ASSESSMENT OF TWO GROUNDNUT (*ARACHIS HYPOGAEA L*) VARIETIES FOR FORAGE, POD YIELD CHARACTERISTICS AND EFFECT OF FEEDING THE HAULM TO YANKASA RAMS

By

Yusuf Hanwa ADAMU

B.Sc. Animal Science (University of Maiduguri) 1996
M.Sc. Animal Science (Ahmadu Bello University) 2011

Ph.D/Agric/1941/2011-2012

A THESIS SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES, AHMADU BELLO UNIVERSITY, ZARIA.

IN PARTIAL FULFILMENT OF THE REQUARMENTS FOR THE AWARD OF A DEGREE OF DOCTOR OF PHILOSOPHY IN ANIMAL SCIENCE.

DEPARTMENT OF ANIMAL SCIENCE
FACULTY OF AGRICULTURE
AHMADU BELLO UNIVERSITY, ZARIA,
NIGERIA.

APRIL, 2015.

DECLARATION

I hereby declare that the work in this Thesis entitle **"Assessment of two groundnut (*Arachis hypogaea L*) varieties for forage, pod yield characteristics and effect of feeding the haulm to Yankasa rams"** has been carried out by me in the Department of Animal Science, Ahmadu Bello University, Zaria. The information derived from the literature has been duly acknowledged in the text and a list of references provided. No part of this Thesis was previously presented for another degree or diploma at this or any other institution.

Yusuf Hanwa, ADAMU.	**Signature**	**Date**

CERTIFICATION

This Thesis entitled **"ASSESSMENT OF TWO GROUNDNU (*ARACHIS HYPOGAEA l*) VARIETIES FOR FORAGE, POD YIELD CHARACTERISTICS AND EFFECT OF FEEDING THE HAULM TO YANKASA RAMS''** by Yusuf Hanwa ADAMU, meets the regulations governing the award of the degree of Doctor of Philosophy (Ph.D) of Ahmadu Bello University, and is approved for its contribution to knowledge and literary presentation.

Dr. D.D. Dung. Chairman, Supervisory Committee, NAPRI/ABU, Shika-Zaria.	**Signature**	Date
Prof. O. S. Lamidi. Member, Supervisory Committee, NAPRI/A.B.U., Shika-Zaria.	**Signature**	Date
Dr. S. B. Abdu. Member, Supervisory Committee, Department of Animal Science, A.B.U.- Zaria.	**Signature**	Date
Dr. S. Duru Head of Department, Animal Science A.B.U.-Zaria	**Signature**	Date
Prof. A. Z. Hassan Dean, School of Postgraduate studies Ahmadu Bello University-Zaria.	**Signature**	Date

DEDICATION

This thesis is dedicated first to the ALMIGHTY ALLAH, Who has made everything Possible for me and to my late Father Malam Adamu Hanwa and My Beloved Mother Malama Alhamdu Adamu Hanwa.who have contributed their time, energy and resources immensely to my well-being and advancement at various stages of my education. I am so grateful to all of you.

ACKNOWLEDGEMENT

I wish to thank Almighty ALLAH for His protection, mercy and blessing upon me and every member of my family. His grace, mercies and will made this work successfully completed.

I wish to express my sincere gratitude and indebtedness to members of my supervisory Committee: Dr. D.D. Dung, Prof. S.O. Lamidi and Dr. S. B. Abdu for their guidance, contributions and untiring efforts in the supervision of this work. I thank you all for the pieces of advice and useful contributions and discussions. I also remember some of my great lecturers for the knowledge they have imparted in me at one time or the other during the course of my studies. I will forever remain grateful to you. Similarly, I want to express my sincere appreciation to the present Head of Animal Science Department, Dr. S Duru. and other staff members of the Department, Prof.G.N Akpa, Prof. G. S. Bawa, Prof. J. J. Omage, Dr (Mrs) G. E. Jokthan., Dr M.R, Hassan. Dr. M. Kabir, and Dr. D. Zahraddeen, Dr. S.M. Yasim and Mal. Balarabe Abdullahi for their cooperation and good working relationship .

My sincere thanks also go to my colleagues especially Dr. Lawal Adamu, Abdullahi Nayawo, Bello Dogon Kade. And all the technical staff of the Biochemistry Laboratory, Department of Animal Science, Ahmadu Bello University, and the Central Laboratory, National Animal Production Research Institute for all the supports, encouragement and good working relationships . My special thanks go to Mal. Yunusa Mohammed, for sparing time besides his normal schedule for the analysis of blood samples. Wonderful supports given to me by the staff of the Departmental Farm Unit, Ahmadu Bello University is appreciated. I am in short of word to express my indebtedness to my lovely wives: Rakiya Mairiga and Rahinatu Abubakar , my children Saudatu, Adamu ,Mujahid , Abubakar ,Husna, Ahmad and Aminat for their patience, endurance moral support and other forms of priceless contributions which in facilitated completion of this study.

I am indebted to my guardians; Prof. Idris Abdulkadir, Alhaji Kailani Mohammed, Hajia Saudat Mohammed , Late Hajia Amina Abdulkadir and Fatima Kera for their encouragement , financial and moral support. The moral support and prayers of my Brothers, Sisters , friends and well wishers, especially Mohammed Adamu, Yahya Adamu Saadatu Adamu, Habiba Adamu, Baba Kera, Alhaji Bature Danja, Shehu Nadada ,Abdussamadu Shehu Citta and Auwal Mohammed are also acknowledged with no less gratitude. I thank the authority of Ahmadu Bello University, Zaria, for providing financial support for this study and the Director,National Animal Production Research Institute, Shika for providing a site for on-Station Trial and provision of *Digitaria smutsii* hay and two varieties of groundnut hay for the feeding trials.

ABSTRACT

The studies were conducted in NAPRI to assess two varieties of groundnut for forage and seed yield characteristics and the effect of feeding the haulms to Yankasa rams. The first experiment was on-farm which was conducted at Shika, and its neighbouring villages, to determine the effect of variety on pod, haulm, seed yields and shelling per cent. Ten farmers were randomly identified in these neighbouring villages given groundnut variety; SAMNUT-22, in early June. Two plots of 10mx10m size were set up per site The second experiment was on-station was conducted at NAPRI to evaluate the effect of varieties and sowing dates on pod, haulm yield number of pods plant^{1}and leaf to stem ratio. Treatments consisted of factorial combinations of three different sowing dates (June, July and August) and two groundnut varieties (SAMNUT22 and Maizabo) laid out in a completely randomised block design with four replicates. In the third trial, fifteen Yankasa rams with an average live weight of 10.50kg $\pm$2 were used to study the effect of inclusion of haulm of two groundnut varieties in concentrate diets on growth performance of rams, blood and rumen metabolites, digestibility and utilisation of nitrogen. The rams were randomly assigned into three groups with five rams per group in a complete randomized design. The experimental diets consist of *Digitaria smutsii* hay as a basal diet which was fed *adlibitum* and concentrates which were supplemented with 10% of groundnut haulm of SAMNUT-22 and Maizabo were offered at the rate of 1% of body weight. The trial lasted for 90 days. Blood samples were collected before feeding and at 4, 8 and 12 hours post feeding. Total protein, blood urea and Ammonia nitrogen concentration were measured. Rumen liquor was collected at the end of growth trial. Liquor was collected before the morning feeding and at 4, 8 and 12 hours post feeding to determine Total Volatile Fatty Acids, blood urea nitrogen and nitrogen. Metabolism study was subsequently conducted using 9 animals from the growth trial. In the second trial twelve yearling Yankasa rams were used to study the effect of inclusion of haulm of two groundnut

varieties in concentrate diet on fattening Yankasa rams. The On-farm trial results revealed that SAMNUT-22 produced significantly (P<0.05) higher pod (5466.7kg/ha), haulm (11354.2 kg/ha) and seed yields (1069.6 kg/ha) than Maizabo (4129.2, 9000.0 and 1016.00 kg/ha, respectively). While he On- Station trial results indicated that delaying of groundnut sowing till August resulted in a significant (P<0.05) decline in pod (4437.5 kg/ha), haulm yields (4687kg/ha) and number of pod plant-^{1} (25.77kg/ha), respectively. Results also revealed that, the late sowing (August) significantly (P<0.05) produced higher leaf to stem ratio yield (62.43%) than the early sowing June and July (48.05 and 49.33%, respectively). The result of growth trial showed that total Dry Matter Intake was highest for the rams fed diet containing 10% SAMNUTN22 (1113.23g) followed by 1102.28g for 10% Maizabo level of inclusion in the supplement. These results were similar (P>0.05) but significantly higher than 1043.59g obtained on rams in control diets. The live weight gain of the rams ranged from 5.74-6.2g/d and were statistically (P<0.05) different across the treatments. The high Ammonia Nitrogen (29.38 Mg/100ml) levels were recorded in rams fed 10% SAMNUT-22. Blood Urea Nitrogen values varied between1.4 and 9.3mg/100ml.The result of the fattening trial depicted that apparent digestibility of dry matter was higher (P<0.05) for animals fed 10%SAMNUT-22 (46.45g) and had the best digestibility of all nutrients and statistically different. Rams fed diets containing 10%SAMNUT-22 had highest nitrogen absorbed (2.14g), nitrogen balance (1.87g) and nitrogen retained as percentage of intake (52.36%) in their body compared to other treatments and were significantly different. The result of fattening trial indicated that highest ADG was obtained in rams fed 10% SAMNUT-22 (65.27g).The highest meat yield (5.5kg) was obtained in animals fed 10% SAMNUT-22. Therefore, it was concluded that early sowing enhanced positive response of pod yield (5875kg/ha), haulm yield (9750 kg/ha) and number of pod plant^{-1} (78.34), but delayed sowing enhanced leaf to stem ratio (62.43%) thus, it can positively improve mixed crop-livestock farming system. It was concluded from

the growth and fattening trials that sheep can be fed with SAMNUT-22 at 10% level of haulm inclusion in concentrate diets for improved growth performance, nutrient digestibility fattening and carcass quality without adverse effect.

TABLE OF CONTENTS

Title **Page**

Contents

DECLARATION ii

DEDICATION iv

ACKNOWLEDGEMENT v

ABSTRACT vi

TABLE OF CONTENTS ix

LIST OF TABLES xiii

LIST OF APPENDICES xiv

ABBREVIATIONS xv

CHAPTER ONE 1

1.1 Introduction 1

1.2 Justification 2

1.3 Objectives of the study 4

1.4 Hypotheses 5

CHAPTER TWO 6

2 **REVIEW OF LITERATURE** 6

2.1 Small Ruminants Production in Nigeria 6

2.2 Feed resources of Ruminants in Nigeria 7

2.2.1 Rangeland forage resources 7

2.2.2 Browse Plants 11

2.2.3 Agro-industrial by-products as feed resource 18

2.2.4 Crop residues 27

2.2.5 Groundnut (*Arachis hypogea L*) 32

2.2.6 Developed Groundnut cultivars 36

2.2.7 Recommended Groundnut Varieties and their development in Nigeria 37

2.2.8 Fodder yield 38

2.2.9 Performance with animals 39

CHAPTER THREE 42

3 **MATERIALS AND METHODS** 42

3.1 Site description 42

3.2 Experiment 1: Effect of two groundnut varieties on forage yield and pod 42

3.2.1 Experimental details 42
3.2.2 Parameters measured 43
3.2.3 Chemical analysis 43
3.2.4 Data analysis 44
3.3 Experiment II: Effect of two groundnut varieties and sowing on forage yield and pod characteristics in the Nigeria Savannah (on-station) 45
3.3.1 Experimental details 45
3.3.2 Parameters measured 45
3.3.3 Chemical analysis 46
3.3.4 Data analysis 46
3.4 Experiment 3: The effect of different groundnut haulm on growth performance of Yankasa rams. 47
3.4.1 Site description 47
3.4.2 Sources of Experimental materials 47
3.4.3 Experimental Animals and management 47
3.4.4 Experimental Feed and Design 47
3.4.5 Rumen and blood metabolites 48
3.4.6 Digestibility trial 49
3.4.7 Chemical analysis 50
3.5 Experiment 4: The effect of different groundnut haulm on fattening performance of Yankasa rams. 51
3.5.1 Site description 51
3.5.2 Animals management 51
3.5.3 Experimental feed and design 51
3.5.4 Carcass analysis. 52
3.5.5 Chemical analysis 52
3.5.6 Data analysis 52
CHAPTER FOUR 54
4 **RESULTS** 54
4.1 Experiment I: Effect of two groundnut varieties on forage yield and pod 54
4.1.1 Pod yield 54
4.1.2 Shelling percentage (SHE %) 54
4.1.3 Haulm yield. 54
4.1.4 Seed yield: 54

4.2 Experiment 2: Effect of two groundnut varieties and sowing dates on forage yield and pod characteristics in the Nigeria Savannah (on-station) 56
4.2.1 Haulm yield:..... 56
4.2.2 Pod Yield 56
4.2.3 . No of Pods /Plant. (NP/P) 56
4.2.4 Leaf to Stem Ratio (L: S) 58
4.2.5 Nutrients and minerals composition..... 58
4.3 Experiment 3: The effect of different groundnut haulm on growth performance of Yankasa rams. 63
4.3.1 Chemical composition of the experimental diets 63
4.3.2 Dry matter intake (DMI) 63
4.3.3 Weight changes in Yankasa Rams 63
4.3.4 Blood Metabolites 67
4.3.5 Rumen metabolites..... 70
4.3.6 Nutrient digestibility and nitrogen retention 73
4.3.7 Nutrient digestibility 73
4.3.8 Cost benefit analysis 77
4.4 Experiment IV: The effect of different groundnut haulm on fattening performance of Yankasa rams. 79
4.4.1 Feed ingredients and nutrient composition of the experimental diets..... 79
4.4.2 Dry Matter intake (DMI)..... 79
4.4.3 Live Weight change in Yankasa rams 81
4.4.4 Carcass analysis 83
CHAPTER FIVE 85
5 **DISCUSSION** 85
5.1Experiment I:Effect of groundnut variety on haulm yield and pod characteristics .85
5.2 Experiment 2: Effect of sowing dates and varieties on pod and forage characteristics (On-station) 88
5.2.1 Chemical composition..... 90
5.3 Experiment 3: The effect of different groundnut haulm on growth performance of Yankasa rams.. 93
5.3.1 Chemical composition of the diets..... 93
5.3.2 Dry Matter Intake (DMI) 93
5.3.3 Live weight gain..... 94
5.3.4 Serum metabolites..... 95
5.3.5 Rumen Metabolites 96

5.3.6 Nutrient digestibility and nitrogen retention 98
5.3.7 Cost benefit 100
5.4 Experiment 4: The effect of different groundnut haulm on fattening performance of Yankasa rams 101
5.4.1 Chemical composition of the diets 101
5.4.2 Dry matter intake 101
5.4.3 Live weight gain 102
5.4.4 Carcass analysis 103
6 **SUMMARY, CONCLUSION AND RECOMMENDATION** 104
6.1 Summary 104
6.2 Conclusion 105
6.3 Recommendations 106
6.4 Future research directions 107
7 **REFERENCES** 108
8 **APPENDICES** 126
Appendix 1: Temperature relative humidity and rainfall distribution in 2012 and 2013 126
Appendix 2: Weight-Unit Conversion Factors 127

LIST OF TABLES

Table No **Page**

4.1 Forage, Pod, Seed yield (kg/ha) and Shelling per cent of two groundnut varieties _____55

4.2 Fresh pod, fresh haulm, dry pod, dry haulm yield (kg/ha), leaf stem ratio per cent and number of pod per plant of groundnut as affected by the dates of sowing and two groundnut varieties ___57

4.3. Chemical and minerals composition of two groundnut v haulm due to different sowing dates and variety at NAPRI shika _____ _____ 60

4.4 Chemical and mineral composition of groundnut seeds at NAPRI Shika _____ 62

4.5. Ingredient composition of concentrates containing varying level of groundnut haulm for growth trial _____ 65

4.6. The effect of different varieties of groundnut haulm on feed intake and growth performance of Yankasa rams fed *Digitaria smutsii* hay as basal diet _____66

4.7. The effect of feeding different varieties of groundnut haulm on blood metabolites in yankasa._69

4. 8 The effect of feeding concentrates diets containing different varieties of groundnut haulm on rumen metabolites in yankasa rams _____72

4.9 The effect of different varieties of groundnut haulm on digestibility Coefficient and nitrogen balance in Yankasa rams fed *D smutsii* hay _____74

4.10 The effect of different varieties of groundnut haulm on nitrogen balance of yankasa rams fed *D smutsii* hay _____76

4.11. Cost benefit of feeding haulms of groundnut varieties on growth performance of Yankasa fed *Digitaria smutsii basal diet* _____ 78

4.12 Ingredient composition of concentrates diets containing groundnut haulm supplement and control for fattening trial _____ 80

4.13. Effect of supplementation of haulm of two groundnut varieties in concentrate diets on fattening performance respons in yankasa rams fed basal diets of *D smutsii* hay. _____82

4.14. The effect of inclusion different varieties of groundnut haulm in concentrate diets on carcass composition v in Yankasarams fed *Digitaria smutsii hay as basal diet*_____84

4.15. The effect of inclusion different varieties of groundnut haulm in concentrate diets on non-carcass composition values in Yankasa rams fed *Digitaria smutsii hay as basal diet* _____84

LIST OF APPENDICES

Appendix 1: Temperature relative humidity and rainfall distribution for 2012 and 2013 **Error! Bookmark not defined.**

Appendix 2: Weight-Unit Conversion Factors **Error! Bookmark not defined.**

ABBREVIATIONS

ADF = Acid Detergent Fibre

ANOVA=Analysis of Variance

AOAC= Association of Official Analytical Chemists

BUN = Blood Urea Nitrogen

CF= Crude Fibre

CP = Crude Protein

CPD = Crude Protein Digestibility

DM = Dry Matter

DMI = Dry Matter Intake

EE= Ether Extract

FAo= Food and Agricultural Organization of the United Nations

g = Gramme

Kcal= Kilo Calorie

Kg = Kilogramme

l = litter

ME = Metabolizable Energy

MJ = Mega Joules

Mg = Milligrams

Mmol= Mili mol

MZ = Maizabo

N = Nitrogen

NFE= Nitrogen Free Extract

NDF = Neutral Detergent Fibre

OM = Organic Matter

PPM= Parts per Million

RAN = Rumen Ammonia Nitrogen

SEM = Standard error of means

SN-22= SAMNUT-22

TP = Total Protein

TDN= Total Digestible Nutrients

CHAPTER ONE

1.1 Introduction

In Nigeria, the agricultural system comprised of mixed crop-livestock system with very low external inputs such as chemical fertilzer, improved seeds, agro-chemicals, livestock feeds and drugs (Hassan, 2014). Optimum productivity of both crops and livestock under this system may be difficult, considering the fact that most of the farmers are under subsistence agriculture with poor living condition. On the other hand, the livestock sector in Nigeria faces problems of lack of inadequate feed supply especially during the dry season period.

