GROWTH PERFORMANCE OF RED SOKOTO BUCKS FED WOOLY FINGER GRASS (*Digitaria smutsii*) HAY-BASED DIET WITH VARYING LEVELS OF SUN-DRIED BROILERLITTER

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A THESIS SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES, AHMADU BELLO UNIVERSITY, ZARIA, NIGERIA IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF SCIENCE DEGREE IN ANIMAL SCIENCE

DEPARTMENT OF ANIMAL SCIENCE,
FACULTY OF AGRICULTURE,
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DECEMBER, 2016

CERTIFICATION

This dissertation entitled “Growth performance of Red Sokoto bucks fed wooly finger grass (*Digitaria smutsii)* hay-based diet with varying levels of sun-dried broiler litter’’ by Afele, Terkula meets the regulations governing the award of the Degree of Masters of Science in Animal Science of the Ahmadu Bello University, Zaria and is approved for its contribution to knowledge and literary presentation.

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DEDICATION

This work is dedicated to the Almighty God who has been doing everything for me.

DECLARATION

I declare that the work in this thesis entitled “Growth Performance of Red Sokoto bucks fed Wooly finger grass (*Digitaria smutsii)* hay-based diet with varying levels of sundried broiler litter” has been written by me, it is a product of research work executed by me. It has not been accepted in any form for Higher Degree in any university. All quotations are indicated and the sources of information are specifically acknowledged by means of references.

Afele, Terkula ____________________ ____________________

Signature Date

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ABSTRACT

This study was conducted to evaluate growth performance of Red Sokoto bucks fed *Digitaria smutsii* hay-based diet with varying levels of sun-dried broiler litter (SBL). A total of 20 Red Sokoto bucks aged 12-14 months and weighing on average 11.5±0.5kg were randomly assigned to four dietary treatments with 5 replicates each in a complete randomized design. The diets contained 0%, 10%, 20%, and 30% SBL levels, each representing a treatment. The animals were fed at 4% body weight throughout the period of 90 days. Total feed intake, weight gain, faecal and urine output, rumen pH, total volatile fatty acid (TVFA), rumen ammonia nitrogen (NH_3-N) as well as serum metabolites were recorded. Results obtained showed significant ($P<0.05$) decrease in Dry matter intake (394.68–325.44g/day) and weight gain (54.17 - 29.63g/day) on diets with SBL inclusion. Feed conversion ratio (FCR) significantly ($P<0.05$) increased across the treatments (7.74 - 11.33) as SBL levels increased in the diets. Nutrient digestibility varied ($P<0.05$) significantly across the treatments with exception of DM. The digestibility of CP, CF, ADF and ME were significantly ($P<0.05$) higher in diets with SBL compared to the control. Nitrogen intake (11.32 - 8.81g/day) and Nitrogen balance (5.99 - 4.01g/day) decreased ($P<0.05$) significantly across the treatments with increasing levels of SBL inclusion but Nitrogen retention (57.14 – 45.52%) was better in bucks on diet with 10%SBL inclusion compared to the other groups. Rumen pH differed significantly ($P<0.05$) among the groups but were within acceptable range (6.0-7.0) for rumen fermentation. Rumen Ammonia (20.83–27.25mg/100ml) were significantly ($P<0.05$) higher in animals on diet with SBL compared to control diets and were higher (14.08–36.42mg/100ml) at 8 hours post feeding. Similarly, TVFA were significantly ($P<0.05$) higher at 8 hours post feeding (28.67– 45.08mmol/l) but decreased (37.25-32.33mmol/l) at 30% SBL inclusion. Serum metabolites varied significantly ($P<0.05$) across the treatments but all fell within the acceptable range for healthy goats. Feed cost per kilogram decreased with increasing levels of SBL in the diets (₦ 61.40 – ₦ 42.55). Feed cost (₦) per kilogram gain was significantly ($P<0.05$) higher in diet with 30% SBL (475.89 – 442.76) compared to the other diets. Although animals on the control diet showed some level of performance over those on SBL diets, the cost of the control diet would obviously hinder farmers in utilizing it. It was therefore concluded from this trial, that SBL used in the formulation of diets for Red Sokoto bucks can be included in the diets for growing goats up to 10%.

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CHAPTER ONE

1.0 INTRODUCTION

Nigeria is the most populous black nation in the world with the threat of nutritional deficiency facing its citizens as a result of high cost and inadequate supply of animal protein (Nkwocha*et al*., 2010). Meat constitutes the foremost animal product that is highly explored by Nigerian households, particularly for direct consumption (ITA, 2004).Meat from goat contributes about 24% of the total meat supply in Nigeria (Oni, 2002).Goats rank next to cattle in income generation and their meat is quite popular and well relished (Ladele *et al*., 1996). Small ruminants are a source of meat products, which if improved upon would augment the existing meat supply (Shaib*et al*., 1997; Ajala*et al*., 2008).This implies that there is room for improvement within the industry.

One of the major factorsresponsible for low performance of livestock in Nigeria is nutrition. Seasonal scarcity and quality fluctuation in feed impairs growth and reproduction of animals as well as increase in morbidity and mortality rate particularly during the dry season (Uppsala, 2012). Proper nutrition of growing goats is essential to ensure their future productivity (Owens *et al*. 1993). On the other hand, diets for growing goats fed in confinement should be cheap and easy to handle (Martinez Marin, 2007).

Tropical grasses are usually associated with high biomass production. However, as the plants mature, the biomass accumulation is associated with thickening and high lignin content in their cell walls. These placeconstraints for microbial digestion and fermentation and consequently decrease the forage quality (Paulino*et al.*,2002; Olafadehan *et al*., 2009).Ruminant animals in Nigeria are underfed due to high costs of feed ingredients especially plant proteins sources like soybean meal, groundnut meal and Cottonseed cake. The use of poultry manure as a substitute to reduce the costs of production and improved animal performance has, however, been demonstrated (Belewu, 1997; Lamidi, 2005; Jokthan *et al.*, 2013) although there is controversy over the inclusion levels of poultry litter in the diets of small ruminants. In a trial by Narasimha *et al.* (2013) on the use of poultry litter to feed sheep and goats, the researchers concluded its use up to 35% level in the diet of small ruminants as un-conventional protein source without any adverse effect. Contrary to this observation, Jokthan *et al.* (2013) recommended a lower level of 30% inclusion in the diet of yankasa rams without any adverse effect on performance. But Nadeem*et al.*(1993) observed mortality in goats fed 25% and 30% broiler litter in Pakistan and recommended about 20% inclusion level in the diet for Barbari goats. This study was carried outto provide information on the optimum inclusion level of Sun-dried broiler litter in the diet of growing goats.

Justification of the Study

Conventional protein supplements such as soyabean meal, groundnut cake and cotton seed cake can no longer be used widely in ruminant diets by average Nigerian farmers.The main constraints to their present and future use are their declining production and escalating price. However, differently processed poultry litteras a substitutehas been successfully used in feeding ruminants (Lamidi, 2005, Negesse *et al.*,2007; Azizi-Shotorkhoft *et al.*, 2013, Jokthan *et al.*, 2013). Broiler litter contains a large amount of protein and other nutrients which are required by animals. About 45 to 67% of its crude protein is available as True Protein, 18 to 30% as Uric acid and 12 to 17% as Ammonia, which can be utilized by ruminants (Belewu, 1997). Moreover, Poultry production is one of the fast growing sectors of livestock production in Nigeria and as suchthe litter may beavailable to farmers and cheaper than conventional protein supplements. Hence, poultry litter can be used as protein supplement to improve the performance of ruminants.

Objectives of the study

This study wascarried out to evaluate the effect of Wooly finger grass (*Digitaria smutsii)* hay -based diets containing varying levels of Sundried Broiler Litter on performance of growing Red Sokoto bucks.

Specific Objectives

The Specific objectives of the study include:

1. To determine the chemical composition of the test ingredients and the experimental diets.

2.To determine effect of inclusion levels of Sun-dried Broiler Litter in *Digitaria smutsii*hay -based diet on growthperformance of growig Red Sokoto bucks.

3. To determine the nutrient digestibility, nitrogen balance, rumen and some serum metabolites of growing Red Sokoto bucks fed the different experimental diets.

4. To study the economics of feeding the experimental diets to Red Sokoto bucks.

Hypothesis

H_o: There is no significant effectin feeding *Digitaria smutsii* hay-based diet with varying levels of Sundried Broiler Litter on growth performance,nutrient digestibility, nitrogen balance, rumen andserum metabolitesas well as cost economics of Red Sokoto bucks.

H_A: There is significant effect in feeding *Digitaria smutsii* hay-based diet with varying levels of Sundried Broiler Litter on growth performance,nutrient digestibility, nitrogen balance, rumen andserum metabolitesas well as cost economics of Red Sokoto bucks.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Small Ruminant Production in Nigeria

2.1.1Population of Small ruminants in Nigeria

The world total numbers of goats and sheep were put at 861.9 and 1078.2 million, respectively, i.e. there is about one goat to approximately 1.25 sheep in the world (FAOSTAT, 2008). The largest number of goats and sheep was observed in Asia, representing about 59.7% goats and 42% sheep. Africa, with 33.8% goats and 26.7% sheep was the second largest producer of small ruminants. Nigeria was fifth of the ten leading countries of the world in small ruminant production with a population of 53.8 million goats and 33.9 million sheep (FAOSTAT, 2008).Sheep andgoats represent about63.7% of total grazing domestic animals in Nigeria (Gefu, 2002).Thiscurrent report about small ruminantpopulation in the country is much higher than the 34.5 million goats and 22.0 million sheep reported by RIMS(1992). This clearly demonstrates increase insmall ruminant production in the country.

2.1.2 Breeds and distribution of Small ruminant in Nigeria

Breeds of sheep

Balami

According to Blench(1999), Balami is the largest bodied native sheep in Nigeria. As a pastoral animal it is confined to thesemi-arid north, but it is favoured as a stall-fed breed by Muslims throughout the Nigerian Middle Belt (Blench, 1999). It is white and hairy with pendulous ears and along thin tail; rams have a throat ruff and are horned but ewes are normally polled. Another featurethat makes the Balami distinctly recognisable is its Roman nose, a large bulbous nose thatdistinguishes it from the Yankasa. Balami is a widespread breed in the northernregion of the country(Buvanendran and Adu, 1990).It has good potential as a meat producer. Balami is fast growing and attains a weaning weight of 18 kg in 12 weeks.The weight of mature males ranges from 45 to 60kg while that of female between 35 and 40kg. The milk yield per lactation range between 28 and 33kg in 70days (Adu and Ngere, 1979).

Uda

TheUda is slightly smaller-bodied than the Balami, although their size ranges overlap. It is easilyrecognised by a distinctive coat colour pattern; entirely brown or black forequarters and whitebehind (Oni, 2002).It is a widespread breed in the northern region of the country. Itis dominant in North Western Nigeria with its crosses found in the North East and Central Nigeria (Oni, 2002).The rams have large wide and spiral horns, which are usually absent in the ewes.The breed appears to thrive in hot, dry environment and suffers from poor survival outside this ecological zone; it is particularly adapted to extensive grazing and is renowned for its trekking abilities.Mature weights range from 35 - 45kg for ewes and 45 – 55kg for rams. Milk yield per lactation lies between 32 and 36kg for an averagelactation length of 91 days (Adu and Ngere, 1979).

Yankasa

The Yankasa is a meat breed of sheep found in the North and North Central Nigeria. It isa white bodied sheep with black patches around the eyes and sometimes on the feet. The muzzle and ears are usually black too. Rams have curved horns and a hairy white mane, while ewes are polled(Mason,1996).Yankasa sheep have been recorded in all parts of Nigeria, though the populations attenuate towards the northern border and the sea-coast (Aganga*et al.*, 1988).It is the most numerous and most widely distributed of the Nigerian breeds of Sheep and is found throughout the Guinea and Sudan Savannah zones (Osinowo*et al.,* 1985; Wamagi*et al.,* 2013).Mature females could weigh 25 to 40kg while male weighs between 35 and 50kg. The milk yield (kg) per lactation is between 30 and 56kg and has a lactation length of 91 days. The peak milk yield per day is 960 grammes(Adu and Ngere, 1979).

West African Dwarf sheep (WAD)

The West African Dwarf is a small-bodied, compact breed which may be all white, black, brown, orspotted black or brown on a white coat. Its variation in colour and patchy distribution make itdifficult to distinguish clearly from the Yankasa (Charray*et al.,*1992).The WestAfricanDwarf is the predominant breed of the humid tropics from Southern West Africa through Central Africa(Mason,1988). In Nigeria, The WAD sheep is common to Southern region of the country (Wamagi*et al.,* 2013).

The breed is relatively small and light.The rams have a well-developed throat ruff and are horned.The horns are wide at the base, curve backwards, outwards and then forwards again, with a maximum of one and a half coils (Wilson, 1991*)*.They weigh between 25 to 35kg (Charray*et al.,*1992). The females are usually polled, but may have slender short horns. Mature ewes weigh between 20 to 30kg.They can be bred at the age of 7 to 8 months. They tend to have a short lambing interval.The prolificacy of adult ewes is low to moderate ranging from 1.15 to 1.50 lambs per lambing. At less than 100 g per day under good feed conditions, their growth rate is low and lamb mortality is high(Mason,1988).This breed is also trypanotolerant(Charray*et al.,*1992).

Breeds of Goat in Nigeria

West African Dwarf Goat(WAD)

West African Dwarf (WAD) goat is common to Southern Nigeria,Wilson (1991).This breed is markedly stunted and has a typical height of 30 to 50 cm. Adult males weigh 20 to 25 kg and females 18 to 22 kg. Both sexes have horns, which curve outwards and backwards in males. Males also have beards, and sometimes manes. The neck is relatively long, the chest is broad and the back straight. The legs are short and the udder is small but usually well-shaped. Most types have short stiff hair, and the colour varies; dark brown with black points is probably the most common, but black, red, white, pied andmulti-coloured goats also occur(Wilson, 1991).

West African Dwarf goats are capable of breeding at twelve to eighteen months. Multiple births are very common with twins being normal and triplets frequent. The kidding interval averages about 220 days. Growth rate and milk yield of this breed is very low; it is kept for meat production. The breed is well adapted to humid environment and very resistant to trypanosomiasis (Ozung*et al.,* 2011; Chiejina*et al.,* 2015).

Sahelian(White Borno)Goat

The Sahelian or Desert goat is found along the northern border of Nigeria, particularly in Borno. This goat is believed by the local Hausa/Fulanis who are the original custodian of the breed to have originally come from the dry lands of Niger (Otoikhian,2012). However, some literatures have traced its origin to Switzerland butcame into Nigeria via Niger and Chad Republic (Moruppa and Ngere, 1986). It is a dual purpose breed kept for meat and dairy products. The White Bornogoats have the ability to breed out of season and areexcellent range animals because of their long limbs. In addition, White Bornu goats are usually characterised as being very hardy, able to survive and thrive under adverse agro climatic conditions with only limited management input (Ngere *et al.,* 1984., Morupa and Ngere, 1986). In Nigeria, this goat is generally the breed preferred by pastoralists (Mason, 1988).

Red Sokoto Goats

The Red Sokoto, Kano Brown or Maradi goats are found in Nigeria and Niger (Ozung*et al.,* 2011). Within the indigenous breeds of goats kept for meat production in Nigeria, Red Sokoto goat is the most numerous and most widely distributed throughout the various ecological zones, particularly Guinea and Sudan savannah vegetation belt (Ibrahim*et al., 2014).* It measures between 55 – 60cm height at withers with an average mature live weight of 25kg(Otoikhian, 2012).Red Sokoto is a large, fast growing, early - maturing meat breed (Ebozoje,1992). It is a small fine goat famous for its skin (Ozung*et al.,* 2011). The skin of Red Sokoto is known for its superior quality and the premium it commands in the world market (Otoikhian, 2012).Red Sokoto was the source of 'Morocco leather' known in Europe from the medieval period onwards(Blench, 1999). This breed is a good dairy animal which produces a daily milk yield of 0.5 to 1.5kg and 100 days of lactation. (Gall, 1996).

2.1.3Small ruminant production systems in Nigeria

Pastoral System

Small ruminants in Nigeria are managed under pastoral, agro-pastoral and peri-urban systems.Pastoralism is defined to mean a situation whereby people herd animals to sustain their livelihoods (Bhasin, 2011). Pastoralists are mainly livestock producers who do not grow crops and therefore depend on the sales of live animals and dairy products to buy grains, other food items and other necessities (Aregheore, 2009). Pastoral agriculture is an integral part of rural economy as livestock serve as a source of cash to the family thereby preventing social depression which arises as a result of lack of financial resources. Grazing livestock remains an important asset to livelihoods, especially for people of dry region (Dickhoeferand Buerkert, 2010).

According to Blench (1999), most pastoralists may move very long distances every year. It is a popular assumption that they wander from place to place without any logic; in general they have set migration routes and often long-standing arrangements with farmers to make use of their crop residues. It is only when there is drought, a failure of the pasture or the spread of diseases that they diverge from their existing patterns.

Agro-pastoral system

This is mixture of crop- livestock system of pastoral farming (Sanni *et al.*, 2004; Ahmed and Egwu, 2014).According to Aregheore(2009),the system is made up of semi-settled pastoralists and they are found in many parts of Northern Nigeria. They cultivate areas sufficient to feed their families from their own cereal production. They hold land rights, use their own or hired labour to cultivate land and grow crops such as yams and cassava in addition to the staple cereals such as sorghum, millet and maize. Sheep and goats are efficiently reared on marginal lands and are good users of crop residues (Fakoya, 2002; Sanni *et al.*, 2004). As such, they provide the only practical means of using vast areas of natural grasslands in regions, where crop production is almost impracticable (Ngatezie, 1989; Rege, 2001). In the system, the average herd of livestock is small compared to other pastoral systems, because they no longer rely solely on livestock and the finite grazing area around their environs that can be reached in a day will limit herd size. Most agro-pastoralists have preferences for particular breeds (Blench, 1999; Aregheore, 2009). The agro-pastoral farmers utilize extensive and semi-intensive management systems (Ajala and Gefu,2003; Mbilu, 2007).

Peri-urban and modern ruminant livestock husbandry

According to Aregheore (2009), this system could be referred to as the commercial or intensive production system. Wealthy urban businessmen, wealthy Fulani and government officials practise this system. These types of farms which were found only on the periphery of major towns in northern and central Nigeria are also found today in the south of the country. The rich individuals who own these farms capitalize on the potential of animals as investment, source of milk and meat for their family and also a status symbol. In this system, a farmer may decide to have only cattle or cattle with small ruminants inclusive. Trained personnel are hired and expected routine management practices carried out in most modern ranching operations are also seen in these farmers. In this type of intensive production system the use of crop residues and agricultural by-products are effectively and economically combined with grazing (Blench, 1999; Aregheore, 2009).

