular as groundnut haulms in the northern region of Nigeria where much livestock activities are practiced (Umunna *et al.,* 1995). Added to that relying only on the poor quality *lablab* haulms for rabbit feeding at the end off harvesting period is inappropriate. Hassan (2014) opined that both the level of awareness and adoption of irrigated leguminous forage such as *Lablab* production were relatively low in all the three states (Kano, Kaduna and Zamfara) where the survey was carried out.

2.10.2.3 *Supplementation with browse plants*

Browse plants are shrubs and trees whose leaves, twigs and woody parts can be eaten by animals. Examples of browse plants include; *Leucaena leucocephala, Gliricidia sepium, Albizia lebbeck, Moringa oleifera* etc. browse shrubs widely available and fed to animals by farmers in the tropics (Ndemanisho *et al.,* 2007). Positive significant effect of *Ficus cyncomorus* leaf meal supplement on voluntary feed intake, nutrient digestibility and nitrogen balance in Yankasa bucks was reported (Abdu *et al.,* 2012). Similarly, Otaru (1998) observed changes in the growth performance of Red Sokoto goats fed varying proportion of *Ficus thoningii* leaves. However, Jokthan *et al.* (2003) reported the utilization of the *Ficus thoningii* by rabbit. Goats are reported to be are good browsers (Yemi, 2008). More than 90% of the ruminant population survives exclusively on natural pasture.

Reports of different works conducted revealed the potentials of *Ficus* as dry season feed (Bankole *et al.*, 2001 and Abdu *et al.*, 2012). The moisture content is usually between 50-85%. The dry matter nutritive value can be varied depending on the stage of growth, or age of the plant, fertility of the soil etc. (Bawa, 2014). When compared with tropical grasses, browse is richer in protein and minerals in the dry season. The crude fibre content of browse also tends to be lower than that of grasses and usually ranges between 20 and 40% and is even lower in shoots and leaves. The low content of crude fibre suggests that the energy content of browse is higher than that of dry grass. Browse could, therefore, supplement the low protein content of grass forage during dry periods (Yami, 2008).

2.10.2.4 *Mineral supplementation*

At the level of productivity obtained under unimproved feeding systems in the small-scale farming setting, goats and sheep do not often show symptoms of mineral deficiencies or respond to mineral supplementation. Responses to mineral supplementation only occur after the major nutrient imbalances have been corrected (Yami, 2008). A feeding strategy based on treated and supplemented crop residues may correct these major nutrient deficiencies and improve productivity to such an extent that mineral requirements increase. Mineral supplementation may then become important, not only to avoid deficiency problems, but also to improve performance further (Smith, 1989).

Crop residue based diets are most likely to be deficient in sodium, copper and phosphorus. These are the same minerals found to be marginal or deficient in tropical grasses (Yami, 2008). Preston (2007) reported that most straws are deficient in the sodium, copper and phosphorus in addition to sulphur, cobalt and calcium. The high concentrations of oxalates and silicates in some of the residues, such as rice straw, may further reduce the availability of calcium and magnesium, which are lost as silicates and oxalates in the urine and faeces.

Mineral supplementation can be done through the use of multi-nutrient blocks that contain the deficient minerals. Ideally, specially formulated mineral supplements are provided in the form of a mineral lick. Supplementation of common salt is widely practiced in many parts of Nigeria. Salt supplementation is especially useful in hot areas where sheep and goats lose large amounts of salt through perspiration. Goats obtain higher amounts of minerals because they consume more browse and consume a wider array of vegetation than sheep (Yami, 2008).

Bone meal

Bone meal is a source of mineral. It is obtained by burning off the organic content of bone. Bone meal is a good source of both calcium (30%) and phosphorus (13%). It has the advantage of being available and can be produced by the local farmer (Onwuka *et al*,. 2014).

2.11 Effect of Crop Residues Treatment on:

2.11.1 Feed intake

The amount of nutrients consumed depends on the amount of nutrient in the food and the quantity of the feed utilizes. Feeding is controlled by a number of physical, psychological and physiological factors. The environment in which the animal lives also affect feed intake (Muhammad, 2012).

Many diets containing low proportion of useful energy or high proportion of indigestible material cannot be consumed at a level sufficient for growth, lactation or even maintenance of body weight which could be as result of physical limitation of intake. There are physical factors that affect intake which include concentrate: forage ratio, roughage quality, forms of the diet, protein and energy content as well as rumen size (Gatemby and Humbert, 1991; Chesworth, 2006).

The distinctive differences between roughages and concentrates are: roughages contain high fibre, large particle size, low content of digestible energy, low density and are generally of low digestibility. Roughages therefore have characteristics that limit intake. Therefore animals offered roughages may not be able to consume the required amount of feed energy (Chestworth, 2006). Supplementation with concentrate improves intake as the roughages: concentrate ratio decreases, intake will rise as the physical limitation of intake is relaxed. Further decrease in the proportion of roughages or indigestible fibre ratio however lower feed intake because of its negative effect on the fermentation process in the rumen (Chestworth, 1992).

Roughage quality also affect feed intake, the higher the quality of the roughage (particularly DM digestibility), the higher the intake (McDonald *et al.,* 2002). The form in which a particular kind of feed is offered to the animal also affects its intake. Grinding of roughages has been shown to increase voluntary feed intake, since intake seems to be limited by restriction placed upon the rate of passage of food out of the rumen through the reticulomasal orifice (McDonald *et al*., 1995). Experimental evidence has shown that grinding of roughages and pelleting of the diets seem to have similar effect, although with varying degrees (Chestworth, 2006). Very finely ground, highly concentrated diets provide too little roughage (fibre) for the proper functioning of the rumen (McDonald *et al.*, 2002; Chestworth, 2006).

Reducing the particle size of foods has two effects on digestion and hence feed intake: it reduces the amount of rumen degradation needed to make individual particles small enough to pass through the reticulo-omasal orifice. It also increases the overall surface area of the food so that microbes can attack the food at the same time. This would enhance rate of digestion and hence feed intake (McDonald *et al.*, 1995).

The physiological state of animals has been shown to affect intake. The physiological factors can override the physical factors associated with rate of breakdown of feed in the rumen. These factors include previous restriction of feed, age and species of the animal, physiological state, water intake, rate of digestion of feed through the gastro-intestinal (GIT); and the gut-fill (Gatemby and Humbert, 2006).

Age and size are physiological factors affecting intake. In young ruminants, important determinants of feed intake appear to be related to the balance between the amount of nutrients that the animal appears to need and the amount and of feed eaten. However, the relationship between size (as measured by body weight) and the amount of food consumed is determined by the metabolic size of the animal, proportional to the animals' metabolic body weight.

Rate of digestion in sheep also controls feed intake. Foods materials enter into rumen largely in an undigested state, and there are only three ways in which they leave the rumen: as gaseous methane, as volatile fatty acids and as particles digester (McDonald *et al*., 2002). The rate at which each of these processes occurs is dependent on the overall fermentation process and the speed which non particles move through the gut (flow rate), which determine the subsequent amount of feed to be consumed (Chestworth, 2006).

When ambient temperature is high, feed intake drops dramatically (Payne and Wilson, 1999). If humidity is also high, feed intake is further reduced due to heat inside the rumen and within their body (Payne and Wilson, 1999). The amount of heat produced by fermentation in the rumen is quite small. It probably amounts for less than one-tenth of the gross energy eaten, despite its small quantity; it may be a serious problem to an animal that is already having difficulties in getting rid of excess heat (Payne and Wilson, 1999). When environmental temperature increases, sheep have to use a lot of heat it produce.

2.11.2 Digestibility

Digestibility of a feedstuff is defined as that portion of feed or of any single nutrient of feed which is not recovered in faeces or in other words the portion which is acted upon by the microbes/digestive enzymes in the digestive tract and is absorbed by the system (Bawa, 2014). The digestibility of a feed determines the amount that is actually absorbed by an animal and therefore the availability of nutrients for growth, reproduction etc.

Digestibility establishes the intake of the basal feed once nutrient deficiencies for the rumen microbes have been corrected; however, intake is affected by a range of numerous factors (Makkar, 2002). The nutritive value (digestion and retention coefficient) of feed is primarily determined by carrying out a digestion trial on the feed (Getachew *et al.*, 2004).

Various methods have been used to improve the digestibility and utilization of low quality crop residues especially the use of urea and or lime solution followed by a period of storage under air-tight conditions may be more practical (Abdel Hameed *et al*., 2013). Significant effect of *Ficus cyncomorus* leaf meal supplementation on voluntary feed intake, nutrient digestibility and nitrogen balance in Yankasa bucks have been reported (Abdu *et al.,* 2012). Some workers have shown that the treatment of crop residues with urea improved digestibility of organic matter, crude protein, NDF and ADF (Hossain *et al.*, 2010; Sarnklong *et al.,* 2010; Huyen *et al.,* 2012 and Gunun *et al.,* 2013).

Other researchers have also reported that the treatment of crop residues with the combination of both urea and lime solution increased the digestibility of DM, lignin, ADF, NDF, CP and NFE (Fadel Elseed *et al*., 2003; Sahoo *et al*., 2000; Trach *et al*., 2001a; 2001b; Wanapat *et al*., 2013 and Yulitiani *et al.,* 2015). In the same vein, the treatment with urea-lime increased the degradability, *in vitro* and *in vivo* as reported by Pradhan *et al.* (1997 and Sarnklong *et al*. (2010).

2.12 Growth and other parameters in sheep

2.12.1 Growth

Growth is defined as the increase in weight and size of an animal until a mature size is reached. Body depends on the multiplication of cells, increase in cell size, and accumulation of extra-cellular substances the pattern of which is systematic in normal growth. Growth is most conveniently measured as live weight change, and the growth curve of the lamb under optimum management conditions is typically sigmoidal. Lambs grow very rapidly during the few months of life, and may in fact reach slaughter weight in less than half the time they were in the uterus (Mohammed, 2012).

Growth performance of sheep is influenced by breed, type of birth, sex, age or parity of the dam, month or season of parturition, disease incidence and management practices such as mortality, nutrition and husbandry practice (Hassan *et al*., 1990; Osinowo *et al.*, 1994 and Hassan 2014).

Ngere *et al*. (1984) reported that significant differences exist in the pre-weaning and post-weaning growth rates of lambs of different breeds. Average daily gain of 103, 96 and 70g was reported for Uda, Yankasa and crossbred lambs respectively during the pre-weaning stage. At post weaning, daily gain of Uda and Yankasa were 51 and 53g respectively. Muhammad *et al*. (2008) and Aruwayo *et al*. (2008) reported ADG of 109 and 80g/day respectively for Uda lambs after weaning.

Male lambs generally weight heavier than their female counterparts (Hassan, 2000). Males also gain faster at various stages of growth (Ngere *et al*., 1984; Adu, 1985 and Osinowo *et al.,* 1994). El-Kimairy *et al*. (1979) attributed this variation to genetic differences. The author noted that the different effects of the gonadal hormones (androgens and estrogens) might be the primary cause of this variation. The androgens in males are anabolic steroids that promote growth, while the estrogens in females restrict the growth of long bones and retard growth.

Age or parity of the dam also affects growth rate of lambs. Lambs born by mature ewes have been found to weight heavier and grow faster than those born by young and older dams (Hassan, 2000). He further reported that birth weight increased steadily form 3.17kg in primiparous ewes to 3.70kg in the fourth and fifth parities, and then declined to 3.39kg in the sixth parity when the dams have lost condition.

Lambs grow quickly during the first 10-12 weeks (gaining 1.8-2.25kg per week), provided they received adequate milk from the ewes that graze on clean pasture. However highest growth rate under optimal conditions is achieved between 1-5 months. After weaning lambs grow rather slowly (gaining 0.45-1kg per week), a period referred to as “store period”, and finally put on about 1-1.3kg per week in the fattening period. Growth rate accelerates up to puberty and slows down progressively as maturity is approached.

Growth rate can be influenced by a combination of factors which include management system, season of the year and physiological state of the animal (Ogebe, *et al.,* 1985). Live weight, when measured under standard conditions, can provide a useful index of muscle growth. The relationship between live weight and muscle or protein content of the body can be distorted by variation in gut fill, the weight, as well as the condition and moisture content of the fleece. Muscle comprises a remarkably constant proportion of the fleece free empty body weight, even in association with considerable variation in fatness. The proportion of viscera, inedible offal and bone varies inversely with the fat content of the body.