Poor nutrition results in low rates of production, often defined by growth and reproduction. It also affects the immune system and the ability of an animal to fight disease. In extreme conditions of malnutrition, death can occur. In many animal production systems, approximately two-thirds of improvements in livestock productivity can be attributed to improved nutrition. In economic terms, feed cost accounts for about 70% of the total cost of livestock production. The feasibility of livestock enterprises is, therefore, a function of the type of feed and feeding system. It is estimated that up to a five-fold increase in tropical livestock productivity can be attained if there is optimal feed resource utilization.

Nigeria has about 140 million hectares of natural range which serves as the major source of forage for livestock (Lufadeju, 1988). Kallah (1982) observed that in Nigeria, over 98% of the dry matter (DM) needed to produce beef is derived from grasses and browses growing on native rangelands. It is however an accepted fact during dry season of the year, grassland in the tropics does not sufficiently supply some nutrients to stock for greater productivity. There is wide variation in the quality and quantity of pasture available from one time of the year to another. Adamu *et al*. (1995) noted that native forage resources of the savannah zones of the country can meet requirement of the animals for maintenance and low levels of production

for only about two to three months of the year. Moreover Range is declining due to increase in land use for crop production, (Lamidi , 2005).

Similarly, Desert encroachment is a serious problem confronting Sub-Saharan African nations where northern part of Nigeria is located. There are no clear cut explanations of the origin of desert encroachment, but it is generally attributed to demographic activities especially felling of trees, burning and overgrazing by herdsmen. (Hugo, 2010)

In order to meet up with increasing demands of animal protein and improve the farming system, livelihood and income of the farmers, and also to reduce the menance of desertification, mitigate environmental pollution and control soil errosion in Nigeria, there is a need to intergrate high quality forage legumes cultivation in the farming system.

The fodder production for supplementary feeding is the only long term means for feeding the livestock. Otchere *et al.* (1994) observed that the immediate intervention suitable for livestock feed production for agro pastoralist is dual-purpose legume fodder. Dual—purpose legumes are crops that improve the soil fertility through their root nodules which fix atmospheric nitrogen, the seeds used for human consumption while the fodder as livestock feed. Thus dual-purpose legumes appear more acceptable to the subsistence crop-livestock farmers of Nigeria, one of such crops is groundnut.

1.2 Justification

Groundnut (*Arachis hypogaea* L.) provides both high quality nuts for human consumption as well as high quality fodder for livestock. It is an important oilseed crop in Nigeria and is widely grown in the tropics and sub-tropics (Nigam *et al*., 1991). Some of the states where groundnut is produced in Nigeria include Kano, Kwara, Kaduna, Sokoto, Bauchi, Katsina, Zamfara, Nassarawa and most of the northern states. Because of its numerous uses,

groundnut is in great demand and this opens an opportunity for interested investors to export the product (Taru *et al.,* 2008).

It is one of the most important crops that have the ability to thrive on newly reclaimed sandy soils as a legume of high nutritive value as well as being a source of edible oil (Desire *et al*., 2010) . Groundnut makes excellent green manure; it is effective for erosion control and soil protection. It is also used as a nitrogen-fixing crop. Arslan (2005) considered groundnut haulm as the most important of its by-products that can be used to supply feed to livestock and its hay providing extra income to smallholder farmers.

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

However, most of the groundnuts grown by famers in the country are local varieties most of which are early maturing. They are harvested during the rainy season when the haulms cannot be properly cured so they rot away. Moreover, such groundnut improvement programmes mostly focus on higher grain/pod yields, pest/disease resistance, and water stress tolerance while crop residue quality is rarely a priority (Pande *et al*., 2003; Parthasarathy *et al*., 2003).

The Institute of Agricultural Research (IAR), ABU Zaria has a groundnut breeding programmes that releases new varieties over a time. It was reported from field studies, that there are set of farmers who grow groundnut for haulms only, seed only, and both. Therefore, ILRI, IAR, NAPRI and ADPs worked in collaboration to develop forage/ seed yield varieties.

Varieties with traits sought by farmers should be promoted and used to build sustainable seed supply systems (Ndjeunga, 2010).

There is therefore, need to introduce the improved variety to the farmers and to investigate the best sowing dates that could meet up demands and to offer better opportunity for distinct sets of farmers with different preferences; those that grow groundnut solely for forage and those for both seeds and forage to support livestock production during the critical periods of the dry season.

1.3 Objectives of the study

1. To enhance mixed crop-livestock farming system by introducing improved dual purpose variety of groundnut to the farmers.
2. To investigate the effect of different varieties and sowing dates on pods yield, haulm yields and yield characteristics of the two varieties of groundnut SAMNUT-22 and Maizabo.
3. To evaluate the effect of inclusion of different varieties of groundnut haulm in concentrate diets on growth and fattening performance in Yankasa rams.
4. To evaluate the effect of inclusion of different varieties of groundnut haulm in concentrate diets on blood metabolites and rumen liquor in Yankasa rams.

1.4 Hypotheses

Ho_1= Different sowing dates have no effect on yield and Chemical composition of groundnut.

Ha= Different sowing dates have effect on yield and Chemical composition of groundnut.

Ho_3 =Haulm of different varieties of groundnut in the supplementing diets have no effect on nutrient digestibility and nitrogen retention in Yankasa rams.

Ha_3=Haulm of different varieties of groundnut have effect on nutrients digestibility and nitrogen retention in Yankasa rams.

Ho_5 =Haulm of different varieties of groundnut in the supplementing diets have no effect on growing and fattening performance of Yankasa rams.

Ha_5= Haulm of different varieties of groundnut have effect on growing and fattening performance of Yankasa rams.

CHAPTER TWO

2 REVIEW OF LITERATURE

2.1 Small Ruminants Production in Nigeria

Africa has a population of 206 million sheep and 172 million goats which represent approximately 19 and 29% of the world total, respectively (FAO, 1993).Small ruminant population in Nigeria is estimated to be about 22.1 million sheep and 34.5 million goats (FDLPCS, 1992). There are about 15.2 million cattle, 28 million goats, 23 million sheep in in Nigeria, (Food and Agricultural Organisation, 2006).Sheep and goats are fairly well distributed throughout Nigeria, but the areas of highest density are in Kano, Sokoto, Borno and Kaduna States.

The ownership pattern of small ruminants in Africa compared to cattle, shows that they are more popular among smallholder farmers. In Nigeria for example goats are kept at the rate of 5.7 per compound and sheep at 3.7 (FLDPCS, 1992). The low initial capital requirement and low maintenance cost of small ruminants endear them to resource-poor farmers who require and allow them to roam about in the villages in search of available feed resources.

In Nigeria, sheep and goats are kept primarily for meat production. They contribute about 35 per cent to the total meat supply in Nigeria (Oni, 2001). They also feature prominently in socio-economic life of the people such as religious festivals. The rams in particular are favorite slaughter animals during sallah festival at which time fattened rams command very high market prices (Adu, 1982). In addition to sheep and goats being kept for meat production, they are valuable source of cash for emergency fund for resource -poor man.

Livestock production is important in Nigeria. It is next to crop within the agricultural sectors as net producer of goods and services contributing over 5.9% of the agricultural components of the GDP (Kallah, 2001).The potentials of small ruminants as a major source of meat

hinges on their comparative advantage over cattle, due to their lower feed requirement and are found more with poor farmers being able to thrive more than cattle in wide ecological zones of the country (David-West, 1985)

2.2 Feed resources of Ruminants in Nigeria

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

2.2.1 Rangeland forage resources

One of the major factors limiting the productivity of animals in sub-Saharan Africa is poor nutrition; especially in the dry season (Walshe *et al.* 1991). In Nigeria ruminants depend on range for most of their feed requirements especially in the Sahel and Sudan zones, where most of the ruminants are concentrated (Yayock *et al.,* 1987). There is wide variation in the quality and quantity of pasture available from one time of the year to another. The potential yield of grasses could be as high as 6 tonnes, DM per hectare, as in *Cynodon dactylon* (Jahnke, 1982) or even higher as in *Panicum maximum* (10-18 tonnes DM/ha and 30 tonnes DM/ha, under good management and appropriate fertilizer regimes (Adegbola, 1982).

Kallah (1982) observed that in Nigeria, over 98% of the dry matter (DM) needed to produce beef is derived from grasses and browses growing on native rangelands. Adamu *et al*. (1995) noted that native forages resources of the savannah zones of the country can meet requirement of the animals for maintenance and low levels of production for only about two to three months of the year.

Davies and Onwuka (1992) reported crude protein (CP) and crude fibre (CF) values of 5.9% and 37%, respectively for *Pennisetum purpureum*, while Bosman *et al*. (1996) and Nuru (1985) reported that crude protein value of *Panicum maximum* hay is 5.3 and 4.2%, respectively. Nuru (1985) reported the crude protein content of some roughage as follows: *chloris gayana* 2.6%, *Andropogon gayanus* 2.75%, *Digitaria smutsii* 5.0%, *Bracharia decumbens:* 3.1%. Feeds with less than 8% Crude protein values are considered deficient as livestock feeds, as they cannot provide the minimum ammonia levels (150-250mg/litre of rumen fluid) required by rumen microbes for optimum activity (Leng,1990).

These grasses exhibit growth characteristics which affect their quality. Their rapid growth and early maturity during the wet season results in a rapidly increasing lignifications and declining nitrogen and soluble carbohydrate content (Haggar, 1970a; Ademosun *et al*, 1989) .Crude protein (CP) content ranging from 7 to 10% has been reported for the native grass in early wet season (Smith, 1992). Also during the wet season some minimum level of animal production can be supported by these grasses without supplementation. However, because of the energy content that may be low due to high moisture during the wet season (Smith, 1992). Provision of energy supplements will enhance utilization of native grass at this period of the year.

Performance of animals grazing tropical pasture during the dry season without supplementation shows that they lose weight and body condition (Adu, 1982). The weight loss may be about 40g per head per day for cattle, sheep or goat (Deleeuw and Agishi, 1978,). During the dry season, the CP of native pasture falls to about 1.5 and 3% (Adamu *et al*., 1993). The importance of supplementing poor quality forages for improved intake and animal performance has been reported (leng, 1991; Alawa *et al*., 1993)

2.2.1.1 Digitaria smutsii

Digitaria smutsii (D. smutsii) belongs to the family Poecea and is commonly referred to as digitaria grass or crab grass. It is said to be native to Southern Africa. Digitaria is a genus of about 300 species of grass family poaceae native to tropical and warm temperature regions. Common names include crabgrass, finger grass and fonio. They are slender monocotyledonous annual and perennial lawn, pasture and forage plants; some are often considered lawn pest. Digitus is the latin word for finger and they are distinguished by the long finger-like inflorescence they produce (Hacker *et. al*., 1993).

Digitaria smutsii is indigenous to Africa and grows well in the dry part of tropical and sub-tropical climates. The grass was first introduced into Nigeria from South Africa in 1956. *Digitaria* performs well in areas with annual rainfall ranging from 600-1800mm, but best rainfall optimum is 900mm/year. Well-drained sandy-1oam soil is preferable for the successful establishment of *D. smutsii*, which is by means of stem cuttings or stolons because no viable seeds are produced. *D. smutsii* is tolerant to acidic or alkaline soils and withstands limited-water logging.

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

Propagation and planting of Digitaria smutsii:

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

Cultivation of Digitaria smutsii:

In Africa, digitaria is been known as a savannah plant, which does not prosper in soils with salinity problems that has low water demands and survives strong drought (Harlan, 1993; Hilu *et al.,* 1997). Propagation can be achieved by transplanting young plants.

Organic fertilisation has been used to increased plant biomass and grain yield. Attempts to improve grain yield with chemical fertilizers have been successful, although not necessary economical. There appears to be low response to chemical fertilizers especially N. When digitaria grows in association with legumes (possibly due to Nitrogen fixation by the legumes) other agrochemical input appears to be very limited.

***Chemical composition of Digitaria smutsii*:**

Digitaria grass comprises of a number of different species (*D. Eriantha, D. Umfolozi, D. Smutsii, D .setivalva, D. Peitzii, D. Polevansii, D. Decumbens* etc.) and they differ in their chemical composition. Minson (1984) attributed such differences to the genetic make-up of the, plant which controls morphological characteristics such as proportion of leaf to stem, and also to different management practices during growth or harvest of the crop. Minson (1990)

reported the dry matter content of six specie to range from 56.1 to 70.9 per cent, neutral detergent fibre content to range 13 to 34%, hemicelluloses 26.5 to 38.2% DM basis .

2.2.2 Browse Plants

Browse is defined as the palatable portion e.g. the leaves, tender twigs, shoots, flowers fruits and pods of woody forage of plants .The illustrated heritage dictionary and information in its own, defines browse as young twigs, leaves and tender shoots of plants or shrubs that animals eat. Browse plants particularly the pod bearing species are very important source of forage for livestock in all parts of the tropical world, especially in the arid areas. This role is more importantly felt the longer the dry season and the less the annual rainfall. They come in to leaf early in the season before the rains come and their leaves retain the nutritive value at a moderately high level long into the dry season.

Browse plants comprise trees, shrubs and woody vines that are either legumes or non-legumes. They are rich in protein and minerals at a time when grasses are deficient in these constituents. (Amodu *et al.*,2004).The unique characteristic that endeared them to livestock farmer lies in their ability to establish and grow fast, produce good leaf biomass which remains green during the dry season when feed is scarce (Adediran, 2002).

2.2.2.1 Nutritive value of browse plants

Even though the nutritive value of browse varies according to the species, generally they remain green even in the dry season just like the perennial legumes; this is because of their adaptation to harsh environments through their deep rooting habits and leathering low transpiration foliage and is therefore able to withstand the adverse climatic condition.

Most of browse species have high protein and low crude fiber contents, which make them suitable as fodder for livestock. The average crude protein of browse in tropical West Africa

is 12.5%, and this rarely falls below 10% in most browses during the dry season. The average crude fiber is 18.5%, while the digestibility of browse plants is moderate to high when fed in fresh form. The calcium content is 1.6% while phosphorus is 0.15 % (Amodu and Otaru, 2004)

2.2.2.2 Anti-nutritive Factors (ANFs) in browse plants

The Anti-nutritive factors may be defined as those substances generated in natural feedstuffs by the normal metabolism of species and by different mechanisms e.g. inactivation of some nutrients interference with the digestive process or metabolic utilization of feed which exert effects contrary to optimum nutrition (Aganga, 2003).