2.1.4The significance of goats to Nigerian livestock economy

The contribution of the livestock sector to the agricultural gross domestic product in Nigeria is 49 % (Amadou*et al.*, 2012). The importance of goats in Nigerian livestock economy can be attributed to its value for meat, milk and leather,primary use being for meat production. In Nigeria, livestock provides about 36.5% of total protein intake (NISER/CBN, 1991). Goats contribute about 24% of Nigerian meat supply (Oni, 2002). Goat meat has low saturated fatty acids and cholesterol compared to other red meats (Devendra, 1988).A diet rich in non-saturated fatty acids is correlated with a reduced risk of stroke and coronary diseases. Hence, the American Heart Association reported that molecular structure of goat meat is different and as a result goat meat is more easily digested (Jamal, 2007). In the rural areas, the value of goat is far greater and it is usually appreciated, being often the most-readilyavailable source of meat.

In addition, goat milk with its special attributes is very valuable to the rural populace. The uniqueness of goat milk, yoghurt and cheese in human nutrition has several aspects, goat milk can be used for the treatment of direct or indirect cow milk allergy (Grezesiak, 1989). Goat milk has predominantly smaller fat globules compare to cow's milk and it is more easily digested (Fevrier *et al*., 1993).The essential amino acids of goat milk are slightly in excess of infant requirement (Ochepo and Momoh, 2010). Goat milk has higher medicinal value, high vitamin B content and high digestibility, which makes it helpful in relieving stress and constipation (James*et al.*, 2005).Hence, goat milk is a valuable alternative not just for babies, but also for adults and especially nursing mothers (Baldo, 1984; Host *et al*., 1988).

Goat skin although is consumed as meat in some parts of the country, is very useful by product with asignificant export trade; the skin of the Red Sokoto breed for example is known for its superior quality and thepremium it commands in the world market (Otoikhian, 2012). 'Emergency cash source' has been reported as the major motivating factor for ruminant production as it serves as 'savings account' for their keepers (Ajala, 2004). The contributions of goats to the people and economies of Nigeria is very much underestimated, basically becausetheir production is considered as small in scale, and goat products seldom enter a formal marketing system. Forthese reasons, goats are accorded a low status and given a low priority in national development in most African countries.

2.2. Nutrient Requirement of Goats

2.2.1 Energy rquirement

Meeting nutrient requirements of any class of livestock isessential for effective and efficient performance.Many factors affect the nutritional requirements of small ruminants: maintenance, growth, pregnancy, lactation, fiber production, activity, and environment(Martinez Marin *et al.*, 2012). Goats require water, energy, protein, vitamins, and minerals to sustain life, produce and reproduce. Energy is supplied in the ration through hay and concentrate mix (Alemu, 2010).As a general rule of thumb, sheep and goats will consume 2 to 4 percent of their body weight on a dry matter basis in feed. The exact percentage varies according to the size (weight) of the animal, with smaller animals needing a higher intake (percentage-wise) to maintain their weight.

Dry matter intakeneeded to meet the energy requirements is determined bythe physiological stage and depends on the energy densityof the diet (Martinez Marin *et al.*,2012). Dry matter intake is limited by the capacity of the digestive system and is determined by the size of the abdominal cavity, also it depends on the volume of the diet, which can be related to its neutral detergent fibre (NDF) content (Williams *et al.*,1989). Daily dry matter intake of young goats at ages of 90, 240 and 350 days old has been reported by AFRC, (1998) to be 0.4, 0.7 and 0.9 kg respectively for long hay. While for chopped hay, it was 0.8, 1.3, and 1.4 respectively. Hence, animals will take more feed if its volumeis decreased.

Understanding energy requirements for goats is important to the rational design of animal production systems so as to provide balanced diets that precisely meet the needs of the animals (Medeiros *et al.*, 2014). A still widely used publication on nutrient requirements of goats was published by the US National Research Council (NRC, 1981). Maintenance requirements increase as the level of the animals' activity increases. For example, a sheep or goat that has to travel a farther distance for feed and water will have a higher maintenance requirement than animals in a feed lot. Environmental conditions also affect maintenance requirements. In cold and severe weather, sheep and goats require more feed to maintain body heat. The added stresses of pregnancy, lactation, and growth further increase nutrient requirements.

The NRC (1981) recommends average values of 239 and 424 $kJ/kg^{0.75}$ of BW for NE_m and ME_m, respectively. On the other hand, the AFRC (1998) suggests an average of 315 and 438 $kJ/kg^{0.75}$ of BW for NE_m and ME_m, respectively.

The most recent energy evaluation systems for goats are INRA (2007) and NRC (2007). INRA (2007) expressed the energy supply and requirements as milk feeding units (UFL), which is the net energy of lactation (NEL) content of the particular feedstuff relative to that of French reference barley (7.11 MJ NEL/ kg as fed). NRC (2007) expresses the energy supply and requirement as ME. The ME content of the feedstuff is calculated from the total digestible nutrients (TDN) content using the relationship: 1kg TDN = 18.37 MJ DE = 15.06 MJ ME. The TDN content is calculated from regression equations or digestible coefficient applicable to crude protein (CP), crude fibre (CF), crude fat and nitrogen free extractives.

The minimum and maximum TDN for mature Does is 53 and 66% respectively. While for growing kids it varies respectively from 67 and 86% (NRC,2007). Maintenance requirement of goat according to NRC (2007) is 4.44 MJ ME/day. Dry matter intake of growing goats reaches a physiological limit when the metabolizable energy (ME) content of the diet isabout 12.55MJ/kg DM. Lu and Potchoiba (1990) supplied three complete pelleted diets,which had increasing levels of ME (10.29, 11.59, and 12.76 MJ/kgDM), to goats between 4 and 8 months old, and they observed that DMI decreased nonelinearly with increasing ME concentration: the intake decreased by 124g/d when dietary ME content increased from 10.29 to 11.59 MJ/kg DM; but increasing dietary ME content from 11.59 to 12.76 MJ/kg, decreased the intake by 326g/d.

The energy ingested by animals during their growing period is an important factor of their growth capacity. The NRC (1981) indicated an energy requirement for weightgain to be equal to 30.3KJ ME/g gain. Lu *et al.*(1987) reported that the growth requirement of Alpine and Nubian young goats within 4 – 8 monthsof age was equal to 37.7, 59 and 57.4 KJME/g gain, respectively, for animals fed diets with 12.8, 11.6 and 10.3 MJ ME/kg dry matter.

2.2.2Protein requirement

Protein is the most expensive feed ingredient for livestock, and a clear understanding of the protein requirements of animals can be valuable for reducing cost and ensuring farm profitability (Dengand Zhang, 2015). Animals require a considerable amount of protein because their bodies and products (meat, milk) are composed of high levels of protein.The minimum protein requirements for ruminants range from 10-12% (ARC, 1985).The most recent protein evaluation systems for goats areINRA (2007) and NRC (2007). INRA (2007) expresses the protein supply and requirements as protein truly digestedin the small intestine.

The results obtained by Negesse *et al.*(2001) inpostweaned goat kids show that inadequate or excessiveinclusion of CP in the diet results in inefficient use of nitrogenintake. In that respect, both INRA (2007) and NRC(2007) took into account the negative effect of inadequateavailable nitrogen in relation to energy on ruminal digestion. NRC (2007) recommended that the relationship of protein digested in the small intestine(DIP) and TDN (DIP: TDN) should be higher than 0.09 for adequate use of nitrogen intake. This recommendation is based on the works of Prieto *et al.*(2000) and Soto-Navarro *et al.*(2003, 2004). Prieto *et al.*(2000) observed satisfactory ADG of wether goats between 4 and 12 months old offered a 70% concentrate diet with 14% CP and a DIP: TDN ratio equal to 0.115. In yearling wether goats offered a maize based diet, Soto-Navarro *et al.*(2003) found that a 9-10% CP content and a DIP:TDN ratio equal to 0.073 was enough to maximize microbial protein synthesis, though organic matter digestibility increased when the CP content and the DIP:TDN ratio was 11.5% and 0.104 or 13.5% and 0.114. Soto-Navarro *et al.*(2004) observed satisfactory ADG of wether goats between 7 and 14 months old offered a 70% concentrate diet with 13% CP and a DIP: TDN ratio equal to 0.09.

2.2.3 Mineral requirement

Many minerals are required by small ruminants. The most important are, calcium, and phosphorus. The maximum content of Ca and P in the diet recommended by NRC (2005) is 1.5 and 0.6% DM, respectively. The requirements of Ca and P are interrelated, but the tolerable limits of the Ca:P ratio are large. ARC (1980) and NRC (1981) recommended a minimum limit of 1:1 and 1.2:1, respectively, while the maximum recommended limit is 7:1 (ARC, 1980, NRC, 1980). Liesegang and Risteli (2005) found no differences in bone characteristics of 8-month old goats fed diets with adequate levels of P and Ca:P ratios of 1.5:1 and 4:1. Moreover, Mejia-Haro*et al.*(2001) found no differences in the apparent absorption and retention of P in 6-month old lambs fed a diet slightly deficient in P and Ca:P ratios of 2.5:1.5, 6:1 and 9:1.

However, Boxebeld *et al.*(1983) observed in 6-month old lambs fed semi purified diets that the negative effects of a P marginal deficiency (decreased phosphatemia and DMI) got worse when Ca was supplied to get a Ca:P ratio equal to 9.1:1. Also, Wan Zahari *et al.*(1990) observed in wether lambs grown from 25 to 50 kg BW that a Ca:P ratio of 3.6:1 had a negative effect on intake and growth rate when P was supplied at 0.75 times its requirement. All these references suggest that the proposed Ca:P ratio limits are acceptable if the minimum requirement of the companion mineral is met. In that respect, studies with 3-month old lambs have shown no negative effects when the diet supplies adequate P but Ca is in excess (Ca:Pratio equal to 5.4:1; Rajaratne *et al.*,1990), or when thediet supplies adequate Ca but P is in excess (Ca:P ratioequal to 0.5:1; Wan Zahari *et al.*,1994).The ratio of calcium to phosphorus should be kept around 2:1 to prevent urinary calculi.

2.3 Nitrogen Metabolism in Ruminants

2.3.1 Sources of nitrogen for rumen metabolism.

In ruminant nutrition, leguminous forages andtheir grains are mainly used as protein supplements (Cutrignelli *et al.*, 2011). The proteins of legume grain are highly degradable in the rumen and digestible in theintestine. Protein rich leguminous forages are not widely grown in many areas grazed by ruminants, and vegetable protein supplements are usually expensive or unavailable (Cutrignelli *et al.*, 2011). However, ruminants can utilize all nitrogen compounds unlike non-ruminants which can digest only real proteins and use only them in their body (Burgstaller, 1983).Feeding grass, fodder and concentrates of low nutritive value does not always meet the nutritional needs of ruminants; hence they should be supplemented with suitable alternative feed resources.

One of such alternative feed resources is the use of non-protein nitrogen (NPN) compounds (Yilkal and Negassie, 2015). Non-protein nitrogen (NPN) is a term used in animal nutrition to refer collectively to components such as urea, biuret, uric acid and anumber of other ammonia compounds which are not proteins but can be converted into proteins by microbes inthe ruminant stomach (Yilkal and Negassie, 2015). A portion of nitrogen in feeds for ruminantsmay be provided in the form of simple nitrogen compounds (NPN) that are degraded in the rumen to release ammonia (NH_3), which is used by rumen microorganisms to produce amino acids (Nadeem *et al*., 2014).

Sources of NPN for ruminants include Urea, Biuret, Poultry litter, ammonia hydroxide (Yilkal and Negassie, 2015) and urea-N recycled back to the rumen via saliva (Reynolds and Kristensen, 2008).

2.3.2 Mechanism of dietary nitrogen degradation in the rumen

Nitrogen metabolism in the rumen is a result of mainly the metabolic activity of rumen microbes as the majority of microbes have proteolytic activity (Prins *et al*., 1983).Approximately 70 to 80% of ruminal microorganismsattach to undigested feed particles in the rumen (Craig *et al.,* 1987).According to Huntington and Archibeque, (2000) the degradation activity of these proteolytic microbes depends on the chemistry and structure of dietary proteins, as well as ruminal pH and predominant species of microbes present in the rumen. The major proteolytic ruminal bacteria are *Prevotella spp., Butyrivibrio sp., Ruminobacter sp.,* and *Selenomomas sp.* (Prins *et al.,* 1983).Wallace *et al*. (1997) reported that as the number of different bonds withina single protein is large, the synergistic action of different proteases is necessary forcomplete protein degradation.

Bach *et al.* (2005) stated that dietary protein entering the rumen is ruminally degraded (RDP) and the undegraded portion,ruminally-undegraded dietary protein; (RUDP) enters the small intestine, where it is further digested. The RDP is comprised of true protein and NPN. True protein is degraded to peptides, AA and NH_3-N, whereas NPN is comprised of N present in nucleic acids, NH_3-N, AA, small peptides, amides and amines. Microbial protein synthesized in the rumen, along with RUDP and endogenous N, are the major sources of AA available at the small intestine.Although ammonia is the major source of nitrogen for microbial growth, some species in the rumen are unable to utilize it and so require peptides and/or amino acids for growth (Pisulewski *et* *al*., 1981).Microbial N synthesis may depend on the nature of the bacterial ecosystem, which differs according to the energy source (Belanche *et al.,* 2012).Kopecny and Wallace (1982) reported that the optimal pH of rumen proteolytic enzymes ranges from 5.5 to 7.0; however, protein degradation is reduced at the lower end of the ruminal pH environment. Cardozo *et al*. (2000; 2002) conducted two dual flow continuous culture fermentation studies comparing high forage vs high concentrate rations at pH ranging from 4.9 to 7.0, and demonstrated that proteindegradation was reduced as pH decreased with both types of rations. Low ruminal pH may occur when feeding high-concentrate diets (Calsamiqlia*et al.,* 2008). The negative effect of pH on rumen microbial fermentation has been associated with the total amount of time that pH is below a certain threshold. However, not only the time, but also the magnitude of the pH reduction, is important(Cerrato*et al.,* 2008).

2.3.3 Urea Nitrogen recycling in ruminants

Ammonia that is absorbed into the portal blood is highly toxic and can lead to tetany and death of an animal, if not detoxified. Hence, NH_3 reaching the liver in portal blood is detoxified primarily to urea in the ornithine cycle, which occurs in periportal cells of the liver which is low affinity, “high capacity system” (Haussinger *et al.*, 1992). A significant portion of urea formed in the liver is excreted in the urine; however, in ruminants 40 to 80% of total endogenous urea production is recycled to digestive tract via saliva (Huntington, 1989) or by direct transfer from blood to the lumen of GIT via simple diffusion down the concentration gradient (Houpt and Houpt, 1968) and/or via carrier-mediated facilitative transport (Ritzhaupt *et al*., 1998).

In ruminants, nitrogen (N) transfer across the GIT can be much greater than N intake, and urea-N recycling to the GIT is considered as an evolutionary mechanism, wherein, under conditions of N deficiency, urea-N recycled to the rumen serves as a N precursor for microbial protein synthesis and as a result ruminants can survive when N supply through diet is inadequate to meet their N requirement (Reynolds and Kristensen, 2008). However, for high producing and rapidly growing ruminants, dietary N supply is usually high enough to meet their protein requirement. Even under such conditions where in animals are fed high N diets, total hepatic urea-N production often exceeds apparent digestible N, and if some of the urea-N is not recycled to the GIT, then those animals would be in negative or zero N balance (Lapierre and Lobley, 2001). In high-producing and rapidly growing ruminants, urea-N recycling to the GIT is so important that it can increase the N availability to the GIT from 43 to 130% (Lapierre and Lobley,2001).

2.4. Feed Resources for Ruminants in Nigeria

2.4.1 Forage rsources of Nigeria

Forage is defined as vegetative materials in fresh, dried, or ensiled state (pasture, hay or silage) which is fed to livestock (Amodu and Abubakar, 2004).Forage and fodder crops include pasture and rangevegetation, as well as crop residues derived from farmcrops (Shiawoya and Tsado, 2011).Forage provides most of the feed for livestock (Amodu and Abubakar, 2004). Ruminants in the tropics in general, are raised predominantly on grasses (Babayemi *et al.*, 2009).About 97 percent of Nigeria's ruminant animals are dependent on forage and fodder crops for their productivity. Forage and fodder crops are, therefore, central to the development of Nigeria's livestock industry (Shiawoya and Tsado, 2011).

Nigeria has a land area of 92.4 million hectares of which about 44% are under permanent pastures, which support its domestic ruminants of over 101 million (Federal

Ministry of Agriculture and Water Resources, 2008).It is estimated that only 3% of this number of animals are reared on improved pastures; the remaining97% are raised on low nutrient native pastures and farmlands (Okorie and Sanda, 1992). According to Kallah (2004), grazing lands in Nigeria, including natural wetlands (*fadama),* woodlands and forest reserves, are estimated to cover about 32.42million hectares, while cultivated croplands amount to about 39.41 million hectares. These lands provide substantial amount of forage and fodder, which are of vital importance in Nigeria's drive towards self-sufficiency in agricultural production, since they provide major source of feed for the country's ruminant livestock, both domestic and wildlife.

Pasture, forbs, and browse are usually the primary and most economical source of nutrients for sheep and goats. In some cases, pasture is all small ruminants need to meet their nutritional requirements. Pasture tends to be high in energy and protein when it is in the vegetative stage of growth. However, it can have a high moisture content, and sometimes it may be difficult for high-producing animals to eat enough grass to meet their nutrient requirements.As pasture plants mature, palatability and digestibility decline.At this period, the performance of the ruminant animals which is dependent on it is seriously impaired; the quality is associated with the fibrous and lignified nature of the pasture which limits intakeand utilization (Olafadehan *et al*., 2009).

Ruminant livestock survival in Nigeria hasdepended largely on the extensive native pastures,browses and farm crop residues across and within thevarious agro-ecological zones (Shiawoya and Tsado, 2011).Rearing of the native goat is largely practised by the rural dwellers where there are stillenough shrubs and trees to provide goat feed. The tender shoots of trees, twigs and leavesof shrubs and woody plants as well as fruits make up a large part of the natural diet of manyruminant animals including goats. Fodder trees and shrubs are an enormous potentialsource of protein for ruminants in the tropics(Devendra, 1983). Most browse species have high protein and low crude fibre contents, which make them suitable as fodder for livestock (Amodu and Otaru, 2004).Fodder and forages are the cheapest source of livestock feeding but their consistent shortage because of extensive urbanization, destruction of range lands due to cultivation, overgrazing and deforestation has further aggravated the condition and increase the gap between demand and supply for animal feeding particularly for small ruminants (Lachica and Agilera, 2003).

2.4.2 The Productivity and nutrient composition of *Digitaria smutsii* grass

The introduction of pasture crops in Nigeria started in the 1950s (Onifade and Agishi, 1988). Among the introduced pasture grass is *Digitaria smutsii* (Onifade and Agishi, 1988).*Digitaria smutsii (D. smutsii)* belongs to the family Poaceae and is commonly referred to as digitaria grass or crab grass. It is said to be native to Southern Africa (Chippindall, 1955). *Digitaria smutsii* is indigenous to Africa and grows well in the dry part of tropical and subtropical climates. The grass was first introduced into Nigeria from South Africa in 1956(Onifade and Agishi, 1988). *Digitaria* performs well in areas with annual rainfall ranging from 600-1800mm, but best rainfall optimum is 900mm per annum. Well-drained sandy- 1oam soil is preferable for the successful establishment of *Digitaria smutsii*, which is by means of stem cuttings or stolons because no viable seeds are produced. *Digitaria smutsii* is tolerant to acidic or alkaline soils and withstands limited-water logging.The dry matter yield of *Digitaria smutsii* in the Northern Guinea savanna of Nigeria range between 5 – 8 tonnes/hectare (Onifade and Agishi, 1988).*Digitaria smutsii* comprised 90.04%DM; 5.36%CP; 30.05% CF; 0.54% EE; 61.40% NFE; 69.23% NDF; 38.88% ADF; 20.40% Lignin and 2.65% Ash (Yashim, 2014). This is lower than values reported by (97%DM; 7.3% Ash; 4.1%EE; 6.3%CP; 73%NDF and 46%ADF) Bukar, (2007).