It has been reported that the average birth weight of Nigerian breeds of sheep are 3-3.5kg for Balami and 2.24-3.6kg for Yankasa (Osinowo *et al.*, 1994). In cross breds, the average birth weights reported are 3.16kg for Balami x Uda, 3.0kg for Balami x Yankasa and 2.66kg for Yankasa x Uda. Studies have shown that the growth rate of lambs is highly variable probably because of differences in genotype and system of management. Hassan (2000) reported a mean daily gain 112g of farm managed Uda lambs in Zamfara reserve of north western Nigeria.

Average daily gain of 33.58g has been reported for yearling under on-station managed Uda sheep in Zamfara reserve while 24.5g was reported as yearling of Yankasa from on-station study (Hassan *et al*., 1990). Variations have been reported in the performance of sheep fed different diets in Nigeria. Bibi-Faruk and Osinowo (2006) indicated a daily weight gain of between 46 and 68g for Yankasa sheep fed fresh *Ficus thonningii* leaves. Arigbede *et al*. (2007) fed hatchery waste meal to West African dwarf sheep and recorded a daily gain of between 41-95g/day. Muhammad *et al.* (2008) fed Columbus grass (*Sorghum almum*) to

Yankasa sheep and reported average daily gain of up to 139g. Aruwayo *et al*. (2007) fed forestomach digesta and poultry litter to growing Uda sheep and recorded an ADG value of 80g. Otchere *et al*. (1986) found the same ADG when they fed cocoa-husk based diets to fattening sheep. Muhammad *et al*. (2008) found an ADG value of 109g when rice milling waste fed to growing Uda sheep.

The effect of season appears to be rather inconsistent on yearling weight, but seems to be related to the amount and quality of forage available to both dams and their lambs (Buvanendran *et al*., 1981; Hassan, 2014). As for year of lambing, the general conclusion is that variations are due to differences in the amount and distribution of rainfall between years, which influence both the quality and quantity of forage available for feeding. Berhanu and Heile (2009) attributed yearly fluctuations in lamb's body weight to variation in diseases and feeding conditions, as well as to differences in genetic make-up, and composition of flock.

2.12.2 Blood metabolites

Reference guide (2016) of Serum bio-chemical reference ranges has reported normal values of different blood metabolites in sheep at 2.8-7.1Mmol/L, 106-168Mmol/L and 60-79g/L for blood urea nitrogen, creatinine and total protein, respectively.

2.12.3 Blood urea nitrogen

Blood urea nitrogen (BUN) measures the amount of nitrogen in blood that comes from the waste product of urea. An animal fed regularly on high protein diet will show elevated blood urea level (Bush, 1991). The blood urea is raised for a few hours after eating protein feedstuffs and may in some cases, exceed the upper limit of the normal range. Bush (1991) reported that raised levels are principally associated with renal disease, obstruction to the outflow of urine, excessive protein breakdown and impaired cardiac function while decreased blood urea may be associated with severe liver disease or protein mal- nutrition. Ewuola *et al.* (2014) reported that the significant depressed in birds fed diatomaceous earth compared to control could be attributed to the effect of the test ingredient which lowered blood urea and thereby increasing protein metabolism and utilization. Blood urea is inversely related to the quality of dietary protein and high serum urea indicates poor dietary protein utilization (Awosanya *et al*., 1999).

A high BUN value can mean kidney injury or disease is present. Kidney damage can be caused by diabetes or high blood pressure that directly affects the kidneys. High BUN levels can also be caused by low blood flow to the kidneys caused by dehydration or heart failure. A low BUN value may be caused by a diet very low in protein, malnutrition, or severe liver damage. Drinking excessive amounts of liquid may cause overhydration and cause a low BUN value. Low BUN-to-creatinine ratio may be caused by a diet low in protein, a severe muscle injury called rhabdomyolysis, pregnancy, cirrhosis, or syndrome of inappropriate antidiuretic hormone secretion (SIADH).

Blood urea nitrogen (BUN) in adults human is 10-20 milligrams per decilitre mg/dl or 3.6-7.1 milimoles per liter (mmol/L) and in children 5-18 mg/dl. Hassan (2014) reported BUN of (5.26-7.50Mmol/L) after feeding Red Sokoto Bucks with graded levels of Lablab

(*Lablab purpureus* L. sweet) hay as supplement to a basal diet of maize (*Zea mays*) stover. Aliyu *et al*. (2002) reported blood urea nitrogen values of 14.00 - 22.40mg/dl from ram lambs fed urea and/or poultry droppings treated *Pennisetum pedicellatum* (*kyasuwa)*

2.12.4 Blood creatinine

Creatinine is nitrogenous compound that is formed as a metabolic end product of creatine. Is produced in the muscle, passes into the blood and is excreted in the urine (Babington, 2006). Creatinine of 60-100Mmol/L was reported by Hassaan (2014) from an experiment conducted on performance of Red Sokoto Bucks fed graded levels of Lablab (*Lablab purpureus* L. sweet) hay as supplement to a basal diet of maize (*Zea mays*) stover.

2.12.5 Blood total protein

Bush (1991) reported that an increase in total blood protein may be due to dehydration, increase in the level of globulin while a decrease in total blood protein level is always due to a low albumin level accompanied either by no increase in the globulin level or by an increase in the globulin level which is less than fall in the albumin level. The reduction in the level of blood protein may be due to heavy loss of albumin, excessive loss of plasma protein due to hemorrhage, increased protein breakdown, failure to ingest adequate amount of protein as in the case of starvation and failure to produce adequate amount of plasma protein.

Coles (1986) observed that high dietary protein could be associated with increase in urea level of the diet. Taiwo and Ogunsanmi (2003) reported total protein of various small ruminants in the range of 5.5-10.0g/dl. Similarly Aliyu *et al.* (2012) obtained total protein value that ranged between 5.2-6.02g/dl from an experiment with ram lambs fed urea and/or poultry droppings treated *Pennisetum pedicellatum* (*kyasuwa).*

2.12.6 Rumen metabolites

2.12.6.1 *Volatile fatty acids*

The VFA, also known as short-chain fatty acids, are produced in the gastrointestinal tract by microbial fermentation of carbohydrates and endogenous substrates, such as mucus. This can be of great advantage to the animal, since no digestive enzymes exist for breaking down cellulose or other complex carbohydrates (Bergman, 1990).

Volatile fatty acids (VFAs) are produced in large amounts through ruminal fermentation and are of paramount importance in that they provide greater than 70% of the ruminant's energy supply. The principal VFA in either the rumen or large intestine are acetate, propionate, and butyrate and are produced in a ratio varying from approximately 75:15:10 to 40:40:20. Virtually all of the acetic, proprionic and butyric acids formed in the rumen are absorbed across the ruminal epithelium, from which they are carried by ruminal veins to the portal vein and hence through the liver. Bergman (1990) observed that continuous removal of VFA from the rumen is important not only for distribution, but to prevent excessive and damaging drops in pH of rumen fluid.

The rumen is lined with stratified squamous epithelium similar to skin, which is generally noted for efficient absorption. Nonetheless, this squamous epithelium has a structure which functions similarly to the columnar epithelium in the small gut and performs efficient absorption of VFA, as well as lactic acid, electrolytes and water. Animals that have been on a high plane of nutrition, with abundant VFA production, have long, luxuriant papillae well suited to promote absorption. In contrast, animals which have been under nutritional deprivation have small, blunted papillae, and require time on a high quality diet to allow for development of their papillae and absorptive capacity (Bergman, 1990).

All the VFA appear to be absorbed by the same mechanism, which is diffusion through the epithelium, down a concentration gradient. As they pass through the epithelium, the different VFA undergo different degrees of metabolism. Acetate and propionate pass through the epithelium largely unchanged, but almost all of the butyric acid is metabolized in the epithelium to beta-hydroxybutyric acid, a type of ketone body. The three major VFA absorbed from the rumen have somewhat distinctive metabolic fates:

Acetic acid is utilized minimally in the liver, and is oxidized throughout most of the body to generate ATP. Another important use of acetate is as the major source of acetyl CoA for synthesis of lipids.

Proprionic acid is almost completely removed from portal blood by the liver. Within the liver, proprionate serves as a major substrate for gluconeogenesis, which is absolutely critical to the ruminant because almost no glucose reaches the small intestine for absorption.

Butyric acid, most of which comes out of the rumen as the ketone beta-hydroxybutyric acid, is oxidized in many tissues for energy production.

2.12.6.2 *Ammonia nitrogen*

The quantity of ammonia in rumen digesta appears to be determined chiefly by the nature and quantity of the diet the sheep is offered. The main sources of the ammonia are nitrogen (N) from the diet, N transferred from the blood to the rumen via saliva or the rumen epithelium and N released during the autolysis of micro-organisms. The important avenues of disposal of ammonia are incorporation into microbial protoplasm, absorption, and passage in digesta to the omasum. The level of ammonia in rumen liquor is of particular nutritional significance as many types of rumen micro-organisms utilize ammonia as a source of N. Thus at very low levels of rumen ammonia, it is to be expected that mircobial activity in the rumen will be reduced and accordingly protein and carbohydrate digestion will be impaired; associated with this impairment, feed consumption will probably decline. (McDonald et al, 2002)

2.12.6.3 *Rumen pH*

Rumen pH is the acidity or alkalinity of the rumen and is determine by the concentration of the produced volatile fatty acids in the rumen. Normal pH differs according to type of feed eaten and ranges between 6-7 in animals on a mostly forage diet but is lower at 5.5-6.5 in animals fed mostly grain and the type and time of sampling (immediately after feeding acidic and after certain period alkaline). High pH 8-10 (rumen alkalosis) indicates simple indigestion, urea indigestion and putrefaction of rumen ingesta. Lower pH 5-5.5 (rumen acidosis) signifies engorgement with readily digestible carbohydrates, chronic rumen acidosis and abomasal reflux from abomasal disease vagal indigestion and intestinal obstruction (Gozar et al., 2001).

2.12.7 Rumen microbial load

Microorganisms that exist in the rumen of ruminant animals are bacteria, protozoa, and fungi.

2.12.7.1 *Bacteria*

Bacteria make up about third of the living organisms but do more than half of the rumen's digestive work. Rumen bacteria are classified into fiber digesters, starch and sugar digesters, lactate using bacteria, and hydrogen-using bacteria but they all work together. (Borne, 1957)

Some bacteria breakdown certain carbohydrates and proteins which are then used by others. Some require certain growth factors, such as B-vitamins, which are made by others. Others help to clean up the rumen of other end products, such as hydrogen ions, which could otherwise accumulate and become toxic to other organisms (Russell, 1988).

2.12.7.2Protozoa

As much as 50% of the microbial mass in the rumen can be made up of protozoa. However, their role, as compared to the rumen bacteria, is not as significant. The protozoa are actually predators to the bacteria in the rumen, they eat up the bacteria. Protozoa are about 40 times the size of rumen bacteria. The rumen protozoa produce fermentation end-products similar to those made by the bacteria, particularly acetate, butyrate, and hydrogen. Rumen methane bacteria actually attach and live on the surface of rumen protozoa for immediate access to hydrogen (Russell,1988). Rumen protozoa eat large amounts of starch at one time and can store it in their bodies. This may help to slow down the production of acids that lower rumen pH, benefiting the rumen.

Rumen protozoa multiply very slowly in the rumen over 15-24 hours – as opposed to the bacteria that may take as little as 13 minutes to multiply (Van Soest, 1982). For this reason, the rumen protozoa hide out in the slower moving fiber mat of the rumen so that they are not washed out before they have a chance to multiply. Low roughage diets reduce the retention of fiber in the rumen and may decrease the number of protozoa in a rumen.

2.12.7.3 Fungi

Fungi are known to exist in the rumen (up to 8% of the total mass) but they are poorly understood. They attach to feed particles and they reproduce very slowly. They may help out the fiber-digesting bacteria by doing some of the initial work of splitting fibrous material apart and making it more accessible for the bacteria. Higher numbers of fungi have been found in the `rumens fed very poorly digestible sub-tropical forages.

2.13 Effects of Nutrition on Carcass Characteristics

2.13.1 Carcass quality

Meat is the animal tissues that are suitable for use as food; chiefly the muscles but it may include liver, heart intestine stomach kidneys and others which are not carcass components. Carcass qualities are the properties or attributes that gives carcass products the necessary characteristics to be accepted, principally nutritional quality-objective and acceptance or consumption quality-subjective. (Bruse, 2016).

2.13.2 Dressing percentage

Dressing percentage is the percent of the live animal that ends up as carcass (Aganga and Tshwenyane 2003). Generally, the carcass weight is taken immediately after skinning and evisceration and is commonly known as hot hanging weight. There are a number of factors that will affect the dressing percentage, including how much the animal has eaten before it is weighed, and how much mud or fibre is on the animal. These factors negatively correlate to the dressing percentage by reducing the dressing percentage (Robert, 2002).