Anti-nutritional factors (ANFs) May be defined as those substances present in the diet which by themselves or their metabolic products arising in the system interfere with the feed utilization, reduce production or affects the health of the animal. Those anti-nutritive substances are often referred to as toxic factors because of deleterious effects they produce when eaten by animals (Reddy, 2007)

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

2.2.2.3 Nitrates and nitrites

Nitrates and nitrites are non-protein nitrogen occurring in plants. Nitrate may not be harmful but may reduce to nitrites (Arkhipov, 1989). Nitrate is converted into nitrite (NO_2) in the rumen of the animal. Nitrite is absorbed into the blood and converts normal blood

hemoglobin into methaemoglobin, a form which is incapable of transporting oxygen to the body tissues. If not treated, the animal dies of anoxia. A more wide spread subclinical influence of nitrate ingestion results in poor growth, depression of milk production, and poor vitamin A and iodine status of the animal. Levels of 0.35 to 0.45% NO_3 in the forage dry matter is regarded as potential toxic (Wright and Davison, 1964) .Forage with potentially toxic NO_3 (Nitrites) levels should be mixed with other feeds before use.

2.2.2.4 Prussic/ Hydrocyanic acid (HCN)

Cyanide in trace amounts is present in the plant kingdom. It occurs in the form of cyanogenetic glycosides. Cyanogenic glycosides are found in some species of sorghum and cynodon. Hydrolysis of the glycosides to hydrocyanic acid (HCN), or prussic acid hydrolysis occurs by enzyme action usually in the same plant or as they are being digested by animals. Hydrolysis can also be brought by bacteria action in the rumen, and the resulting cyanide is rapidly absorbed into the blood. Cyanide combines with hemoglobin to form cyanic-hemoglobin which does not carry oxygen (Aletor, 1993).

The cyanide-poisoned animal shows an increased rate of respiration, increased pulse rate, gasping, muscular twitching and convulsions; death occurs very rapidly from respiratory paralysis. Levels of 0-25mg HCN/100g dry plant tissues have been considered as safe for pastured animals. Levels of 50-75mg/100g as doubtful, and concentrations greater than 100mg/100g as highly dangerous (Reid and Jung, 1978) .

Ruminant are more susceptible to HCN poisoning than are horses and pigs , because the enzyme required for the release of HCN is destroyed in horses and pigs by gastric HCL . Cattle are most susceptible than sheep. It usually causes reduced growth; poor feed efficiency and result in death if consumed in increased amounts. Clinical symptoms are characterized by mental confusion, generalized muscle paresis and respiratory distress, abdominal pain and

vomiting. Animals which have not shown much evidence of toxicity may be injected intravenously with 3g sodium nitrate and 15g sodium thiosulphate in 200ml H2O for cattle and for sheep 1g sodium nitrate and 2.5g sodium thiosulphate in 50Ml H2O (Reddy,2007)

2.2.2.5 Forage saponins

These are another class of glycoside whose hydrolysis products lower surface tension and form stable foams with ability to haemolyze blood cell and alter permeability of cell walls and dispersion of organized tissues. They are glycosides characteristics by bitter taste, foaming in aqueous solution. They are present in all plant parts flower, leaves, stems and roots.

Generally Saponnins are less important because their levels are low in most common feed ingredients for monogastrics animals. The important common forages which cause saponnin poisoning of livestock are Lucerne, Soya bean, e.t.c. Average Saponin content of the leaves are twice as much as those of the stems and that the saponin content declines as the plant becomes older.

Poultry are more sensitive than pigs since 0.4-0.5% Saponin in the feed has been reported to depress feed consumption in birds. Egg production and body weights are also depressed. Feeding Lucerne meal beyond 5-7% in poultry mash show decreased weight gain and egg production. The effect can partly reversed by feeding of cholesterol and cottonseed oil in the diet with which Saponins get binded.

Saponins in Legumes forages lower the surface tension of ruminal contents leading to accumulation of gas in the digesta. This condition known as bloat. Turpentine and paraffin oil are helpful in reducing bloat. For ruminant 1 to 2 kg dry fodder should be fed before letting the animal on legume pastures or before excessive feeding of green legume fodder as a

preventive measure (Reddy, 2007) . Available literature suggested that the dietary presence of saponins can either be beneficial or be deleterious (Aletor, 1993).

2.2.2.6 Mimosine

Mimosine, β- [N - (3-hydrozypyridone - 4) – α -aminopriopionicacid], is degraded by ruminants to the toxic 3, 4 dihydroxypyridine (DHP). Therefore, prolonged feeding of diets containing more than 1% mimosine (on DM-basis) may be harmful (Jones and Hegarty, 1984). For example, goats that had no previous exposure to *Leucaena* fodder and fed sole diet of L*eucaena* for 45 days showed mimosine toxicity symptoms which include hair loss, reduced feed intake, increased salivation, excitation ulceration, swollen papillae and vomiting of fodder (Martinez and Seifert, 1992).

2.2.2.7 Gossypol

Gossypol is present in pigment glands of leaves, stems, roots and seeds. These pigments can exist either in a free form or as a gossypol-protein in complex. It is highly toxic to monogastric animals. Pigs and rabbits are more sensitive than poultry. Horses are resistant. Ruminant are more resistant due to the formation of stable complexes with soluble protein in the rumen which are resistant to enzymatic breakdown. Gossypol form complex with metals like iron and the toxic effect can be overcome by supplementing iron as ferrous sulphate. Whole cotton seed contain a total of 1.09 to1.53% of which free form is 0.19%.

The physiological effects of free gossypol are reduced appetite, loss of body weight, accumulation of fluid in the body cavities, cardiac irregularity, reduced oxygen carrying capacity of the blood and reduced haemoglobin content. Decreased egg size and decreased egg hatchability are also observed. Heat treatment as in the commercial production of cottonseed meal decreases the content of free gossypol. However, availability of lysine is

reduced because of interaction of the aldehyde groups of gossypol with amino group of lysine (Reddy 2007)

2.2.2.8 Tannins

The term tannin was coined by Seguin in 1796. It is a polyphenolic substance with molecular weight greater than 500 (Reddy, 2007). Tannins are water soluble phenol compounds with the ability to precipitate protein from aqueous solution (Aganga *et al.,* 2003). Tannins may be further categorized into hydrosable and condensed tannin. Generally, tree and shrub leaves contain both types of tannins. The two types differ in their nutritional and toxic effects. Mueller-Harvey and McAllen (1992) and Reed *et al.,* (1990) reported that tannins in forage legumes have both positive and negative effect on nutritive value.

Condensed tannins containing forages have different benefits for ruminants, depending on the species of plant. (Abdu *et al.,* 2008) . For example, loitus has been proven beneficial in the prevention of bloat (Beddows, 1956). Other condensed tannins have been efficient at improving live-weight gain (Waghorn *et al*., 1999). In sheep, they have been shown to increase milk protein concentration (Wang *et al*., 1996), improve lambing percentages (Min *et al*., 1999).In sheep (Athanasiadou *et al*. 2000, 2001) and deer (Hoskin *et al.,* 2000). Condensed tannins are capable of reducing parasite infection. Tannins reduce dependence on synthetic anthehelmintics. Which is ecologically sustainable (Abdul *et al.,* 2008).

During disintegration of plant material, such as chewing by ruminants, tannins interact with salivary glycoprotein to form insoluble tannin-protein complexes (Getachew *et al*., 2000). Further binding to protein may occur in the rumen (pH 5.5-7.2) this astringency increase salivation and decrease voluntary feed intake. Donnelly and Anthony (1969) reported that the tannins level required for rejection by grazing animal is about 20mg/g of dry matter. Tannins reduced digestibility of dry matter and nitrogen. Reed (1995), reported negative digestion

coefficients for neutral detergent insoluble nitrogen (NDIN) and Acid detergent lignin (ADL).

A positive mechanism for the defense against the negative effects of tannins in ruminants is the secretion of prolin rich salivary protein and glycoprotein (Getachew *et al*., 2000). Robins *et al.* (1987) carried out studies on deer, sheep and cattle and showed that salivary glycoprotein could be involved in the utilization of forages that contain tannins. Prolin rich salivary protein and glycoprotein have a high affinity for tannins. However, Austin *et al*., (1989) reported that salivary protein from sheep and cattle do not produce tannin binding protein. Beever and Siddons (1985) and Reed *et al*. (1990) hypothesized that tannins increased microbial yield. Tannins in moderate concentration are also reported to prevent bloat (Reed, 1995).

2.2.2.9 Oxalic acid

Plant food stuffs have much oxalic acid. Foodstuffs of animal origin have relatively little oxalic acid. Oxalic acid is present in free and in salt form. It is a dicarboxylic acid $(COOH)_2$.The greater part of oxalic acid in plants is present in the form of soluble oxalates (potassium, sodium and ammonium oxalates) and only 10-20% appears as insoluble calcium and magnesium oxalate especially within the cells. In general young leaves contain smaller quantities than mature leaves. Ageing as well as over ripening of vegetables is accompanied by increase in the proportion of calcium oxalate.

Pigs and poultry are affected by oxalic acid. Growth is depressed and blood calcium is decreased. Animal's response to oxalate poisoning varies with species of animal and species of plant consumed. Thus cattle sheep and horses differ in their responses to oxalate. Cattle fed on paddy straw or other grasses containing 2% oxalate develop negative calcium balance

but sheep is not affected at this level. Rumen micro flora (*Pseudomonas streptomyces*) decomposes much of the soluble oxalate to its calcium salts (Reddy, 2007) .

2.2.2.10 Phytic acid:

Phytic acid is an ester formed by combination of the 6 alcoholic groups of inositol with 6 molecules of hexaphosphoric acid. Hence its name hexaphosphoric acid. Because of the presence of the large number of phosphoric acid radicals, it can form simple salts or mixed salts as well as metabolic or protein complexes. Sodium and potassium salts are soluble. Calcium, iron, magnesium, copper, zinc and lead salts (phytates) are insoluble even at pH 3-4. Phytate phosphorus is a poor source of phosphorus. Seeds of cereals, dried legumes, oilseeds and nuts are rich in phytic acid.

Horses utilize phytate less efficiently than ruminants but more efficiently than pigs. Addition of the enzyme phytase to the ingredients of vegetable origin can increase phosphorus digestibility considerably. Phytase produced by rumen microorganism makes phytin phosphorus available to ruminant's phytic acid depresses the utilization of several mineral elements such as Ca, Mg, Fe, and Zn. It forms insoluble compounds which are eliminated in the faeces. (Reddy, 2007)

2.2.3 Agro-industrial by-products as feed resource

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

The use of these by-products for livestock feeding is justified when the forage supply is inadequate for the animals' needs, either in terms of quantity or quality. Agro-industrial by-products in Nigeria vary from primary processing of farm produce wastes to wastes from

agro allied industries. Some of these wastes are left unutilized, often causing environmental pollution and hazard. Those that are utilized do not have their full potentials harnessed.

Inadequate supply and poor quality feeds are the most limiting factors to increase small ruminant productivity in tropical Africa (Ademosun, 1994). Since the mid-80s, the use of cereal grains and oil seed cakes such as groundnut and cottonseed cake has been on the decline due to spirally inflation and increased competition from humans whose population has increased tremendously. Conventional feed ingredients still constitute the diets of monogastrics e.g. poultry. Presently, the high cost of grains due to competing needs have generated interest in sourcing alternative feed resources to match animal production with available and relatively cheap feedstuffs (Jokhtan, 2001).

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

Alawa and Umunna (1993) reviewed the utilization of agro-industrial by-products and other farm level residues by ruminants. They concluded that inclusion of low quality feedstuff to replace conventional energy source in production rations should not exceed 25-30%, whereas for maintenance rations in ruminants, these levels may be exceeded.

Apart from problems of availability that might limit its usage in some ecological zones of the country, cassava peels have hydrogen cyanide that is toxic to animals. Two processing methods for reducing the levels of cyanide in cassava peel have been investigated. For instant the work of Adegbola *et al.* (1989) indicated that sun-drying of cassava peels reduced

cyanide level by 60% whereas ensiling (for 14 days after initial sun drying for two days to 40%DM) reduced it by 83%. Onwuka *et al, (*2014) demonstrated the effectiveness of elemental sulphur in detoxifying cyanide in cassava flour-based diet for ruminant.

2.2.3.1 Oil seed by-products (Cakes and meals)

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

Cotton seed cake (CSC):

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

In Nigeria, most of the CSC is used in the feeding of ruminants and ruminants can utilize the CSC without dehulling. The most widely used oil seed cake for feeding ruminant animals in Nigeria is undelinted, undecorticated cotton seed cake. This is because of its availability and cost in relation to that of its closest competitor, groundnut cake. The crude protein content of delinted decorticated cotton seed cake (CSC) is about 26%. It is however low in cystine,

methionine and lysine (Ikurior and Fetuga, 1984). The decline in production of cotton in Nigeria has seriously affected the availability of CSC in the country. The use of CSC as ruminant feed is also constrained by its popularity in monogastric diets, which makes the cake to be over priced and very uneconomical for ruminants.

Cotton seed:

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

Groundnut cake (GNC):

Groundnut cake (GNC) is the major plant protein supplement used in Nigeria. The availability of which depends on the production level of groundnut. The unextracted groundnut has about 26 - 30% protein and it mainly consumed by humans. The residue remaining from extraction of oil from groundnut either by solvent or hydraulic method is the groundnut cake. This has a protein content of about 38 - 47%. GNC is palatable. It is however, deficient in lysine, methionine and threonine (Onwuka *et al.*, 2014) .

This is much higher in crude protein (45%) than CSC but it is more expensive and scarce. GNC is highly degradable in the rumen with nitrogen degradable value range of between 0.71 and 0.90 (ARC, 1980). Lufadeju and Olorunju (1986) also reported degradable value of 0.86 for GNC. However, the use of GNC as ruminant feed is not economical because of its high cost.

Soybean cake:

Soya beans are by far the most widely used oil seed protein and as such is assigned the standard against which other plant proteins are compared. The commonest form in which soybean is fed is as soya bean meal after oil extraction by solvent or hydraulic method. Soya bean meal has about 40 - 48% protein depending on the efficiency of oil extraction and whether or not the beans were dehulled (Onwuka *et al.,* 2014).

The crude protein content of soybean meal is about 50%. The cake is considered to be one of the best protein sources because it contains all the essential amino acids, although the quantity of cystine and methionine are sub-optimal. Ruminants generally are not affected by some inhibitory and toxic factors (Trypsin inhibitor) present in soybean. In addition, the lack of Vitamin B12 associated with feeding soybean cake does not affect cattle. However, soybean cake is highly priced making it uneconomical for feeding ruminants.(Lamidi, 2008).

Palm Kernel cake:

Palm kernel cake (PKC) is a product of oil palm processing. It is obtained after oil extraction from Palm kernel. PKC is deficient in lysine, methionine, histidine and threonine. PKC is gritty and high in fibre content (at least 9%).The crude protein content of palm kernel cake (PKC) ranges between14 and 16% (ARC, 1980). The cake is dry and gritty and high in oil content. It is not readily acceptable by all classes of livestock.

The solvent extracted cake is unpalatable and should be increased gradually when fed to livestock. Adult cattle can be fed up to 2-3kg/head/day. The degradation of protein in PKC is low (ARC, 1980). Although, PKC is cheaper than GNC and CSC, the cost of transporting it to the northern parts of the country from the south or the middle belt where it is produced makes it slightly expensive.

Nigeria has been and probably still a leading producer of palm kernel, over 75% of which used to be exported before the installation of processing mills as such a considerable amount

of work has been done on palm kernel meal as feed supplement in Nigeria. PKC is an agro-industrial by- product that is being produced locally; it is easily available and affordable. Its potentials should therefore be exploited fully for sustainable livestock production in Nigeria (Oluwafemi, 2009). According to Sundu *et al.* (2006), palm kernel meal (also called palm kernel cake) is aflatoxin free, palatable and has considerable potential as carbohydrate and protein sources. Umunna *et al*. (1980) studied the utilisation of dietary levels of palm kernel meal (PKM) varying from 0 to 65% by Yankasa sheep in the growth phase (22.0 to 34.0kg and in the fattening phase (31.0 to 38.4kg).