2.4.3 Agro industrial by products

Agro-industrial by-products such as maize bran (MB), rice bran (RB) and wheat offal (WO) has been used to form different rations for livestock especially ruminant (Alikwe*et al*., 2012). Supplementary feeds can be obtained from agro-industrial by-products such as residues of oil extracted from oil bearing seeds (groundnuts, coconut, palm kernels, cotton seed, soyabean etc), by-products of grain processing (maize, rice, wheat, sorghum, millet etc), peelings of tubers and fruits (yams, cassava, potatoes, plantains etc) and industrial by-products (brewers' dried grains, fruit cannery by-products, molasses etc). The types and quantities available tend to be location and season specific (Ademosun, 1988).

2.4.4 Cottonproduction in relationship to cottonseed cake output in Nigeria

Cotton is grown primarily for the fiber, but cottonseed meal and cake secured in the production of oil from cottonseed are among the most important feeds for livestock (Osti and Pandey, 2006). One ton of cottonseed canproduce 405kgcottonseed meal (CSM) or cake (NCPA, 2000).

In Nigeria,prior to the oil boom, cotton was one of the main source of foreign exchange and second largest employer of labour after the public sector (Gbadegesin and Uyovbisere, 1994).The peak period of cotton production in Nigeria was as far back as 1976/77 when about 453,126 bales (183.43kg/bale) were produced (Olukosi and Isitor, 1990). Thereafter production started declining due to price fluctuation, pest infestation and other related problems. By 1983/84 only 69,000 bales was produced while the demand for lint that year was about 531,000 bales which might have been satisfied through importation at the expense of foreign reserves(olukosi and Isitor,1990).Cotton productionin the country has taken a downward trendas the gap between demand and supply is becomingwider and wider every year because thesupply does not equate demand (Mshelia, 1991).This has posed serious challenges on use of cotton products.The current cotton production in Nigeria as reported by United States Agency for international Development (USAID) (2012) is 120,000 tons in the year 2012.

Nutritive value of cottonseed cake

The crude protein content of pre-pressed and direct solvent extracted cottonseed mealvaries between 41 - 45% depending on the method of extraction (NRC, 1998). However, it has been reported that the crude protein for undecorticatedcottonseed cake is between 24 - 26% (Aduku, 1992; Lamidi, 2005). It has the gross energy values of 4200 - 4600 kcal/kg depending on the level of oil extraction (NRC, 1998; NCPA, 2002). The fat, fibre, and ash content of cottonseed cake range between 4.0 -9.6%, 10.2 -18.4%, and 6.2 - 6.8% respectively (NRC, 1998; NCPA, 1999). The NDF and ADF range between 26 – 28% and 19-20%, respectively (NRC, 1988).While calcium and phosphorus range between 0.18 – 0.21% and 1.16 and 1.21%, respectively (NRC, 1988).

2.5 Poultry Litter

2.5.1 Poultry industry in relation to litter output

The poultry industry is one of the largest and fast growing sector of livestock production in the world (FAO, 2010). The 2010 world annual census data, estimated the world flock to be over 18 bilion birds with an estimated yearly output of 22 million tonnes of manure (Bolan *et al.,* 2010; FAO, 2010). The introduction of commercial poultry in Nigeria has resulted to rapid evolutionary changes (Adene, 1997). Morokolo (2012) reported that production of broiler meat increased continuously from 2004 to

2011 in Africa by 36%. In Nigeria about 932.5 metric tonnes of poultry litter are produced annually from the well-established poultry industries which keep expanding at a rate of 8% per year (Adewumi and Adewumi, 1996; Adewumi*et al*., 2011). This indicates that there will be no short fall in availability of poultry litter for livestock feeding in the world at large and Nigeria in particular.

2.5.2 Poultry litter as animal feedstuff

Poultry litter has traditionally been used efficiently as a fertilizer; but it is now also used as a cost-saving livestock feed supplement for ruminants especially cattle, goats and sheep (Murthy *et al*., 1995; Anonymous, 2006; Adegbola *et al*., 1990; Nwaigwe *et al*., 2011). Bolan *et al* (2010) reported that dried poultry litter has a value that is more than four times higher as an animal feed than its use as a soil conditioner. It is high in urea, a source of nitrogen, which improves the rumen environment making feed more efficiently utilized and the animal better nourished with whatever feed that is made available (Murthy *et al*., 1995; 1990).

Uric acid which is a major content of poultry waste can be utilized by rumen microbes for protein production as it is not easily dissolved in the rumen fluid and the ammonia is only slowly released making it more efficiently utilized than other non-protein nitrogenous sources (Abdel-Baset and Abbas, 2010).Poultry litter either on its own or when mixed with other feed ingredients like feed grains, proved to be a valuable feed for ruminant animals, fish and even monogastric animals like pigs (Snow and Ghaly, 2007; Adesehinwa*et al.,*2010; Bolan*et al.,* 2010; Sharpley*et al*., 2012). Research on feeding poultry litter to animals especially ruminants has been conducted since 1950 (Fontenot and Hancock, 2001).

2.5.3 Nutrient composition of broiler litter

Crude protein

Poultry litter is composed of poultry excreta, bedding, feathers, spilled feed, etc. Contributions of these components vary considerably with poultry production practices, among and within regions of the world (Goetsch and Aiken, 2000).Broiler litter has high crude protein, typically ranging between 15 - 35%(Belewu, 1997;Goetsch and Aiken, 2000).Tawadchai and Pakkapong (2010) reported 26% crude protein in heat processed broiler litter. Non-protein nitrogen usually accounts for slightly more than half of total crude protein, and amino acid nitrogen makes a somewhat lesser contribution. Uric acid represents roughly half of non-protein nitrogen, with the remaining arising from compounds such as ammonia, urea, and creatinine (Goetsch and Aiken, 2000).The uric acid can be utilized by rumen microbes for protein production as it is not easily dissolved in the rumen fluid and the ammonia is only slowly released making it more efficiently utilized than other non-protein nitrogenous sources (Abdel-Baset and Abbas, 2010).

Crude fibre

The crude fibre of broiler litter is fairlylow in comparison to grain (Ruffin and McCaskey, 1990). According toTawadchai and Pakkapong (2010) the crude fibre of heat processed broiler litter is 15.4%. The fibre in broiler litter cannot effectively meetthe cattle's need for fibre, because cattle also need long roughage to properly maintain their digestivesystems (Boyles and Golden, 2000).Concentrations of neutral detergent fibre(NDF) in broiler litter are quite variable, affected bythe number of growing periods before harvest and type of bedding material, as well as by extent of heat damage. Levels of NDF are usually between 30 and 60%. Acid detergent lignin concentration is also variable (5 to 15%) and generally affected by the same factors influencing NDF concentration. Park *et al.* (2000)reported the value of NDF, ADF and ADL to be 45.4, 29.4 and 8.9% and 47.62%, for rice hull broiler litter and 55, 40, and 17% for sawdust broiler litter, respectively.Fibre in broiler litter, other than that from bedding materials, appears to be of relatively high ruminal digestibility (Park *et al.*, 1995).

Energy

Although availability of energy in broiler litter varies greatly, Ruffin and McCaskey (1990)reported an average of 50% TDN concentration in broiler litter used for feeding cattle in Alabama.It has a total digestible nutrients value similar to average quality hay and can provide a major portion of energy to maintain ruminants if it is readily consumed (Abdel-Baset and Abbas, 2010). High concentrationof ash indicates excessive soil contamination and thus results to low dry matter intake and energy digestibility. A wide range in ash concentration (10 to 54%;average 25%) of broiler litter was reported by Stephenson *et al*. (1990). Ruffin and McCaskey (1990)suggested that ash levels greater than 28% reflect insufficient energy availability for efficient feedingof ruminants.Low energy levels were however reported at inclusion levels greater than 50% (Evers *et al*., 1996). Belewu and Adeneye (1996) observed that the gross energy of autoclaved broiler litter is 3.21 Mcal/kg.

Minerals

Poultry litter is high in ash content. According to Kwak, *et al*. (2000), broiler litter has 26.8% crude ash content. Similarly, Anigbogu and Nwagbara (2013) reported its crude ash content of 27%.Ash content is one of the important measures of a quality of broiler litter so ash contents of over 28.0% are too high and should not be fed to beef cattle (Davis *et al*.,2002).However, Suppadit *et al.*(2011) reported 19.5% total ash in pelleted meat quail litter.They explained that the high ash content may have beencaused by the soil that contaminated the beddingmaterials. Broiler litter is an excellent source of minerals. NRC (1984), Van Ryssen (2001), and Ghaly and McDonald (2012) respectively reported 1.8, 2.9 and 2.5% as calcium content of broiler litter respectively. While phosphorus content of 2.3% has been reported by Robinson and Beauchamp (1991).Excessive macro mineral levels in broiler littergenerally have not caused production problems (Goetsch and Aiken, 2000). Although, Pugh *et al.* (1994) reported that lactating beef cows consuming broiler litter ad libitum suffered from a milk hypocalcaemia, and Ruffin and McCaskey (1990) suggested removing brood cows from broiler litter diets at least 20 days before calving.Evers*et al.* (1996) found that poultry litter inclusion at more than 50% of the total ration resulted in over feeding protein and minerals.

2.5.4 Safety in feeding poultry litter to livestock

Livestock waste may contain various types of parasitic and non-parasitic pathogens as well as toxigenic fungi capable of causing diseases in humans, livestock and poultry. Livestock faecal waste may also contain drugs (Belewu, 1997). Gadberry (2000) and Rankins (2000) reported that dried poultry litter has been used as a feed ingredient for more than 40 years without harmful effects to people who have consumed such animals or animal products. From a hygiene stand point, unprocessed dietary litter contained potential pathogenic microorganisms like *Salmonella, Enterobacter* and *Clostridium species* (Ghaly and McDonald, 2012).

Drugsresidues in poultry litter

The presence of drugs in the litter could be associated with feed spillage, if the concentrated feed contains it. Some drugs are also excreted at high concentration level in the faeces and these include arsenicals, coccidiostats, antibiotics, sulphonamides, hormones, nitrofurans, nitrobenzenes, purines, organophosphates, chlorinated hydrocarbons, heavy metals and pesticides (Belewu, 1997). To reduce the risks from drug residues in the tissues of animals that are fed rations with poultry litter, feeding of such rations should be discontinued 15days before the animals are marketed for slaughter (Snow and Ghaly, 2007). There is need to thoroughly check for wires, nails and broken bottles in poultry litter before rations are formulated and fed to animals (Evers *et al.*,1996).

Pathogens in poultry litter

Poultry are potential agent of several pathogens which are communicable to humans as well as other livestock through the litter. Raw poultry manure contains many potentially harmful pathogens, such as Salmonella and *E coli*, which are harmful to ruminants. Another source of risk from poultry manure is Mycotoxins which are produced from moulds (Lanyasunya., 2006). All litter regardless of its source should be processed to eliminate pathogenic microorganisms. Mavimbela *et al.* (1997) reported on the need to vaccinate ruminants against botulism and also the need to deworm against helminths. No cases of the disease botulism caused by *Clostridium botulinum* were reported from vaccinated sheep fed sun dried poultry litter based rations. All the recorded botulism cases were caused by the presence of poultry carcasses in the poultry litter.

The poultry carcasses harbour the preformed toxins which when ingested by cattle proliferate resulting in hind limb paralysis and finally the forelimbs. The best method suggested to prevent the disease included good management practices like the exclusion of dead birds and other extraneous material of the litter prior to ration formulation and feeding. Processing of poultry litter enhanced feed intake, controlled odour and contribute to both animal and human health (Bernhart and Fasina, 2009). In feeding crossbred steers (Thai indigenous x brahman cattle) Tawadchai and Pakkapong (2010) reported that broiler litter pellets at 50% can be handled by the steers without the likelihood of carcass / meat contamination with pathogenic bacteria. However, they suggest a 15-day withdrawal time for exclusion of BL from diets of cattle before slaughterin order to avoid drug residue in meat.

2.5.5Methods of processing poultry litter

Mechanical method

Mechanical method is the mechanical drying of the poultry litter to reduce the bulkiness by 70-80% of the original volume (Fontenot, 1996; Belewu, 1997; Snow and Ghaly, 2007). Ghaly and McDonald (2012) outlined the process of drying as the removal of moisture from the poultry litter so that it is near equilibrium with the atmospheric air. Litter stickiness was eradicated completely and easy handling was enhanced in the trials carried out. Rate of deterioration due to chemical and biological activity was also minimised.

Drying can be carried out using a variety of heat sources like solar energy, electricity, natural gas or other fossil fuels. The sun drying method was recommended over other methods because other methods are associated with high cooking and drying energy costs and also high costs of equipment for cooking and drying for example autoclaves (Bernhart and Fasina, 2009). Sun drying method was recommended because the sun is available in abundance throughout the year especially in the tropics and the method proved to be effective in most of the experimental trials carried out in different parts of the world (Obasa *et al.*, 2009). Higher oxidation rate, odour control, pathogen destruction and good waste stabilization were all reported from sun-dried poultry litter (Belewu, 1997).

Sun drying proved to be an economic method of processing poultry manure compared to other mechanical methods like heat air drying where the use of expensive electric driers is required. Ghaly and MacDonald (2012) reported that heatedair drying was most efficient at 60°C and at a depth of 3 cm. For fast drying thin layers of about 1cm proved to be effective and the moisture content was recommended to be left at around 12-13%. Poultry litter with moisture content below 12% had low CP due to nitrogen losses and when such litter were incorporated in rations, dust causereduced feed intake by animals (Fontenot, 1991). Cases of Mycotoxins that are produced by Aspergillus were observed in poultry litter with moisture content above 13% (Van Ryssen, 2001).

Biological method

The biological methods involve the use of living organisms for example insect culture. In a study carried out by Belewu (1997) larvae of dipteral species transformed 80% of organic matter in poultry litter and reduced moisture content from 75% to 50%. Poultry litter can also be ensiled alone or with any soluble carbohydrate so as to enhance the quality of the fermentation process. Deep stacking method was found to be effective in eliminating pathogens present in the poultry litter (Ghaly and McDonald, 2012).

Chemical method

In this method poultry litter is collected and is then chemically treated with substances such as purple iodine and ethylene oxide which do not affect the chemical composition of DPL (Belewu, 1997). Immediate harvesting and low energy and labour requirements are the reported advantages. The main disadvantages associated with the chemical method include the expensive mixing equipment and the costly chemicals. Martens and Bohm (2009) found that ethylene oxide is commonly used in the chemical treatment of DPL in developed countries like USA.

2. 5.6 Response of animals fed dried poultry litter

Performance of ruminant animals fed broilerlitter has been reported bymany authors.Jokthan*et al*. (2013) reported significantly higher dry matter intake in lambs at 40 percent inclusion of broiler litter. Similarly,significant increase in daily weight gain at 40 and 60 per cent litter inclusion in Bunaji heifers has been reported by Belewu (1992).Animut*et al*. (2002) observed that dietary inclusion of broiler litter resulted in gain in Alpine Doeling similar to that with urea treatment of wheat straw and soybean meal supplementation of untreated straw. However, Lamidi (2005) reported linear decrease in daily live weight of bulls fed on diets containing 0, 25, 50, 75 and 100% SDBL replacement respectively. In the same vein, Nadeem*et al*. (1993) reported significant linear depression in feed consumption of Barbari kids by increasing levels of broiler litter in the diets.

Evers *et al.* (1996) revealed the importance of gradually introducing rations with poultry litter to animals at whatever inclusion level. Maximum feed intake in most of the feeding trials carried out was observed after two weeks when the animals were accustomed to the formulated rations. Mavimbela*et al.* (1997) found that molasses inclusion in rations containing dried poultry litter as the major protein source enhanced feed intake by animals.This clearly indicates that poultry litter diets are low in palatability, thus lower intake of diets containing litter can affect gain in animals.Chaudhry and Naseer (2012) replaced cotton seed cake by deep stack broiler litter at level of 0, 130, 260 or 390g/kg DM in diet of buffalo steers and conclude that it can be used up to 260g/kg DM in ruminant rations. Gebreslassie *et al.* (2015) studied effects of supplementing graded levels of poultry litterand wheat bran on performance of Abergelle bucks and observed that feeding ration containing 74% poultry litter at

300g/day was biologically more efficient but feeding at 150g/day was more economically profitable for fattening of the bucks.

2.6Feeding of Complete Diet to Ruminants

Forages and concentrates are usually fed separately to ruminants; however, in the recent times complete diet feeding is advocated.The objective of complete rations is to provide a blend of all the feed ingredients including roughages without giving any choice to the animal for selection of specific ingredient (Khan *et al.,* 2010).In this feeding system, all feed ingredients inclusive of roughages are proportioned, processed and mixed into a uniform blend. The product is fed as a sole source of nutrients (Kirubanath*et al*., 2003, Devasena and Rama Prasad, 2014).

Besides, these complete rations facilitate control ratio of roughage to concentrate, provide uniform feed intake, reduce feed wastage, enhance nitrogen balance and milk production and reduces the cost of feeding (Lailer *et al.,* 2010). Such rations also reduce eating and rumination time and increase resting time (Reddy *et al.,* 2003). Intake of feed provides stable rumen environment, reduce fermentation losses, and is also associated with less fluctuation in rumen-release of ammonia so that non-protein nitrogen may be more efficiently utilized (Gill, 1979; Reddy*et al.,* 2003, Devasena and Rama Prasad, 2014).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Experimental Site

The study was carried out at the Small Ruminant Research Programme of the National Animal Production Research Institute (NAPRI), Ahmadu Bello University, Shika-Zaria, Nigeria. Shika is located within the Northern Guinea Savanna Ecological Zone (latitude 11^0 and 12^0N and longitude7^0 and 8^0E), with an elevation of 640m above the sea level (Ovimaps, 2012). The annual rainfall is about 1100mm and it starts in April/May, establishes by June and ends in mid-October. Maximum temperature varies between 27^0C and 35^0C depending on the season. The relative humidity is about72% during the rainy season and about 21% during the dry season (I.A.R. Meteorological service unit, 2012).

3.2 Management of Animals

Twenty (20) growing Red Sokoto bucks of average weight of 11.5 kg were used for the experiment. The bucks were sourced from the Small Ruminant Research Programmeof the National Animal Production Research Institute (NAPRI), Ahmadu Bello University, Shika- Zaria.The bucks were randomly assigned into four treatment groups of five (5) bucks each in a Completely Randomized Design (CRD). The animals were housed in individual pens of concrete floor with full shade.Prior to the experiment the bucks were dewormed using *Abendazole* ® suspension and dipped in acaricide(Amitix®) solution one week before the commencement of the feeding trial to control *endo* and ecto-parasites.Feed were offered to animals at 4% body weight at 8.00h and 14.00h, and the left over were weighed the following morning before any other subsequent feeding. Drinking water was made available ad libitum.