Dressing percentage is based on the relationship between the dressed carcass weight and the live animal weight after things like the hide and internal organs have been removed. In general, animals that hare heavier muscled have a higher dressing percent than animal that are lighter muscled (Bruce, 2016). Additionally, as the fat thickness on the outside of a carcass increases, the dressing percent also increases.

Dressing percentage is calculated as:

Dressing percentage (DP) = Carcass weight/ live weight x 100

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Description of the Study Area.

The study was conducted at the Teaching and Research Farm (Small Ruminants Unit0 of Animal Science Department, Faculty of Agriculture, Ahmadu Bello University, Zaria. Zaria is located in the Northern Guinea Savannah of Nigeria, on Latitude $11^0 12^I$ N and Longitude 7^0 33^I E at an altitude of 610m above sea level (GPS, 2012). Annual rainfall of 1100 -1200mm and temperature that fluctuates within the range of 14.5-39.5^{0}C (IAR, Metrological Service Unit, 2015).

3.2 Source and Processing of Experimental Material

Groundnut shell used in the experiment was obtained from groundnut processing unit in Wanke, Zamfara state. It was ground using hammer mill machine fitted with 2.5mm seive to ease mixing with other ingredients. In treatment 1 the shell was left chemically untreated but groung, therefore served as untreated groundnut shell (UNTGNS).

3.2.1 Ensiling

Each kilogram of groundnut shell was treated with 5% urea and 5% lime for treatments 2 urea treated groundnut shell (UTGNS) and 3 lime treated groundnut shell (LTGNS), respectively. For treatment 4 urea plus lime treated groundnut shell (ULTGNS), in which 1 kg of groundnut shell was treated with 2.5% urea and 2.5% lime. The urea and lime were diluted in water at 2kg in 20 litres of water and sprayed on 40kg of the groundnut shell. The treated shell was ensiled in Persue Cowpea Improved Sacks (PICS) for a period of three weeks then dried for a day and packed into another bags till the period of the feed formulation.

3.2.2 Experimental diets

Four treatment diets were formulated to contain 15% CP with inclusion of the test ingredients untreated groundnut shell (UNTGNS), urea treated groundnut shell (UTGNS), lime treated groundnut shell (LTGNS) and urea plus lime (ULTGNS) 40% in each of the treatment diet. Other ingredients in the complete diets were wheat offal, cotton seed cake, bone meal, salt and ruminant premix (Table 3.1).

Experiment I: Effect of Urea and Lime Treated Groundnut Shell in a Complete Diet on Growing Yankasa rams

3.3.1. Experimental animals and their management

20 Yankasa ram lambs aged between 9-10 months were purchased from Giwa market in Giwa Local Government Area of Kaduna State were used in the experiment. The animals were given prophylactic treatment and quarantined for two weeks before the commencement of the experiment and were dewormed with *Albendazole* 10% 3ml/20kg orally, sprayed with Ametic (*Ascaracide*) 20ml/15lts of water, injected with Oxytetracycine L.A 1ml/10kg (im), Tylosin L A1ml/10kg(im) and *Ivomectine* 1ml/50kg (sc). The ram lambs were also given Intramuscular application of Oxytetracycline and B-complex at the dosage of 1ml/10kg body weight.

3.3.2 Experimental design

All the 20 ram lambs were weighed and randomly assigned to the four treatment diets while balancing their weight with five animals per treatment in a completely randomized design (CRD). They were housed individually in pens of 2x1x2m dimension which were cleaned and disinfected with septol.

3.3.3 Growth feeding trial

The complete diet was formulated using Modified Pearson Square Method and was done after proximate analysis was conducted to determine protein content of the untreated, urea treated, lime treated and urea plus lime treated groundnut shells (5,10,6 and 8%, respectively). For other ingredients, values from literature were used. After the formulation of the complete diets proximate analysis was carried out to determine the proximate composition of each treatment diet. The ingredients compositions of the growth trial diets are presented in Table 3.1. A daily allowance of complete diet at the rate of 4% body weight per head was offered. Fresh and clean water were given *ad libitum*. The diet was formulated to contain 15% crude protein (CP) content.

Table 3.1. Growth composition of the experimental diets fed to growing Yankasa ram lambs.

Ingredient (%)	Treatments diets			
	Untreated	Urea	Lime	Urea/Lime
Groundnut shell	40.00	40.00	40.00	40.00
Maize offal	14.00	27.00	16.50	22.00
C S C	44.00	31.00	41.50	36.00
Bone meal	1.25	1.25	1.25	1.25
Salt	0.50	0.50	0.50	0.50
Rumen Premix	0.25	0.25	0.25	0.25
Total	100.00	100.00	100.00	100.00
Calculated CP %	15	15	15	15
Calculated energy ME (Kcal/Kg)	2349	2825	2850	2889

CSC=Cotton Seed Cake, CP=Crude Protein ME=Metabolizable energy Kcal=Kilo calories Kg=Kilogram

Daily feed intake was taken throughout the experiment by weighing the feed offered each day and the left over (orts) in the following day. Daily intake of the diets was estimated for each animal by subtracting the left over from the quantity served to the animal. Daily water intake and ambient temperature of the environment was recorded. The experiment lasted for 90 days. Weight of the individual animal was measured at the onset of the trial after an overnight fasting to obtain their initial weights and subsequently at 2 weeks intervals between 8:00-9:00am throughout the feeding trial. Weight gain was determined by subtracting the initial weight from the final weight within the periods. Feed conversion ratio was also determined, by dividing feed intake by weight gain.

3.3.4 Blood sampling

Blood samples were collected at the end of the growth trial from three out of the five animals in each of the treatment groups, using disposable syringe through the jugular vein before feeding them at 0 and 4 hours post feeding. Blood samples collected were put in the ETDA free bottles and were taken to Biochemical Laboratory, Faculty of Veterinary Medicine, Ahmadu University, Zaria for total protein (TP), blood urea nitrogen (BUN) and blood creatinine analysis. Total protein was evaluated using refractometer as described in the routine laboratory procedures (Cole, 1986) Blood samples were analyzed for urea nitrogen level (BUN) using the procedure of Archer and Robb (1925).

3.3.5 Digestibility trial

At the end of the growth trial, three animals from each of the treatment groups were randomly selected and housed in individual metabolism crates, ideal for easy collection of urine and faeces as described by Osuji *et al.* (1993). The experimental animals were allowed for 7 days to adjust to the diets and experimental conditions in the metabolism crates, the animals were maintained on similar treatment diets as indicated in feeding trial. Then followed by seven days of total faecal and urine collection to determine nutrient digestibility of the experimental diets and nitrogen retention in the experimental animals.

The total faecal output was collected daily in the morning, weighed and mixed thoroughly and sub-samples were taken. The total faecal samples collected over the 7 days collection period was bulked and sub sampled for laboratory analysis after treating with 20% formaldehyde to prevent further microbial activity. The sample were taken to Animal Science Biochemical Laboratory of Ahmadu Bello University, Zaria for analysis.

The total urine output for 24 hours was collected. This was done by using graduated plastic containers acidified with 10mls 0.1N H_2SO_4 which was placed under the metabolism crates. Ten percent of the daily urine output (aliquot) was taken during the collection from each animal bulked and stored in a freezer at (- 20 ^oC) and later taken to the Biochemical Laboratory for chemical analysis.

Experiment II: Performance of Fattening Yankasa rams Fed Diet Containing Urea and Lime Treated Groundnut Shell

3.4.1 Experimental animals and treatments diets

A total of 16 intact Yankasa rams weighing 24±4kg were purchased from Sheme market of Katsina state. They were randomly allotted to the four treatment diets at four animals per treatment, in a completely randomized design (CRD). Four treatment diets were formulated with other ingredients to contain 14% CP with 40% inclusion of UNTGNS, UTGNS, LTGNS and ULTGNS, respectively. Table 3.2 shows the ingredients composition of the fattening diet.

3.4.2 Management and feeding of the experimental animals

A daily allowance of complete diet at the rate of 4% body weight per head was offered. The rams were quarantined for two weeks in which prophylactic treatments were given. Dewormed with *Albendazole* 10% 3ml/20kg orally, sprayed with Ametic (*Ascaracide*) 20ml/15lts of water, injected with Oxytetracycine L.A 1ml/10kg (im), Tylosin L A1ml/10kg(im) and *Ivomectine* 1ml/50kg (sc). Fresh and clean water were provided *ad libitum*, good sanitation practice was adhered to. The fattening trial lasted for 90 days. The animals were weighed bi-weekly to determine weight gain. Daily records of feed intake were taken throughout the experimental period by weighing the feed offered and the left over (orts) in the following day. Daily intake of the diets was calculated for each animal by subtracting the left over from the quantity already served to the animals. Daily water intake and temperature were also recorded.

Table 3.2. Gross composition of experimental diets for fattening trial..

Ingredient (%)	Treatments diets			
	Control	Urea	Lime	Urea/Lime
Groundnut shell	40.00	40.00	40.00	40.00
Maize offal	20.50	33.50	23.00	28.50
C S C	37.50	24.50	35.00	29.50
Bone meal	1.25	1.25	1.25	1.25
Salt	0.50	0.50	0.50	0.50
Premix	0.25	0.25	0.25	0.25
Total	100.00	100.00	100.00	100.00
Calculated CP	14	14	14	14
Calculated energy (ME Kcal/Kg)	2976	2932	2940	2947

CSC-Cotton Seed Cake, CP-Crude Protein ME=Metabolizable energy Kcal=Kilo calories Kg=Kilogram

Weight of the individual animal was measured at the onset of the trial after an overnight fasting to obtain their initial weights and subsequently at 2 weeks intervals between 8:00-9:00am throughout the feeding trial. Weight gain was determined by subtracting the initial weight from the final weight within the periods. Feed conversion ratio was also determined, dividing the feed intake by weight gain.

3.4.3 Digestibility study

Three rams were selected from each treatment group and housed in an individual metabolism crates. The experimental animals were allowed for 7 days to adjust to the experimental conditions in the metabolism crates, followed by seven days of total faecal and urine collections to determine nutrient digestibility of the and nitrogen retention in the experimental animals. The total faecal output was collected daily in the morning, weighed and mixed thoroughly and sub-samples were taken for dry matter determination. The total faecal sample collected over the 7 days collection period was bulked and sub sampled for laboratory analysis after treating with 20% formaldehyde to prevent further microbial activity. The samples were stored in a freezer at (- 20^0 C) and ;later taken to Animal Science Biochemical Laboratory for analysis.

The total urine output for 24 hours was collected. This was done by using graduated plastic containers acidified with 10mls 0.1N H_2SO_4 to trap ammonia and was placed under the metabolism crates. Ten percent of the daily urine output (aliquot) was taken during the collection from each animal bulked and stored in a freezer at (- 20^0 C) and later taken to the Biochemical Laboratory for chemical analysis.

3.4.4 Rumen liquor collection

Rumen fluid was collected from each ram at the end of the experiment at 0 and 4 hours post feeding. Suction tube was used for the rumen fluid collection. The pH of the rumen fluid was determined using digital pH meter immediately after collection in the farm. Particulate matter was removed by filtering the sample through 4 layers of cheese-cloth. The samples were then put in a 30 ml bottle and acidified with 5 drops of concentrated sulphuric (0.1N H_2SO_4) acid to trap ammonia and stored in a refrigerator (-4^0 c) for the analysis of total protein and ammonia nitrogen using simple micro Kjeldahl distillation (AOAC, 2005) procedure, and total volatile fatty acids was determined by Gas Chromatography (Cottyn and Bonque, 1968). Microbial count was also carried out using Boyne *et al.* (1957) procedure at the Microbiology Laboratory of College of Veterinary Medicine of Ahmadu University, Zaria.

3.4.5 Laboratory Analysis

Treated and untreated groundnut shells, experimental diets and faecal samples were analysed for dry matter (DM), crude protein (CP), crude fibre (CF), ether extract (EE), ash and nitrogen free extract (NFE), according to the method of AOAC (2005). The fibre fractions such as: acid detergent fibre (ADF), neutral detergent fibre (NDF) and lignin were determined according to the method described by Georing and Van Soest (1970). Urine samples were analyzed for nitrogen using the simple micro-Kjeldahl distillation method of AOAC (2005).

Blood samples collected were analyzed to determine blood creatinine, blood urea nitrogen (BUN), total protein (TP).