Sunflower meal:

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

2.2.3.2 Agro - industrial by-products of animal origin

By-products from animal origin supply protein or minerals. Most mineral sources are foun in feed of animal origin. Animal proteins are derived from the processing of meat, fish and milk and products of hatchery wastes. By-products from animal's sources which supply minerals include; bone-meal, Oyster shells, Periwinkle shells, Snail shells and Egg shells.

Fishmeal:

Fishmeal is made of dried, ground whole fish or fish cuttings with or without oil extraction. Fishmeal varies in protein between 54 - 75% with about 10% fats, making it a high protein, high energy feedstuff. Fishmeal protein is high in biological value, supplying all the known essential amino acids. It is also an excellent source of minerals including calcium (3 - 6%),

phosphorus (1.5 - 3%) and micro-minerals. It is rich in vit. B12. The main constraint to its use is its high cost. High dietary levels of high fat fishmeal may lead to problems of rancidity in the diet. (Onwuk*, et al.,* 2014) .

Blood meal:

Blood accounts for 7 - 9 % of the animal live-weight and so it can be harvested. Blood meal is essentially boiled and dried. The drying could be done naturally or artificially. Blood meal contains 80 - 82% protein and very little ash. The protein is very high in lysine but deficient in isoleucine. The processing temperature may affect the quality of protein. The protein contained in blood meal has a low digestibility. There is also the fear of disease transmission through the use of blood meal. Well processed blood is however safe for use. Blood meal should not be used beyond 8% inclusion level (Onwuka *et al.,* 2014) .

***Meat meal*:**

Meat meal is made up of trimmings that originate from the slaughter of animals. Meat meal should be devoid of hair, hoof, horn, manure and stomach content. The typical meat meal has 50 - 55% of high quality protein. The level of protein varies with the amount of bone contained in the meal. If the phosphorus content of the meal is more than 4.4%, it is regarded as meat and bone meal and contains 45 - 50% proteins. Meat meal is used at about 7 - 10% dietary inclusion. It is however, virtually not in use in Nigeria as all parts of the animal are virtually consumed (Onwuka *et al.,* 2014).

Feather meals:

Feather meals have protein contents ranging from 85 - 95%. Feather meals cannot be utilized by animals unless it is treated. Hydrolyzed feather results from heat treatment of this by-product under pressure. It is deficient in lysine, methionine and tryptophan. The protein is about 75% digestible. It should be used at low dietary inclusion levels (Onwuka *et al.,* 2014).

Other by-products from animal origin supplying proteins include hatchery waste, insect meal, milk and milk by-products.

Bone meal:

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

Oyster/Periwinkle/Snail/Egg shells:

Oyster/Periwinkle/Snail/Egg shells are all made of calcium carbonate with about 38% calcium. Oyster shell is predominantly used in most feed mills in the country. However, snail shell and egg shell are also excellent sources of calcium and could be used as a substitute for oyster shell (Onwuka, *et al.,* 2014).

By-products which belong to this category include dry rumen content (rumen digesta). At present this is a major abattoir pollutant. Rumen content has the potential as protein supplement. It has CP content of about 16% and can be raised to 34% with the addition of blood (Alhassan *et al.,* 1983).

2.2.3.3 By-products from sugar industry

Molasses:

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

Sugarcane molasses has become an important component of diets for virtually all classes and types of farm livestock. It may be mixed or sprayed unto unpalatable rations to increase palatability and consequently consumption. Molasses is by far the most important by-product of sugarcane because of its high minerals content, energy value and palatability. In ruminant diets, molasses has been utilised at level ranging from 0 to 60% in two growth trials with cattle.(Onwuka, *et al.,*2008). Ani (1980) reported a decrease in DM digestibility of roughage-based diets by cattle as the level of sugar cane molasses increased while Osuji (1993), in a review concluded; on the basis of sheep feed intake data that DM intake generally decreases when molasses contributes more than 50% of the dietary DM.

In another study by Alhassan *et al*. (1987), in which molasses was added to millet straw fed to sheep and goats maximum straw intake was reported at 25% level of molasses addition with corresponding marked improvement in rate of gain. The best feed efficiency was also reported for the 25% molasses level

Bagasse:

Bagasse is another by-product from sugar cane processing. Sugar cane is processed for its sugar which leaves two by-products, molasses and a fibrous residue termed *bagasse* Bagasse is a high fibre, low protein product of very low digestibility which is sometimes mixed with the cane molasses for cattle feeding (Onwuka *et al.,* 2014).

Bagasse is a good source of cellulose but is poor in protein (1.3%) and high in lignin (16%). It has been used successfully as roughage for ruminants. High pressure treatment improves the palatability and digestibility of bagasse (Morrison and brice, 1984). However digestibility of unprocessed bagasse is low because it contains high lignin content (Bhatti and khan 1996)

Tomato pomace contains 14.3% DCP and 65%TDN. After drying and grinding, it can be used as a part of animal feed up to 35% level (Verma, 1997). It can replace satisfactory wheat bran on eqi-weight bases up to one third portion of a concentrate mixture (Ranjhan, 1993)

2.2.4 *Animal wastes*

The most important animal waste used in ruminant diets is poultry litter. The CP content of Poultry litter varies depending on the type of feed offered to the birds (Calvert, 1979). Usually a bird will defecate about ¼ of the quantity of feed consumed as faeces (Ogundipe, Personal communication). Various authors have reported various values of CP for poultry litter. Adegbola *et al*. (1990) reported 16.5% CP for layer litter while Lamidi (1995) reported 17.00 CP %.

Broiler litter has higher CP content than layer litter (Lamidi, 1995). Adu and Lakpini (1983). Devendra, (1978) and Lamidi (1995) all reported 25% CP for broiler litter. Poultry litter is an excellent nitrogen source for rumen microbes and it has been used as a source of nitrogen in ruminant diets containing moderate to high energy levels (El-Sabban *et al.*, 1970; Smith and Calvert, 1976) . Poultry litter is also a source of minerals and vitamins. Utilization of poultry litter in ruminant diets will serve as a means of disposing the huge quantities of the litter produced across the nation. The greatest advantage associated with poultry litter is its low cost, making it very economical to incorporate in ruminant diets. However, because of its low palatability, especially for the layer litter, maximum inclusion rate of 30% has been recommended by Devendra, (1978). Adu and Lakpini (1983) suggested 10% optimum level of inclusion in molasses based diets for sheep.

2.2.4 Crop residues

2.2.4.1 By-products from Roots and Tubers

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

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

Cassava peels:

Cassava peels from gari processing is richer than the cassava pulp in protein, ether extract and ash (Oyenga, 1968). The waste produced from cassava starch or tapioca factories may be used for feeding livestock known as tapioca meals in United States of America, the waste is fed to horses, cattle and pigs substitute for the grain portion of diets (Oyenga, 1968).

Onyuka (1983) suggested 25% inclusion of cassava peels to be best for goats in terms of feed intake and dry matter digestibility. Adebowale (1981) fed fermented cassava peels at levels of 0, 20, 40 or 60% in the diet over 6 month period. The 40 and 60% cassava peel rations had lower digestibility of dry matter, crude fibre and TDN, feed intake, body weight gain and feed efficiency, but had no effects on weights of liver and hides.

2.2.5.3 Sugar Cane Wastes

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

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

2.2.5.4 Cereal Crop Residues

It is known that most of the ruminants in Nigeria are found in the guinea savanna and Sahel zones where they are managed by pastoralists. These zones are the major cereal (sorghum, millet and maize) growing areas of Nigeria. The amount of straws and leaves left in the cereal plants after grain harvest can be estimated. For example in the case of sorghum the ratio of grains to straw is 1:4 at the time of harvest. Thus with a production of about 6 million tons of sorghum in Nigeria, 24 million tons of straw would be available for use in livestock production annually. Also with a ratio of 1.3:1 for leaves and grains in maize 5.2 million tons of leaves would be left behind. In addition to this, there is an estimated amount of over 400,000 tons of maize cobs available for livestock feeding after the necessary treatment. (Reddish *et al.* 1987)

More than 340 million tons of maize stover are produced annually in Africa (Mosi and Butterworth, 1985).The intensification of crop production as a result of population increase has over the years increased the quantity of these maize stover. Shaib *et al.(*1997) gave the production target for the year 2010 of the main cereal crops in Nigeria as million tons of maize, millet, sorghum and rice, respectively per annum. Generally, since the straw: grain ration of these crops is 2:1, about 256,450,000 tons of crop residue was made available. These maize stovers are potential sources of energy for the ruminant-livestock population.

The feeding value of cereal crop residue is, however, limited by major deficiencies of protein, metabolizable energy and minerals (Dutta *et al.*, 1999). The chemical composition and

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

2.2.5.5 Wastes from Legumes

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

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

Cowpea:

The main by-product from cowpea is the remnants of cowpea harvest; include cowpea vines, leaves and husk. Alhassan *et al* (1984) stall-fed cowpea vines, cowpea leaves and cowpea-shells to cattle, sheep and goats in experiments intended to determine the voluntary intake and digestibility of these residues. Sheep and cattle consumed in excess of 1.2% of their body weights of cowpea vines with DM digestibility of 48.8 and 78%, respectively. Although it is likely that animal consuming in excess of 2.0% of their body weight of these residues, notably cowpea leaves and shells may have maintained or even increased their weights.

***Lablab* (*Lablab purpureus*):**

Lablab otherwise known as *Dolichos lablab* has been reported to be one of the most popular leguminous forage species in various parts of the world (Murphy and Colucci, 1999). According to these authors, there are many varieties of lablab that are currently utilized for different purpose, ranging from green manuring to grazing of livestock. Lablab has been known to acclimatize to many tropical and subtropical countries in the world (Purseglove, 1968) .The lifespan of lablab has been found to extend into early dry season in Nigeria (Nworgu and Ajayi, 2005). It is a legume which produces high quality conserved feed (Agishi, 1983; Amodu *et al.,* 2004).

In a study where lablab was used as a supplement to Oat hay, average daily gain in sheep fed the supplement was almost double than that of sheep fed solely the basal diet (Umunna *et al* 1995). Ndlovu and Sibanda (1996) had similar results when sheep fed lablab as a supplement to Zimbabwe scrub land herbage gained a total of 3.1 kg in two months while unsupplemented sheep only gained 1.0 kg. Results from a goat study by Makembe and Ndlovu (1996), showed that maize stover diets supplemented with lablab resulted in better body weight changes of the does, higher kid birth weights, faster growth rates and more milk as compared to traditional small holder practices in which no supplementation was used.

Though lablab is known in many countries and has the capability of being an outstanding resource for agricultural systems in the tropics, it is not being used to its full potential. In many areas where lablab could be beneficial, ability to buy seed is restricted by economic constraints and producers' willingness to take the risk in trying a new practice is guarded by traditional paradigms.

Eno (2009) stated that lablab forage haulms gathered after harvesting the seeds are not as popular as groundnut haulms in the northern region of Nigeria where much livestock activities are practiced. Added that Relying only on the poor quality lablab haulms for rabbit feeding at the end off harvesting period is inappropriate.Hassan (2014) concluded that both the level of awareness and adoption of irrigated leguminous forage such as lablab production were relatively low in all the three states (Kano, Kaduna and Zamfara) where the survey was carried out.

2.2.5 Groundnut (*Arachis hypogea L*)

Groundnut is a small erect or trailing herbaceous legume, about 15 to 60 cm high. The flowers are a typical pea flower in shape, 2 to 4 cm across, yellow with reddish veining. Hypogeal means under the earth after, the pollination, the flower stalk elongates causing it to bend until the ovary touches the ground. Continued stalk growth then pushes the ovary underground where the mature fruit develops into a legume pod. The fruit is a pod with one to five seeds that develops underground within a needle-like structure called a peg. The seeds are rich in oil 38-50 protein, calcium, potassium, phosphorous, magnesium and vitamins (IAN, 2003)

2.2.6 .1 Intercropping Groundnut with cereal crops

The predominant cropping pattern is a mixture of cereal-legume, with maize being the major cereal. Other cereals include sorghum and millet. Elsewhere, groundnut is often grown in

rotation with cotton, tobacco, maize and other cereals and is usually grown late in the rotation (Gram, 1958).

Groundnuts are grown as a sole crop and also intercropped with maize, soybean and cassava. It is also a good intercrop for upland rice, sorghum, okra, sugarcane, and sunflower. To get a good yield however, proper planting distance should be observed along with the other recommended cultural practices. In some areas, they are grown under perennial tree crops such as coconut, oil palm or rubber. Groundnuts when used as intercrop for upland maize and planted along the contour reduce soil runoff. The plant also reduces population of African bollworm because it serves as a hiding place for beneficial insects. .There is an increase in the yield of groundnuts when intercropped with early maturing pigeon pea.(Holbrook, 2003)

2.2.6.2 Cultural practices

To achieve maximum economic yields, weeds must be eliminated. Groundnuts are very poor competitors with weeds during early stages of growth. Weeding should be done early while at the same time earthing up the ridges to encourage "pegging" i.e. young nuts penetration through the soil. Once pegging has started, only hand weeding should be undertaken to avoid disturbing the young nuts or damaging the flowers. Clean weeding should be done up to 6 weeks after which hand weeding should take over.

Nitrogen is the most limiting nutrient for crop production in agro-ecosystems (Singh *et al*., 1990; Ssali and Keya, 1980). This is because atmospheric N and fertilizer N make up the main source of nitrogen in crop production, whilst N is lost through harvested produce, decaying materials, denitrification, leaching and volatilization (Singer and Munns, 1991; Loomis and Connor, 1992).

Nodulation and nitrogen fixation is only effective after three weeks and groundnut respond well to small doses of nitrogen fertilizers at the early stage of growth in some areas. The substantial nitrogen needs of groundnuts are partly satisfied by symbiotic fixation. However, numerous reports in the literature indicate positive responds to an application of N at sowing (starter nitrogen), reflecting the absence of biological nitrogen fixation at the early stages of growth (Piggott, 1960; Ssali and Keya, 1980).

Phosphorus is the major nutrient most needed by groundnuts. Groundnut can utilize phosphorus at lower levels than most crops and there is little response to phosphorus in many areas. However, high economic returns and long residual effects have been obtained from single super phosphate applied at the rate of 5.5 Kg P_2O_5 per acre in northern Nigeria (Groundnut CRSP, 1997). In Sierra Leone, Piggott (1960) reported that the only fertilizers improving yield were calcium, Potassium and Magnesium, the last two elements having no effect alone, but only in the presence of calcium when a combination of all three gave the highest yields. Calcium was found to be effective in improving the shelling percentage by reducing the number of "pops" or empty pods (CIRAD-CORAF, 1988-1995). Piggott (1960) indicated that Calcium was important in pod formation, particularly in large-seeded Virginia varieties and should be applied at the peak of the flowering stage, in the form of $CaSO_4$.

Groundnut also takes up large amounts of potassium, even absorbing more than it can use during the growth stages. It is however found not to show much response to application of potassium fertilizers. Application of K in large quantities can upset the ratio of K: Ca, including uptake of calcium during pod formation (Schilling and Gibbons, 2002).

The only peculiar nutrient requirement is for calcium (Ca) in the podding zone. Calcium is absorbed directly by the pods, if soil moisture is adequate. A shortage of Ca in that zone will result in empty pods. The crop's needs for nitrogen should be satisfied with symbiotic fixation by strains of *Rhizobium* of the cowpea group, so nitrogen fertilisers are not generally

required. In some areas of acid soils, lime is applied to raise the pH and supply Ca. Moisture stress during flowering or pod filling reduces yield so that irrigation during those periods to minimise or eliminate the stress increases production and seed quality. Where yields are unsatisfactory (heavily eroded soils) an application of 200 kg/ha of rock phosphate are recommended (AIC, 2002).

2.2.6.3 Utilisation

Groundnuts have many uses. They can be eaten raw, used in recipes, made into solvents and oils, used in make-up, medicines, textile materials, groundnut butter, as well as many other uses. Popular confections made from groundnuts include salted groundnuts, groundnut butter (sandwiches, groundnut candy bars, groundnut butter cookies, and cups), groundnut brittle, and shelled nuts (plain/roasted). Salted groundnuts are usually roasted in oil and packed in retail-size plastic bags or hermetically sealed cans. Dry roasted salted groundnuts are also marketed in significant quantities. Groundnuts are often a major ingredient in mixed nuts because of their inexpensiveness compared to Brazil nuts, cashews, walnuts,. (FAO.2007).