The faecal remains were removed daily and environment kept clean to avoid disease outbreak.The bucks were weighed at beginning of the feeding trial and then fortnightly and the changes in weights were calculated. The animals were weighed in the morning before feeding and feed offered adjusted, in line with the changes in their body weights.The growth trial lasted for ninety (90) days. This was followed by digestibility trial which lasted 21 days.

3.3 Experimental Diets and Procedure

Four (4) *Digitaria smutsii* hay-based diets were formulated. The diets composed of varying levels of sun-dried broiler litter. The broiler litter and *Digitaria smutsii* hay were sourced from the Poultry Research Programme and from Feeds and Nutrition Research Programme, respectively of the National Animal Production Research Institute, Ahmadu Bello University, Shika- Zaria. The broiler litter were sun-dried for four (4) days to ruduce moisture content, sieved and stored in a dried and cool place.

The hay materials were chopped into about 2 to 4cm pieces with the aid of cutlass. This was done to prevent wastage and preferential selection of the feed materials by the experimental animals. Other feed ingredients including Cotton Seed Cake, maize offal, brewers dried grain, table salt and bone meal were sourced from nearby Giwa and Samaru markets of Kaduna State. Sun-dried broiler litter were mixed with the concentrate ingredients at 0, 10, 20, and 30% levelsof inclusion in replacement of Cotton Seed Cake, each representing a treatment. Thereafter, the hay and concentrate portion were thoroughiy mixed together at a ratio of 40% hay and 60% concentrate. The composition of the experimental diets is given on Table 3.1.

Table 3.1 Composition of the Experimental Diets

	Inclusion Levels of sun-dried broiler litter (SBL) (%)			
Ingredients (%)	0	10	20	30
Digitaria smutsii hay	40	40	40	40
Maize Offal	17	17	18	18
Cotton Seed Cake	30	20	10	0
Sundried Broiler Litter	0	10	20	30
Brewer's Dried Grain	11	11	10	10
Bone meal	1.5	1.5	1.5	1.5
Total (%)	100.00	100.00	100.00	100.00
Calculated Chemical composition				
Dry Matter (%)	91.80	91.50	91.20	90.89
Crude Protein (%)	15.00	15.03	15. 07	15.10
Crude fibre (%)	24.66	23.40	22.00	21.96
Ash (%)	5.00	7.20	9.65	10.56
ME (MJ/kg DM)	12.56	12.25	12,01	11.98
Cost/kg of diet (₦)	61.40	53.50	48.00	42.00

3.4 Rumen Fluid Sampling

Three bucks from each treatment were used for rumen fluid collection at the end of feeding trial. Rumen fluid samples measuring approximately 30ml were collected from each buck before the morning feeding, then at 4, 8, 12 hours post feeding using a Stomach Tube. The pH of the samples was determined immediately using Philips Digital pH Meter (Model 9409). The fluid samples were made free of coarse particles by filtration with cheese cloth, and about 10ml of the liquid fraction sampled, acidified with 2ml of 10% H_2SO_4 acid and stored at -20^0C in a freezer pending analysis of Ammonia Nitrogen (NH_3-N) and Total Volatile Fatty Acids (TVFAs).

3.5 Blood Sampling

Approximately 10ml of blood samples were collected from jugular vein at the end of feeding trial using disposible syringe via Jugular Vein Puncture into vacutainer tubes containing no Anticoagulant and were spuned and the plasma stored at a temperature of -20^oC in a freezerpending analysis for serum biochemical parameters such as Total Protein (TP), Blood Urea Nitrogen (BUN), Albumin, calcium, phosphorus, potassium, chlorine and sodium.

3.6 Digestibility Study

At the end of the feeding trial, three(3) bucks from each treatment were placed in an individual metabolic cages. The bucks were allowed 14 days feed adjustment period, followed by 7 days of collection of faeces and urine as described by Osuji*et al*.(1993). Total daily feacal output for individual animal were collected after every 24 hours in the morning, weighed, mixed thoroughly and then 10% sub-sampled and stored in freezer at -20^0C pending analysis.

Urine output for each animal was collected after every 24 hours in the morning. This was done using graduated plastic containers containing 100mls 0.1N H_2SO_4 which were placed under the metabolism cages. The volume were recorded and subsequently 10% of daily urine output for each buck were bulked and stored at -20^{0}C in a freezer pending analysis.

3.7 Chemical analysis

The hay, Sundried Broiler Litter, Cotton Seed Cake, the diets, feaces and urine samples were analyzed for their proximate compositions: Crude protein, Crude fiber, Ether extract and Ash using the Procedure described byAOAC, (1990). Neutral Detergent Fiber (NDF), Acid Detergent Fiber (ADF) and Acid Detergent Lignin (ADL) were determined by the Method of Van Soest (1991). Cellulose and hemicellulose were calculated as differences between ADF and ADL and NDF and ADF, respectively. Metabolisable energy of the diets was estimated using the Method of Alderman (1985) as follows: ME (MJ/kg DM) 11.78 + 0.00654CP + $(0.000665EE)^{2}$ – CF (0.00414EE) – 0.0118A, Where DM= Dry Matter, CP = Crude Protein, EE = Ether Extract, CF = Crude fibre, A = Ash.

Rumen ammonia nitrogen (NH_3-N) were determined using the Steam Distilation Method of Whitehead and Chapman, (1976). Total volatile fatty acids were analyzed using the procedure of Barnett and Reid, (1957). Blood samples were analyzed for Blood Urea, Total Protein, Albumin, Globulin and Creatinine as described in the Routine Laboratory Procedures (Coles,1974).

3.8 Economic analysis

The market prices of various feed ingredients as at the time of the study, including the cost of the *Digitaria smutsii* hay were used to compute the total cost of feed consumed within the feeding period and feed cost per kilogram weight gain. This was used to determine how profitable or otherwise to include Cotton Seed Cake and Sundried Broiler Litter in the diet of Red Sokoto bucks fed*Digitaria smutsii* hay-based diet.

3.9 Statistical analysis

The data obtained wereanalyzed using the General Linear Model (GLM) Procedure of SAS (2008) and significant differences in the treatment Means were separated using Dunnett Test (Dunnett,1955). The Models of the experiment are stated below;

$$Y_{ij} = \mu + T_i + e_{ij}$$

Where: μ = overall mean

T_i = treatment effect

e_{ij} = ramdom error

The Model used for rumen metabolites is stated below;

$$Y_{ijk} = \mu + T_i + P_j + (TxP)_{ij} + e_{ijk}$$

Where: μ = overall mean

T_i = treatment effect P_j= effect of time of rumen fluid collection

$(TxP)_{ij}$ = interaction between treatment effect and time of rumen fluid sampling

e_{ijk}= ramdom error

CHAPTER FOUR

4.0 RESULTS

4.1 ChemicalComposition of theExperimental Diets and the Experimental Materials.

The results of chemical composition of the experimental diets and the experimental materials arepresented in Table 4.1. The dry matter of the ingredients were 90.19, 91.29 and 94.68% for SBL, CSC and DSH, respectively. The crude protein of sundried broiler litter (SBL) was slightly higher (27.89%) than thatof cottonseed cake (CSC) (26.31%) and very low in*Digitaria smutsii* hay (DSH) (6.10%). The value for Crude fibre was highest (30.31%) in DSH compared to SBL (18.67%) and CSC (13.61%). Ether extract was highest (12.69%) in CSCand lowest in DSH (1.82%). Neutral detergent fibre (NDF) and acid detergent fibre (ADF) were 34.50 and 29.87%, 66.36 and 33.59%, 70.48 and 49.06% for CSC, SBL and DSH, respectively.The highest NDF (70.48%) and ADF (49.06%) values were recorded in DSH. Lignin content of the test ingredients range from 7.60 in DSH to 12.28% in CSC. The lignin content was highest (12.28%) in CSC and lowest (7.60%) in DSH. Ash content was higher (27.45%) in SBL compared to that of CSC (7.41%) and DSH (6.89%). The calculated metabolisable energy(ME MJ/kgDM)according to Alderman (1985) were 11.60, 11.51 and 11.64 for CSC, SBL and DSH, respectively.

The dry matter of the experimental dietsrange from 90.07 in 30% inclusion level to 91.46% in 0% inclusion level. The CP of the diets were isonitrogenous and range from 14.69 to 14.94%. CF, NDF, ADF, Cellulose and Lignin ranged from 18.79 - 25.86%, 49.79 – 60.28, 34.60 – 39.44, 27.85 – 35.73 and 6.76 – 8.39%, respectively. The value of ash in the diets increased(6.98 - 16.06%) with increase in levels of SBL inclusion. While EE decreased (6.10 -9.19%) as SBL levels increase in the diets. The diets were isocaloric with metabolisable energy rangingfrom 11.79 in 30% inclusion level to 12.20 MJ/kgDM in 0% inclusion level.

Table 4.1: Chemical composition of the Experimental diets and the Experimental materials (%)

Inclusion Levels of SBL (%)							
Parameters	0	10	20	30	CSC	SBL	DSH
Dry matter	91.46	90.96	90.90	90.07	91.29	90.19	94.68
Crude protein	14.96	14.81	14.75	14.94	26.31	27.89	6.10
Crude fibre	25.86	18.78	24.21	19.07	13.61	18.69	30.31
Ether extract	9.19	8.40	7.55	6.10	12.69	1.94	1.82
NDF	57.45	49.79	60.28	58.95	34.50	66.36	70.48
ADF	39.44	35.54	34.70	34.60	29.87	33.59	49.06
Cellulose	31.05	29.03	35.73	27.85	17.59	25.74	41.46
Hemicellulose	18.01	14.25	25.58	24.35	4.63	32.77	21.42
Lignin	8.39	7.51	7.97	6.76	12.28	7.85	7.60
Ash	6.98	12.78	13.21	16.06	7.41	27.45	6.89
ME(MJ/kgDM)	12.20	11.88	12.06	11.79	11.60	11.51	11.36

CSC= Cotton seed cake; SBL= Sundried broiler litter; DSH= *Digitaria smutsii hay*

4.2Performance Characteristics

The results of performance characteristicsof Red Sokoto bucks fed the experimental diets are presented in Table 4.2. Iinitial weightof the bucks(12.00 -11.4kg) were not siginificantly (P>0.05) different across the treatments.However, final weight (16.88 - 14.33kg), total weight gain (4.88 - 2.67kg), and average daily gain (ADG) (54.17 - 29.63g)were significantly (P<0.05) higher in the control groupand decreasedlinearly with increase in SBL inclusion.Total feed intake(36.56 - 30.25kg) and average dry matter intake (394.68 - 302.77g/day) were significantly (P<0.05) highestin the control group and lowest at 30% level of SBL inclusion. Feed Conversion Ratio (FCR) was significantly (P<0.05)highest (7.74) in animals on the control dietand lowest in diets with 30%SBL inclusion.

Table 4.2.Performance characteristics of Red Sokoto bucks fed *Digitaria smutsii* hay-based diet with varying levels of SBL.

	Inclusion Levels of SBL (%)					
Parameters	0	10	20	30	SEM	LOS
Initial weight (kg)	12.00	11.50	11.40	11.67	0.80	-
Final weight (kg)	16.88^{a}	15.30^{b}	15.06^{b}	14.33^{c}	0.94	*
Total Weight gain (kg)	4.88^{a}	3.80^{b}	3.66^{b}	2.67^{c}	0.46	*
Average Daily Gain (g)	54.17^{a}	42.22^{b}	40.67^{b}	29.63^{c}	5.10	*
Total feed intake (kg)	36.56^{a}	32.36^{c}	33.76^{b}	30.25^{d}	1.73	*
Average DMI (g)	394.68^{a}	325.44^{c}	341.78^{b}	302.77^{d}	12.88	*
FCR	7.74^{a}	8.59^{b}	9.24^{c}	11.33^{d}	0.39	*

[a,b,c,d] Means with different Superscripts within the same row are Significantly different (P<0.05). SEM = Standard Error of Means. LOS = Level of Significance.

4.3Nutrient Digestibility

The result of nutrient digestibility of animals in this study is presented in Table 4.3. Dry matter digestibility wasnot significantly (P>0.05) different among the groups. However, digestibility of other nutrients was significantly affected by SBL inclusion. The digestibility of CP(83.80 – 81.60%), EE (93.10 – 92.07%) and NFE (93.70 - 89.87%) were significantly (P<0.05) higher in the group on diet with30% SBL compared to the other diets tested. While digestibility of CF (85.20 - 77.03%),ADF (85.77 - 80.07%) andME (85.70 - 81.57%) were significantly (p<0.05) higherin group on diet with 20% SBL inclusion levelcompared to the other diets tested.However, the digestibility of OM (87.06%) and NDF (85.38%) in groupon diet with 20% SBL were statistically (P>0.05) similar to that of the control group (0%SBL)(87.20 and 85.67%, for OM and NDF, respectively),but was significantly(P<0.05) higher than the other groups studied.

Table 4.3: Nutrient digestibility of Red Sokoto bucks fed *Digitaria smutsii* hay-based diet with varying levels SBL (%).

Inclusion Levels of SBL (%)						
Parameters	0	10	20	30	SEM	LOS
Dry Matter	85.73	85.67	85.77	85.63	0.16	NS
Organic matter	87.20^{a}	86.27^{c}	87.06^{a}	86.90^{b}	0.22	*
Crude Protein	81.60^{d}	83.17^{c}	83.30^{b}	83.80^{a}	0.49	*
Crude Fibre	82.93^{b}	77.03^{d}	85.20^{a}	81.93^{c}	0.81	*
Ether Extract	92.47^{b}	92.77^{b}	92.07^{b}	93.10^{a}	0.56	*
Nitrogen Free Extract	91.20^{b}	90.87^{b}	89.87^{c}	93.70^{a}	1.01	*
Neutral Detergent Fibre	85.67^{a}	82.30^{c}	85.38^{a}	84.27^{b}	0.47	*
Acid Detergent Fibre	81.97^{c}	80.07^{d}	85.77^{a}	83.80^{b}	0.53	*
ME (MJ/kgDM)	85.40^{b}	83.40^{c}	85.70^{a}	81.57^{c}	0.02	*

^{a,b,c,d} Means with different Superscripts within the same row are Significantly different at (P<0.05). SEM = Standard Error of Means. LOS = Level of Significance.

4.4Nitrogen Balance

The results on nitrogen balancefor this study are presented in Table 4.4. Nitrogen balance was significantly affected by SBL inclusion. Nitrogen intake was significantly (P<0.05) higherin the control group and decreased (9.80 – 8.81g/day) linearly across the treatments with increase in SBL inclusion. Faecal nitrogen (3.40 - 2.20g/day) and digested nitrogen (7.92 - 6.30g/day) followed a similar trend. Urinary nitrogen (P<0.05) increase linearly (2.60 – 1.93%) across the treatments with increase in levels of SBL in the diets. Urinary nitrogen loss was significantly (P<0.05) higher in bucks on dietshaving 20 and 30% SBL compared to the other diets. Nitrogen balance was significantly (P<0.05)higherinthe control group and decreased linearly across the treatments with increasein levels of SBL in the diets(5.99 - 4.01g/day). Nitrogen retained was significantly(P<0.05) higherin bucks on diet with 10% SBL,followed by those on diet with 0, 20 and 30% SBL (57.14 - 45.52%), respectively.

4.5 Effect of Diet on Rumen Metabolites

Table 4.5. Shows the effect of *Digitaria smutsii* hay-based diet with varying levels of SBL on rumen metabolites. Rumen pHwas significantly (P<0.05) higher in animals on the control diet and lower in animals on diet with SBL (6.81 - 6.62). While rumen ammonia was significantly (P<0.05) higher in bucks on SBL diets (27.25 - 24.75mg/100ml) compared to those on the control diet. TVFA was significantly (P<0.05) higher (37.25 - 32.33Mmol/l) in bucks on diet with 0, 10, and 20%SBL than in those on 30% inclusion.

Table 4.4: Nitrogen balance in Red Sokoto bucks fed *Digitaria smutsii* hay-based diet with varying levels of SBL.

	InclusionLevels of SBL (%)					
Parameters	0	10	20	30	SEM	LOS
Nitrogen intake (g/d)	11.32^{a}	9.80^{b}	9.60^{b}	8.81^{c}	0.66	*
Feacal Nitrogen (g/d)	3.40^{a}	2.37^{b}	2.30^{b}	2.20^{c}	0.32	*
Digested Nitrogen (g/d)	7.92^{a}	7.43^{b}	7.30^{c}	6.61^{d}	0.11	*
UrinaryNitrogen (g/d)	1.93^{b}	2.0^{b}	2.6^{a}	2.6^{a}	0.36	*
Nitrogen Balance (g/d)	5.99^{a}	5.60^{b}	4.70^{c}	4.01^{d}	0.09	*
Nitrogen Retaintion (%)	52.54^{b}	57.14^{a}	48.96^{c}	45.52^{d}	0.44	*

^{a,b,c,d}Means with different Superscripts within the same row are Significantly different at (P<0.05). SEM = Standard Error of Means. LOS = Level of Significance.

Table 4.5 Rumen metabolite of Red Sokoto bucks fed *Digitaria smutsii* hay-based diet with varying levels of SBL

	Inclusion Levels of SBL (%)					
Parameters	0	10	20	30	SEM	LOS
pH	6.81^{a}	6.61^{b}	6.61^{b}	6.62^{b}	0.04	*
NH_3-N (mg/100ml)	20.83^{c}	25.00^{b}	27.25^{a}	24.75^{b}	2.90	*
Total VFA (mmol/L)	37.25^{a}	35.42^{a}	35.25^{a}	32.33^{b}	3.98	*

^{a,b,c} Means with different superscripts within the same row are Significantly different at (P<0.05).TVFA= Total Volatile Fatty Acids.SEM= Standard Error of Mean. LOS = Level of Significance.

4.6 Effect of sampling time on rumen metabolites

The trends showing effect of sampling time on rumen pH,ammonia and TVFA of Red Sokoto bucks fed *Digitaria smutsii* hay-based with varying levels of SBL are illustrated in Figure 4.1.Rumen pH, ammonia and TVFA were significantly (P<0.05) affected by sampling time. Rumen pH wassignificantly (P<0.05) similar and higher at 0 and 4 hours post feeding (6.75) and lower at 8 and 12 hours (6.57 and 6.58), respectively. Rumen ammonia increased significantly (P<0.05) from 0 hourand reached the peak at 8 hours (36.42 – 14.08mg/100ml), and then decreased at 12 hours post feeding. TVFA concentration followed a similar trend with rumen ammonia (45.08 – 28.67Mmol/l).