3.5 Carcass analyses

Three rams were randomly selected from each of the treatment group following the termination of the fattening study. They were starved of feed and water overnight to get shrunk body weight before slaughtering. They were each weighed before slaughtering to determine and record their slaughter weight. They were later weighed after slaughtering and reweighed after evisceration to determine hot carcass weight.

The external offals such as head, tail and skin were removed and weighed separately after slaughtering. Following evisceration the internal offals (liver, lung, heart and spleen) were removed and weighed separately. The gastrointestinal tracts (GIT) were measured. Total weight and meat composition were also determined. The dressing percentage was determined using the method of Aganga *et al*. (2003).

3.6 Statistical Analyses

All the data collected on the growth, fattening, digestibility and carcass characteristics were subjected to analysis of variance (ANOVA), (SAS, 2002). Differences among treatment means, were compared using the Duncan's Multiple Range Test (DMRT) of SAS software.

The following model was used:

$$\mathbf{X_{ij}=\mu+t_i+e_{ij}}$$

Where:

X_{ij}=Observation measured

μ= Population mean

t_i=Treatment effect (control, urea, lime, urea/lime treatment)

e_{ij}=Experimental error

Repeated measure model was used to statistically analyze samples that were collected twice at 0 and 4 hours post-feeding i e blood and rumen liquor.

Repeated measure model

$Y_{ijk} = \mu + \tau_i + \delta_{ij} + t_k + (\tau * t)_{ik} + \varepsilon_{ijk}$

where:

Y_{ijk} = Observation ijk

μ = The overall mean

τ_i= The effect of treatment i (i= 1,2,3,4)

δ_{ij}=Treatment effect within the animals

t_k = the effect of period k (k= 0 & 4hrs)

$(\tau * t)_{ik}$ = The effect of interaction between treatment i and period k

ε_{ijk} = random error with the mean 0 and variance σ2, the variance between measurements within animals

3.7 Cost Benefit Analyses

Profitability of inclusion of treated groundnut shell in the diet of both growers and fattening Yankasa rams fed urea and lime treated groundnut shell based diets were determined. Input and output costs were based on prevailing market prices of the commodities.

CHAPTER FOUR

4.0 RESULTS

4.1. Chemical Composition of the Untreated, Urea and Lime Treated Groundnut Shell

The proximate composition of the treatment material (groundnut shell) is presented in Table 4.1 and the results revealed that, dry matter content was higher in untreated groundnut shell (UNTGNS) (96.79%) followed by urea treated groundnut shell (UTGNS) and urea plus lime treated groundnut shell (ULTGNS) that had the least value (85.91%). Organic matter followed a similar trend only that lime treated groundnut shell (LTGNS) recorded 86.83% little bit higher than UTGNS (86.55%). The proximate analysis indicated that crude protein (CP) content of the UTGNS had 10.88%, ULTGNS 8.93%, LTGNS 6.31% and the least was the UNTGNS with 5.38%. Acid detergent fibre ranged from 21.45%-25.71 with LTGNS recording the highest value of 25.71% and least was ULTGNS. In both ADF and NDF, LTGNS haD the highest percentage while ULTGNS recorded least value 21.45 and 21.45, respectively.

4.2. Chemical Composition of Growth Experiment Diets

The chemical composition of the treatment diets in Table 4.2 indicated dry matter (DM) content of 91.56, 91.22, 91.15 and 90.56% for UNTGNS, LTGNS, UTGNS and ULTGNS diets, respectively. However, crude protein (CP) content was higher in ULTGNS treatment diet (15.30%) with the least in LTGNS diet (14.68%). The results showed more of ether extracts (EE) in UNTGNS diet (4.31%) and the least was in LTGNS diet (3.86%). Acid detergent fibre (ADF) and neutral detergent fibre (NDF) were like in the treated groundnut shell, LTGNS treatment diet had the highest value of 25.11% and 47.77%, respectively.

Table 4.1. Proximate composition of the experimental material.

Parameters (%)	Treatment test material			
	UNTGNS	UTGNS	LTGNS	ULTGNS
Dry matter	96.79	91.42	89.21	85.91
Organic matter	92.59	86.55	86.83	83.79
Crude protein	5.38	10.88	6.31	8.93
Ether extract	2.01	2.42	2.38	2.12
Lignin	8.39	9.01	8.41	7.40
Crude Fibre	70.31	64.29	67.87	67.34
Ash	4.20	4.87	2.38	2.12
ADF	24.31	24.76	25.71	21.45
NDF	47.71	48.43	48.64	21.45

ADF= acid detergent fibre, NDF= neutral detergent fibre

Table 4.2. Proximate composition of experimental diets fed to growing Yankasa ram lambs.

Parameters (%)	Treatment diets			
	UNTGNS	UTGNS	LTGNS	ULTGNS
Dry matter	91.56	91.15	91.22	90.56
Organic matter	85,23	85.37	85.18	86.53
Crude protein	15.25	14.75	14.68	15.30
Crude fibre	10.52	10.81	9.76	10.38
Ether extract	4.31	3.97	3.86	4.03
Lignin	9.39	10.01	9.41	8.40
Ash	6.33	5.78	3.6	4.02
ADF	23.48	24.21	25.11	19.86
NDF	46.60	45.62	47.77	44.84

ADF= acid detergent fibre NDF= neutral detergent fibre

4.3. Performance of Growing Yankasa Ram Lambs Fed UNTGNS, UTGNS, LTGNS and ULTGNS in a Complete Diet

Table 4.3 presents the growth performance of Yankasa ram lambs fed complete diets containing UNTGNS, UTGNS, LTGNS and ULTGNS The final weight showed no significant difference (P>0.05) among ram lambs fed UNTGNS**,** LTGNS and ULTGNS diets but they differed significantly (P<0.05) with ram lambs on UTGNS diet.

The results in the Table showed that ram lambs on ULTGNS diet had the highest daily weight gain of 95.34g which was better than those fed LTGNS and UNTGNS diets, though there were no significant differences (P>0.05) among the three treatments, but they were significantly (P<0.05) higher than those fed UTGNS diet (68.42g). On daily dry intake there was no significant difference (P>0.05) among ram lambs fed UNTGNS and ULTGNS diets but they differed significantly (P<0.05) with ram lambs on UTGNS diet and ram lambs fed ULTGNS were significantly (P<0.05) higher than those on LTGNS diet.

However, ram lambs on LTGNS diet showed a better feed conversion ratio of 8.94 which was significantly (P<0.05) higher than those fed ULTGNS diet but similar (P>0.05) to those on UNTGNS diet. Ram lambs on UTGNS diet had the highest feed conversion ratio (13.12), which was significantly (P<0.05) lower compared to the other treatment groups, as least value in feed conversion ratio (FCR) indicate better feed conversion efficiency.

Table 4.3. Growth performance of Yankasa ram lambs fed UNTGNS, UTGNS, LTGNS and ULTGNS in a complete diet.

Parameters	Treatment diets				
	UNTGNS	UTGNS	LTGNS	ULTGNS	SEM
Initial weight (Kg)	16.40	16.56	16.28	16.18	0.28
Final weight (Kg)	24.50[a]	22.50[b]	24.60[a]	24.76[a]	0.64
Total weight gain (Kg)	8.10[a]	6.16[b]	8.52[a]	8.58[a]	0.55
Daily weight gain (g)	90.02[a]	68.42[b]	94.66[a]	95.11[a]	6.13
Total dry matter intake (Kg)	77.04	73.74	75.04	79.82	3.23
Daily dry matter intake (g)	858.42[ab]	819.36[c]	833.7[b]	886.92[a]	17.54
Feed conversion ratio	9.68[ab]	13.12[c]	8.94[a]	10.20[b]	0.61

Means within the same rows with different superscripts differed significantly ($P<0.05$) SEM=Standard error of means

4.4 Blood Metabolites Characteristics

Results of blood urea nitrogen (BUN), creatinine and total protein (TP) are summarized in Tables 4.4, 4.5 and 4.6 for treatment, sampling periods and treatment and period's interaction effects. In the table ram lambs on UTGNS diet had the highest BUN of 13.00Mmol/L which was significantly ($P<0.05$) higher than those on LTGNS and ULTGNS diets, which were similar and significantly ($P<0.05$) higher than those on UNTGNS. Creatinine followed similar trend. Animals on UNTGNS (59.00g/L) and ULTGNS (59.20g/L) diets had the highest TP values and both differed significantly ($P<0.05$) from those on UTGNS (52.33g/L) and LTGNS (52.33g/L) diets.

Table 4.4. Blood metabolites of growing Yankasa ram lambs fed UNTGNS, UTGNS, LTGNS and ULTGNS in a complete diet.

Parameters	Treatment diets				SEM	Normal value*
	UNTGNS	UTGNS	LTGNS	ULTGNS		
BUN (Mmol/L)	9.38[c]	13.00[a]	11.50[b]	11.70[b]	0.51	2.8-7.1
Creatinine Mmol/L)	127.17[c]	150.00[a]	123.17[d]	131.18[b]	1.81	106-168
Total protein (g/L)	59.00[a]	52.33[b]	52.33[b]	59.20[a]	1.52	60-79

[abc]Means within the same rows with different superscripts differed significantly ($P<0.05$) SEM=Standard error of mean. Ref.guide and Cole, 1986

Results of the interaction in Table 5 showed that BUN was highest at 4 hours post feeding in UTGNS UTGNS diets (14.5Mmol/L), but was not significantly different (P>0.05) from UTGNS diet at 0 and 4hrs post feeding. These were followed by those on LTGNS diet at 0 and 4hrs along with those fed ULTGNS diet at 0 and 4hrs which were significantly (P<0.05) lower than those on UTGNS but significantly higher than those on UNTGNS.

Creatinine levels in animals on UTGNS diet had the highest values both at 0 and 4 hrs post feeding (124.00 and 143.27Mmol/L) and least values recorded were in animals fed UNTGNS diet and LTGNS (114.00 and 116.677Mmol/L) at 0 hour post feeding. Total protein was higher in ram lambs fed ULTGNS **d**iet (54.67 and 63.33g/L) at 0 and 4 hours followed by those fed LTGNS diet. However, at 4 hours post feeding animals on UNTGNS diet showed the highest TP than those on ULTGNS diet with numerical differences. But they were significantly (P<0.05) higher than the animals on the other treatment diets.

Table 4.5. Treatment and period interaction effect on blood metabolites of growing Yankasa ram lambs fed UNTGNS, UTGNS, LTGNS and ULTGNS in a complete diet.

Parameters	Hr	Treatment diets				SEM	Normal value
		UNTGNS	UTGNS	LTGNS	ULTGNS		
BUN	0	7.50^{c}	12.17^{a}	10.67^{b}	9.88^{b}	0.51	2.8-7.1
(Mmol/L)	4	11.27^{c}	13.83^{a}	12.33^{b}	14.50^{a}	0.41	
Creatinine	0	114.00^{c}	141.67^{a}	116.67^{c}	123.67^{b}	1.81	106-168
(Mmol/L)	4	140.33^{c}	158.33^{a}	129.67^{d}	145.50^{b}	2.05	
Total protein	0	54.67^{a}	51.33^{b}	48.67^{b}	57.33^{a}	1.52	60-79
(g/L)	4	63.33^{a}	52.67^{c}	56.00^{b}	62.00^{a}	1.33	

^{abc} Means within the same rows with different superscripts differed significantly (P<0.05) SEM= standard error of means

4.5 Nutrients Digestibility and Nitrogen Retention of the Growing Yankasa Ram Lambs.

4.5.1. Nutrient digestibility of the growing Yankasa ram lambs

The results of the nutrient digestibility are summarized in Table 4.6. Ram lambs fed UTGNS diet recorded the highest dry matter digestibility (DMD) of 50.79% closely followed by 48.33% for ram lambs fed ULTGNS treated diet although no significant difference (P>0.05) between the two treatment groups. Ram lambs fed UNTGNS diet (45.90%) recorded similar DMD with ULTGNS diet, but was significantly lower (P<0.05) than those on UTGNS diet (50.79%). Ram lambs on LTGNS diet had the least DMD (41.48%) and statistically lowers than ram lambs on the rest of the treatment diets.

Crude protein digestibility in ram lambs fed ULTGNS diet showed the highest value (66.00%) and were significantly (P<0.05) higher than the those on the other diets. The results revealed that, there was no significant difference (P>0.05) between ram lambs fed UNTGNS (59.91%) and those on UTGNS (62.88%) and LTGNS diets (57.03). Animals on UTGNS diet (62.88%) were significantly (P<0.05) higher than those on LTGNS treated diet. Ether extract digestibility (EED) showed that ram lambs on UNTGNS and UTGNS diets had the highest EED and had statistically higher (P>0.05) than those on LTGNS and ULTGNS diets. Acid detergent fibre digestibility (ADFD) and neutral detergent fibre digestibility (NDFD) followed similar trend as in EED.