Although groundnut butter has been a tradition on camping trips and the like because of its high protein content and the fact that it resists spoiling for long periods of time, the primary use of groundnut butter is in the home, but large quantities are also used in the commercial manufacture of sandwiches, candy, and bakery products. Boiled groundnuts are a preparation of raw, unshelled green groundnuts boiled in brine and often eaten as a snack. More recently, fried groundnut recipes have emerged - allowing both shell and nut to be eaten. Groundnuts are also used in a wide variety of other areas, such as cosmetics, nitroglycerin, plastics, dyes and paints (FAO.2007).

2.2.6 Developed Groundnut cultivars

Groundnut cultivars are usually developed for various ecological zones to help improve productivity Lee *et al.* (1991) developed a large seed high yielding Virginia type groundnut variety which has few branches and a high shelling percentage of about 69%. It has a high oil content (53.3%) and a protein content of 23.8% and is resistant to logging. Manoharan *et al.* (1991) developed a drought resistant variety which produces average pod yields of 1.79t and 2.06t/ha under rain fed and irrigation conditions respectively. This matures in 100-105days and its leaves remain green until maturity and pods have 1-3 seeds which ripen at the same time.

Chandra *et.al* (1991) introduced the cultivar "Somnath" which is high yielding, has a shelling percentage of 72.3%. Its pest and disease resistance is however, not superior to those of standard varieties. Another cultivar release in 1989 was ICGV87141 (ICGVS76) by ICRSAT, for cultivation in indias zone five. It is adapted to low input rain fed cultivation. In three years trial, it gave pod yield of 1.2- 2.6t/ha and seed yield of 0.85-2.05t/ha exceeding the standards by an average of 30 and 36% respectively. The seeds contain 43% oil and 20% protein. Hadjichristodoulou (1991) evolved a new cultivar HYQ 25 which out yield the local by 2.3% in pod yield and 6.2% in seed yield. Oil and crude protein contents were similar

Mohapatra *et al.* (1996) conducted a three year trial to find the most suitable kharif groundnut varieties for sandy loams of the North West zone of Orissa. India under rain fed condition. OG-line genotypes were the most promising among the 13 varieties tested of these, OG86-15-1 gave the highest yield (2247kg pods/ha) followed by OG86-12-4 9(2203 kg/ha) and OG86-5-9 (2105 kg/ha) under agronomic practices.

2.2.7 Recommended Groundnut Varieties and their development in Nigeria

SAMNUT – 10 characterised by late maturing 135-150 days, tan and white seed colour and adapted Guinea savannah and forest area of Nigeria. SAMNUT 21 characterised by medium maturity110-120 days, tan and white seed colour and adapted to Sudan and Guinea savannah. SAMNUT 22 characterised by medium maturity 110-120 days with seed colour tan and adapted to Sudan and guinea savannah and SAMNUT 23 referred to as early maturing variety 90-100days with seed colour red adapted to Sudan and Sahel savannah (IAR,2003).

Since 1990, ICRISAT and IAR developed and tested more than 44 groundnut varieties. These Varieties were tested in multi-location trials in partnership with Agricultural Development Programs (ADP) and Sasakawa Global 2000 in many states including Kaduna, Kano, Jigawa and Katsina. Following an on-farm testing program in 2001, 3 groundnut varieties UGA 2 (SAMNUT21); M 572.80I (SAMNUT 22) and ICGV-IS-96894 (SAMNUT 23)) were formally released. In 2003, the groundnut seed project (GSP) started to promote a range of high yielding groundnut varieties resistant to rosette disease with market and farmers' preferred traits through PVS (Participatory varietal selection trials), seed multiplication and delivery systems. Four states were targeted, namely, Kaduna, Kano, Katsina and Jigawa Ndjeunga *et al.* (2010)..

On-farm trials with farmers' management were conducted under the supervision of ADPs, the extension services in Nigeria. Once farmers had selected the preferred varieties, the next task was to increase access to seed of modern varieties and evaluate the size of the seed market. Thus, scientists initiated the sale of small seed packs. Besides, seed was produced through the private sector with seed companies such as Alheri and Premier Seeds, and farmers' associations. Seed was also sold through private company outlets (Ndjeunga *et al.*,2010).

2.2.8 Fodder yield

Groundnut fodder has been widely used as livestock feed supplement in farming systems where the bulk of feed available is from cereal- based crop residues. In farming systems in the northern part of Nigeria, groundnut has been widely cultivated for the dual purpose needs of seed parts of the world today is the perennial groundnut.

Field work on dual purpose legumes by Tanko *et al*. (1990) showed a fodder yield of groundnut ranging from 2.4-5.0 tDm/ha over a period of three years. Most of the leaves were retained at maturity. Relatively higher yields were recorded by Chiteka (1993) with trials involving three cultivars (Flamengo, Makulu Red and Egret) mean hay yields for the three cultivars at 141DAS were 6.5 tDm/ha while CP content gradually decreased from 19.7% at 120DAS to11.8% 160DAS.Suriyajantratong and Sekanas (1985) reported average DM yield for whole groundnut vines ranging from 2282 to 2988 kg/ha. This excludes the roots. The average DM yield for groundnut vine tops (approximately 30cm length from the top of the plant) was 638 kg/ha. Groundnut tops contained more CP 15.1 against 12.1%) but less neutral detergent fibre (NDF) than the whole groundnut vines.

Work on the establishment and yield of forage groundnut has been extensively. The two species commonly cultivated are *Arachis pintooi* and *Arachis glabrata*. Several cultivars of these two species are in use for livestock feeding Forage groundnut is rhizomatous, therefore survives underground in unfavourable conditions. This makes it difficult to eradicate. Enabling it exhibit its perennial characteristics. Under good management it gives high fodder yields and it is persistent in terms of resistance to grazing pressure

Grof (1985) worked on the forage attributes of *Arachis Pintoi* in oxioltype savannah conditions in associated with *brachiaria* spp. Total grass and legume DM yields were 20.5-25.4t/ha yearly. *A. Pintoi* in a mixture yielded 5.2-9.6t/ha yearly when harvested at 4-wk

intervals. Forage yields have been enhanced with fertilizer treatment. This also has a rippling effect on animal performance because of the increase in nutrient uptake by the plants Valentim *et al*. (1987) worked on the yield and quality responses of tropical grasses, a legume and grass/legumes associations as affected by fertilizer nitrogen in field trials. There were remarkable yield increases with fertilizer input. The grass species that gave the highest yields when grown in association with *Arachis glabrata* cultivars .

2.2.9 Performance with animals

Groundnut haulms have widely used in animal feeding with good responses. Their high nutritive value has been reported by Ayoade *et al.* (1983) and Ikhatua and Adu (1984). The fodder could be fed fresh, as silage or as hay. The hay form is the most commonly used in areas of feed shortage in the tropics. Its high crude protein content which varies from 11.4-16.7% in some cultivars (Alhassan, 1985) helps immensely in augmenting protein deficiencies in cereal residue based diets.

Daily gains of 130.7g by lambs were reported by Adu and Lakpini (1983) when the lambs were fed chopped groundnut haulms. This is useful information for crop-livestock farmers especially in northern Nigeria where groundnut haulms are widely used. Apart from fattening, it is used to augment the shortage and low quality of feed prevalent in this area for most part of the dry season.

Work done by Oyawoye *et al.* (1990) on some tropical legumes as replacements for alfafa in rabbit diets proved further the quality of groundnut haulms. Forage meals of groundnut, cowpea (*Vignan unguiculata),* lablab (*Lablab purpureus)* and Stylo (S*tylosanthes hamata)* were analysed for proximate and mineral composition at two stages of growth. They were generally higher in CP, EE and minerals at flowering stage than at maturity. All legumes were fairly high in Ca, Na and K but low in P.

Work on the physical form of haulms with regards to utilisation was conducted by Ayoade and Njewa (1986) in their report on bean Phaseolus *vulgaris* and groundnut haulms. Chopping or grinding did not affect the voluntary dry matter consumption and digestibility coefficient of the nutrients of both feeds by goats. In an earlier study by Ayoade *et al* (1983), residues of groundnut and bean *Phaseolus vulgaris were* evaluated as feed for indigenous Malawian goats. Nutrient in bean haulm were better digested and utilised by goats than those in groundnut haulms. The goats however, met their requirements of dry matter intake and digestible crude protein when adequate amounts of both roughages were made available.

In forage utilisation, species differences as regards performance do occur. Devendra (1982) reported on the utilisation of cassava, pigeon pea, leucaena and groundnut hay by sheep and goats, respectively. He observed a daily goat DM intake of 33.0 to 64.0g/kgw0.75 and 27.8 to 53.7g/kgw0.75 for sheep. Goats had a higher digestibility of DM, organic matter OM , crude fibre CF and higher nitrogen retention than sheep.

McBrayer *et al.* (1982) in their comparison of high quality groundnut hay and Tifton 44 Bermuda grass hay used by 26 crossbred yearling heifers for 84 days. Over average daily weight gain was 0.51 and 0.66kg with groundnut hay and Bermuda grass hay adapting to groundnut hay feeding. Apparent digestibility of DM and nitrogen-free extract NFE were significantly greater for groundnut hay but the digestibility of CF and neutral detergent fibre were significantly greater for Bermuda grass.

In comparing *Digitaria smutsii* hay and groundnut hay, Ikhatua and Adu (1984) reported daily gains by red Sokoto goats of 59g and 88g feed intake 494 and 603 g, feed efficiency 8.4 and 6.8, daily nitrogen N retention 38 and 43g/kgw$^{0.75}$ and apparent nitrogen digested 61.8 and 67.9%, significantly better for groundnut hay. It was concluded that groundnut hay was better and had adequate protein to maintain ruminants

Secondary product of harvest could also be of used in achieving some weight gains at cheaper costs. Herera and combellas (1986) worked on the substitution of *Cenchrus ciliaris* hay for groundnut husks in complete rations for lambs. The lambs were fed a 30% *C ciliaris* hay (b) 15% *C ciliaris* and 15% groundnut husks or (c) 30% groundnut husks. After 63 days. daily live weight gains were 156, 133.8 and 184.5g for (a) (b) and (c), respectively. Corresponding daily intake values were 673, 695, and 755gDM.

CHAPTER THREE

3 MATERIALS AND METHODS

3.1 Site description

The study was conducted at the National Animal Production Research Institute (NAPRI) Shika. Shika is geographically located between latitude 11^0 and $12^{'}59^{''}$N and longitude 7^0 and $33^{'}40^{''}$E, at an altitude of 640m above sea level, about 20km from Zaria town along the Sokoto road in Northern Guinea Savannah zone of Nigeria. The climate is characterized by defined wet season that normally begins in April/May and ends in late September/October. The dry season starts from October to April with a low relative humidity and northeast wind. The total Annual rainfall ranges from 748.6 to 1156.7mm with long term average of 1058.6mm.Highest mean air temperature of 36^0C recorded in April while the lowest mean minimum temperature of about 11.5^0C occurs in December/January (Kowal and Knabe, 1972). The top soil (0-15cm) of the site has 15.5% Clay, 9.8 % Silt, 75.1% Sand, 5.4 pH, 0.1% N, 3.5 (ppm) Zn, 95.7(ppm) P 2.5 meq/100g Ca^{2+}, 0.3 meq/100gK^+ and 0.7meq/100g Mg^{2+} and 0.1 Meq/100g Na^+ , respectively (Akpensuen, 2012).

3.2 Experiment 1: effect of two groundnut variety on forage yield and pod Characteristics in farmer's fields (on- farm)

3.2.1 Experimental details

The First experiment On- farm trial was laid out in a randomized complete block design (RCBD).Ten farmers were randomly identified in shika and five neaby neighbouring villages (Mahuta, Tsibiri, Nasarawa, Anguwar Galadima and Biye) they were given SAMNUT-22, groundnut variety in early June . The variety was evaluated along with Maizabo on farmers' fields. Two demonstration plots size 10m x10m demarcated were also set up at the pilot site using SAMNUT-22 and Maizabo. The seeds were manually sown at the rate of 2 seeds per

hole at intervals of 25cm in rows and 75cm apart, in the month of early June. Inorganic fertilizer (NPK and SPP 2bags /ha each) was applied using top dressing method. Pre-emergergence herbicides (pendimenthalim 4L/ha) was applied immediately after sowing.

3.2.2 Parameters measured

Chemical compositions for the forages and seeds of the two varieties were analysed. Total pod yield total haulm yield seed yields and shelling percentage of the two varieties were determined.

The forage and pod yields of the two groundnut varieties were estimated using a quadrant measuring 1.0m x1.0m in each net plot. The groundnut plants were harvested using hoe and pods were carefully detached from the plants. The two fractions of fresh fodder and fresh pods were separately weighed in the field. Sub samples of the fodder were sun-dried and reweighed to determine the dry forage.

Pod samples were also taken, weighed fresh, sun-dried before dry weights were recorded. The pods from the net plots of groundnuts were each put in open bags and air dried thoroughly to a moisture level of 10% before shelling. After shelling, the shelled nuts were weighed and recorded. The shelling percentage was determined. The weights of pods, forages and seeds harvested from each plot were then extrapolated to total yield per hectare basis.

3.2.3 Chemical analysis

Proximate analysis was conducted on cultivated groundnut forage and seed samples, to determine the Dry Matter (DM), Crude Fibre (CF), Ether Extract (EE), Ash and Crude Protein (CP) (determined by kjeldahl method) using the AOAC, (2000) methods. NFE (Nitrogen free Extract) was determined by calculation. ADF (Acid Detergent Fibre) and NDF (Neutral Detergent Fibre) was analysed using Van Soest, (1991) methods. Mineral components (Ca, Na, P, Mg, and K) were determined according to AOAC, (2000) methods

using the '2380 model of Atomic Absorption Spectrophotometer. Metabolizable energy of the diets was estimated using the method of Pauzenga (1985):

ME (Kcal/kg) = % CP × 37 + EE × 81.8 + NFE × 35

3.2.4 Data analysis

All data generated from the on-farm study were subjected to one-way analysis of variance (ANOVA) of the General Linear Model Procedure (GLM) of the Statistical Analysis System (SAS, 2002). Duncan multiple range tests of the SAS package was used to compare treatment means (Duncan, 1955). All statistical test were done at 5% probability level

The following model was used

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

Where

μ = Overall mean

A_i = Effect of the i^{th} variety (i= 1… 2)

e_{ij} = Random error

3.3 Experiment II: Effect of two groundnut variety and sowing dates on forage yield and pod characteristics in the Nigeria Savannah (on-station)

3.3.1 Experimental details

The on-Station trial was carried out at NAPRI, ABU Zaria. The treatment consisted of a 3x2 factorial combination of 3 sowing dates (June, July and August) and 2 groundnut varieties (SAMNUT-22 obtained from IAR seed store and Maizabo from Sabon Gari market). The treatment Combinations was laid out in a randomized complete block design with replication each plot measure 10m x 10m. The Plots sizes 10mx10m were demarcated for the experiments.. The plots were prepared and ridged using animal drawn implements. The seeds were manually sown at the rate of 2 seeds per hole at intervals of 25cm in rows and 75cm between ridges, in the early month of June, July and August, respectively. Inorganic fertilizer (NPK and SPP 2bags /ha each) was applied using top dressing method. Pre-emergence herbicides (Pendimenthalim 4L/ha) was applied immediately after sowing.

3.3.2 Parameters measured

Chemical compositions of the haulm and seeds of the two varieties for the different planting dates were analysed. Leaves/Stem ratio and total pod yield, total haulm yield seed yields and shelling percentage of the two varieties were determined.

The forage and pod yields of the two groundnut varieties were estimated using a quadrant measuring 1.0m x1.0m in each net plot. The groundnut plants were harvested using hoe and carefully detached the pods from the plants. The two fractions of fresh fodder and fresh pods were separately weighed in the field. Sub samples of the fodder were sun-dried and reweighed to determine the dry haulm yield after which they were separated into leaves and stems. The dry leaves and stem fractions were weighed to determine leaf: stem ration on dry matter basis.