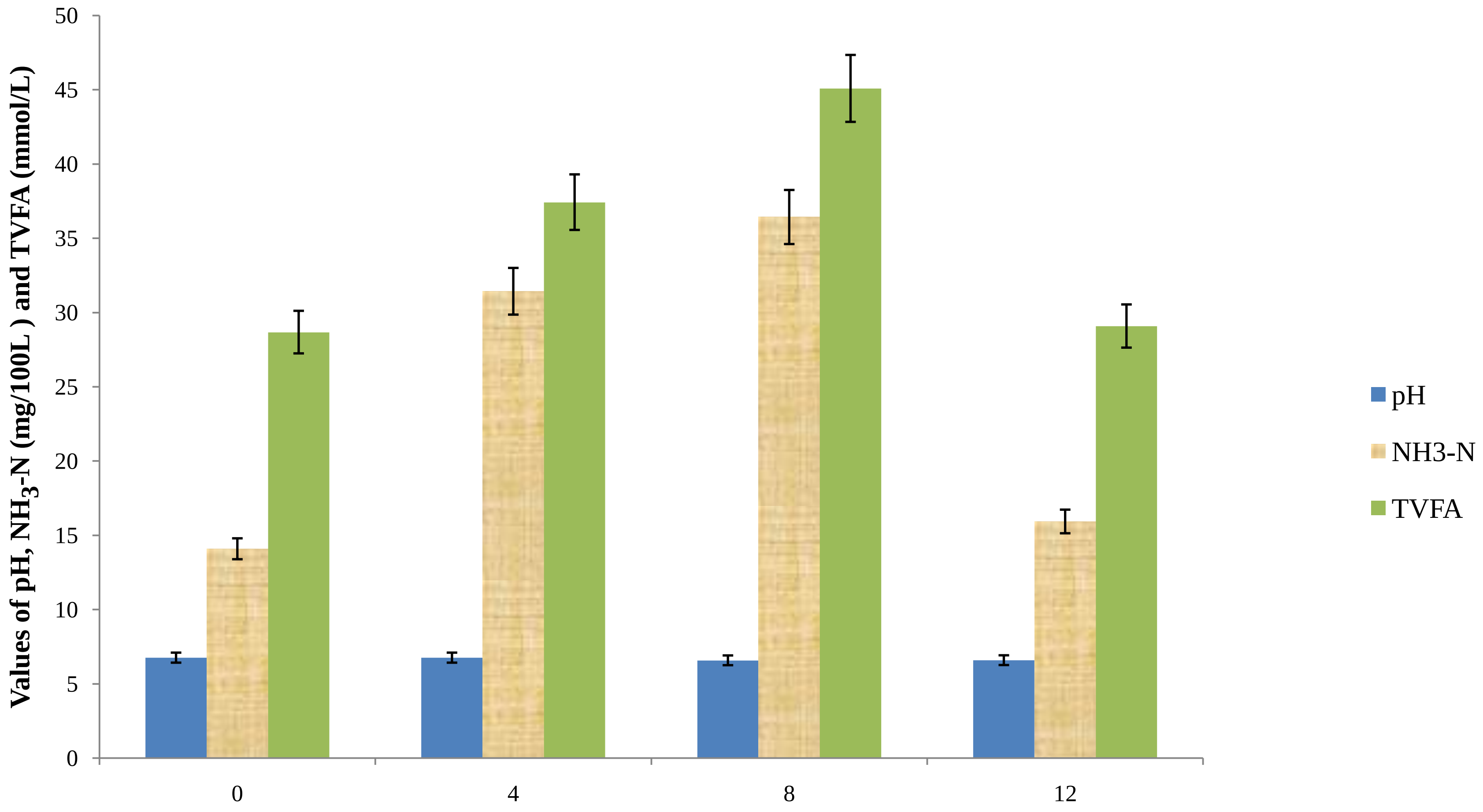

Figure 4.1: Effect of time of sampling rumen samples on pH, NH_3-N and TVFAs

4.7 Serum Metabolite

The results of serum metabolite of the experimental animals are presented in Table 4.6. Blood urea nitrogen was significantly ($P<0.05$) higher (10.27mg/dl) in the control group and least (8.87mg/dl) in group on diet having 10% SBL.Total protein (70.33mg/dl) in animals in groups on diets with 20 and 30% SBL were statistically ($P>0.05$) comparable to that of the control group (70.00mg/dl), but was statistically ($P<0.05$) lower (66.00mg/dl) in bucks on diet with 10% SBL. Serum albumin (43.67 - 37.33mg/dl), calcium (9.93 - 9.40mg/dl), phosphorus (10.49 - 8.63mg/dl), and potassium (5.03 - 4.00Mmol/l) were significantly ($P<0.05$) higher in group on diet with 20% SBL compared to those on the other diets. Serum sodium of groups on diets having 0, 10, and 20% SBLwere not statistically ($P>0.05$) different but was significantly ($P<0.05$) lower (144.33 - 141.00Mmol/l) in bucks on diet having 30% SBL. Similarly, serum chrolineinthe group on diet with 20% (108.33Mmol/l) SBL was statistically ($P>0.05$) comparable to that of the control group (108.67M mol/l), but significantly lower ($P<0.05$) (105.67 and 105.67Mmol/l) in animals on the other diets.

Table 4.6. Serum metabolites of Red Sokoto bucks fed *Digitaria smutsii* hay-based diet with varying levels of SBL.

	Inclusion Levels of SBL (%)					
Parameters	0	10	20	30	SEM	LOS
Urea Nitrogen(mg/dl)	10.27^{a}	8.87^{c}	9.33^{b}	9.33^{b}	0.74	*
Total protein (g/dl)	70.00^{a}	66.00^{b}	70.33^{a}	70.33^{a}	1.69	*
Albumin (g/dl)	37.67^{b}	37.33^{b}	43.67^{a}	37.33^{b}	3.47	*
Calcium (mg/dl)	9.45^{b}	9.48^{b}	9.93^{a}	9.40^{b}	0.26	*
Phosphorus (mg/dl)	8.63^{b}	9.71^{b}	10.49^{a}	9.84^{b}	1.15	*
Potassium (Mmol/l)	4.77^{b}	4.50^{c}	5.03^{a}	4.00^{d}	0.27	*
Sodium (Mmol/l)	143.00^{a}	143.00^{a}	144.33^{a}	141.00^{b}	1.39	*
Chlorine (Mmol/l)	108.33^{a}	105.67^{b}	108.67^{a}	105.67^{b}	1.05	*

^{a,b,c,d} Means with different Superscripts within the same row are Significantly different at ($P<0.05$).SEM= Standard Error Means. LOS = Level of Significance.

4.8Feed Cost Analysis

The result of cost implication of feeding the experimental diets to Red Sokoto Bucks is presented in Table 4.7. Feed cost per kilogram was in the range of₦ 42.00 -₦61.40 for diet with 30% SBL and control diet, respectively. Inclusion of SBL decreases the cost of feed per kilogram across the treatments. The cost of total feed intake (₦ 2244.8 - ₦1270.00), and average daily dry matter intake (₦24.63 - ₦14.12) were significantly (P<0.05) higher in animals on the control diet and decreasedwith increase in levels of SBL inclusion across the treatments. Feed cost per kilogram gain (₦475.89 – ₦442.76) was significantly (P<0.05) higher in animals on 30% SBL inclusion compared to the other groups.

Table 4.7 Feed cost of Red Sokoto bucks fed Digitaria hay-based diet with varying levels of sundried broiler litter.

	Inclusion Levels of SBL (%)					
Parameters	0	10	20	30	SEM	LOS
Feed Cost/kg (₦)	61.40	53.50	48.00	42.00	-	-
Total FI (kg)	36.56^{a}	32.36^{c}	33.76^{b}	30.25^{d}	1.73	*
Total cost of FI (₦)	2244.8^{a}	1731.30^{b}	1620.50^{c}	1270.00^{c}	68.76	*
Cost of DMI/day (₦)	24.63^{a}	18.96^{b}	18.08^{c}	14.12^{d}	0.63	*
Weight gain (kg)	4.88^{a}	3.80^{b}	3.66^{b}	2.67^{c}	0.46	*
Cost/ kg gain (₦/kg)	460.00^{b}	455.59^{b}	442.76^{b}	475.89^{a}	17.5	*
Savings (₦)	-	4.41	17.24	- 15.89	-	-

^{a,b,c,d}Means with different Superscripts are within the same row Significantly different at (P<0.05). SEM = Standard Error of Means. LOS = Level of Significance. FI=Feed intake. DMI = Dry matter intake.

CHAPTER FIVE

5. 0 DISCUSSION

5. 1 Chemical composition of test ingredients and experimental diets

Thedry matter (91.29%) of the broiler litter used in the present study falls within the range of 85 to 93% reported by Park *et al*. (1995). The values obtainedwere close to 91.24%DMreported by Lamidi (2005) but higher than 90.16% recorded by Shahid, *et al*. (2008) and lower than 92.66 and 93% reported by Jokthan *et al*. (2013) and Ayoub *et al*. (2015), respectively. The 27.89% Crude protein value forbroiler litterobserved in this study was higher than 24.5, 23.8 and 26.33% reported by Bakshi and Fontenot (1998), Ayoub*et al*. (2015)and Lamidi, (2005),respectively.

The crude protein of broiler litter used in this study was the same with Crude Protein (27.8%) reported for pelleted meat quail litter (Suppadit, *et al.*,2011) and almost the same with the 27.3%crude protein reportedreported for broiler litter by Jokthan *et al*. (2013). Crude fibre of broiler litter in present study(18.67%CF) was higher than 15.4 and 11.09% reported by Tawadchai and Pakkapong, (2010)and Jokthan, *et al*. (2013), respectively.Similarly, the ash content of broiler litter observed in this study was higher than the 19.9 and 16.02% value reported by Tawadchai and Pakkapong, (2010); and Jokthan, *et al*. (2013), respectively.

The variation in nutrient composition of broiler litter could be as a result of variations in type of ingredients used in the diets of broiler birds, the materials used as litter as well as their nutrient absorption and metabolism as well as the level of soil contamination.

The nutrient compositionof *Digitaria smutsii* hay used in the present study were higher compared to 90.04, 5.36, 30.05, 0.54, 61.40, 2.65, 69.23, 38.88 for DM, CP, CF, EE, NFE, Ash, NDF and ADF, respectivelyreported by Yashim (2014). The variation in the nutrient value could be as a result of level of fertilization, age at harvest and length of preservation time.

5. 2 Effect of experimental diets on growth performance of Red Sokoto bucks.

Dry matter intake was significantly affected by SBL inclusion in the diets.The significantdecreasein dry matter intake by bucks in the presentstudy is supported by the report of Nadeem*et al*. (1993)who observed linear depression in dry matter intake in Barbari goats in Pakistan with increasing proportion of broiler litter in the diet.The decrease in feed intake might be due to low palatability of SBL. However, Jokthan*et al*. (2013) observed high (819.42g/d) dry matter intake in Yankasa rams at 40% substitution of sundried broiler litter with cottonseed cake at Shika in the Northern Guinea Savanna of Nigeria.Obeidat *et al*. (2011) observed that there was no effect on dry matter intake in feeding autoclaved (121^{0}C; 15 minutes) broiler litter to Awassi lambs at 0, 100, or 200g/kg diet DM.Ayoub*et al*. (2015)also found no significant effect inDMI of fattening lambs fedheat processed broiler litter pelletsin diet at 0, 70, 140 or 210g/kgDM. This might be due to variations amongruminant species in poultry litter utilization. Narasimha *et al.* (2013) had observed higher voluntary intake of poultry litter rations in sheep compared to goats.

The significant decline in average daily weight gain with the increase in levels of SBL in this study agree with the report of Nadeem *et al.* (1993) in Pakistan who observed significant decline in average daily weight gain, being highest (70.83g/day) in diet without SBL and lowest (41.67g/day) with the group fed on ration having 30% SBL. However,Elemam*et al*. (2009) recordedthe highest final body weight and average daily gain in lambs fed on diet with450g broiler litter.It was also noted that some authors observed no significant difference in average daily weight gainofgoats (Jackson, *et al*., 2006) andinSheep (Obeidat *et al*., 2011; Jokthan, *et al*., 2013 and Ayoub*et al*., 2015)fed diets with broiler litter. The significant decline in weightmight be due to low dry matter intake and consequently low energy availability to enhance performance.It is also likely that animals on control diet (0% SBL) might have obtained higher by pass protein compared to those on diets with SBL inclusion. Cotton seed cake has been reported to have good quality by pass protein that can be well utilised by ruminants (Wekesa *et al.*, 2006). The decline average daily weight gain as SBL inclusion rates increased in the diets indicated that NPN alone could not maximize microbial growth.

Feed conversion ratio (7.97)observedinthe control diet in the present study is in agreement with the report of Nadeem*et al*. (1993) in Barbari goats who observed best FCR among the group fed diets without broiler litter. FCR is the quantity of feed required to produce one unit (1kg) gain. The lower the FCR, the most efficient the feed value consumed by the animal. The increased FCR as SBL inclusion rates increased in the diets indicated that diet with 10%SBL was better than diets containing 20 and 30% SBL inclusion. However, Anigbogu and Nwagbara (2013) noted the best feed conversion ratio in West African Dwarf goats on diets containing poultry excretawas compared toanimals onthe control diet. Many researchers found no differences in feed conversion ratio in Cross bred goats fed poultry litter pellets (Jackson, *et al*., 2006) nor lambs fed diets having different levels of deep- stacked broiler litter (Elemam*et al*., 2009), autoclaved broiler litter (Obeidat *et al*., 2011)as well asheat processed pelleted (Ayoub *et al*., 2015) broiler litter.

In this trial, the bucks in the control Treatment (0% SBL) and 30%SBLrecorded mortality of 1 and 2, respectively. The highest mortality recorded on diet with 30%

SBL on day 85 and 86 of this trial might be as a result of urinary calculi. This is consistent with the report of Nadeem *et al.* (1993) who observedmortality in two Barbari goats on day 75 and 86 of trialin bucks fed diets containing 25 and 30% broiler litter. Nadeem*et al.* (1993) attributed the mortality observed in their trial to urinaryCalculi and further explained that calculi formation may be due to mineral imbalances in the animals fed broiler litter in the diets having high ash content.

5.3 Effect of the experimental diets on nutrient digestibility in Red Sokoto bucks

The non-significant (P>0.05) differences in dry matter digestibilityin the current study isconsistent with the report of Jokthan*et al.* (2013) who observed no significant differences in dry matter digestibility in the diets of Yankasa rams supplemented with broiler litter. However, this finding is in disagreement with the report of Nadeem *et al*. (1993) who observed lower DM digestibility in all diets with broiler litter.The lower digestibility of ash at 20 and 30% SBL inclusion is consistent with the report of Nadeem *et al.* (1993)on broiler litter diets in Barbari goats which the authorssuggested that the lower ash digestibility by the animals might be due to availability of minerals or merely its high content.

The digestibility of crude protein observed in this study (81 – 84.30%) is higher than the 77 to 82% crude protein digestibility range reported byBelewu (1992), Belewu and Adeneye (1996) for rations that consisted only poultry litter.Similarly, Abdulwaheed and Tsado, (2014) observed higher crude protein digestibility (76.8 - 86%) in growing Yankasa rams fed diet containing different proportions of poultly litter.Ether extract digestibility in the present study (92.07 – 93.10%) is slightly higher than 58.2 - 92.1% reported by Abdulwaheed and Tsado (2014). While the present study recordhighest EEdigestibility at 30%SBL inclusion, Elemam*et al*. (2009) observed a decreasing trend in ether extract digestibility(89.05 to 78.67 at 30 and 45%)with increasing level of broiler litterin diets. The highest digestible EE in group on 30%SBL diet indicated that maximum amount of dietary EE was utilized by rumen microbes to fulfill the energy requirement of their body and lowest digestiblevalue of EE in the other groups remarked that easily digestible energy was available to fulfill the requirement.

The nitrogen free extract digestibility observed (89.87 – 93.70%) in the present study is slightly lower than that (94.4 – 96.4%) reported by Abdulwaheed and Tsado (2014). The highestOM, CF, NDF, ADF and ME digestibility at 20% SBLinclusion in the current study is in contrast with the report of Jokthan *et al*. (2013), who observed no differences in DM, OM, CP, NFE, NDF, ADF and MEin Yankasa rams on similar diets. Inclusion of SBL stimulated activities of the rumen microbes which resulted in increased digestibility of the diets.

5.4Effect of the experimental diets on Nitrogen balance in Red Sokoto bucks

The significant ($P<0.05$) decrease in nitrogen intake(11.32 to 8.81g/d) with increase inSBLinclusion observed inthe present study agree with the report of Nadeem *et al*. (1993) who observed decrease (14.24 -10.35g/d)in nitrogen intake by Barbari goat fed with broiler litter.These findingshowever, disagree with the report of Jokthan *et al*.(2013) who observed no effect of nitrogen intake by Yankasa rams on similar diets.The significant difference in DM intake might be attributed as the cause for the significant differencein nitrogen intake bythe bucks.The urinary nitrogen (1.9 to 2.6g/d) recorded in the present study falls below 2.7 to 4.0 reported by Asrat *et al*. (2008) and higher than 1.53 to 1.64 reported by Nadeem*et al*. (1993). The significant ($P<0.05$) high urinary excretion of nitrogen at 20 and 30% SBL inclusion could be attributed to the expected high rumen degradability of nitrogen contained in the broiler litter. Nitrogen excretion in the faeces and urine is related to the digestion and absorption of nitrogen. High excretion of urinary nitrogen is associated with high rumen nitrogen degradability (McDonald *et al.,* 2002).

Asrat *et al*. (2008) also reported increase in nitrogen balance in goatsat 14 and 28% and then decrease at 45% broiler litter inclusion in diet.The significant (P<0.05) high total nitrogen excretedat 20 and 30% SBL in this study is at variance with the report of Jokthan *et al*. (2013) who observed decrease in total nitrogen excreted with increase in broiler litter across treatments in Yankasa rams.The observed decrease in nitrogen balance with SBL inclusion in the current studyis in disagreement with the report of Jokthan *et al.* (2013) who reported increase in nitrogen balance at higher level of broiler litter inclusion. The significant higher nitrogen retention at 10%SBL inclusion might be due to high energy availability in the diet which helped rumen microbes to digest dietary nitrogen and hence absorption and retention in the body of host animal.The variation in nitrogen balance among the various studies can be related to differences in breeds on poultry litter utilization.The values ofN-retained indicate that all the bucks were in positivenitrogen balance.

5.5 Effects of the experimental diets onrumen metabolites in Red Sokoto bucks.

Thesignificant (P<0.05) decline in rumen pH (6.81- 6.61) in bucks on SBL diets agrees with the report of Jokthan *et al*. (2013) who observed similar trend in rumen pH of Yankasa rams fed diets containing broiler litter. The significant decline in rumen pH at 8 hours post feeding could be as a result of high concentration of volatile fatty acids.Highconcentration of VFA has a reducing effectover rumen pH (Abubakar *et al.*, 2010).The ruminal pH in this study is similar to that Sreported by Kwak *et al.* (2003)(6.5 – 6.6) in sheep fed processed broiler litter.Similar trend in rumen pH has also been reported by Jose *et al*. (2015) in Ojalada ewes fed total mixed ration (TMR) containing chopped forage.The authors suggested that this decline could be as a result of fast ingestion of food with a smaller particle size whichcauses decrease in saliva production and consequently leading to less buffer capacity to maintain pH within optimal range.