Table 4.6. Nutrient digestibility of growing Yankasa ram lambs fed UNTGNS, UTGNS, LTGNS and ULTGNS in a complete diet.

	Treatment diets				
Parameters %	UNTGNS	UTGNS	LTGNS	ULTGNS	SEM
Dry matter	45.90^{b}	50.79^{a}	41.48^{c}	48.33^{ab}	1.84
Organic matter	44.99^{b}	49.99^{a}	49.91^{a}	48.12^{ab}	1.92
Crude protein	59.91^{bc}	62.88^{b}	57.03^{c}	66.00^{a}	1.51
Crude fibre	72.67	75.55	66.31	75.86	
Ether extract	88.24^{a}	88.56^{a}	84.53b	85.84b	0.79
Lignin	54.46^{bc}	59.48^{a}	56.94^{a}	55.65^{ab}	1.51
ADF	54.33^{b}	57.60^{a}	54.30^{b}	50.82^{c}	1.24
NDF	52.36^{b}	56.84^{a}	51.37^{b}	52.09^{b}	1.45

ADF=acid detergent fibre NDF=neutral detergent fibre NFE=nitrogen free extract

Means within the same rows with different superscripts differ significantly (P<0.05)

SEM=Standard error of means

4.5.2. Nitrogen retention

Table 4.7 shows the results of intake, loss and retention of nitrogen among the ram lambs fed the different treatment diets. The results indicated that animals on ULTGNS diet had the highest nitrogen intake (22.70g/day) and were significantly ($P<0.05$) higher than those in the other treatment groups. Ram lambs on LTGNS diet had the highest total nitrogen loss **(**9.57g/d**)**, though, not different from those on UNTGNS diet, but both were significantly ($P<0.05$) higher than those on UTGNS and ULTGNS diets. However, animals on ULTGNS diets had the highest nitrogen balance (13.92g/day) than those on UNTGNS and UTGNS diets which were statistically similar, but significantly ($P<0.05$) higher than those on LTGNS diet.

Nitrogen retained as percent intake was in range of 52.81-61.18%, with animals fed ULTGNS diet having the highest nitrogen, though not significantly different ($P>0.05$) from those on UTGNS diet but statistically higher than those on UNTGNS and LTGNS diets. Ram lambs fed ULTGNS diet absorbed more nitrogen (g/day) and were significantly ($P<0.05$) higher than those on all the other treatments. Nitrogen absorption in ram lambs on UNTGNS and UTGNS diets was significantly ($P<0.05$) lower than those fed LTGNS lime and ULTGNS.

Table 4.7. Nitrogen balance of growing Yankasa ram lambs fed UNTGNS, UTGNS, LTGNS and ULTGNS in a complete diet.

Parameters	Treatment diets				SEM
	UNTGNS	UTGNS	LTGNS	ULTGNS	
Nitrogen intake g/day	21.38[b]	20.63[b]	20.33[b]	22.70[a]	0.54
Faecal nitrogen g/day	8.46[a]	7.60[b]	8.71[a]	7.69[b]	0.18
Urine nitrogen g/day	0.90[b]	.90[b]	0.86[b]	1.09[a]	0.03
Total nitrogen lost g/day	9.34[a]	8.50[b]	9.57[a]	8.78[b]	0.19
Nitrogen balance g/day	12.02[b]	12.13[b]	10.76[c]	13.92[a]	0.62
Nitrogen absorbed g/day	12.92[b]	13.03[b]	11.62[c]	15.02[a]	0.62
N retained as % intake	55.64[b]	58.49[ab]	52.81[c]	61.18[a]	1.60

Means within the same rows with different superscripts differ significantly (P<0.05) SEM=Standard error of means

4.6 Cost Benefit Analysis

Analysis of the expenses and accruable revenue results are shown in Table 4.8. The results showed that average feed intake among the animals in the treatment groups ranged from 73.74-79.82kg the highest value from ram lambs fed ULTGNS treated diet. Similarly, animals fed ULTGNS treated diet had the highest total weight gain (8.58kg) and the least 6.16kg was from ram lambs fed UTGNS diet. Cost of feed per kg weight was higher (₦65.02) in LTGNS diet than in ULTGNS diet, the least was recorded in UNTGNS diet (₦38.40). Cost of feed per kilogram live weight gain was higher (₦ 600.78) in ram lambs fed lime treated diet. The results showed that apparent profit was highest in ram lambs fed UNTGNS diet (₦1774.50) followed by ULTGNS diet (₦7613.95) and the least was in the ram lambs fed LTGNS diet which had negative value (₦ -30.43).

Table 4.8. Cost benefit analysis of growing Yankasa ram lambs fed UNTGNS, UTGNS, LTGNS and ULTGNS in a complete diet.

Parameters	Treatment diets			
	UNTGNS	UTGNS	LTGNS	ULTGNS
Initial weight (Kg)	16.40	16.56	16.28	16.18
Final weight (Kg)	24.50	22.50	24.60	24.76
Total feed intake (Kg)	80.35	76.61	79.09	83.01
Total dry matter intake (Kg)	77.26	73.74	76.79	79.82
TWG (Kg)	8.10	6.16	8.52	8.58
Price per $(Kg)^{LW}$	600.00	600.00	600.00	600.00
Cost of feed /Kg (₦)	38.40	46.45	65.02	55.72
Cost of total feed consumed (₦)	3085.46	3562.23	5142.43	4625.47
Cost of feed/Kg^{LW} gain	380.92	598.28	600.78	4634.05
Income accruable (₦)	4860.00	3696.00	5112.00	5148.00
Apparent profit (₦)	1774.50	441.77	-30.43	513.95

TWG-Total Weight Gain, Kg-Kilogram. LW-Live Weight N-Naira

Source: Generated from field and market Feb-June 2016

4.7. Chemical Composition of Fattening Diets

The results of the proximate analysis on the fattening diets are summarized in Table 4.9 Organic matter (OM) content in the treatment diets ranged from 84.04% in the UNTGNS diet to 86.49% in the LTGNS diet. Crude protein content was highest (14.31%) in UTGNS diet, followed by ULTGNS diet and least CP was recorded in UNTGNS diet (13.88%). Similarly, the UTGNS diet had the highest EE (4.79%). ULTGNS treated recorded the least (3.77%). In contrast, LTGNS and ULTGNS diets had the highest mean values for ADF and NDF (26.00 and 49.12%), respectively. The least value was in ULTGNS diets (22.455 and 46.30%. LTGNS diet has the highest nitrogen free extract (NFE) of 58.89% and the least was recorded in ULTGNS diet.

Table 4.9. Proximate composition of fattening diets.

Parameters (%)	Treatment diets			
	UNTGNS	UTGNS	LTGNS	ULTGNS
Dry Matter	91.28	90.88	92.04	90.87
Organic Matter	84.04	85.32	86.49	84.92
Crude Protein	13.88	14.31	13.76	14.13
Crude fibre	8.47	9.36	8.84	9.43
Ether Extract	4.56	4.79	4.68	3.77
Lignin.	9.40	8.64	9.92	9.56
Ash	7.24	5.56	5.97	5.95
Acid detergent fibre	23.30	24.01	26.00	22.45
Neutral detergent fibre	48.72	48.02	49.12	46.30

4.8 Effect of UNTGNS, UTGNS, LTGNS and ULTGNS Fed in a Complete Diet on Fattening Yankasa Rams

Table 4.10 showed the fattening performance of Yankasa rams fed UNTGNS and UTGNS, LTGNS and ULTGNS in complete diets. The results revealed that there was no significant (P>0.05) effect in terms of final weight among the treatment diets. For total weight gain, rams fed UNTGNS, LTGNS and ULTGNS diets were significantly (P<0.05) higher than those on UTGNS diets. However, daily weight gain indicated that rams on UTGNS diet were significantly (P<0.05) lower than those fed UNTGNS, LTGNS and ULTGNS diets which were not significantly different from each other.

Daily feed intake results showed that values on rams fed UNTGNS (1027.37g), LTGNS (993.78g) and ULTGNS (1016.22g) were not significantly (P>0.05) different but were significantly (P<0.05) higher than those fed UTGNS diets. Rams fed UNTGNS diet had a better feed conversion ratio, though it was not statistically different (11.52) with rams on the other treatment diets which are significantly (P<0.05) higher than those on urea treated diet but statistically similar (P>0.05) with those fed lime and urea/lime treated diets.

Table 4.10. Fattening performance of Yankasa rams fed UNTGNS, UTGNS, LTGNS and ULTGNS in a complete diet.

	UNTGNS	UTGNS	LTGNS	ULTGNS	
Initial weight (Kg)	30.25	29.75	30.00	29.75	1.01
Final weight (Kg)	38.25	36.85	37.75	37.55	1.25
Total weight gain (kg)	8.00^{a}	7.10^{b}	7.75^{ab}	7.80^{a}	0.34
Daily weight gain (g/d)	88.89^{a}	77.78^{b}	86.11^{a}	86.67^{a}	3.21
Total dry matter intake (Kg)	92.45	87.78	89.44	91.46^{a}	2.43
Daily dry matter intake (g/d)	1027.37^{a}	975.27^{b}	993.78^{a}	1016.22^{a}	18.14
Feed conversion ratio	11.52	12.53	1156	11.743	0.81

Means within the same rows with different superscripts differ significantly ($P<0.05$) SEM=Standard error of means

4.9 Nutrients Digestibility and Nitrogen Retention in the Fattening Yankasa Rams

4.9.1 Nutrients digestibility

Results of the nutrients digestibility presented in Table 4.11 shows that rams on UNTGNS diet had significant (P<0.05) lower digestibility in terms of DM, OM, CP, NDF and NFE compared to the other treatment groups. However, highest ether extract digestibility (EED) was recorded on diet containing UNTGNS, which was similar (P>0.05) to the EED of UTGNS and ULTGNS (87.53 and 87.12%) diets but significantly (P<0.05) higher than in LTGNS diet (85.14%).

Table 4.11. Nutrient digestibility of fattening Yankasa rams fed UNTGNS, UTGNS, LTGNS and ULTGNS in a complete diet.

	Treatment diets				
Parameters (%)	UNTGNS	UTGNS	LTGNS	ULTGNS	SEM
Dry Matter	31.99[b]	43.28[a]	42.34[a]	40.87[a]	3.77
Organic Matter	29.20[b]	41.28[a]	40.25[a]	38.70[a]	3.90
Crude Protein	52.34[b]	60.78[a]	62.36[a]	62.36[a]	1.69
Crude fibre	71.31	73.26	70.54	74.55	
Ether Extract	88.50[a]	87.12[a]	85.14[b]	87.53[a]	1.25
Lignin.	13.86[b]	38.16[a]	35.79[a]	29.60[ab]	3.81
Ash	60.73[a]	57.22[a]	58.83[a]	46.71[b]	3.14
Acid detergent fibre	11.06[b]	10.05[b]	35.76[a]	10.73[b]	5.40
Neutral detergent fibre	13.63[c]	31.97[a]	37.55[a]	25.46[b]	4.63

Means within the same rows with different superscripts differed significantly ($P<0.05$)

SEM=Standard error of means

4.9.2 Nitrogen retention

Nitrogen intake, utilization and loss in nitrogen from rams fed UNTGNS, UTGNS, LTGNS and ULTGNS UTGNS diets are summarized in Table 4.12. The results indicated that nitrogen intake was similar (P>0.05) among rams fed ULTGNS, UNTGNS and UTGNS diets which were significantly (P<0.05) higher than those on LTGNS diet. Faecal nitrogen was observed to be higher in rams fed UTGNS diet, though, were similar (P>0.05) with those on ULTGNS diet, but significantly (P<0.05) higher than those on LTGNS diet. There was no significant difference (P>0.05) among the rams across the treatment diets in nitrogen balance and nitrogen retained as % intake. Nitrogen absorbed was significantly (P<0.05) lower in rams fed UTGNS diet compared to those on ULTGNS, UNTGNS and LTGNS diets.

Table 4.12.Nitrogen balance in fattening Yankasa rams fed UNTGNS, UTGNS, LTGNS and ULTGNS in a complete diet.