Pod samples were also taken, weighed fresh, sun-dried before dry weights were recorded Number of pods per plant; Pod harvest from three consecutive groundnut plants were counted and the average of this taken as the number of pods plant^{-1}

3.3.3 Chemical analysis

Proximate analysis was conducted on cultivated groundnut forage and seed samples, to determine the Dry Matter (DM), Crude Fibre (CF), Ether Extract (EE), Ash and Crude Protein (CP) (determined by kjeldahl method) using the AOAC (2000) methods. NFE (Nitrogen free Extract) was determined by calculation. ADF (Acid Detergent Fibre) and NDF (Neutral Detergent Fibre) were analysed using Van Soest (1991) methods. Mineral components (Ca, Na, P, Mg and K) were determined according to AOAC (2000) methods using the '2380 model of Atomic Absorption Spectrophotometer. Metabolizable energy of the diets was estimated using the method of Pauzenga (1985):

ME (Kcal/kg) = % CP × 37 + EE × 81.8 + NFE × 35

3.3.4 Data analysis

All Data collected during the on-station studies were analysed using ANOVA of the General Linear Model Procedure of the Statistical Analysis System (SAS, 2002). Duncan multiple range tests of the SAS package was used to compare treatment means (Duncan, 1955). All statistical test were done at 5% probability level

The following model was used

$Y_{ijk}=\mu + A_i + B_j + (A \times B)_{ij} + e_{ijk}$

Where

μ = overall mean

A_i =effect of the variety (i=1-2)

B_j =effect of the planting date (j=1-3)

$(A \times B)_{ij}$ =interaction between planting dates and variety.

e_{ijk} = uncontrollable error

3.4 Experiment 3: The effect of different groundnut haulm on growth performance of Yankasa rams.

3.4.1 Site description

The growth trial was conducted at the Department of Animal Science Teaching and Research Farm, Ahmadu Bello University Zaria. The farm is located at an elevation of 676m, latitude 11.1623^0 North and longitude 007.6353^0 East (GPS, 2012).

3.4.2 Sources of Experimental materials

Groundnut haulms (SAMNUT-22 and Maizabo) from harvest at seed maturity were used for this study and the *Digitaria smutsii* hay were obtained from National Animal Production Research Institute (NAPRI).

3.4.3 Experimental Animals and management

Fifteen Yankasa weaned rams obtained from open market with an average weight of 10.50kg ±2 were used in the feeding trial.They were given prophylactic treatment consisting of ivomectin (Ivomec®) at 0.5ml/25kg body weight subcutaneously against parasites, oxytetracycline (Tridox®) antibiotics at 1.0ml/10kg body weight intramuscularly against bacterial infections one week before the start of the experiment. Other routine management practices include; deworming against intestinal parasites using Albendazole® in which 10% solution was administered in drinking water. Rhodiacides solution was sprayed on the animals using knapsack sprayer against external parasites.

3.4.4 Experimental Feed and Design

The animals were weighed and randomly assigned into three groups with five animals per group in a completely randomized design. The experimental diets consisted of *Digitaria smutsii* hay as basal diet. The basal diets were fed *adlibitum.* In addition, the animals were

offered concentrates (14% CP) which was supplemented with haulm from *SAMNUT 22* and Maizabo of groundnut at 0% (control), and 10 %. The concentrates was fed at the rate of 1% of body weight per head daily, The supplement consisted of other ingredients maize offal (67.84 %), cottonseed cake (30.15%), bone meal (1.50%) and salt (0.5%). Fresh clean water was provided *ad libitum*. Quantity of feed of offered and refused was measured daily to determine feed intake. Animals were weighed bi-weekly and feed adjusted accordingly. The growth trial was lasted for 90 days.

3.4.5 Rumen and blood metabolites

3.2.5.1 *Blood metabolites*

Blood samples were collected from the jugular vein before feeding at the end of the growth trial using disposable syringe into plastic container and then at 4, 8 and 12 hours post feeding to measure, Total Protein (TP), Blood Urea Nitrogen (BUN) and Ammonia Nitrogen concentration. Total protein was evaluated using refractometer as described in the routine laboratory procedures (Cole, 1974) Blood samples were analyzed for urea nitrogen level (BUN) using the procedure of Archer and Robb (1925).

3.2.5.2 *Rumen metabolites*

Rumen liquor was collected using a suction tube before the morning feeding then at 4, 8 and 12 hours post feeding. A digital pH meter was used to determine the rumen fluid pH immediately after collection on the farm. This was strained through double layer cheese cloth and centrifuged at 2500 rpm force for 10 minutes. It was then treated with 100mls of concentrated sulphuric acid (0.1N H_2SO_4) to trap the ammonia and stored in a refrigerator (-20^0 C) until when required for determination of Total Nitrogen (N), Ammonia Nitrogen (NH_3-N) and Total volatile fatty acid (TVAs). Rumen ammonia concentration was

determined by steam distillation into boric acid and back titrated with 0.01N hydrochloric acid, according to the procedure described by Whitehead *et al.* (1976). Rumen fluid pH was determined using Philips digital pH meter (Model 9409).

3.4.6 Digestibility trial

At the end of the growth trial, three animals from each of the treatment groups were randomly selected and housed in individual metabolism crates, ideal for easy collection of urine and faeces as described by Osuji *et al. (*1993). The experimental animals were allowed 14 days to adjust to the metabolism crates, followed by seven days of faecal and urine collection to determine Nutrient digestibility and Nitrogen retention of the experimental diets. During the trial, animals were maintained on similar treatment diets as indicated in the feeding trial.

3.2.6.1 *Faecal collection*

The total faecal output from individual animals was collected daily in the morning, weighed, mixed thoroughly and 10% sub sample taken for DM determination. The total faecal sample collected over the 7 days period was bulked and sub sampled for laboratory analysis after treating with 20% formaldehyde to prevent further bacterial activity.

3.2.6.2 Urine collection

The total urine output for 24 hours was collected from individual animals. This was done by using graduated plastic containers containing 100mls 0.1N H_2SO_4 which was placed under the metabolism crates. Ten per cent of the daily urine output (aliquot) was taken from each ram bulked and stored in a freezer at (- 20 ^oC) .

3.4.7 Chemical analysis

Dry matter content of the feed and feacal samples was determined by drying at 60^0 C for 48 hours. Nitrogen content of the feed samples and urine was determined using Kjeldahl procedure (AOAC, 2000). The feed samples were ashed by charring in muffle furnace at 500^0C for about 3 hour. Ether extract and crude fibre of the samples were analyzed according to AOAC (2000) procedure. The acid detergent fiber (ADF) and neutral detergent fiber (NDF) of feed samples, and feaces were analyzed according to the procedure of Van Soest *et al.* (1991). Metabolizable energy of the diets was estimated using the method of Pauzenga, (1985):

ME (Kcal/kg) = % CP × 37 + EE × 81.8 + NFE × 35

3.2.7 Data analysis

All data generated from the study were subjected to one-way analysis of variance (ANOVA) using procedure of the Statistical Analysis System (SAS, 2002). Data on serum and rumen metabolites were analyzed using repeated measures ANOVA and trend analysis. Duncan multiple range tests of the SAS package was used to compare treatment means (Duncan, 1955).All statistical tests were done at 5% probability level.

The following model was used

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

Where

μ = Overall mean

A_i = Effect of the i^{th} treatment diet (i = 1… 3)

e_{ij} = Random error.

3.5 Experiment 4: The effect of different groundnut haulm on fattening performance of Yankasa rams.

3.5.1 Site description

The experiment was conducted at the Department of Animal Science Teaching and Research Farm. Ahmadu Bello University Zaria. The farm is located at an elevation of 676m, latitude 11.1623^0 North and longitude 007.6353^0 East (GPS, 2012).

3.5.2 Animals management

Twelve yearling Yankasa rams with average live weight of 19 $\pm$ 2kg were purchased from the open market within Zaria. They were given prophylactic treatment consisting of ivomectin (Ivomec®) at 0.5ml/25kg body weight subcutaneously against ectoparasites, oxytetracycline (Tridox®) antibiotics at 1.0ml/10kg body weight intramuscularly against bacterial infections one week before the start of experiment. The animals were dewormed with anthelmintics in form of Albendazole (Valbazen® 7.5mg/kg of body weight) to control endoparasites.

3.5.3 Experimental feed and design

The rams were randomly allocated to three dietary treatments of four animals each in a completely randomised design. The animals were housed in individual pens and each animal was fed 1% body weight of the concentrate mixture (12%CP). The concentrate consisted of maize offal (82.92%), cottonseed cake (15.07 %) , Bone meal (1.0%) and Salt (0.5%) The basal diet *Digitaria smutsii* hay and water were provided *ad libitum* throughout the experimental period. Quantity of feed offered and refused was weighed daily to determine voluntary feed intake. Animals were weighed biweekly and feeding adjusted accordingly. The fattening trial lasted for ninety days.

3.5.4 Carcass analysis.

Three Rams were randomly selected from each treatment at the end of the fattening experiment for carcass analysis. The rams were starved of feed and water overnight to get shrunk body weight before slaughtering. After slaughtering, the external offal (head, limb, tail and hide) were removed and weighed separately. After evisceration the internal offal (liver, spleen, kidney, heart and lungs) were removed and weighed individually. The GIT was weighed with the contents and reweighed after removing. The direct rumen content was measured. The dressing percentage was determined (National livestock and meat board, 1973; Warris, 2000; Aganga *et.al.,* 2003) .Total boneless lean were separated and weighed.

3.5.5 Chemical analysis

Proximate analysis was conducted on , feed samples to determine the dry matter (DM), crude fibre (CF), ether extract (EE), Ash and crude protein (CP) (determined by kjeldahl method) using the AOAC (2000) methods. NFE (Nitrogen free Extract) was determined by calculation. ADF (Acid Detergent Fibre) and NDF (Neutral Detergent Fibre) was analysed using Van Soest *et al.* (1991) methods. Metabolizable energy of the diets was estimated using the method of Pauzenga (1985):

ME (Kcal/kg) = % CP × 37 + EE × 81.8 + NFE × 35

3.5.6 Data analysis

All data generated from the study were subjected to one-way analysis of variance (ANOVA) using procedure of the Statistical Analysis System (SAS, 2002). Duncan multiple range tests of the SAS package was used to compare treatment means (Duncan, 1955). All statistical tests were done at 5% probability level.

The following model was used

$Y_{ij} = \mu + A_I + eij$

Where

μ = Overall mean

A_i = Effect of the i^{th} treatment diet ($i = 1 \ldots 3$)

e_{ij} = Random error

CHAPTER FOUR

4 RESULTS

4.1 Experiment I: effect of two groundnut variety on forage yield and pod Characteristics in farmers' fields (On- farm)

4.1.1 Pod yield

The results of pod yield, haulm yield, seed yield and shelling per cent of two varieties of groundnut affected by variety are presented in Table 4. 1. The result shows that SAMNUT 22 had significantly (P<0.05) higher wet and dry pod yields. The largest dry Pod Yield (5466.7 kg/ha) was produced by SAMNUT 22 and was higher (P<0.05) than4129.2 kg/ha produced by Maizabo .

4.1.2 Shelling percentage (SHE %)

The results of shelling per cent for both varieties are shown in Table 4. 1. Shelling per cent ranged between 56.42 and 62.62 % produced by Maizabo and SAMNUT 22, respectively. There was a significant difference (P<0.05) between the two varieties. SAMNUT 22 recorded the highest shelling per cent of 62.62%.

4.1.3 Haulm Yield.

The dry haulm yield was 9000.0 and 11354.2 kg/ha for Maizabo and SAMNUT-22 respectively. The results were significantly different (P<0.05) across the seasons. The bulkiest dry haulm yield of 11354.2 Kg/ha was produced by SAMNUT 22 which was statistically higher (P<0.05) than 9000.0 kg/ha produced by Maizabo.

4.1.4 Seed yield:

There were no significant differences between the two varieties for seed yield. The SAMNUT 22 produced1069Kg/ ha yield though not significantly higher (P>0.05) than that of Maizabo. Where produced 1016Kg/ ha

Table4.1: Forage, Pod, Seed yield (kg/ha) and Shelling per cent of two groundnut varieties

	Parameters					
	FHY	FPY	DPY	DHY	SEED	SHE%
Variety						
SAMNUT 22	24917.00 [a]	10937.50[a]	5466.70[a]	11354.20[a]	1069.60	62.62[a]
Maizabo	17917.00 [b]	8270.50[b]	4129.20[a]	9000.0[b]	1016.00	56.42[b]
SEM	74.90	96.58	49.39	37.02	27.61	0.11

[a,bc] Mean values with different superscripts within a column differed significantly ($p<0.05$) SEM standard error of means FPY =Fresh pod yield, FHY = Fresh haulm yield, DPY =Dry pod yield , D H Y= Dry haulm yield and SHE=Shelling per cent.

4.2 . Experiment 2: Effect of two groundnut variety and sowing on forage yield and pod characteristics in the Nigeria Savannah (on-station)

Table 4.2 presents the on-station results of haulm yield, pod yield leaf to stem ratio and number of pods plant^{-1} of groundnut as affected by sowing dates and varieties.

4.2.1 Haulm yield:

Haulm yield declined significantly ($P<0.05$) in response to delay in sowing. Dry haulm yields were 4687 and 9750 kg ha^{-1}, obtained in August and June sowing dates, respectively. The results show that groundnut variety significantly ($P<0.05$) affected both wet and dry pod yields. SAMNUT 22 variety was significantly higher ($P<0.05$) than that of Maizabo. Dry haulm yield was 5833 and 8958 kg/ha obtained for Maizabo and SAMNUT 22 respectively and were statistically different ($P<0.05$).

4.2.2 Pod Yield

Table 2 indicates the on-station results of total haulm and pod yield (kg//ha) of groundnut as affected by the different varieties and sowing dates. SAMNUT 22 out yielded Maizabo. The Dry Pod yield obtained in this study ranged from 4580.3 to 5830.3 kg/ha dry pod yield declined significantly ($P<0.05$) with delayed sowing date. The dry pod yield harvested in mid June (5875kg/ha) was higher ($P<0.05$) than the values obtained in mid August (4437kg/ha) but similar ($P>0.05$) to 5312.5 kg/ha obtained in mid July.

4.2.3 . No of Pods /Plant. (NP/P)

The on-station results of number of pods per plant of groundnut as affected by different sowing dates are shown in Table 4. 2. The results very significantly different ($P<0.05$). The largest number of Pods occurred in June and July (78.34 and 66.87 kg/ha respectively) which were statistically similar ($P> 0.05$). The least (25.77) was in August and statistically different ($P< 0.05$). The number of pods per plant declined significantly ($P<0.05$) with delayed sowing and steadily as sowing was delayed from June through August.

Table4. 2:Fresh pod, fresh haulm, dry pod, dry haulm yield (kg/ha), leaf stem ratio per cent and number of pod per plant of groundnut as affected by the dates of sowing and two ground varieties

	Parameters					
	FPY	FHY	DPY	DH Y	LS	NP/P
Sowing dates						
June	19375.00[a]	37560.00[a]	5875.00[a]	9750.00[a]	48.05[b]	78.34[a]
July	16250.00[a]	33375.00[ab]	5312.50 [a]	8125.00[a]	49.33[b]	66.18[a]
August	9375.00[b]	27500.00[b]	4437.50[b]	4687.00[b]	62.43[a]	25.77[b]
SEM	123.47	322.26	38.19	60.70	0.30	0.35
Varieties						
SAMNUT22	17083.00[a]	37917.00[a]	5830.30[a]	8958.00[a]	55.15[a]	30.32[a]
Maizabo	12917.00[b]	27667.00[b]	4580.30[b]	5833.00[b]	51.39[b]	22.45[b]
SEM	134.47	320.16	68.70	161.13	0.30	0.35

[a,bc] Mean values with different superscripts within a column differed significantly (P<0.05)SEM standard error of means ,FPY =Fresh pod yield, FHY = Fresh haulm yield, DPY =Dry pod yield and DHY = Dry Haulm yield

Results of number of pods plant^{-1} at NAPRI as affected by ground varieties are presented in Table.4.2. Number of pods plant^{-1} ranged between 30.32 and 22.45 plant^{-1}. There was significant difference between the two varieties. SAMNUT-22 recorded the highest number (30.32) of pods plant^{-1} which was higher ($P<0.05$) than that produced by Maizabo.

4.2.4 Leaf to Stem Ratio (L: S)

Results of leaf to stem ratio as affected by sowing dates are presented in Table 4.2.The leaf to stem ratio declined significantly ($P<0.05$) with early sowing. Actually Leaf to stem ratio increased steadily as sowing was delayed from mid-June through mid-August. The results were different ($P<0.05$) across the sowing dates. The leaf: stem in August was higher ($P<0.05$) than the values obtained in June and July but the two later were statistically similar ($P>0.05$).

Table 4.2 shows the results of leaf to stem ratio as affected by groundnut varieties. SAMNUT 22 had the higher leaf to stem ratio compared to Maizabo with 51.39% and were different ($P>0.05$).