In contrast, Pereira *et al*. (2009) found no differences in ruminal pHof goats fed 5mm chopped forage versus whole forage. The rumen pHin this study were within the optimal physiological range of 6.0 – 7.0 suggested by Hespell and Bryant (1979) and Van Soest (1994).The significant ($P<0.05$) drop in rumen fluid pH at 8 and 12 hours post feeding (6.75 – 6.57) agrees with the report of Finangwai *et al.*(2013) who observed higher rumen pH at 0 hour compared to 8 hours post feeding of urea treated maize stover to crossbred bulls. The drop in rumen pHis an indication of high level of diet fermentation (Jokthan *et al.,* 2013).

The significantly higher rumen ammonia in bucks on SBL diets observed in the present study agreeswith the observation ofHarmeyer andMartens (1980) that Ammonia concentration in rumen fluid had direct relationshipwith poultry litter intake. The rumen ammonia (20.83 – 27.25mg/100ml) recorded in the present study is higher than 11.17mg/dl and 4.84 – 8.56mg/dl reported by Abubakar *et al*. (2010) and Jokthan *et al.* (2013), respectively.However, it is close 19.24 to 24.14mg/100ml reported by Finangwai *et al.* (2013). Rumen ammonia value of 2-8 mg/100ml is required for high producing ruminant livestock (Drewnoski and Poore, 2012). According to Silanikove and Tiomkin (1992), the optimal ammonia level for maximum fermentation and microbial protein synthesis is 10mg/dl. However, Preston and Leng (1987) suggested 15mg/100ml of rumen ammonial to maximize fibre digestion and 20mg/100ml to maximize intake.But Satter and Slyster (1974) observed that 50mg/100ml ammonia nitrogen concentration is optimum for microbial growth. The high rumen ammonia observed in this study is an indication that there was high degradability of nitrogen in the rumen.

The linear increase in rumen ammonia nitrogen concentration from 0 hour to 8 hours post feeding shows that rumen ammonia increase with time after feeding. Naik and Sengar (1999) observed the peak of ammonia nitrogen concentration at 4-6 hours post feeding in buffaloes fed diets with different sources of nitrogen. The rumen ammonia at 12 hours post feeding is an indication of its absorption.

TVFA in the present study (32.33-37.25mmol/l) were higher compared to the value (14.02-15.67) reported by Jokthan*et al.* (2013) in Yankasa rams fed diets containing broiler litter,but lower compared to the (79 - 102.9mmol/l) reported by Kwak *et al.* (2003) insheep fed diets with processed broiler litter in USA. The significantly (P<0.05) higher TVFA in bucks on diets with 0, 10, and 20%SBL inclusion could be due to higher level of feed intake compared to intake on diet with 30%SBL inclusion. TVFAare the primary source of energy in ruminants and have been estimated to provide up to 75% of the total ME(Bergman, 1990). TVFA production is an indicator of carbohydrate digestion especially the CF (Girdhar and Balaraman, 2003) which is reflected in better NDF digestibility of diet with 0 and 20% SBL.

The present study showed that TVFA significantly (P<0.05) increased from 0 hour and reaches the peak at 8 hours post feeding (28.67 – 45.08). However, Konka *et al.* (2015) observed the peak of TVFA concentration at 4 hours post feeding in fistulated buffalo bulls fed crop residues based complete rations in india. The peak of TVFA at 8 hours post feeding might be due to higher ruminal microbial activity, hydrolysis of protein and non-protein nitrogen (Samanta *et al.,* 2006).

5.6 Effects of the experimental diets on Serum metabolites in Red Sokoto bucks.

Thesignificant ($P<0.05$) decreasing trend in serum urea nitrogenobserved in the present study wasin agreement with the report of (Nadeem*et al.,* 1993) who observed increasing trend in blood urea nitrogen inBarbari goats with increase in proportion of broiler litter in the dietsacross the treatments.However, theobserved urea nitrogen in the present study falls within the normal range(3.5 – 10.7mmol/l) reported for healthy goats (Sirois, 1995).

The significantly ($P<0.05$) higher total protein observed in goats on diet without or with 20 and 30%SBL is an indication of the level and availability of dietary protein. The significantly ($P<0.05$) higher serum albumin ingoats on diet with20%SBL is an indication of relatively good quality protein of the diet. However,the serum protein quality indices for all the treatments were within the range (56-96g/l and 18.5-44.5g/l)reported for total protein and albumin, respectively, for healthy goats (Zubcic, 2001).TheSerum calcium, phosphorus, potassium, sodium and chlorine observed in the present study were all within the range of 9.2 – 11.6mg/dl, 4.0 – 11.2mg/dl, 3.4 – 6.1mmol/l, 135 – 156mmol/l, and 98 – 110mmol/l respectively, for normal healthy goats (Matthews, 1999).

5.7 Feed cost analysis of the experimental diets of to Red Sokoto bucks

The decrease in cost per kilogram of feed with SBL inclusion observed in this study agrees with the report of Jokthan*et al.* (2013) in a study carried out on Yankasa rams.The significant ($P<0.05$) decrease in cost of daily feed consumedobserved in the present study is consistent with the report of Jokthan*et al*.(2013) in Yankasa rams fed with similar diets.This decrease in feed costis as a result of low cost of the broiler litter used. The significantly($P<0.05$) higher feed cost per kilogram gain at 30%SBL inclusion in the present study disagree with the report of Jokthan *et al.* (2013) who observed no significant difference in feed cost per kilogram gain in Yankasa rams fed Sun-dried broiler litter in concentrate diet up to 40%. The result of this study indicates that inclusion of SBL below 30% saved cost of production of growing goats.

CHAPTER SIX

6.0 SUMMARY CONCLUSION AND RECOMMENDATION

6.1 **Summary**

The study was conducted to investigate the performance, nutrient digestibility, nitrogen balance, rumen and serum metabolites of Red Sokoto bucks fed *Digitaria smutsii* hay-based diets containing different levels of SBL.

A total of 20 Red Sokoto Bucks with average weight of 11.5 ± 0.1kg were used for the study. Four iso-nitrogenous and iso-calorie*Digitaria smutsii* hay-based complete diets containing 0, 10, 20 and 30% SBL were formulated. Each inclusion level of SBL served as treatment. The experimental animals were randomely alloted to the four dietary treatments with five animals each in complete randomized design.

6.2 **Conclusion**

Inclusion of SBL as an alternative protein supplement had a decreased effect on performance indices. Bucks onthe control (0% SBL inclusion) diet recorded the highest DMI, weight gain, FCR and nitrogen balance but nutrient digestibility were better in animals on SBL diets.Nitrogen retention was better in bucks on 10%SBL inclusion. Serum metabolites were not altered by inclusion of SBL in the diets.Feed cost per kilogram gain was better in animals on SBL diets. The useof SBL could perhaps be a simpler and cheaper way of providing protein supplements to growing goats.

6.3 **Recommendations**

- Diets containing poultry litter as the only protein supplement should not be fed to growing goats but should be combined with conventional protein sources.
- Farmers are advised to replace SBL up to 10% in diets forgoats.
- Further studies should be conducted on feeding pelleted form of dietswith poultry litter to ruminants.

REFERENCES

Abdel-Baset, N. S. andAbbas, S. F. (2010). Study on the use of dried poultry litter in the camel's ration. *Journal Veterinary Research,* 2: 65-71.

Abubakar, M., Adegbola, T.A., Abubakar,M. M., Shehu, Y., Ngele, M.B. and Kalla,D.J.U.(2010). Nutritional evaluation of different sources of nitrogen on digestible nutrient intake, nitrogen balance and production of rumen metabolites in growing Yankasa Sheep. *Journal of Food Agriculture*,22(4): 298-307.

Abdulwaheed, A. B. and Tsado, D. N. (2014). Effect of supplementing Sorghum (*Sorghum bicolor* L moench) stover with dried poultry dropping based diet on performance of growing Yankasa rams. *IOSR Journal of Agriculture and Veterinary Science*, 7 (1): 34 -39.

Adegbola, A.A., Smith, O.B. and Okendo, N.J. (1990). Response o f W est African Dwarf sheep Fed Cassava Peel and Poultry Manure Based Diet. Proceeding of the 1st Joint Wkshop, Lilongwe-Malawi, 16-19th December, Pasture Network for Eastern and Southern African (PANESA) and African Research Network for Agricultural By-products (ARNAB)

Ademosun, A. A. (1988). Trends in Small Ruminants Productionover the last two decadesand its future in West and Central Africa. In: K.O. Adeniji (Editor) roceedings of the Workshopon the Improvement of SmallRuminants in West and Central Africa, 21-25 November 1988, Ibadan, Nigeria, Pp. 19-29.

Adene, D.F. (1997). Diseases of poultry in Nigeria: An overview of problems and solutions. *Tropical Veterinary Journal,* 15: 103-110.

Adesehinwa, A. O. K., Obi, O. O.,Makanjuola, B.A., Adebayo, A.O. and Durotoye, E.S. (2010). Utilization of sun-dried on-farm generated poultry litter as a feed resource for growing-finishing pigs. *African Journal of Biotechnology*, 9 (19): 2821- 2825.

Adewumi, I. K. and Adewumi, A. A. (1996). Managing poultry Wastes, a paper presentation. Proceedings of the Workshop on Indigenous Knowledge and Biotechnology, September 16-24, 1996, Obafemi Awolowo.

Adewuni, A. A., Adewuni, I.K. and Olaleye, V.F. (2011). Livestock waste-menace: Fish wealth-solution. *African Journal of Environmental Science and Technology,* 5(3): 149-154.

Adu, I. F. and Ngere, L. O. (1979). The indigenous sheep of Nigeria. *World Review of Animal Production*, 15(3): 51-62.

Adu, I.E. and Onwuka, C.F.I. (1991). Problems and Prospects of Commercialisation ofSheep and Goats in Ogun State. Invited paper presented at the training workshop on effective management of agricultural enterprises at the local government level in Ogun State, Nigeria, held at Gateway Hotel, Abeokuta, July 29 -31.

Aduku, A. O. (1992). Practical Livestock Feed Production in the Tropics.

AFRC, (1998).*The nutrition of goats*. Agricultural and Food Research Council, CAB International, Wallingford, UK.

Aganga, A.A., Umunna, N. N., Oyedipe, E.O. and Okoh, P.N. (1988) Seasonal variations in water requirement and influence of intermittent watering on grazing Yankasa sheep. *Small Ruminant Research,*1: 381–386.

Ahmed A. and Egwu G. O. (2014). Management Practices and Constraints of Sheep Farmers in Sokoto State, North-western Nigeria, *International Journal of Science, Environment and Technology*, 3(2): 735 – 748.

Ajala, M.K. andGefu, J. O.(2003).Socio-economic Factors Influencing Small Ruminants Management Practices in Kaduna State. *Moor,Journal of Agricultural Research,* 4: 274-280.

Ajala, M. K. (2004). Household decision-making in the production of small ruminants in Giwa Local Government Area of Kaduna State of Nigeria. In: *Proceedings of the 29th Annual Conference of the Nigerian Society of Animal Production, 21st-25th March, 2004. Sokoto, Nigeria.* Pp 399-402.

Ajala, M. K.,Lamidi,O. S. and Otaru, S. M. (2008). Peri- urban Small Ruminant Production in Northern Guinea Savanna, Nigeria. *Asian Journal of Animal and Veterinary Advances,* 3: 138 – 146.

Alderman, G. (1985). Prediction of the energy value of compound feeds. In Recent Advances in Animal Nutrition 1985,(eds Haresign,W. and Cole,D.J.A.), Butterworth,London, England, Pp. 1-52.

Alemu, Y. (2010). Feeding different Classes of Sheep and Goats. In: Merkel, R. C. and Goetsch, A. L. (Ed) *Technical Bulletin* No.34. Ethiopia Sheep and Goat Productivity Improvement Programme, Pp. 17.

Alikwe, P.C.N., Lamidi, A. A. and Aina, A. B. J. (2012). Comparative Digestibility and Nitrogen Balance of Maize bran, Wheat offal and Rice bran in West African dwarf goats. *Journal of Agriculture and Social Research,* 12 (1): 108. (Abstr.).

Amadou, H., Dossa, L. H., Lompo, D. J., Abdulkadir, A. and Schlech, E. (2012). A comparison between urban livestock production strategies in Burkina Faso, Mali and Nigeria in West Africa**.***Tropical Animal Health and Production,*44(7): 1631–1642.

Amodu, J. T. and Abubakar, S. A. (2004). Forage conservation practices. In: Gefu, J. O. and Amodu, J. T. (Ed) Forage Production and Management in Nigeria. *A Training Manual*. National Animal Production Research Institute, Ahmadu Bello University, Zaria, Nigeria. October, 2004. Pp. 60 – 66.

Amodu, J. T. and Otaru, S. M. (2004). Production and Utilization of Browse Plants. In:. October Gefu, J. O. and Amodu, J. T. (Ed) Forage Production and Management in Nigeria. *A Training Manual.* National Animal Production Research Institute, Ahmadu Bello University, Zaria, Nigeria, 2004. Pp.23 – 27.

Anigbogu, N. M.and Nwagbara, N. N. (2013). Performance of West African dwarf goats fed maize offal diets supplemented with dry poultry excreta. *Livestock and Veterinary Medicine Journal of tropical countries*, 66 (2): 51- 56.

Animut, G. G., *Merkel*, R. C., Abebe, G., Sahlu, T. and Goetsch, A. L. (2002). Effects of level of broiler litter in diets containing wheat straw on performance of AlpineDoelings. *Small Ruminant Research*,44:125-134.

Anonymous, (2006). Better utilization of locally available feed resources. What Local Supplements Are Available to Feed Dairy Cows and How to Use Them?, http://www.fao.org/ag/againfo/themes/documents/PUB6/P621.htm.

AOAC. (1990). Association of Official Analytical Chemists. Official Method of Analysis. Washington, D. C.

ARC, (1980). *The nutrient requirements ofruminant livestock*. Agricultural Research CouncilCommonwealth Agricultural Bureau, Farnham Royal, UK.

ARC, (1985). The Nutrient requirements of farm animals. Ruminants. Agricultural Research Council, Technical Review of Summaries.Pp. 150-200.

Aregheore, E. M. (2009). Country Pasture/Forage Resource Profiles. FAO 2009. Pp. 1- 42.

Asrat, G. T., Berban, T. and Solomon, M.(2008). Inclusion of different proportions of poultry litter in the rations of yearling Hararghe Highland goats. *Livestock Research for Rural Development,*20:3.

Ayoub, A., Javad, R., Nader, P., Davod, M. and Hasan, F. (2015). Effect of heat – processed broiler litter in pellet form diet on the performance of fattening lambs. *Journal of Applied Animal Research*,43 (2): 184-190.

Azizi-Shotorkhoft, A., Rezaei, J.and Fazaeli, H. (2013). The effect of different levels of molasses on the digestibility, rumen parameters and blood metabolites in sheep fed processed broiler litter. *Animal Feed Science and Technology*, 179: 69–76.

Babayemi, O. J., Ekokotu, O.A.and lyang, U. A. (2009). Evaluation of ensiled Cassava peels together with Albizia Samam pods In: Umoh, B. I. Udedibie, A. B. I. Solomon, L. P.Obasi, O. L. Okon, B. I. and Udoh, E. J. (eds). *Animal Agriculture and Global Food challenges. Proceedings of the 34th annual conference of the NSAP held atUniversity of Uyo, Uyo, Akwa Ibom State, Nigeria*: Pp.544 - 546.

Bach, A. Calsamiglia, S. and Stern, M. D.(2005). Nitrogen metabolism in the rumen.*Journal of Dairy Science,*88: 9-21.

Bakshi, M. P. S. and Fontenot J. P. (1998). Processing and nutritive evaluation of broiler litter as livestock feed. *Animal Feed Science and Technology,* 74: 337-345.

Baldo, B.A. (1984). Milk allergies. *Austral Journal of Dairy Technology* 39:120 (Abstr.).

Barnett, J. G. and Reid, R. L. (1957). Studies on the Production of Volatile Fatty Acids from grass in artificial rumen 1. Volatile fatty acid production from grasses. *Journal of AgriculturalScience,* 48:315-321.

Belanche, A.,Doreau, M., Edwards, J. E., Moorby, J. M., Pinloche, E. and C. J. Newbold, C. N.(2012). Shifts in the rumen microbiota due to the type of carbohydrate and level of protein ingested bydairy cattle are associated with rumen fermentation. *Journal of Nutrition,* 142:1684–1692.

Belewu, M. A. (1992) Evaluation of broiler litter and cassava waste as feeds for White Fulani cattle. (Ph D Thesis). University ofIbadan, Nigeria.

Belewu, M.A. and Adeneye, J.A. (1996). The effects of broiler litter as protein source on the performance of Bunaji (white Fulani) bull calves. *Nigeria Journal of Animal Production,* 23(1): 66-71.

Belewu, M. A. (1997). Broiler litter as feed for ruminants -Potential and limitations under Nigerian conditions. *Ghana Journal of Agricultural Science, 30*: 79 – 85
.
Bernhart, M. and Fasina, O.O. (2009). Moisture effect on the storage, handling and flow properties of poultry litter. *Waste Management,* 2*9:* 1392-1398.

Bergman, E.N. (1990). Energy contributions of volatile fatty acids from the gastrointestinal tract in various species. *Physiology Review*, 70:567-590.

Bhasin, V. (2011). Pastoralists of Himalayas, *Journal of Human Ecology,* 33 (3): 147-177.

Blench, R. (1999). *Traditional livestock breeds: Geographical distribution and dynamics in relation to the ecology of West Africa*. Pp. 1-62.

Bolan, N. S., Szogi, A. A., Chuasavathi, T., Seshadri, B. Rothrock, J. R. and Panneerselvam, M. J. (2010). Uses and management of poultry litter. *World's Poultry Science Journal, 66:*673-698.

Boxebeld, A., Gueguen, L.,Hannequart, G. and Durand, M.(1983). Utilization of phosphorus and calcium and minimal maintenance requirement for phosphorus in growing sheep fed a low-phosphorus diet. *Reproduction Nutrition Development*,23: 1043-1053.

Boyles, S. and Golden, p. (2000). Feeding Broiler Litter to Beef Cattle. OSU Extension, Coshocton, County Agriculture & Natural Resources. Oklahoma State University, Oklahoma, USA.

Bukar, H. F. (2007). Comparative feeding value of Cynodon dactylon and Digitaria smutsii forages supplemented with concentrate for weaned female yankasa lambs. MSc. Thesis submitted to postgraduate school, Ahmadu Bello University, Zaria.

Burgstaller, G.(1983). Practical Cattle Feeding. 3rd Edn., Verlag Eugen Ulmer, Stuttgart, Germany, Pp. 19-24.

Buvanendran, V. and Adu, I. F. (1990). Balami Sheep: Performance in North Eastern Nigeria. *Nigerian journal of Animal Production*, 17: 29 – 35.

Calsamiglia, S.,Cardozo, P. W.,Ferret, A.and Bach, A. (2008). Changes in rumen microbial fermentation are due to a combined effect of type of diet and pH. *Journal of Animal Science,* 86(3):702-711.