Parameters	Treatment diet				SEM
	UNTGNS	UTGNS	LTGNS	ULTGNS	
Nitrogen intake g/day	24.70^{a}	23.43^{ab}	22.65^{b}	25.44^{a}	1.01
Faecal nitrogen g/day	7.58^{b}	8.30^{a}	6.79^{c}	7.93^{a}	0.20
Urine nitrogen g/day	1.75	1.62	1.62	1.75	0.26
Total nitrogen loses g/day	9.33^{a}	9.91^{a}	8.59^{b}	9.69^{a}	0.36
Nitrogen balance g/day	15.37	13.52	14.06	15.75	1.17
Nitrogen absorbed g/day	17.12^{a}	15.13^{b}	15.68^{ab}	17.50^{a}	0.97
N retained as % intake	62.25	59.75	61.23	61.62	2.59

Means within the same rows with different superscripts differ significantly ($P<0.05$) SEM=Standard error of means

4.10 Characteristics of Rumen Metabolites in Fattening Yankasa Rams

Tables 4.13 and 4.14 present results of treatments, sampling periods and interaction effects, respectively at 0 and 4hrs post feeding measurements of rumen ammonia nitrogen (NH_3-N), volatile fatty acids (VFAS), total nitrogen (TN) and pH. The results showed that the mean values of NH_3-N differed significantly ($P<0.05$) among the treatment groups with rams in ULTGNS diet having the highest significant value (31.96 mg/L). TVFs were significantly ($P<0.05$) higher in rams fed UNTGNS diet, and higher in total nitrogen, though not significantly different ($P>0.05$) among the rams fed UNTGNS, LTGNS and ULTGNS diets which were significantly ($P<0.05$) higher than those rams on UTGNS diet. Effect of sampling periods revealed that NH_3N, TVFs and TP were significantly ($P<0.05$) higher in rumen fluid collected 4hrs post feeding among the rams across the treatment groups, but rumen fluid pH was significantly ($p<0.05$) higher in 0 hour post feeding in all the rams in the treatment diets.

In the treatment and sampling period's interaction effects, animals on ULTGNS diet had the highest mean values of NH_3N in both 0 and 4 hours post feeding and were significantly ($P<0.5$) higher compared to rams on the other treatment diets. Rams on UNTGNS diet followed similar trend. However, rams on UNTGNS diet were significantly ($P<0.05$) high in VFAs in both collection periods compared with those on the other treatment diets. Surprisingly, rams on LTGNS diet had the highest mean values of total nitrogen in the both collections and were significantly ($P<0.05$) higher than the rams on the other treatment diets. No statistical difference ($P>0.05$) was observed among the rams across the treatment diets in rumen pH at the both 0 and 4 hours post feeding periods.

Table 4.13. Rumen metabolites of fattening Yankasa rams fed UNTGNS, UTGNS, LTGNS and ULTGNS in a complete diet.

Parameters	Treatment diets				SEM	Normal value*
	UNTGNS	UTGNS	LTGNS	ULTGNS		
NH_3 N mg/100l	31.22[b]	30.85[c]	30.30[d]	31.96[a]	0.15	28.40-33.23
TVFAs mg/L	14.33[a]	13.98[b]	14.05[b]	13.78[c]	0.08	10.00-20.50
Total Nitrogen %	2.88[b]	2.48[b]	2.86[a]	2.87[a]	0.03	2.50-3.45
Rumen Ph	6.53	6.60	6.57	6.52	0.18	6.0-7.00

Means within the same rows with different superscripts differ significantly ($P<0.05$) SEM=Standard error of means NH_3N=Ammonia nitrogen TVFTs=Total volatile fatty acids * Cole, 1986 and Khan and Scott,2005

Table 4.14. Treatment and period interaction effect on rumen metabolites characteristics of fattening Yankasa rams fed UNTGNS, UTGNS, LTGNS and ULTGNS in a complete diet.

Parameters	Hr	Treatment				SEM	Normal value
		UNTGNS	UTGNS	LTGNS	ULTGNS		
NH_3 N mg/100/l	0	30.8^{b}	30.7^{b}	30.1^{c}	31.6^{a}	0.15	28.40-33.23
	4	31.6^{b}	30.9^{c}	30.4^{d}	32.4^{a}	0.32	
TVFAs mg/L	0	14.0^{a}	13.7^{b}	13.4^{d}	13.6^{c}	0.08	10.00-20.50
	4	14.6^{a}	14.1^{b}	14.6^{a}	14.0^{b}	0.12	
Total Nitrogen %	0	2.1^{d}	2.7^{c}	2.9^{a}	3.2^{b}	0.03	2.50-3.45
	4	2.7^{d}	3.01^{c}	3.2^{b}	3.5^{a}	0.07	
Rumen pH	0	6.8	6.8	6.9	6.8	0.18	6.00-7.00
	4	6.2	6.3	6.2	6.1	0.16	

^{abc} Means within the same rows with different superscripts differed significantly ($P<0.05$) SEM= standard error of means

4.11 Rumen Microbial Load of the Fattening Yankasa Rams

Tables 4.15 and 4.16 for treatment and sampling periods' interaction, respectively. Table 4.15, shows the results of the treatment effect. Rams on UTGNS diet had the highest bacteria load of $4.96X10^5$/ml which were significantly ($P<0.05$) higher than microbial load of animals fed UNTGNS, LTGNS **a**nd ULTGNS diets. Fungi load on rams fed LTGNS diet was significantly ($P<0.05$) higher compared to those fungi load in rams fed UNTGNS, ULTGNS and UTGNS diets. However, protozoa counts were significantly ($P<0.05$) higher in rams fed UTGNS diet then followed by ULTGNS diet. The least value was obtained from those on UNTGNS diet.

The interaction effect is shown in Table 4.16 and the results revealed that rams on UTGNS diet had significantly ($P<0.05$) higher values at both rumen fluid samplings periods (0 and 4 hours). However, at 0 hour post feeding rams on UNTGNS and LTGNS diets had significantly ($P<0.05$) higher bacteria count than those on ULTGNS diet and the bacteria counts of the rams on UTGNS diet was significantly ($P<0.05$) higher than those on ULTGNS, UNTGNS and LTGNS diets at 4 hours post feeding. Fungi load was significantly higher ($P<0.05$) in rams fed LTGNS diet at both 0 and 4 hours post feeding. Protozoa counts were significantly ($P<0.05$) higher in animals fed UTGNS diet at 0 hour, but at 4 hours post feeding animals on LTGNS diet were significantly ($P<0.05$) higher than protozoa load of the animals on the other treatment diets.

Table 4.15. Rumen microbial load of fattening Yankasa rams fed UNTGNS, UTGNS, LTGNS and ULTGNS in a complete diet.

Parameters	Treatment diets				SEM	Normal value*
	UNTGNS	UTGNS	LTGNS	ULTGNS		
Bacteria ($X10^5$/ml)	4.12^b	4.96^a	3.93^b	4.06^b	0.11	$8.55-8.18x10^5$
Fungi ($X10^5$/ml)	17.67^b	15.50^d	25.17^a	16.60^c	0.48	$6.32-2.87x10^5$
Protozoa ($x10^5$/ml)	8.37^c	11.67^a	10.21^b	10.36^b	0.31	$3.95-5.34x10^5$

Means within the same rows with different superscripts differ significantly (P<0.05) SEM=Standard error of means. * Cole, 1986 and Khan and Scott,2005

Table 4.16.Treatment and period interaction effect on rumen microbial load of fattening Yankasa rams fed UNTGNS, UTGNS, LTGNS and ULTGNS in a complete diet.

Parameter	Hr	Treatment				SEM	Normal value
		UNTGNS	UTGNS	LTGNS	ULTGNS		
Bacteria ($x10^5$/ml) CFU	0	4.24^b	5.29^a	4.15^b	3.81^c	0.11	$8.55\text{-}8.18x10^5$
	4	4.00^b	4.64^a	3.71^c	4.43^a	0.12	
Fungi ($x10^5$ml) Spores	0	18.33^b	19.00^b	30.33^a	15.00^c	0.48	$6.32\text{-}2.87x10^5$
	4	17.00^c	12.00^d	20.00^a	19.00^b	0.41	
Protozoa ($x10^4$ml) Count	0	8.72^c	13.13^a	8.71^c	10.44^b	0.31	$3.95\text{-}5.34x10^4$
	4	8.02^d	10.21^b	11.67^a	9.85^c	0.50	

[abc] Means within the same rows with different superscripts differed significantly (P<0.05) SEM= standard error of means

4.12 Carcass Characteristics of the Fattening Yankasa Rams Fed Urea and Lime Treated Groundnut Shell in a Complete Diet

The results of carcass characteristics of the fattening Yankasa rams are presented in Table 4.17. The results showed that the live weight and weight after slaughter were significantly ($P<0.05$) higher in animals fed UNTGNS and those on ULTGNS diets compared to UTGNS and LTGNS. In hot carcass weight, rams fed UNTGNS diet were significantly ($P<0.05$) higher than those fed UTGNS, LTGNS and ULTGNS diets and rams fed UTGNS diet were significantly ($P<0.05$) lower than those on LTGNS and ULTGNS diets. There was significant difference ($P<0.05$) in the rams fed UNTGNS in terms of dressing percent (53%) compared to rams on UTGNS and LTGNS diets which were significantly ($P<0.05$) higher than those on ULTGNS diet (49.21%). However, meat yield ratio was significantly ($P<0.05$) higher in rams fed ULTGNS diet followed by those on LTGNS and the least was in rams on UNTGNS diet.

Table 4.17. Carcass characteristics of fattening Yankasa rams fed UNTGNS, UTGNS, LTGNS and ULTGNS in a complete diet

Parameters	Treatment diets				SEM
	UNTGNS	UTGNS	LTGNS	ULTGNS	
Live weight (Kg)	32.20	28.00	29.00	31.50	2.11
Weight after slaughter (Kg)	31.25^{a}	26.80^{b}	27.45^{b}	30.15^{a}	1.29
Hot carcass weight (Kg)	17.10^{a}	14.00^{c}	14.55^{bc}	15.50^{b}	0.66
Carcass dressing %	53.11	50.00	50.17	49.21	0.15
Meat yield (Kg)	12.65^{a}	10.45^{c}	11.37^{bc}	12.25^{ab}	0.60
Bone yield (Kg)	4.38	3.38	3.15	3.30	2.81
Meat yield %	38.75	37.27	39.06	38.91	1.20
Meat bone ratio	2.89^{d}	3.09^{c}	3.44^{b}	3.71^{a}	0.10

Means within the same rows with different superscripts differ significantly ($P<0.05$)

SEM=Standard error of means

4.13 Effect Urea and Lime Treated groundnut shell in a Complete Diet on prime cuts of Fattening Yankasa Rams

Results of the prime cuts are summarized in Table 4.18. The results had shown that leg weight of the rams on UNTGNS and ULTGNS diets were significantly ($P<0.05$) higher than those on the other treatment diets. But the chump weight was statistically higher ($P<0.05$) in the carcass of animals fed LTGNS diet than those on the other treatment groups. Rams on ULTGNS diet showed a higher value for loin which was significantly ($P<0.05$) higher than that of the other groups. However, rams on UNTGNS diet had the highest mean values of breast, neck, mid rib, main rib and shoulder which were significantly ($P<0.05$) different from those on the other treatment groups. Though, for the mean values of shoulder there was no statistical difference ($P>0.05$) between rams fed UNTGNS diet and those on ULTGNS diet. Tail weight was not significantly different ($P>0.05$) among the animals on the treatment diets.

Table 4.18. Prime cuts of fattening Yankasa rams fed UNTGNS, UTGNS, LTGNS and ULTGNS in a complete diet.

	Treatment diets				
Parameters (Kg)	UNTGNS	UTGNS	LTGNS	ULTGNS	SEM
Leg	3.70^{a}	3.35^{c}	3.30^{c}	3.90^{a}	0.15
Chump	0.70^{b}	0.55^{c}	0.85^{a}	0.70^{b}	0.05
Loin	1.30^{b}	1.15^{bc}	1.00^{c}	1.55^{a}	0.09
Breast	2.50^{a}	1.80^{c}	2.00^{b}	2.05^{b}	0.07
Neck	1.90^{a}	1.60^{c}	1.65^{bc}	1.75^{b}	0.07
Mid rib	1.10^{a}	1.05^{ab}	1.00^{b}	0.80^{b}	0.11
Main rib	1.85^{a}	1.30^{b}	1.50^{b}	1.25^{b}	0.13
Shoulder	3.15^{a}	2.60^{c}	2.8^{b}	3.15^{a}	0.08
Tail	0.10	0.10	0.13	0.10	25.00

Means within the same rows with different superscripts differ significantly (P<0.05)

4.14 Effect of Urea and Lime Treated Groundnut Shell in a Complete Diet on Non Carcass Components of the Fattening Yankasa Rams

Table 4.19 presents the results of the non-carcass components of the rams. The results showed that in components like head, skin, feet, empty intestine, heart and liver, animals on UNTGNS diet had the highest significant ($P<0.05$) values and statistically differed from those on the other treatment diets. For empty stomach, testes and bladder there was no statistical difference ($P>0.05$) between those fed UNTGNS diets. However, significant differences ($P<0.05$) was observed among the rams on the treated diets in skin, heart, liver and trachea.