4.2.5 Nutrients and minerals composition

4.2.4.1 Haulm

Table 4.3 shows the effect of sowing dates and varieties on nutrients and mineral composition of groundnuts haulm cultivated at NAPRI. The DM and CP were in the range of 93.28 to 94.40%, and 14.65 to 16.92% respectively. The CP contents recorded in mid-august was significantly higher ($P<0.05$) than the value obtained in mid-July but statistically similar ($P>0.05$) to the value analysed in mid-June (Table4.3). However, ASH, NFE, NDF, ADF, LIG and mineral composition exhibited no significant differences irrespective of the sowing dates.

The effect of variety on nutrients and minerals contents of groundnut haulm are presented in Table 4.3.The lowest CP, CF and ADF contents13.37%, 25.13%, and 36.52%, respectively, were obtained in Maizabo The DM CP and CF contents (94.27 18.56 and 31.48 % respectively)were higher in SAMNUT-22. The results showed significant differences between varieties ($P<0.05$).

The results of mineral contents as affected by variety are also summarised in table 4. 3. There were significant differences ($P<0.05$) between the two varieties. All the mineral contents except Ca content obtained in this study were significantly higher ($P<0.05$) in SAMNUT-22 than the Maizabo,

Table 4. 3: Chemical and minerals composition of groundnut haulm due to sowing dates and variety of ground at NAPRI shika .

	Chemical composition (%)									minerals (%)			
	DM	**CP**	**EE**	**CF**	**Ash**	**NFE**	**NDF**	**ADF**	**LIG**	**Ca**	**P**	**Mg**	**K**
Sowing dates													
June	94.14^{a}	16.32^{a}	3.67^{a}	28.34^{ab}	8.55	43.10	28.73	31.58	5.60	8.47	1.16	2.16	14.29
July	94.40^{a}	14.65^{b}	3.29^{ab}	29.43^{a}	8.73	44.02	28.65	31.14	5.72	8.85	1.13	2.20	14.16
August	93.28^{b}	16.92^{a}	2.8^{b}	27.14^{b}	8.79	43.96	28.40	31.50	5.89	9.30	1.14	2.19	13.99
SEM	0.02	0.04	0.02	0.05	0.03	0.05	0.07	0.04	0.01	0.03	0.06	0.06	0.02
Variety													
SN22	94.27^{a}	18.56^{a}	2.13^{b}	31.48^{a}	11.32^{a}	36.16b	30.67^{a}	45.03^{a}	7.85^{a}	1.60^{b}	2.1^{a}	4.02^{a}	2.60^{a}
MZ	93.61^{ab}	13.37^{b}	4.40^{a}	25.13^{b}	6.05^{b}	51.22^{a}	36.52^{b}	17.78^{b}	3.62^{b}	1.73a	0.14^{b}	0.35^{b}	2.29^{b}
SEM	0.03	0.05	0.03	0.07	0.04	0.07	0.10	0.05	0.02	0.05	0.008	0.008	0.03

^{a,bc} Mean values with different superscripts within a column differed significantly ($p<0.05$)SEM standard error mean, SN22= SAMNU22, MZ= Maizabo.

4.2.4.2. Seeds

The Chemical and mineral compositions of cultivated groundnuts seeds are shown in Table 4.4. The DM, CP, CF EE Ash and Mineral contents were not significant (P>0.05) irrespective of their sowing dates. June planted groundnut recorded the highest values of NFE and which was higher (P<0.05) than the values obtained in August and similar (P>0.05) to the values recorded in July. (Table4.4)

The per cent chemical composition and minerals of groundnut Seeds as affected by the variety are also indicated in Table 4.4. The crude protein content ranged between 18.56 – 19.96% .SAMNUT 22 recorded the highest CP content of 19.96% and the lowest value18.56% was recorded in Maizabo. The ash content of the different varieties ranged between 11.33 – 16.13%. SAMNUT-22 had the highest ash contents of 16.13%. There were no significant differences (P> 0.05) between the two varieties for NFE, but all other nutrients and minerals differed significantly (P<0.05). The P and K values obtained in SAMNUT-22 were significantly higher P<0.05). than the values recorded in Maizabo. Maizabo recorded higher Mg (4.02%) compared to the values obtained in SAMNUT-22(1.94%) and was statistically different (P<0.05).

Table 4. 4: Chemical and mineral composition of groundnut seeds at NAPRI Shika

	Chemical composition (%)									minerals (%)			
	DM	CP	EE	CF	ASH	NFE	NDF	ADF	LIG	CA	P	MG	K
Sowing dates													
June	90.15	19.43	21.38	16.47	6.56	37.01[a]	25.20	37.30	5.76	1.47	2.29	2.95	7.52
July	89.80	18.86	20.95	16.55	6.52	35.60[b]	25.50	37.74	5.59	1.32	2.49	3.01	7.47
August	90.00	19.48	20.99	16.01	6.33	35.67[a]	25.24	37.75	5.94	1.35	2.42	2.96	7.81
SEM	0.03	0.02	0.02	0.04	0.02	0.03	0.05	0.03	0.09	0.02	0.009	0.008	0.006
Variety													
SN22	89.39[b]	19.96[a]	40.09[a]	18.11[b]	16.13[a]	36.03	19.96[b]	30.16[b]	3.68[b]	1.42[a]	2.55[a]	1.94[b]	12.23[b]
MZ	90.63[a]	18.56[b]	21.30[b]	31.48[a]	11.33[b]	36.16	30.67[a]	45.03[b]	7.85[a]	1.34[b]	2.26[b]	4.02[a]	2.98[a]
SEM	0.01	0.05	0.03	0.03	0.06	0.03	0.0	40.07	0.05	0.01	0.01	0.009	0.02

[a,bc] Mean values with different superscripts within a column differed significantly (P<0.05)SEM= standard error of mean,

4.3 Experiment 3: The effect of different groundnut haulm on growth performance of Yankasa rams.

4.3.1 Chemical composition of the experimental diets

The chemical compositions of the growth trial diets are presented in Table 4. 5. The dry matter (DM) content of the diets ranged from 88.69% - 89.91%. The CP contents decreased slightly with inclusion of Maizabo of groundnut haulm. The CP ranged between 13.71% and 13.92%. In contrast, the levels of acid detergent fibre (ADF) increased with inclusion of groundnut haulm. The least gross energy content of the diets was in 10% SAMNUT-22 diet. The cost per kg of feed contents decreased slightly with inclusion of groundnut haulm. The SAMNUT-22 variety had the least feed cost per kg of feed.

4.3.2 Dry matter intake (DMI)

The results of the feeding trial (Table 4.6) showed that DMI was highest (1113.23g) in rams fed 10% SAMNUT-22 variety followed by (1102.28g) 10% Maizabo in the supplement and were not different ($p > 0.05$) but higher ($p < 0.05$) than the control diet (1043.59g). Animals fed diet containing Maizabo variety of groundnut had the highest supplement intake (393.81g) and *Digitaria smutsii* hay intake (798.63g) of which was significantly higher compared to control but similar to 10% SAMNUT-22 level of inclusion in concentrates diet .The least was recorded in animals fed in control diets.

4.3.3 Weight changes in Yankasa Rams

The results of weight change are presented in Table 4.6.There were no significant differences ($P>0.05$) in the initial and final weight, irrespective of dietary treatments. Treatment diets with 10% SAMNUT-22 level of inclusion in concentrates had the highest weight gain of 6.2Kg although ($P>0.05$) similar to those rams fed 10% Maizabo. Even though the weight gain seems to decrease a little in rams fed 10% Maizabo levels of inclusion (5.92kg) but this value was numerically higher than those animals in control diets. The Average daily gain of

63.71, 65.77 and 68.88g, respectively for control, 10% of Maizabo and SAMNUT-22 level of groundnut haulm in concentrate diets, respectively are shown in Table 4.6. Rams fed diet containing 10% of SAMNUT-22 inclusion in concentrate significantly out weighed ($P<0.05$) the control diets (63.71g)

Table 4.5: Ingredient composition of concentrates containing

Varying level of groundnut haulm for growth trial

Parameter	Per cent of different varieties of groundnut haulm 0%	10% Maizabo	10% SAMNUT-22
Groundnut haulm	0.00	10.00	10.00
Maize offal	67.84	58.48	59.90
Cottonseed cake	30.15	29.51	28.09
Bone meal	1.50	1.50	1.50
Salt	0.50	0.50	0.50
Total	99.99	99.99	99.99
Cost/kg of feed **(N)**	40.24	38.14	37.73
ME(kcal/kg calculated)	3504	3309	3308
Analysed chemical composition of experimental diets (%)			
Dry matter (DM)	88.91	89.02	88.69
Crude protein (CP)	13.86	13.71	13.92
Ether Extract (EE)	12.51	11.78	11.85
Crude fibre (CF)	9.26	13.29	13.20
Nitrogen Free Extract (NFE)	56.03	52.42	52.76
Acid detergent fibre (ADF)	35.57	35.79	35.75
Neutral detergent fibre (NDF)	60.79	58.73	58.68

Table 4. 6:The effect of feeding different varieties of groundnut haulm on feed intake and growth performance of Yankasa rams fed *D smutsii* hay as basal diet

	Per cent of different varieties of groundnut haulm			
Parameter	**0%**	**10% Maizabo**	**10% SamnutN22**	**SEM**
Intake (g/d)				
Supplement	371.39[b]	393.81[a]	388.58 [a]	2.6
D smutsii hay	750.5[b]	798.63[a]	792.01[a]	5.12
TDMI	1043.59[b]	1102.28[a]	1113.23[a]	7.15
Body weight change (Kg)				
Initial	11.52	11.48	11.4	0.17
Final	17.26	17.40	17.60	0.18
Weight change (Kg)	5.74[b]	5.92[ab]	6.20, [a]	0.16
ADG(g/d)	63.71[b]	65.77[a]	68.88[a]	2.0
FCE DMI/ADG (g)	16.38[b]	16.75 [c]	16.16 [a]	0.08

[a,bc] Mean values with different superscripts within a row differed significantly (P<0.05)SEM standard error of means, TDMI = Total dry matter intake, ADG =Average daily gain, FCE= feed conversion efficiency**.**

4.3.4 Blood Metabolites

4.3.4.*1 Blood glucose*

Table 4.7 shows the results of blood metabolites (glucose, blood urea nitrogen and total protein) as influenced by two varieties of groundnut haulm. The parameters measured differed significantly ($P < 0.05$) The rams fed the control diet had the highest serum glucose level (4.0 Mmol/L) followed by the animals fed the diet containing 10% Maizabo inclusion (3.86 Mmol/L) at 4 hours post feeding (Table 4.7). The blood glucose sharply increased at 4 hours post feeding reached the peak and sharply dropped at 8 hours post feeding. The trend in concentration looked similar for all the treatments over time.

4.3.4.2 *Total protein (TP)*

The results of Total protein (TP) are presented in table 4.7.The total Protein recorded in this study ranged from 4.72 to 5.3 Mmol/L .The results showed that overall TP concentration was significantly different ($P < 0.05$) due to dietary treatments and sampling time The rams fed group on the control diets and 10% SAMNUT- 22 inclusion level of groundnut haulm in the supplement had the highest level of total blood protein (5.32 Mmol/L) at 4 hour post feeding and were significantly different ($P<0.05$). The total protein of all treatments increased and reached the peak at 4 hours post feeding while it declined at the 8 hours post feeding.

4.3.4.*3Blood urea nitrogen (BUN)*

The results of the blood urea nitrogen (BUN) are presented in Table.4. 7. The result shows that overall BUN concentration was significantly ($P<0.05$) affected by dietary treatments before feeding and at 4 hour- post feeding. The BUN ranged between 1.3 to 9.4 mmol/l (Table 4. 7) . The highest BUN value

was recorded in rams on 10% Maizabo inclusion (9.4 Mmol/l). The least value was obtained in rams on control diet. (as shown in Table 4.7) and were significantly different ($P<0.05$) among the various treatments

The trend of BUN in shows that BUN increased sharply after animal were fed with the experimental diets (4 hours post feeding) but slightly decreased at 8 hours post feeding and eventually dropped (12hours post feeding).

Table 4. 7: The effect of feeding different varieties of groundnut haulm on blood metabolites in Yankasa rams fed *Digitaria smutsii* hay as basal diet.

		per cent of different varieties of Groundnut haulm			
Parameters		**0%**	**10%Local Varity**	**10%SAMNUT-22**	**SEM**
	Hrs				
Glucose (Mmol/L)	0	2.08[a]	1.92[b]	1.08[c]	0.05
	4	4.00[a]	3.86[b]	3.70[c]	0.04
	8	1.36[a]	1.34[b]	0.74[c]	0.05
	12	1.04[a]	0.84[b]	1.36[c]	0.04
BUN(Mmol/L)	0	3.90[b]	4.40[a]	4.70[a]	0.16
	4	7.80[b]	9.40[a]	7.70[b]	0.16
	8	7.60[a]	1.50[b]	6.30[a]	0.22
	12	2.00[a]	1.30[b]	2.60[a]	0.11
TP(Mmol/L)	0	5.16[a]	5.12[a]	4.92[b]	0.05
	4	5.32[a]	5.20[b]	5.32[a]	0.04
	8	5.30[a]	4.72[c]	5.16[b]	0.04
	12	5.24	4.92	4.80	0.82

[a,bc] Mean values with different superscripts within a row differed significantly (P<0.05) SEM standard error of means BUN= Blood urea nitrogen, TP = Total protein, MZ= Maizabo and SN22=SAMNUT-22.

4.3.5 Rumen metabolites

4.4.5.1 *pH value of rumen metabolites*

The results of rumen liquor metabolites are shown in Table 4.8. Rumen pH was in the range of 6.38 to 6.74 .There was significant variation ($P<0.05$) in rumen pH between treatments and time of sampling. The pH differed significantly with highest value of 6.74 in the diet containing 10% SAMNUT 22 inclusion compared pH value was observed in the control 6.40 .Sampling time significantly ($P<0.05$) influenced rumen pH. The rumen pH at 8 hours post feeding was higher than the values obtained at 0 and 4 hours post feeding (6.54 and 6.64 respectively).

4.4.5 .2 *Ruminal Ammonia Nitrogen (NH_3-N)*

The results of ruminal ammonia nitrogen concentration are presented in Table 4.8.Ruminal NH_3-N concentration was higher in 10% SAMNUT-22 and 10% Maizabo groundnut haulm inclusion level in supplement (29.38 and 24.89 mg/100ml respectively), than in control treatment (23.66 mg/100ml).and were different across the treatments ($P<0.05$). The result of this study showed that rumen NH3-N concentrations were significantly ($P<0.05$) different both across the treatments and time of sampling.

The NH_3-N increased with sampling time, recording its lowest value 4 hours post feeding and peak value at 12 hours post feeding in rams fed 10% SAMNUT-22. The peak NH_3-N concentration time at 12 hours showed that NH_3-N concentration increased with increasing sampling time

4.4.5.3 *Total Volatile Fatty acids (TVFAs)*

The average concentrations of ruminal TVFAs are presented in Table 4.8. The TVFAs recorded in the present study ranged from 36 to 58.8 (Mmol/100ml)..there were significant

difference ($p<0.05$) in the total VFA concentration among treatment groups in response to type of diets given .The Total volatile fatty acids (TVFAs) were higher in the control diet than in treatment diets (10% Maizabo and SAMNUT-22 treatment) . The least was obtained in animal fed10% Maizabo levels of inclusion. The $TVFA_S$ recorded in the present study ranged from36 to 58.8. (Mmol/100ml)

There was significant effect on TVFA concentration in the rumen. It decreased until it reached 8 hours post feeding after which it increased. The trend in concentration looked similar for all the treatments over time.

Table 4.8: The effect of feeding concentrates diets containing different varieties of groundnut haulm on rumen metabolites in Yankasa rams

		Inclusion level of two varieties of groundnut haulms			
Parameter		**0%**	**10% Maizabo**	**10% SAMNUT-22**	**SEM**
	hrs				
NH_3-N (Mg/100ml	0	23.66[b]	19.62[c]	27.70[a]	0.82
	4	13.84[c]	15.95[b]	18.96[a]	0.37
	8	18.96[c]	24.89[b]	26.31[a]	0.72
	12	17.76[c]	22.34[b]	29.38[a]	0.85
TVFAS(Mg/100ml)	0	58.80[a]	47.40[c]	51.80[b]	1.00
	4	56.20[a]	50.40[b]	50.40[b]	0.92
	8	44.20[a]	38.40[b]	28.40[c]	1.12
	12	47.00[a]	36.00[c]	44.20[b]	0.88
N (mg/100ml)	0	0.06	0.070	0.06	0.01
	4	0.07[a]	0.05[b]	0.07[a]	0.001
	8	0.07[a]	0.06[b]	0.06[b]	0.0011
	12	0.06[c]	0.07[b]	0.08[a]	0.0009
pH	0	6.40	6.56	6.38	0.02
	4	6.42[c]	6.56[a]	6.50[b]	0.01
	8	6.60	6.72	6.74	0.32
	12	6.58[c]	6.64[b]	6.70[a]	0.01

[a,bc] Mean values with different superscripts within a row differed significantly (P<0.05)SEM standard error of means NH3-N = Ammonia Nitrogen, TVFA = Total Volatile fatty acids, N = Nitrogen, MZ= Maizabo and SN22=SAMNUT-22

4.3.6 Nutrient digestibility and nitrogen retention

4.3.7 Nutrient digestibility

Mean values for the digestibility of nutrients are presented in Table 4.9. The dry matter digestibility of rams fed 10% SAMNUT 22 diet was at par (P>0.005) with those on the control diet. However, rams fed 10% SAMNUT 22 diet had 46.45% higher (P<0.05) dry matter digestibility compared (30.54%) to those rams fed 10% Maizabo groundnut haulm. Digestibility of crude protein (CPD) increased in the diets with 10% SAMNUT-22, and slightly declined in diets with at 10 % Maizabo (Table 9).