Cardozo, P. S., Calsamiglia, S. and Ferret, A.(2000). Effect of pH on microbial fermentation and nutrient flow in a dual flow continuous culture system. *Journal of Dairy Science*,83(1):265 (Abstr.).

Cardozo, P., Calsamiglia, S. and Ferret, A.(2002). Effects of pH on nutrient digestion and microbial fermentation in a dual flow continuous culture system fed a high concentrate diet. *Journal of Dairy Science*, 85(1):182 (Abstr.).

Cerrato-Sánchez, M.,Calsamiglia, S. and Ferret, A. (2008). Effect of the magnitude of the decrease of rumen pH on rumen fermentation in a dual-flow continuous culture system. *Journal of Animal Science.* 86(2): 378-83.

Charray, J., Humbert, J. M. and Levif, J. (1992). Sheep farming in humid tropical Africa. CAB International, Wallingford, UK. Pp. 187

Chaudhry, S. M. and Naseer, Z. (2012). Processing and nutritional value of broiler litter as a feed for buffalo steers. *Journal of Animal andPlant Science*, 22:358–364.

Chiejina, S. N., Behnke, J. M. and Fakae, B. B. (2015). Haemonchotolerance in West African Dwarf goats: contribution to sustainable, anthelmintics-free helminth control in traditionally managed Nigerian dwarf goats.*Parasite***22**:7. *doi*:*10.1051/parasite/2015006*. *ISSN 1776-1042*.

Chippindall, L. K. A. (1955). In: The Grasses and Pastures of South Africa. Ed. D. Meredith. Part 1. Pp. 405. (Central News Agency).

Coles, E. H. (1974). *Veterinary Clinical Pathology*. Second edition. Saunders Company Philadelphia. London and Toronto. Country Studies.http://www.photuis.com/countries/Nigeria-econmy-ivestock.html.

Craig, W. M., Broderick, G. A.and D. B. Ricker. (1987). Quantification of microorganisms associated with the particulate phase of ruminal ingesta. *Journal ofNutrition*, 117:56-62.

Cutrignelli, M. I., Calabrò, S., Tudisco, R., Infascelli, F.and Piccolo, V. (2011). Protein Sources in Ruminant Nutrition, Recent Trends for Enhancing the Diversity and Quality of Soybean Products, Dora Krezhova (Ed.), ISBN: 978-953-307-533-4 http://www.intechopen.com/books/recent-trends-for-enhancing-the-diversity-and-uality-of-soybeanproducts/protein-sources-in-ruminant-nutrition

Davis, J.R. Apple, J.K., Hellwig, D.H., Kegley, E. B. and F.W. Pohlman. (2002). The effects of feedingbroiler litter on microbial contamination of beef carcasses. *Bioresource and Technology,* 84: 191-196.

Deng, H. J. and Zhang Y. (2015). 3DRobot: automated generation of diverse and well packed protein structure decoys.Bioinformatics: btv601

Devasena, B.and Rama, P. J. (2014).Performance of Goats fed Crop Residue Based Complete Rations. *Haryana Veterinary Journal,*53 (1): 68-71.

Devendra, C. (1983). Small farm systems combining crops with livestock. *Proceedings of thefifth World Conference on Animal Production.* Tokyo, Japan.1: 173- 191.

Devendra, C. (1988). The nutritional value of goat meat. *Proceeding (IDRC- 268e). goat meat production in Asia*. March 13-18, pp 76-86.

Dickhoefer, U., Buerkert, A., Brinkmann, K., and Schlecht, E. (2010). The role of pasture management for sustainable Livestock production in semi-arid subtropical mountain regions, *Journal of Arid Environments,*74(8): 962-972.

Drewnoski, M .E. and Poore, M. H. (2012). Effects of supplementation frequency on ruminnal fermentation and digestion by steers fed medium-quality hay and supplemented with soya bean hull and corn gluten feed blend. *Journal of Animal Science,* 90(3): 881-891.

Dunnett, C. W. (1955.) "A multiple comparison procedure for comparing several treatments with a control", *Journal of the American Statistical Association*, 50:1096–1121.

Ebozoje, M.O. (1992). Preweaning Performance of WAD and WAD X Maradi Half-bred Goats in Ibadan, Nigeria. PhD Thesis, University of Ibadan, Ibadan, Nigeria, Pp. 239.

Ehoche, O.W. (1996). The use of non-conventional feedstuffs in the diets of growing and fattening bulls: Poultry manure. Report presented at the Inaugural Review and Planning Workshop on Nationally Coordinated Research Programme in Livestock held from 13-15 November, 1996 At NAERL, Ahmadu Bello University, Zaria, Nigeria.

Elemam, M. B. Fadelelseed, A.M. and Salih, A.M. (2009). Growth performance digestibility, Nitrogen balance and rumen fermentation of lambs fed different levels of deep stack broiler litter.*Journal of Animal and Veterinary Science,* 4:9-16.

Evers, G. W., Greene, L. W., Carey, J.B.and Doctorian, D.S. (1996). *Feeding Broiler Litter to Beef Cattle.* Texas Agricultural Experiment Station.

FAOSTAT (2008): Retrieved form http://faostat.fao.org/default.aspx.

FAO, (2010). *Agricultural Handbook*: Poultry meat and eggs. 1st Edition FAO investment Centre Division, Rome Italy.

Fakoya, E.O. (2002). Utilization of crop-livestock production systems for sustainable agriculture in Oyo state. *Proc. of 7th Annual conference of Animal Science Association of Nigeria*. Sept 16- 19th, Abeokuta, Nigeria.

Federal Ministry of Agriculture and Water Resources (FMAWR),(2008). Federal Republic of Nigeria, Draft National Security Programme. Pp107.

Frevrier, C., Mourot, J., Jaguelin, Y., Mounier, A. and Lebreton, Y. (1993). Comparative digestive utilization of UHT goat and cow’s milk: nutritional effects of galation-use of a swine model. *Lait* 73:581-592.

Finangwai, H. I., Ehoche, O. W., Akpa, G. N. and Barje, P. P.(2013).Effect of Urea treated Maize Stover based Complete diets on the biochemical changes in the rumen and blood parameters of crossbred bulls. *Journal of Animal Production Research,* 25:87-89.

Fontenot, J. (1991). Recycling animal waste by feeding to enhance environmental quality.SA-ANIM SCI 2001,vol2http://www.sasas.co.za/Popular/Popular.html, 1-8.

Fontenot, J. P. (1996). Feeding poultry waste to cattle. Cooperative Extension Service Publication, pp. 21- 23. Virginia Polytechnic and University of Blacksberg, USA.

Fontenot, J.P. and Hancock, J.W. (2001). *Utilization of Poultry Litter as Feed for Beef Cattle.* Department of Animal and Poultry Sciences Virginia Polytechnic Institute and State University Blacksburg, Virginia 24061.

Gadberry, S. (2000). Feeding Broiler Litter to Beef Cattle. *Agriculture and Natural Resources FSA 3016.*

Gall, C. (1996) Goat breeds of the world. Margraf Publishing, Weikersheim, Germany.Ibrahim, M. A. (1986). Veterinary traditional practice in Nigeria. In R. von Kaufmann, Chater, S. & Blench, R. (Eds). *Proceedings ILCA/NAPRI Symposium*, Kaduna, Nigerian. Retrieved February 2201 from http://www.fao.org/Wairdocs/ILRI/x5463E/x5463e0b.htm#paper9

Gbadegesin, J. and Uyovnisere, K.(1994). *Cotton Production in Nigeria.* Kaduna: Baraka Press and Publishers Ltd.

Gebreslassiee, G. B., Meseret, R. and Desta, T. (2015). Effect of supplementing graded level of poultry litter and wheat bran on performance of Abergelle bucks. *Scientific Journal of Animal Science,* 4(10). (Abstr.).

Gefu, J.O.(2002). Socio-economic Considerations in Small Ruminant Production. In: Lakpini, C.A.M.,Adamu,A.M., Edoche,O.W. and Gefu, J.O.(eds). *Manual for Small ruminants.*National Animal Production Research Institute, Ahmadu Bello University, Zaria, Nigeria. Pp.8-11.

Ghaly,A.E. and MacDonald, K.N. (2012). drying of poultry manure for use as animal feed. *American Journal of Agricultural and Biological Sciences,*7(3):239-254.*http://www.thescipub.com/ajabs.toc*.

Gill, M. (1979). The principles of feeding ruminants on complete diet. *Grass and Forage ScienceJournal,* 34: 155-164.

Girdhar, N.and Balaraman N. (2003). In *vitro* evaluation of tatal mixed rations with different energy and protein levels. *Indian Journal of Animal Nutrition,* 20:42-48.

Goetsch, A. and Aiken, G.(2000). Broiler litter in ruminant diets implications for use as a low-cost byproduct feedstuff for goats. The Opportunities and Challenges of Enhancing Goat Production in East Africa. Langston University, Langston, OK, USA. Pp 58-69.

Grezesiak, I. (1989). Prescription of goat milk in Paediatrics revolutionary. *Le Concours Medical,* 111: 3059-3064.

Harmeyer, J. and Martens, H.(1980). Aspects of urea metabolism in ruminants with reference to the goat. *Journalof Dairy Science*, 63:1707- 1728.

Haussinger, D. Lamers,W. H. and Mooman, A. F. M.(1992). Hepatocyte heterogeneity in the metabolism of amino acids and ammonia. *Journal of Enzyme*, 46:72-93.

Hespell, R. B. and Bryant, M. P. (1979): Efficiency of rumen microbial growth: Influence of some theoretical and experimental factors on YATP. *Journal Animal Science,* 49: 1640-1659.

Host, A., Husby, S. and Osterballe, O. (1988). A prospective study of cow's milk allergy in exclusively breast - fed infants. *Acta PaeConsud. Scand.* 77:663-670.

Houpt, T. R. and Houpt, K. A. (1968). Transfer of urea nitrogen across the rumen wall. *American Journal of Physiology,* 214:1296-1303.

Huntington, G. B. (1989). Hepatic urea synthesis and site and rate of urea removal from blood of beef steers fed alfalfa hay or a high concentrate diet. *Canadian Journal of Animal Science,* 69:215-223.

Huntington, G. B. and Archibeque, S. L.(2000). Practical aspects of urea and ammonia metabolism in ruminants. *Journal of Animal Science*, 78:742-749.

Ibrahim, A. A., Hudu, S., Tamburawa, M. S. and Ashiru, R. M.(2014). Growth Performance, Nutrient Digestibility and Haematological Parameters of Red Sokoto Goats Fed Sabara*Guiera senegalensis*) Leaf Meal.*Iranian Journal of Applied Animal Science* 4(1): 53-58.

INRA (Institut National de la Recherche Agronomique), (2007).Valeurs des aliments. Editions Quae; Paris, France: 2007. Alimentation des bovins, ovins et caprins. Besoins des animaux.

Institute of Agricultural Research, ABU. (2012). *Weather report*. Institute of Agricultural Research, Samaru, Ahmadu Bello University, Zaria.

International Technology Association (ITA, 2004). Nigerian livestock. The Library of Congress Country Studies; CIA World Fact book. Retrieved April 8, 2012 from http://www.photius.com/countries/nigeria/economy/nigeriaeconomylivestock tml

Jackson, D. J., Rude, B. J., Karanja, K. K., and Whitley, N. C.(2006). Utilization of poultry litter pellets in meat goat diets. *Small Ruminant Research* 66: 278-281.

Jamal, S. (2007). Fancy eating mutton? It is not goat meat http://bernama.com.my/bernama/v3

James, I. J., Osinowo, O. A. and Ajegbile, L. T. (2005). Factors affecting Milk yield in WestAfrican Dwarf Goats. *Proceedings. of 30th Annual Conf. of Nigerian Society of Animal Production, 30: 19-21.*

Jokthan, G. E., Muhammad, S. A.and Osuhor, C. U. (2013) Effect of cottonseed cake replacement with broiler litter on performance of yankasa rams fed maize husk basal diets.*FUTA Journal of Research in Sciences*, (1): 147-155.

Jose, A. M., Jose, L. C., Jesus, C. and Begona, A. (2015). Effect of feeding and housing system on rumen properties and plasma metabolite stress indicators in autochthonous Spanish Ojalada sheep. *Science Investigation Agriculture*, 42(1): 65-73.

Kallah, M. S.(2004). Range land in Nigeria.A Partial Resource Appraisal Towards Improving Livestock Production. In: Gefu, J. O. and Amodu, J. T. (Ed) Forage Production and Management in Nigeria. *A Training Manual.*National Animal Production Research Institute,Ahmadu Bello University, Zaria, Nigeria. October, 2004. Pp.1 – 10.

Khan, S.R., Sigh S.K. and Vishal, M. (2010). Effect of feeding complete rations on the performance of lactating crossbred cows. *Indian Journal of Animal Nutrition,* 27: 261-264.

Kirubanath, K., Reddy, D. N. and Nagalakshmi, D. (2003). Effect of processing cotton straw based complete diet with expander-extruder on performance of cross-bred calves. S*Asian Journal of Animal Science,* 16(11): 1572-1576.

Konka, R. K., Dhulipalla, S. K., Jampala, V. R., Arunachalam, R., Pagadala, E. P. and Elineni R. R.(2015). Evaluation of crop residue based complete rations through in vitro digestibility. *Journal of Advanced Veterinary and Animal Research,* 2(1):64-68.

Kopecny, J.and Wallace, R. J.(1982). Cellular location and some properties of proteolytic enzymes of rumen bacteria. *Applied Environmental Microbiology*, 43:1026-1033.

Kwak, W. S., Roh, S. C. and Park, J. M. (2000). Feeding of Poultry Wastes to Cattle in Korea. *Asian-Aus. Journal of Animal Science,* 1: 175-177.

Kwak, W. S., Fontenot, J. P. and Herbein, J. H. (2003).Digestion and Nitrogen Utilization by Sheep Fed Diets Supplemented with Processed Broiler Litter. *Asian-August Journal of Animal Science,* 16(11) : 1634-1641.

Lachica, M. and Augilera,J. F. (2003). Estimation of energy needs of free ranging goats with particular reference to the assessment of its energy expenditureby tne 13C-bicarbonate method. *Journal of Small Ruminant Research.* 49:309-318.

Ladele, A. A., Joseph, K.,Omotesho, O. A. and Ijaiya, T. O (1996). Sensory qualratings, consumption pattern in Nigeria. *British Journal of Food Science Nutrition,* 47:141-145.

Lailer, P.C., Dahiya, S.S.and Lal, L. D. (2010). Effect of complete feed blocks on growth performance of Murrah male calves. *Indian Journal of Animal Nutrition*, 27: 220-223.

Lamidi, O.S. (2005). *The Use of Some Non-conventional Protein Sources for Fattening Cattle. PhD thesis.*Ahmadu Bello University, Zaria. Pp 1 – 177.

Lanyasunya, T.P., Rong, W.H., Abdulrazak, S.A., Kaburu, P.K., Makori, J.O., Onyango, T.A. and Mwangi, D.M. (2006). Factors Limiting use of Poultry Manure as Protein Supplement for Dairy Cattle on Smallholder Farms in Kenya. *International Journal of Poultry Science, 5(1)*: 75- 80.

Liesegang A.and Risteli, J.(2005). Influence of different calcium concentrations in the diet on bone metabolism in growing dairy goats and sheep. *Journal Animal Physiology and Animal Nutrition,*89: 113-119.

Lapierre, H. and Lobley.G. E. (2001). Nitrogen recycling in the ruminant: A review. *Journal of Dairy Science,* 84:223–236.

Lu, C. D., Sahlu T. and Fernandez, J. M. (1987). Assessment of energy and protein requirements for growth and lactation in goats. In: Proc. of the 4 th International Conference on Goats, 13 -18 March, 1987, Brasilia, Brazil, 3: 1229 – 1248.

Martens, W. and Bohm, R. (2009). Overview of the ability of different treatment methods for liquid and solid manure to inactivate pathogens. *Bioresource Technology,100:*5374-5378.

Martínez Marín, A. L. (2007). Cabritas replacement power (I). *World Livestock*, 201: 44-48.

Martínez-Marín, A., Pérez-Hernández, M., Pérez-Alba, L. M., Carrión-Pardo, D. andGómez-Castro, A. G. (2012). Nutrient limits in diets for growing dairy goats. *Arch Medical and Veterinary Journal,* 44: 13-20.

Mason, I. L. (1988). *A world dictionary of livestock breeds, types and varieties*. (3rd ed)CAB International, Wallingford, UK.

Mason, I. L. (1996). *A world dictionary of livestock breeds, types and varieties*. (4th ed) CAB International, Wallingford, UK.Pp.273.

Matthews, J. (1999). Diseases of the goat. Blackwell Science, Oxford. P p 332.

Mavimbela, D.T., van Ryssen, J.B.J. and Last, R. (1997). The effect of high broiler litter diets as a survival ration on the health of sheep. *Journal of South African Veterinary Association, 68*: 121-124.

Mbilu, T. J. N. K. (2007). Status of Mastitis in Lactating Goats at Sokoine University of Agriculture and neighboring smallholder farms in Morogoro municipality, Tanzania. *Livestock Research for Rural Development* 19(3). URLhttp://www.cipav.org.co/lrrd19/3/mbil19040.htm

McDonald P., Edwards R. A., Greenhalgh J. F. D. and Morgan C. A.(2002). *Animal Nutrition*. 6th Edition, Pearson Education LTD. Essex. UK.

Medeiros,A. N., Resende K.T., Teixeira, I. A.M.A., Araujo M. J., Yanez, E.A. and Ferreira, A. C. D. (2014).*Energy Science,* 27(9): 1293–1302.

Mejia-Haro I., Brink, D. R., Fajardo, J. and Ortiz, B.(2001). Effects of different Ca:P ratios in lamb diets on apparent absorption and retention of phosphorus. *Agrociencia*,35: 497-502.

Morokolo, B. (2012). *A Profile of the South African Broiler Market Value Chain.* http://www.daff.gov.za/docs/AMCP/Broiler2012-13.

Moruppa, S.M. and L.O. Ngere (1986). Biometric studies on Bornu White and Red Sokoto (Maradi) goat breeds, paper presented at the 11th annual conference of Nigerian Society for Animal Production. Ahmadu Bello University, Shika - Zaria, Nigeria. Pp.5 -15.

Mshelia S. I. (1991). *Economic Analysis of Cotton Production in Nigeria: A Case Study of Afcott out Growers Scheme in Adamawa State*. *MSc Thesis*, Unpublished. University of Ibadan, Pp. 45-47.

Murthy, K. S., Reddy, M. R. and Reddy, G. V. N.(1995). Utilization of cage layer droppings and poultry litter as feed supplements for lambs and kids. *Journal of Small Rumuminant Research,* 16: 221-225.

Nadeem, M. .A., Ali, A., Azim, A. and Khan, A.G. (1993). Effect of Feeding Broiler Litter on Growth and Nutrient Utilization by Barbari Goat. *American journal of animal science,6(1)* : 73-77.

Nadeem, M. S., Pasha, T. N., Jabbar, M. A., Javed, K., Khan, M. Z., Naveed, S. and Ditta, Y. A. (2014). Effectof Different Non-Protein Nitrogen (NPN) Sources on Performance of Lactating *Nili*-Ravi Buffaloes, *The Journalof Animal and Plant Sciences*, 24(1): 2 Page: 1-4.