Table 4.19. Non-carcass components of fattening Yankasa rams fed UNTGNS, UTGNS, LTGNS and ULTGNS in a complete diet

	Treatment diets				
Parameters	UNTGNS	UTGNS	LTGNS	ULTGNS	SEM
Head (Kg)	2.50^{a}	1.80^{c}	2.15^{b}	2.25^{b}	0.08
Skin(Kg)	2.20^{a}	1.85^{b}	1.50^{c}	1.85^{b}	0.13
Feet(Kg)	0.88^{a}	0.70^{b}	0.83^{a}	0.70^{b}	0.05
Full stomach(Kg)	3.70^{a}	3.10^{b}	3.15^{b}	2.75^{c}	0.14
Empty stomach(Kg)	0.85^{a}	0.75^{b}	0.70^{c}	0.83^{a}	0.02
Rumen Content (Kg)	3.33^{a}	2.70^{b}	2.80^{b}	2.15^{c}	0.17
Empty intestine(Kg)	1.45^{a}	1.05^{bc}	1.25^{b}	1.13^{b}	0.07
Full intestine(Kg)	2.50^{a}	1.90^{b}	2.05^{b}	2.05^{b}	0.11
Heart(g)	174^{a}	142^{c}	129^{d}	163^{b}	5.27
Kidney(g)	96^{a}	78^{b}	83^{b}	82^{b}	5.04
Liver (g)	575^{a}	500^{b}	350^{c}	550^{b}	31.25
Lungs(g)	350	350	320	400	40.23
Trachea(g)	13^{a}	10^{b}	05^{c}	10^{b}	0.01
Spleen (g)	76	76	58	61	13.61
Testes (g)	45^{a}	39^{b}	36^{c}	45^{a}	0.05
Bladder (g)	50^{a}	46^{b}	57^{a}	52^{a}	3.78

Means within the same rows with different superscripts differ significantly ($P<0.05$) SEM=Standard error of means

4.15 Cost Benefit Analysis of the Fattening Yankasa Rams

The results of the feed expenses and value gain are summarized in Table 4.23. The results showed that animals on UNTGNS diet had the highest total feed intake (96.15kg) followed by those on ULTGNS diet, the least were in those fed UTGNS (91.29kg). Cost of feed per kilogram was higher in rams fed LTGNS diet (₦52.57) followed by those fed ULTGNS diet and the least was in animals fed UNTGNS diet (₦37.95). Cost of feed per kilogram live weight gain was higher (₦ 630.96) in rams fed lime treated diet. Total weight gain was higher (8.00kg) in rams fed untreated diet followed by those on ULTGNS diet and the least (7.10kg) was in those on UTGNS diet. Similarly, rams on the UNTGNS diet had the highest (₦1551.18) apparent profit followed by those fed LTGNS diet and the least (₦47.56) was from those on lime treated diet.

Table 4.20 Cost benefit analysis of fattening Yankasa rams fed urea and lime treated groundnut shell in a complete diet.

Parameters	Treatment diets			
	UNTGNS	UTGNS	LTGNS	ULTGNS
Initial weight	30.25	29.75	30.00	29.75
Final weight	38.25	36.85	37.75	37.55
TWG (Kg)	8.00	7.10	7.75	7.80
Total feed intake	96.15	91.29	93.02	95.12
Total dry matter intake (Kg)	92.45	87.78	89.44	91.46
Cost of feed /Kg (₦)	37.95	41.21	52.57	47.27
Price /Kg^{LW}	650.00	650.00	650.00	650.00
Total cost of feed (₦)	3648.42	3762.11	4989.94	4496.25
Cost of feed /Kg^{LW} gain	456.10	529.07	630.96	576.44
Income accruable (₦)	5200.00	4615.00	5037.50	5070.00
Apparent profit (₦)	1551.18	852.89	47.56	573.75

TWG-Total Weight Gain. Kg-Kilogram, N-Naira ^{LW} Live Weight

Source: Generated from field and market Feb-June 2016

CHAPTER FIVE

5.0 DISCUSSION

5.1 Chemical Composition of UNTGNS, UTGNS, LTGNS and ULTGNS

Results of chemical composition of groundnut shell obtained from this study indicated that the protein content of the UNTGNS was within the range (4.8-7.2%CP) reported by Jumia (2002), however, it was slightly lower than the 7.3% CP content reported by Abdurrazak *et al.* (2014). The difference may be due to the methods involved in processing the groundnut; shells from shelling machines may contain bits and skins of nuts. These may add the protein and lipid contents of this waste material.

5.2 Chemical Composition of Growth Diets

Organic matter content obtained from the treatment diets was similar to the work of Aduku (2005) but higher than 79.85-83.54% reported by Hassan (2014) and is in the normal range required for animal growth. Crude protein content was also within the values of 13-15% CP content requirements for sheep as stated by Aduku (2005).

5.3 Growth Performance of Growing Yankasa Ram Lambs Fed UNTGNS, UTGNS, LTGNS and ULTGNS in a Complete Diet

Daily dry matter intake recorded in this study has indicated that grinding of groundnut shell can increase its intake in a complete diet. This was in conformity with the report of McDonald *et al.* (2002) that grinding of roughages has been shown to increase voluntary feed intake, since intake seems to be limited by restriction placed upon the rate of passage of food out of the rumen through the reticulomasal orifice.

Daily weight gain recorded (68.43-95.11g/day) was higher than those reported by Bibi-Faruk and Osinowo (2006) who reported a daily weight gain of 46 - 68g/day for Yankasa sheep fed fresh *Ficus thonningi* leaves, (28 to 47g//d) reported by Lamidi *et al.* (1998) for Yankasa sheep fed graded levels of *Ficus thonnigii* leaves as replacement for fresh *Hyparrhenia rufa.* This result is similar to what Osinowo *et al.* (1994) reported as growth rate of 92.9g/day for Yankasa sheep. However, the result was lower than 112g/day and 139g/day reported by Hassan (2014) and Yankasa sheep fed Columbus grass (*Sorghum alum),* respectively and 130.7g/day, when lambs were fed chopped groundnut haulms reported (Adu and Lakpini, 1983). Ram lambs fed ULTGNS had the highest daily weight gain those had no differed with those from on UNTGNS and ULTGN this may attributed to the fact that ligaments between the bonds of the cellulose were losing and hence made digestion and absorption easy.

Feed conversion ratio of the ram lambs fed untreated and differently treated groundnut shell in a complete diet of 13.12-8.94 in order of efficiency was better than the one (16.75-16.16) reported by Adamu (2015) who fed different varieties of groundnut haulm and *D smutsii* hay as basal diet to growing Yankasa rams. The results shows that ram lambs fed lime treated diet had a feed conversion efficiency.

5.4 Blood Metabolites Characteristics

The normal values of blood urea nitrogen (BUN), creatinine and total protein (TP) as quoted from Reference guide (2016) of Serum bio-chemical reference ranges were 2.8-7.1Mmol/L, 106-168Mmol/L and 60-79g/L respectively. BUN from the present study was higher than normal values reported, but similar to the findings, (5.26-7.50Mmol/L) of Hassan (2014) and Adamu (2015). The creatinine range was in conformity with normal value quoted but higher than 60-100Mmol/L obtained (Hassaan, 2014).

Results of total protein were similar to the values quoted from the Reference guide (2016) but higher than the values reported by Adamu (2015), however, confirmed the 48.0-58.0g/L TP reported by Hassan (2014). Though, it was lower than that in the report of Taiwo and Ogunsasanmi (2003) that total protein of various small ruminants is in the range of 50.50-100.0g/L. Similarly, Aliyu *et al.* (2002) obtained total protein value that ranged between 50.2-60.02g/L from an experiment with ram lambs fed urea and/or poultry droppings treated *Pennisetum pedicellatum* (*kyasuwa).*

5.5 Nutrients Digestibility and Nitrogen Retention

Increased digestibility of DM, OM EE, ADF, NDF and NFE recorded in rams fed UTGNS diet is conformity with report McDonald *et al.* (1995) that treatment of crop residue with urea increased digestibility and was attributed to the effect of urea in loosening lignocelluloses complex and consequently some of the cellulose might have been freed for microbial digestion. However, crude protein digestibility was higher on ram lambs fed ULTGNS diet this was in line with findings of other researchers who reported that the treatment of crop residues with the combination of both urea and lime solution increase digestibility of DM, lignin, ADF, NDF, CP and NFE (Fadel Elseed *et al*., 2003; Wanapat *et al*., 2013 and Yulitiani *et al*., 2015).

Nitrogen retention is the major indicator used to assess the protein nutrition status of ruminant livestock (Abdu *et al.*, 2012). Increase in nitrogen absorbed and retained as percentage intake in rams fed both urea plus lime and urea treated diet was in agreement with the report of Sarwar *et al*. (2003) that nitrogen retention depends on good digestibility of nutrients and / or utilization. In some cases this effect is sufficient to maintain an adequate N balance.

5.6 Cost Benefit Analysis

The results of the economic analysis of growing ram lambs showed that ram lambs on ULTGNS diet had the highest total weight gain, followed by those fed LTGNS diet. Though, they had the highest total feed intake they still had the highest accruable income, but a better apparent profit was realized from ram lambs fed UNTGNS diet. This may be attributed to cost of treatment material (lime and urea) which cost N1000/kg and N56/kg, respectively. Cost of treatment materials had serious impact on the profitability of in animal production in spite of the increase in weight gain and income accruable. Accruable revenue generated from the weight gain could not justify the cost of the test material(s).

5.7 Chemical Composition of Experimental Diets for Fattening Yankasa Rams

The dry matter content of the treatment diets were similar to the 90.13-92.12% DM reported by Hassan (2014) who worked on performance of Red Sokoto Bucks fed graded levels of Lablab (*Lablab purpureus* L. sweet) hay as supplement to a basal diet of maize (*Zea mays*) stover. But the crude protein contents were within the values of 13-15% CP requirements for sheep (Aduku, 2005) and the 14% CP recommended by Osuhor (2002) for fattening sheep and goat. Increase in the crude protein content of UTGNS diet may be attributed to the urea treatment and was in conformity with the report of Vadiveloo (2003) that treatment of crop residue with urea improves its crude protein content. Decrease in the lignin in the urea treated diet also confirmed the work of Smith (2002) that treatment of residue with urea causes the linkages between lignin and hemicellulose to be broken, which resulted in increasing the feed surface area of microbial attack to digest fibre.

5.8 Fattening Performance of Yankasa Rams Fed Groundnut Shell Treated with Urea and Lime in a Complete Diet.

Daily dry matter intake was observed to be higher in UNTGNS diet and least in the UTGNS. The result was in conformity with that of Chaudhry (1998) who reported that although urea and lime treatment increased the degradability of rice straw, the dry matter intake decreased, due to a reduced acceptability of the treated feed by animals. The author suggested that a combination of lime and urea gave better results than urea or lime alone.

Rams on the UNTGNS diet had the highest TVFAs and VFAs are the main energy sources for ruminant feeding solely on roughages. Thus their concentration in the diet gave indication of their energy value.

The ADG in this study were lower than the daily gains of 150g/day (Aduku, 2005), but higher than the value (31.86g/d to 54.92g/d) reported by Abdu (2011) in fattened rams on *Zizyphus Mauritania* leaf. Feed conversion ratio from the present study was better than 59.72-16.38 reported (Adamu, 2015). Rams on UNTGNS diet had a better feed conversion ratio than those on the other treatment diets (10.74).

5.9 Nutrients Digestibility and Nitrogen Retention in the Fattening Yankasa Rams

Though, results of crude protein and ether extract digestibility coefficient were in conformity with many other findings (Wanapat *et al*., 19996; Yulistiani *et al*., 2015) digestibility of dry matter, organic matter, acid detergent fibre, neutral detergent fibre and nitrogen free extract across the treatment diets were very low. This is in contrast with the findings of other researchers who reported that the treatment of crop residues with the combination of both urea and lime solution increase digestibility of DM, lignin, ADF, NDF, CP and NFE (Fadel Elseed *et al*., 2003, Sahoo *et al*., 2000, Trach *et al*., 2001a, 2001b, Wanapat *et al*., 2013 and Yulitiani *et al*., 2015).