Naik, P.K. and Sengar, S.S. (1999). Rumen fermentation pattern in Buffaloes maintained on complete diets with different sources of nitrogen. *Indian Journal of Animal Nutrition*, 16(3): 233 – 237.

Narasimha, J.,Preetham, V. C. andRao, S. T. V.(2013).Utilization of poultry waste an un-conventional protein source in small ruminant rations.*Journal of Research ANGRAU,* 41 (1) : 47-50.

NCPA. (1999). National Cottonseed Products Association. Cottonseed and its products. CSIP, 10th (edition) NCPA, Cordova, TN*/www.cottonseed.com.*

NCPA, (2002). National cottonseed Products Association. Cottonseed feed product Guide. NCPA, Cordova, TN, USA.*http://www.cottonseed.com/publications.*

Negesse, T. M. and Rodehutscord, E. P. (2001). The effect of dietary crude protein level on intake, growth, protein retention and utilization of growing male Saanen kids. *Small Ruminant Research,* 39: 243-251.

Negesse T., Patra, A. K., Dawson, L. J., Tolera, A., Merkel, R. C., Sahlu, T. and Goetsch, A. L. (2007). Performance of Spanish and Boer × Spanish doelings consuming diets with different levels of broiler litter. *Journal Small Ruminant Research*, 69:187–197.

Ngategize, P.K. (1989). Constraints, identification and analysis in African small ruminantresearch and development. *Proceedings of Conference held at Bamenda, Cameroon, 18 - 25thJanuary*. ILCA, Addis Ababa.

Ngere, L.O., Adu, I.F. and A. O. (1984).The indigenous goats of Nigeria. *Animal Genetic Research Information,* 1984. Pp. 1 – 9 FAO and UNEP, Rome – Italy.

NISER/CBN. (1991). The impact of Structural Adjustment Programme (SAP) on Nigeria agricultural and rural life. Jointly published by Nigerian Institute for

Social and Economic Research (NISER) and Central Bank of Nigeria (CBN). Nigeria. Pp. 16-25.

Nkwocha, G. A., Anukan, K. U. and Nkwocha, V. I. (2010). Animal Agriculture as panacea for increased protein intake in Nigeria. *Journal of Animal Production Research Advances, 6: 3.*(Abstr.).

NRC, (1980). Nutrient Requirements of Small Ruminants, Sheep, Goats, Cervids, and NewWorld Camelids. National Research Council. The National Academic Press;Washington DC, USA.

NRC, (1981). Nutrient Requirements of Goats: Angora, Dairy and Meat Goats in Temperate and Tropical Countries. National Research Council, National Academy Press; Washington, D. C. USA.

NRC, (1984). Nutrient Requirements of Beef Cattle. National Research Council, 6th Edn. National Academy Press; Washington D.C., USA.

NRC, (1988). Nutrient Requirements of dairy cattle. National Research Council, 6th Edn. National Academy Press; Washington D.C., USA.

NRC. (1998). National Research Council.Nutrient Requirements of Swine. (10^{th} edition).National Academy Press Washington D.C. USA.

NRC, (2005). *Mineral tolerance of animals*. 2nd revised edition, National Research Council. National Academy Press, Washington D. C. USA.

NRC, National Research Council. (2007). *Nutrient requirements of small ruminants*. National Academy Press, Washington D. C, USA.

Nwaigwe, C. O., Nwankpa, C. A. and Nwaigwe, C. U(2011). The effects of sawdust/poultry litter and *Brachiaria ruziziensis* silages on the performance of West Africa dwarf goats. *Asian Journal of Biotechnology,* 3: 581-587.

Obasa, S.O., Alegbeleye, W.O. and Amole, J.B. (2009). Dried Poultry Manure Meal as aSubstitute for SoybeanMeal in the Diets of African Catfish (Clarias gariepinus)(Burchell 1822) Advanced Fry. *Turkish Journal of Fisheries and Aquatic Sciences 9*: 121-124.

Obeidat, B.S,. Awawdeh, M. S., Abdullah, A.Y., Muwalla, M.M. Abu, Ishmais M. A, Telfah, B.T. Ayrout, A.J. Mtarneh, S.K. Subih, H.S. and Osaili, T.O. (2011). Effect of feedingbroiler litter on performance of Awassi lambs fed finishing diets. *Animal Feed Science Technology* 165:15–22.

Ochepo, G.O. and Momoh, M. (2010). Developing the Dairy Goat Industry in Nigeria: AReview. Proceedings of 35Conference of Nigerian Society For Animal Production, 14 - 17 March. University of Ibadan, Nigeria. Pp. 530- 532.

Okorie, A. U., Sanda, L. U. (1992). Rangeland and grazing reserve. In: Nigeria: Livestock sub - sector review. FAO (Food and Agriculture Organization), Rome 2:2 -15.

Olafadehan. O.A., Olafadehan, O.O., Obun, C.O., Yusuf, A.M., Adeniji, A.A., Olayinka, O.O.and Abdullahi, B. (2009). In: Akinlade, J. A. Olayeni, J.A Rafiu, T. B.,Akinwunmi, T. A., Aderinola, O. A., Ojebiyi, O. O., and Odunsi, A.A (eds.) *Global14th annual conference of Animal Science Association of Nigeria* held at LadokeAkintola the University of Technology, Ogbomoso, Oyo State, Nigeria: Pp. 572 - 574.

Olukosi, J.O. and Isifor, S.U. (1990). *Introduction to Agricultural Marketing and Prices*: living Bookshop Series Gu Publications, Abuja, FCT pp 1 -67.

Onider, G.O.,Siebenmorgen, T. J. and Mauromoustakos, A. (2010). Low-temperature, low-relative humidity drying of rough rice. *Journal of Food Engineering*, 100: 545-550.

Oni, O. O. (2002). Breeds and genetic improvement of small ruminants. *Small ruminant production training workshop*. National Animal Production Research Institute, Ahmadu Bello University, Shika-Zaria, Nigeria, Pp. 1-7.

Onifade, O. S. and Agishi, E. C. (1988). A review of forage production and utilization in Nigeria Savannah. In: B. H. Dzowela, A. N. Said, A. W. Ageneh and J. A. Kategile (Eds.). Utilization of Research Results on forage and Agricultural by-products materials as animal feed resources. Proceedings of the First Joint workshop held in Lilongwe, Malawi, by the Pasture Network for eastern and Southern Africa (PANESA) and African Research Network for Agricultural by-products (ARNAB). International Livestock Centre for Africa (ILCA). 5-9 December, 1988. Pp. 114-125.

Osinowo, O. A., Koning M. L. and Buvanendran V. (1985). A study of coat type, pigmentation and wattle incidence in Yankasa sheep and their effects on fertility and weaning weight:*Proceedings of the National Conference on Small Ruminants*. 6 – 16thOctober, 1985. Held at National Animal Production Research Institute (NAPRI), Shika ABU. Nigeria.

Osti, N.P. and Pandey, S.B. (2006). Use of Whole Cotton Seed and Cotton Seed Meal as a Protein Source in the Diet of Ruminant Animals : Prevailing situation and opportunity. Proceedings of the 6th National Workshop on Livestock and Fisheries Research, Pp. 111 - 119.

Osuji, P. U., Nsahlai, I.V. and Khalili, H. (1993). *Feed evaluation*. ILCA Manual 5: ILCA, Addis Ababa, Ethiopia. Pp. 40.

Otoikhian, C. O S.(2012).Quantitative traits and blood biochemical characterization of White Bornu and Red Sokoto goat breeds in Nigeria.*African Scientist journal,* 13(1): 41-48.

Ovimaps (2012). Ovi location map: Ovi earth imagery data.

Owens F. N., Dubeski, P. and Hanson, C. F. (1993). Factors that alter the growth and development of ruminants. *Journal of Animal Science,* 71: 3138-3150.

Ozung, P. O., Nsa, E. E.,Ebegbulem, V. N. and Ubua, J. A. (2011). The Potentials of Small Ruminant Production in Cross River Rain Forest Zone of Nigeria: A Review.*Continental Journal of Animal and Veterinary Research,* 3 (1): 33 – 37.

Park, K.K., Goetsh, A.L., Pahl, A.R., Kouakou, B., Forster, L.A. Jr., Galloway, D.L.Sr. and Johnson, Z.B.(1995). Effects of xylose and soyabean meal additions to deep-stacked broiler litter on nutritive characteristics for ruminants. *Journal of Applied Animal Research,* **7**:1–26.

Park, K. K., Yang, S. Y., Kim, B. K. and Jung, W. H. (2000). Effect of Bedding Materials and Season on Composition and Production Rate of Broiler Litter as a Nutrient Resource for Ruminants. *Asian August Journal of Animal Science,*13(11): 1598 – 1603.

Paulino, M. F., Zervoudakis, J. T. and Morees, E. H. and B. K. (2002). Bovinocultura de ciclo curt em pastagens. In:Simposio De Producao De Gado De Cortse, 3:2002,Vicosa,Mg. Anais; vicosa,Mg: Simcorte, Pp. 153-196. Feeding parent stock. Zoo-technician Iternational pp. 22-27.Pauzenga, U. (1985). Feeding parent stuck. Zoo-tecnician International December, Pp. 22-25.

Pereira, E. S., Mizubuti, I. Y., Villarroel, A. B. S., de Olieira, S. M. P. and Pimentel, P. G. (2009). Ruminal variables in steers fed with Tifon 85 (*Cynodon spp)* hay with different particle sizes. *Semina – Ciencias Agrarias* 30: 248- 250.

Pisulewski, P.M., Okorie, A.U. and Buttery P.J. (1981). Ammonia concentration and protein synthesisw in the rumen. *Journal of Science of food Agriculture,* 32: 759-766.

Preston T. R. and Leng, R. A. (1987).Matching Ruminant Production Systems with Available Resources in the Tropics and Subtropics. Penambul Books, Armidale, Australia. Pp. 245.

Prieto I., Goetsch, A. L., Banskalieva, V.,Cameron, M., Puchala, R.,Sahlu, T., Dawson, L. J. andColeman, S.W.(2000). Effects of dietary protein concentration on postweaning growth of Boer crossbred and Spanish goat wethers. *Journal Animal Science*,78:2275-2281

Prins, R. A. vanRheenen, D. L. and van‟t Klooster, A. T.(1983). Characterization of microbial proteolytic enzymes in the rumen. *Journal of Microbiology Serol*. 49:585-595.

Pugh, D. G., Wenzel, J. G. W. and D'andrea, G. (1994). Survey of incidence of disease in cattle fed broiler litter. *Food Animal Practice Journal,* 7:665- 671.

Rajaratne A. A. J., Scott, D.,Thompson, J. K., Buchan, S. and Pennic, K.(1990). The effect of variation in dietary calcium supply on the phosphorus requirements of growing lambs.*Journal of Animal Production,*51:135-142.

Rankins, D. (2000). Feeding Broiler Litter to Beef Cattle. Alabama Cooperative Extension System. Pp.1-6.

Reddy, G. V. N., Wilhelina, P. D. and Reddy, M. S. (2003) Effect of differently processed complete diet on performance of Murrah Buffaloes. *Indian Journal of Animal Nutrition*20: 131-135.

Rege, J. E. O.(2001). Indigenous African small ruminants: A case for characterization andimprovement. ILCA, pp. 1-12.

Reynolds, C. K. and Kristensen, N. B.(2008). Nitrogen recycling through the gut and the nitrogen economy of ruminants: An asynchronous symbiosis. *Journal of Animal Science,* 86:293-305.

RIMS (1992). Nigerian Livestock resources. Four volume report to the Federal Government of Nigeria. Submitted by Resource Inventory Management Limited. 1. Executive Summary and Atlas. 2. National synthesis. 3. State Reports. 4.Urban Reports andcommercially managed livestock survey report.

Ritzhaupt, A., Wood, I. S.,Jackson, A.A., Moran, B.J. S. P. andShirazi-Beechey, S. P.(1998). Isolation of RT-PCR fragment from human colon and sheep rumen

RNA with nucleotide sequence similarity to human and rat urea transporter isoforms. *Biochemistry Society Trans.*26:122 (Abstr.).

Robinson, J.B. and Beauchamp, E.G. (1990). A Review of Poultry Manure Management: Directions for the Future. Canada: Agriculture and Agri-Food Canada.

Ruffin, B. G. and McCaskey, T. A. (1990). *Feedstuffs*, 62 (15):13.

Samanta, A. K., Singh, K. K., Das, M. M and Kundu, S. S. (2006). Rumen fermentation pattern in crossbred cattle maintained on complete feed block. *Indian Journal of Animal Nutrition*, 23: 50-52.

Sanni, S.A., Ogungbile, A. O and Atala, T.K. (2004). Interaction between livestock and crop farming in Northern Nigeria: an integrated farming systems approach. *Nigerian Journalof Animal Production*, 31(1) 1-2: 94-99

SAS, (2008). *Statistical Analysis System User's Guide*. SAS Institute Inc; Cary,N.C. 27513. U.S.A.

Satter, L. D. and L. L. Slyter. (1974). Effect of ammonia concentration on rumen microbial protein production in vitro. *British Journal of Nutrition*, 32:199–208.

Shahid, R., Raza, S.H. and Tanveer, A.(2008). Rumen metabolism of sheep fed silagecontaining poultry litter poster. FAO electronic conference on tropical silage. www.n0143855.servername.com/fulltex.

Shaib, B., Aliyu, A. and Bakshi, J. S. (eds.) (1997). Agricultural zones. *Nigeria:National Agricultural Research StrategyPlan 1996 - 2010*. Department of Agricultural Sciences, Federal Ministry of Agriculture and Natural Resources, Abuja, Nigeria: Ibadan Intec Printers limited Pp. 41 – 57.

Sharpley, A., Slaton, N., Tabler, T., VanDevender, K., Daniels, M., Jones, F. and Daniel, T. (2012). *Nutrient Analysis of Poultry Litter.* University of Arkansas Cooperative Extension Service.

Shiawoya E. L. and Tsado, D. N. (2011). Forage and fodder crop production in Nigeria: Problems and prospects. *World Journal of Life Science and Medical Research,1(4): 88.*

Silanikove, N. and Tiomkin D. (1992). Toxicity induced by poultry litter consumption. Effect on measurements reflecting liver function in beef cows. *Animal production Journal*, 54: 203 – 209.

Sirois, M. (1995). Veterinary Clinical Laboratory procedure. Mosby Year Book, Inc. St Louis Missouri, USA.

Snow, A.M. and Ghaly, A.F. (2007). The nutrition value of wastewater barley and it's utilization in fish feed. *American Journal of Agricultural and Biological Science, 2*: 159-167.

Soto-Navarro S. A.,Goetsch, A. L.,Sahlu, T.,Puchala, R. and Dawson, L. J.(2003). Effects of ruminally degraded nitrogen source and level in a high concentrate diet on site of digestion in yearling Boer x Spanish wether goats. *Small Ruminant Research,*50, 117-128.

Soto-Navarro S.,Goetsch, A. L.,Sahlu, T. and Puchala, R.(2004). Effects of level and source of supplemental protein in a concentrate-based diet on growth performance of Boer x Spanish wether goats. *Small Ruminant Research,*51, 101-106.

Stephenson, A., McCaskey, T. and Ruffin, B (1990). A survey of broiler litter composition and potential value as a nutrient resource. *Biological Wastes*, 34:1-9.

Suppadit, T., Sunthorn, N. and Sangla, L. (2011). Evaluation of the nutritive values of quail litter for ruminants after pelleting. *African Journal of Agricultural Research*, 6(27): 5948-5952.

Tawadchai, S., and Pakkapong P. (2010). Utilization of broiler litter pellets to substituteMixed feed pellets in fattening steers.*Journal of ISSAAS 16 (1):55-67*

United State Agency for International Development (USAID),(2012). Global Cotton Production Trend. From<http// www.Usaid.

Uppsala, K. S. (2012). Effects of different feed resources and conservatives techniques. Doctoral thesis, Swedish university of Agriculture science; ActaSlu service/reprs.

Van Ryssen, J. B. J. (2001). Poultry litter as a feedstuff for ruminants: A South African scene. South African-Animal Science, 2: 1-8.
retrived from http://www.sasas.co.za/Popular/Popular.html

Van soest, J. P. (1991). The use of detergent in the analysis of fibrous feeds. Determination of plant cell cosnstituents. *Journal of Agricultural Chemistry*, 50, 50-55.

Van Soest, P. J. (1994) Nutritional Ecology of the Ruminant, 2nd eddition. Cornell university press, Ithaca, NY, USA. Pp 476.

Wallace, R. J., Onodera, R. and Cotta, M. A.(1997). Metabolism of nitrogen-containing compounds. In The Rumen Microbial Ecosystem. Pp. 283–328, 2nd ed. P. N. Hobson and C. S. Stewart, ed. Chapman & Hall, London, UK.

Wamagi, I. T., Mbap, S. T., and Tahir, I. (2013).Phenotypic distribution of sheep and goats in Southern parts of Kaduna State, Nigeria. *World Journal of Agricultural Sciences,* 1(3): 100-105.

Wan Zahari, M., Thompson, J. K., Scott, W. and Buchan, D. (1990). The dietary requirements of calcium and phosphorus for growing lambs. *JournalAnimal Production,* 50: 301-308.

Wan Zahari, M., Scott, D., Loveridge, N., Buchan, W. and Milne. J.(1994). The effect of high phosphorus intake on calcium and phosphorus retention and bone turnover in growing lambs. *ExperimentalPhysiology Journal,*79: 175-181.

Wekesa, F. W., Abdulrazak, S. A. and Mukisira, E. A. (2006). The effect of supplementing Rhodes grass hay with cotton seed cake and pyrethrum marc based rations on performance of Sahiwal female weaners. *Liverstock Research for rural Development,* 18 (11) Retrieved September 25, 2014 from http://www.irrd.org/irrd18/1/weke 18011.httm

Whitehead, C. H. and Chapman, B. T. (1976). *Automation in Analytical Chemistry Technician symp,* 2: 377. Basingstoke Intants, Technico Instruments Company Limited.

Williams C. B.,Oltenacu, P. A. and Sniffen, C. J.(1989). Application of neutral detergent fibre in modelling feed intake, lactation response, and bodyweight change in dairy cattle. *Journal of Dairy Science*,72:652-663.

Wilson,R.T. (1991).Small Ruminant Production and the Small Ruminant Genetic Resource in Tropical Africa*. Food and Agriculture Organisation. Pp. 106–114.*

Yashim, S. M. (2014). Effect of inclusion levels of fig (*ficus sycomorus*) leaf meal in concentrate diets on the performance of yankasa rams fed *digitaria smutsii* hay. *PhD Dissertation submitted toAhmadu Bello University, Zaria, Nigeria.* Pp. 1-101.

Yilkal, T. and Negassie, A. (2015). Use of Different Non Protein Nitrogen Sources in Ruminant Nutrition: A review.*Journal ofAdvances in Life Science and Technology,* 29.http://www.iiste.org.

Zubcic, D. (2001). Some biochemical parameters in the blood of grazing German improved fawn goats from Istria, Croatia. *Veterinary Arhiv.* 71: 237 – 244.