It has also been reported that when nitrogen is limiting in the diet, there is reduction in the size and efficiency of the microbial population, resulting to lowered digestibility and reduced voluntary feed intake (McDonald *et al*., 1999; Chestworth, 2006) the reason perhaps why digestibility was least in rams fed untreated diet.

Nitrogen retention is the major indicator used to assess the protein nutritional status of ruminant livestock (Abdu *et al.,* 2012). Increase in nitrogen absorbed and retained as percentage intake in rams fed both ULTGNS and UNTGNS diet were in agreement with the report of Sarwar *et al*. (2003) that nitrogen retention depends on good digestibility of nutrients and/or utilization. In some cases this effect is sufficient to maintain an adequate N balance.

Increase in the faecal nitrogen in rams fed UTGNS diet can be attributed to rapid breakdown of dietary protein to ammonia which increases nitrogenous excretion rather than contribution directly to the animal nutrient requirements, what was observed might be connected with the degree of CP utilization in the diet. Yulistiani, (2015) found that the addition of high protein fed in a diet changes the pattern of nitrogen excretion towards increasing nitrogen excretion.

5.10 Rumen Metabolites in the Fattening Yankasa Rams

Ammonia nitrogen (NH_{3}-N), Volatile fatty acids (VFAs) and Rumen pH obtained in this study were within the values (NH_{3}-N 30.30-31.96mg/100L, TVFAs 13.78-14.33Mmol/L and pH of 6.52-6.60) reported by Hassan (2014) when Red Sokoto Bucks fed graded levels of Lablab (*Lablab purpureus* L. sweet) hay as supplement to a basal diet of maize (*Zea mays*) stover. Though, the NH_{3}-N value was higher than 11.42-14.43mg/100ml recorded by Jonas and Vilma (2007) and was slightly higher than 19-25mg/100ml observed by Mehrez *et al.* (1977). NH_{3}-N needs to be adequate for forage digestion. However, the result was in conformity with the finding of Saadullah (1981). The authors reported that ruminal NH_3–N concentration above 20mg/100ml is required for sufficient voluntary intake of low quality roughage. The results were also in consonance with the findings of Osinowo *et al.* (1994). These authors reported that rumen NH_3–N concentration had a good profile, with values suggested between a minimum to maximum for microbial growth in the rumen. Malau-Aduli (1990) reported an optimal range of ruminal NH_3-N of (15-30 mg/100L) for low quality roughages.

The production of NH_3-N which increased from 0- 4hrs post feeding suggested that treatments improved the anaerobic fermentation of the diet which stimulated it to yield more NH_3-N. Value of the TVFAs obtained from this study was in agreement with 10.00-20.50Mmol/L reported by Hassan (2014), but was lower than 19.57-36.57Mmol/L reported by Jokthan (2007) when pigeon pea forage was supplemented in Sheep diet and the 28.8-56.8 Mmol/L reported by Adamu (2015). Volatile fatty acids are the main energy sources for ruminant feeding solely on roughages. Thus their concentration in the diet gave indication of their energy value. The increase in total volatile fatty acid noticed across the time of sampling means that the microbes in the rumen of the rams had enough time to act on the feed thereby producing TVFAs.

The production of TVFA, increased at 4hs post feeding. The increase suggested that the treatment diets improved the anaerobic fermentation of the diet which stimulated the yield of more volatile fatty acid. This improved yield of VFA may be due to the increased of organic matter digestibility in treated diets. Total nitrogen of the fattening rams of this study showed that rams fed UNTGNS diet had the highest value followed by those on ULTGNS diet.

Ruminal pH is an important factor that measure the acidity and alkalinity of rumen content in ruminants and for optimum rumen microbial fermentation. Gozah *et al*. (2001) also reported that when the ruminal pH is low, microbial diversity is reduced as protozoa numbers may sharply be declined and the bacterial population is altered and largely reduced. The pH values in this study agree with the findings of Wells and Russels (1996) who recommended 5.5-7.5 range to be the standard rumen pH values. Osinowo *et al.* (1994) reported that for optimum rumen microbial fermentation the rumen pH should range between 6.00 and 7.00.

5.11 Rumen Microbial Load of the Fattening Yankasa Rams

The microbial loads recorded in the current study were in contrast with the report of Sulta and Kundu (2011) who observed a range of 3.95-5.34x10^5/ml protozoa, 8.53-9.18x10^7/ml bacteria and 6.32-12.87x10^4/ml fungi from the rumen of sheep fed *Dicatium annulatum* grass supplemented with *Leucaena leucolephala* and *Hardwickia binata* tree leaves. The increase in the number of fungi across the treatments may be as a result of fibrous nature of the treatment diet (40% inclusion of groundnut shell) which was in conformity with the report of Van Soest (1982) that the initial work of fungi is splitting fibrous material apart and making it more accessible for the bacteria. Decrease in bacteria in the rumen of all the rams was a result of the protozoa inhabiting the rumen which may feed on the bacteria as confirmed by Russell, (1988) that protozoa are actually predators to the bacteria in the rumen.

5.12 Dressing Percentage and Carcass Characteristics of the Fattening Yankasa Rams Fed UNTGNS, UTGNS, LTGNS and ULTGNS in a Complete diet

Dressing percentage of the fattening rams in this study was higher than the 42.07-43.62% reported by Adamu (2015) on assessment of two groundnut varieties for forage, pod yield characteristics and effect of feeding haulms to Yankasa rams and 44 % reported by Intesar and Muna (2011). However, the dressing percentage was within the range of 48-54% for

Sheep reported by Bruce (2016). It is important to note that beside feed there are other factors that can affect dressing percentage, for example in animal that is weighed “full of feed” versus fasted for a day can dress up to 5 percent lower, also heavier muscled and fatter animals will in general, have higher dressing percentage than lighter muscled and leaner animals respectively, amount and length of hair may also influence dressing percentage.

Meat yield of rams fed untreated diet was not much different with the value obtained in rams on ULTGNS diet. Meat yield percentage was surprisingly higher in rams fed LTGNS diet. This mighty be attributed to the bone yield value of the rams in both UNTGNS and ULTGNS diets. Meat to bone ratio was also higher in rams fed ULTGNS diet.

5.13 Carcass Prime Cuts of the Fattening Yankasa Rams Fed UNTGNS, UTGNS, LTGNS and ULTGNS in a Complete Diet

Prime cuts determine the carcass cutting yield of an animal and can be bone-in or boneless (Bruce, 2016) depending on the need of the farmer, butcher or customer. Rams on ULTGNS diet recorded the highest value in leg and loin cuts. The mean value of chump was observed to be higher in rams fed LTGNS diet. However, breast cut mean value indicated that rams fed UNTGNS diet have the highest value, but for shoulder cut, rams on UNTGNS diet had similar value with those fed ULTGNS diet.

5.14 The Non Carcass Components of the Fattening Yankasa Rams Fed UNTGNS, UTGNS, LTGNS and ULTGNS in a Complete Diet

The weight of non carcass components like head, skin, full stomach, full intestine and liver were observed to be highest in rams fed UNTGNS diet which had the highest carcass percentage. This is in contrast with report of Bruce (2016) that animal weighed " full of feed" and the amount and length of hair may also influence dressing percentage. The mean value of lungs and spleen of the fattening rams was similar across the treatment diets.

5.15 Cost Benefit Analysis of the Fattening Yankasa Rams Fed UNTGNS, UTGNS, LTGNS and ULTGNS in a Complete Diet

Rams fed Lime treated diet had the highest cost of feed per kilogram (₦ 52.57). The highest total cost of the feed was as a result of the cost of the lime which was much expensive (N25,000/25kg bag). This led to highest cost of kilogram live weight gain of ₦630.96. Rams fed UNTGNS diet had the highest accruable income, consequently better apparent profit. The assumption that, increase in cotton seed cake which was N2500/50kg bag (N50/kg to balance the protein requirement of the fattening rams will increase the cost of the feed in favor of the other diets did not work to the expectation, as the price of maize bran used in the substitution was equally expensive, about N3500/75kg (N46.667). The results also confirmed the assertion that not only feed quality that influences the performance of animals but also other factors like rumen environment.

CHAPTER SIX

6.0 SUMMARY, CONCLUSION AND RECOMMENDATIONS

6.1 Summary

The studies conducted determined growth and fattening performance of Yankasa rams fed complete diet containing urea and lime treated groundnut (*Arachis hypogaea*) shell. In the first study four treatment diets were formulated containing 40% untreated groundnut shell (UNTGNS), 40% urea treated groundnut shell (UTGNS), 40% lime treated groundnut shell (LTGNS) and 40% urea plus lime treated groundnut shell (ULMTGNS). 20 Yankasa ram lambs of 9-10 months were used and randomly assigned to the four treatments diets with five animals per treatment in completely randomized design (CRD). Growth trial, digestibility study were conducted and blood sample was also collected.

Second study was conducted to determine effect of the treatment diets on fattening Yankasa rams. Sixteen Yankasa rams were used and randomly assigned to the four treatment diets with four animals per treatment in a completely randomized design (CRD). Fattening trial and digestibility study were conducted. Rumen liquor was collected. Carcass analysis was carried out using three rams from each of the treatment group.

Results of the first study indicated that ram lambs fed ULMTGNS diet had the highest daily dry matter intake of 88.69g/day. However highest daily weight gain (94.66g) was observed in ram lambs fed LTGNS diet with least in ram lambs on UTGNS. In feed conversion ratio ram lambs on LTGNS diet had the least mean values (8.94) and was significantly ($P<0.05$) different from those on UTGNS and ULMTGNS diets. Ram lambs on UTGNSU diet showed highest digestibility coefficient among the treatment diets (49.99%). Blood urea nitrogen (BUN) was higher than normal values reported by other authors (2.8-7.1Mmol/L). Creatinine range of (123.17-150.00Mmol/L) across the treatment diets was in conformity with the normal value (106-168Mmol/L). Total protein was within the range of the normal values (60-79g/L). Results of the economic analysis of growing ram showed that ram lambs on LTGNS diet had the highest feed cost (N4987.03) and those on ULMTGNS diet had the highest total weight gain (8.58Kg), followed by those fed LTGNS diet but a better apparent profit was realized from ram lambs fed UNTGNS diet (N1774.50).

The results of the second study showed that rams fed UNTGNS diet had the highest daily dry matter intake (1027.37g) with least mean value in those on UTGNS. Rams fed UTGNS had the least daily weight gain (77.78g) rams on UNTGNS diet still had the highest daily weight gain. Feed conversion ratio was least but better in rams fed UNTGNS diet. Rams on UTGNSU diet had the highest digestibility coefficient in most of the feed components. Higher ammonia nitrogen and total volatile fatty acids were observed in rams fed UNTGNS diet. On rumen microbial load, more bacteria were observed in animals fed UTGNS diet followed by those on UNTGNS diet. The dressing percentage of the rams fed UNTGNS diet (53%) was higher followed by those on LTGNS diet. Results of the studies showed that daily dry matter intake and weight gain were better in growing ram lambs fed LTGNS diet, but for fattening, rams on UNTGNS diet had the better daily intake and daily weight gain.

6.2 Conclusion

- Use of groundnut shell in the diet of small ruminant animals reduce the menace of its pollution consequences and also boost the production of the animals.
- Urea treatment improves digestibility coefficient of DM, OM, ether extract acid detergent fibre, neutral detergent fibre and nitrogen free extract, in the growing ram lambs.
- Urea and lime treatment had no any adverse effects on the ram lambs as blood metabolites such as BUN, total protein and creatinine are within the normal range.
- Urea plus lime treatment improves the total weight gain of the ram lambs (8.58Kg), while ram lambs fed LTGNS diet had the better feed conversion ratio (8.94)
- Urea plus lime treatment increases nitrogen absorption and nitrogen retained as percent intake of the fattening rams (15.75g/day and 61.62%).
- Urea and lime treatment did not influence the carcass dressing percentage of the rams as animals fed UNTGNS diet had the highest (53%), but chump weight was higher in rams on LTGNS diet, rams fed ULTGNS diet had a higher mean value of loin.

6.3 Recommendations

- Farmers should be encouraged to conduct physical treatment of groundnut shell and incorporate it up to 40% inclusion in diet formulation for growing and fattening rams.

- Other test materials cheaper than urea and lime like salt and potash should be sourced and tested in order reduce total production cost experienced in the urea and lime treated diets.
- The Federal, State and Local Government should identify major groundnut processing areas and support them financially in the processing and use of shell in ruminants feed.
- More researches should be carried out on the potentials of groundnut shell and its utilization.

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