Digestibility of ether extract increased with 10% levels of SAMNUT-22 in the diets, the range was between75.66% and 80.95% for the control diet and 10% SAMNUT-22 diets respectively. The differences in the digestibility of ether extract between control and diet containing 10% Maizabo were statistically similar (P>0.05).The digestibility of ADF and NDF were significantly (P<0.05) affected by 10% inclusion levels of groundnut in the diet

Table 4. 9: The effect of two varieties of groundnut haulm on digestibility Coefficient and nitrogen balance of Yankasa rams fed *Digitaria smutsii* hay

	Per cent of inclusion level of groundnut haulm varieties			
Parameters	**(0%)**	**(10%Maizabo)**	**(10% SAMNUT 22)**	**SEM**
Digestibility coefficient *(%)*				
Dry Matter	46.44[a]	30.54 [b]	46.45[a]	1.04
Organic Matter	51.13[a]	34.76[b]	49.20 [a]	1.01
Crude Protein	56.76[b]	56.68[b]	59.78[a]	0.45
Ether Extract	76.99[b]	75.65 [b]	80.94[a]	0.51
Crude Fibre	52.89[a]	49.86[b]	51.5[ab]	0.15
Nitrogen Free Extract	56.77[b]	54.24c	59.18[a]	0.55
Acid Detergent Fibre	67.58[b]	76.40[a]	79.76[a]	1.25
Neutral Detergent Fibre	40.02[b]	40.31[b]	44.94 [a]	0.54

a, b, c means within the same row bearing different superscript are significantly differed (P<0.05) SEM= standard of error of means

4.3.5.2 *Nitrogen balance*

The results of nitrogen balance study are summarized in Table 4.10. Rams on control diets, had the highest nitrogen loss in faces, urine and total nitrogen and which was significantly ($P<0.05$) higher compared to the other groups. The quantity of nitrogen retained by the rams increased significantly ($P<0.05$) with the inclusion of 10% of SAMNUT-22 (11.68g) which was significantly higher than those fed 10% Maizabo (9.94g). Nitrogen retention was higher in of rams on diets containing 10% SAMNUT-22 level

When the quantity of nitrogen retained was expressed as per cent of nitrogen intake, rams on the diet containing 10% SAMNUT-22 had the highest nitrogen retained (52.36%), and it was statistically different ($P<0.05$) compared to those of rams on the control diet (46.97%) and 10% Maizabo (48.48%), respectively. Rams on control diets and diets containing 10% Maizabo had the least ($P<0.05$) per cent of nitrogen retention.

Table4. 10: The effect of feeding different varieties of groundnut haulm on nitrogen balance of Yankasa rams fed *Digitaria smutsii* hay

	Per cent of inclusion level of groundnut t varieties haulm			
Parameters	**0% Control**	**10%Maizabo**	**10% SAMNUT 22**	**SEM**
Nitrogen balance, g/day				
Nitrogen Intake	22.50[a]	20.50[c]	22.43[b]	0.03
Nitrogen losses in Urine	1.930[a]	1.62[c]	1.75[b]	0.004
Nitrogen losses in faeces	10.00[a]	8.87[b]	9.00[b]	0.01
Total nitrogen lost	11.93[a]	10.56[c]	10.75[b]	0.02
Nitrogen absorbed	13.31[a]	11.56[b]	13.37[a]	0.02
Nitrogen balance	10.57[a]	9.94[b]	11.68[a]	0.02
N retained as % of intake	46.97[b]	48.48[b]	52.36[a]	0.27

NOTE: a, b, c and d means within the same row bearing different superscript are significantly differed (p<0.05) SEM: standard error of means

4.3.8 Cost benefit analysis

The results of economic analysis of the growth trial are presented in Table 4.11. The cost of the supplementary diets decreased from ₦40.28 in the control diet to N37.73 in 10% inclusion level of SAMNUT-22. Cost of total feed consumed decreased in the SAMNUT-22 diet. The result of the value of gain shows that the control diet had the lowest value of gain of N3788 while the highest value of mutton income over fed cost was recorded in rams fed 10% SAMNUT- 22 (N357) inclusion level in concentrates.

Table 4. 11: Cost benefit of feeding haulms of groundnut varieties on growth performance of Yankasa fed *Digitaria smutsii basal diet*

	Inclusion levels of haulm of groundnut of different varieties		
Parameter	**0%**	**10% Maizabo**	**10% SAMNUT-22**
Feed cost/kg (N=)	**40.28**	**38.14**	**37.73**
Total cost of feed consumed (N)=	**3766**	**3775**	**3735**
Value of gain (N)	**3788**	**3907**	**4092**
Income over feed cost (N)	**22**	**131**	**357**

.

4.4 Experiment IV: The effect of different groundnut haulm on fattening performance of Yankasa rams.

4.4.1 Feed ingredients and nutrient composition of the experimental diets

The feed ingredients and chemical composition of experimental diets for fattening trial are presented in Tables 4.12.The CP contents of the experimental diets were similar across the treatments. The highest ME content was obtained in control diets (3483 KCAL/KG) followed by (3289 Kcal/ kg) 10% SAMNUT-22 groundnut haulm inclusion level in the supplementary diets. The NDF, EE and NFE of the experimental diets decreased while DM and CF content increased with inclusion level of groundnut haulm in the diets.

4.4.2 Dry Matter intake (DMI)

Table:4. 13 shσws the results of feed intake and growth rate of Yankasa ram fed two varieties of groundnut haulms. Rams fed 10% SAMNUT-22 inclusion in concentrates diets had higher intake of supplement (689.21g) compared to rams fed 10% Maizabo (567.86g).among the groups.

Table 4.12: Ingredient composition of concentrates diets containing groundnut haulm supplement and control for fattening trial

	Per cent of different varieties of groundnut haulm		
Parameter	**0%Control**	**10% Maizabo**	**10% SAMNUT-22**
Groundnut haulm	0.00	10.00	10.00
Maize offal	82.92	73.78	75.20
Cottonseed cake	15.07	14.21	12.79
Bone meal	1.50	1.50	1.50
Salt	0.50	0.50	0.50
Total	99.99	99.99	99.99
Cost/kg of feed (N)	36.12	33.74	33.34
ME(kcal/kg calculated)	3483	3288	3289
Analysed chemical composition of experimental diets (%)			
Dry matter	87.94	88.13	88.08
Crude protein	11.75	11.92	11.93
Ether Extract	10.10	9.54	9.36
Crude fibre	7.54	11.58	11.51
Nitrogen Free Extract	62.96	59.35	59.67
Acid detergent fibre	35.05	35.27	35.25
Neutral detergent fibre	63.59	61.33	61.5

4.4.3 Live Weight change in Yankasa rams

The results of weight change are presented in Table 4.13.There were no significant differences (P>0.05) in the initial, live weight of the treatments group. Rams on control diets had the highest (P0<05) weight change of 5.87kg followed by the rams on 10% SAMNUT-22 (5.37kg). However, they were not different (P>0.05) . The ram fed 10% Maizabo recorded the least weight change (3.10kg) which was statistically lower (p<0.05) compared to control group.

Table 4.14: Effect of supplementation of two groundnut haulm varieties in concentrate diets on performance fattening response in Yankasa rams fed basal diets of *D smutsii* hay

	Per cent of two varieties of groundnut haulm			
Parameter	**control**	**10% Maizabo**	**10% SAMNUT-22**	**SEM**
Intake (g/d)				
Supplement	564.12	567.86	689.21	107.92
Digitaria smutsii hay	1275.65^{a}	1207.21^{b}	1227.44^{a}	8.76
TDMI	1715.40^{b}	1657.10^{c}	1784.90^{a}	14.17
Body weight change (Kg)				
Initial	18.75	18.75	19.00	0.17
Final	24.62^{ab}	21.85^{b}	25.37^{a}	0.19
Weight change (Kg)	5.87^{a}	3.10^{b}	4 .37^{ab}	0.12
ADG(g/d)	65.27^{a}	34.44^{b}	59.72^{ab}	1.39
FCE DMI/ADG (g)	16.38^{c}	48.11^{a}	29.88^{b}	0.02

^{a,bc} Mean values with different superscripts within a row differed significantly (P<0.05)SEM= standard error of means.

4.4.4 Carcass analysis

The results of carcass yield are presented in Table 4.14. There were significant differences (P>0.05) among treatments for slaughter weight, empty body weight, hot carcass weight and dressing per cent, respectively. The rams fed 10% SAMNUT-22 diet obtained the highest hot carcass weight (10 Kg,) followed by those on control (9.5kg) diet while the lowest hot carcass weight (9.25 Kg) was recorded in Rams fed 10% Maizabo in concentrate diets and were significantly different (P<0.05).

No significant (P>0.05) difference in dressing Per cent was observed between the Control and the rams on 10% SAMNUT-22 (Table 4.13). The rams on the control group achieved the highest dressing Per cent (43.62 %) compared to other groups. The least per cent was obtained by the rams fed 10% Maizabo (42.07g)

The result on table 4.14 showed that there were significant differences (P<0.05) among the treatment groups for total muscles and total bones yield across the treatment .Rams fed control diet and 10%SAMNUT-2 2diets appeared to have higher values of total muscles and meat yield per cent. While rams fed 10% Maizabo recorded the least values of dressing and meat yield per cent respectively.

Table 4.14 shows the effect of supplementation of two variety of groundnut haulm on non-carcass components. The three groups of rams were significantly (P<0.05) different in non-carcass components. Rams fed 10% SAMNUT-22 recorded the highest (<0.05) head weight (2.05 Kg) higher compared to other groups.Moreover,6.00kg of the rumen content obtained in rams fed the control diet was higher (P<0.05) than the values obtained in the other groups.

Table 4.14: The effect of inclusion different varieties of groundnut haulm in concentrate diets on carcass composition in Yankasa rams fed *Digitaria smutsii* hay as basal diet

	inclusion of groundnut varieties			
Parameter s(Kg)	**0%**	**10% Maizabo**	**10% SAMNUT-22**	**SEM**
Live weight	21.75[b]	22.00[b]	23.50[a]	0.46
Live weight after Slaughter	20.75[b]	20.75[b]	22.25[a]	0.45
Hot Carcass Weight	9.50[b]	9.25[b]	10.00[a]	0.21
Meat Yield	5.40[b]	4.80[c]	5.50[a]	0.15
Bone Yield	4.30[a]	3.55[b]	3.50[b]	0.17
Carcass Dressing %	43.62[a]	42.07[b]	43.55[a]	0.31
Empty body	16.26[b]	16.15[b]	17.06[a]	0.33
Meat %	56.54[a]	51.77[c]	55.08[b]	0.63

[a,bc] Mean values with different superscripts within a row differed significantly (P<0.05)SEM= standard error of means.

Table 4.15: The effect of two varieties of groundnut haulm on non-carcass composition in Yankasa rams fed *Digitaria smutsii* hay as basal diet

	Per cent of two varieties of groundnut haulm			
Parameter s (kg)	**0% Control**	**10% Maizabo**	**10% SAMNUT-22**	**SEM**
Pelt	1.55	1.55	1.50	0.009
Head	1.80[b]	1.75[c]	2.00[a]	0.02
Leg	0.60	0.60	0.60	0.00
Full stomach	4.05[a]	3.75[b]	4.55[a]	0.005
Empty stomach	0.50	0.50	0.50	0.01
Full intestine	1.90	1.90	1.95	0.07
Empty intestine	1.00 [a]	0.70[b]	0.80[b]	0.06
Rumen content	6.00[a]	5.00[b]	5.50[b]	0.15
Lung	0.15[b]	0.22[a]	0.22[a]	0.004
Heart	0.10	0.10	0.10	0.00
Kidney	0.05	0.05	0.05	0.00
Liver	0.30	0.30	0.30	0.00

[a,bc] Mean values with different superscripts within a row differed significantly (p<0.05)SEM= standard error of means.

CHAPTER FIVE

5 DISCUSSION

5.1 Experiment I: ffect of groundnut variety on haulm yield and pod characteristic (on-farm) .

In the current study the dry pod yield varied between varieties from 4129.2 kg in Maizabo to 5466.7kg/ha SAMNUT-22, respectvely. The value reported in this study was higher than the value (5130 kg/ha) reported by Merwe and Swanevelar (1989), 4587 kg/ha for Ex-dakar (Musa *et al.*,.2012) 3062 kg/ha for M571-801 by Iwo *et al* (2010) *but* lower than the value (6700kg/ha) reported by Ishaq (1989) and the value of 5,646.20 kg ha^{-1} for SAMNUT-22 reported by Gabasawa *et al.* (2011).

The results show that groundnut variety significantly ($P<0.05$) affected both wet and dry pod yield. Treatment effect of the SAMNUT-22 variety was significantly higher ($P<0.05$) than that of Maizabo. The significant higher yield obtained from the SAMNUT 22 variety over Maizabo was probably due to the genotype since differences in yield among varieties grown under the same environmental conditions. The ability of the SAMNUT 22 variety to out yield the other variety in two different environments shows that the plant factors controlling yield in the variety is genetically stable. The differences in pods yield among the varieties could be attributed to genotypic differences and their response to adverse environmental effects .The performance of SAMNUT-22 could be attributed to its early maturity (1AR, 2003) over the Maizabo.

The dry haulm yield ranged from 9000.0 to 11354.2 kg/ha. The largest value of 11,354.2 kg/ha (SAMNUT 22) reported in this study was lower than the values of SAMNUT 10 (12,138.90 kg ha^{-1}), SAMNUT 21 (11,972.20 kg ha^{-1}) and SAMNUT 22 (11,638.90 kg ha^{-1}) reported by Gabasawa *et al*. (2011) . However the values obtained in the current study were

higher than the value of 7831 kg/ha reported by Dung (1998) , 6500 kg/ha by Chiteka *et al* (1993) , 6414kg/ha by Sokoto (2013) and 5840 kg/ha for UGA-5 by Iwo (2010)

The large variation in yield in the present trial compared to other may be attributed to differences in genetic material, ecological zones and probably cultural practices adopted, This may, among other reasons, be due to anatomical, physiological and morphological differences in the genotypes (Gabasawa *et al.,* 2011) and the inherent soil properties obtainable at savannah zone of Nigeria where that trial was conducted.

In the current study, seed yields varied from 1016 kg/ha for Maizabo to 1069.6 kg/ha for SAMNUT-22. These yields are lower than those obtained by Chung *et al* (1989) for CVS Dangkong3000 kg/ha and Youngho Dangkong 2770 kg/ha, respectively but are within the range of 729 kg/ha for RGI to 2218 Kg/ha for M572-801 reported by Dung (1998).

The result showed that groundnut variety affected the yield obtained by farmers. The higher significant yield obtained from the SAMNUT-22 variety over the Maizabo in this study was probably due to the genotype of the variety since differences in yield among varieties grown under the same conditions have been reported to result largely from genotypic effects (Ahmad *et al*., 2007).

Shelling per cent, as an index of crop yield indicates the proportion of the total DM synthesized that has been allocated to the seed. The shelling per cent reported in the present study ranged from 56.42 in Maizabo to 62.62 % in SAMNUT-22 are within the range of 51% for ICGV 86868 to 75% for RMP12 reported by Dung (1998), The highest shelling per cent was recorded by SAMNUT-22 (62.62%).and this is in agreement with values reported in previous studies. Arslan *et al.* (2005) reported a shelling per cent of 63.42% while Musa e*t al.* (2012) reported a value of 61.83% for other groundnut cultivar RAMP-12.

The shelling per cent is affected by varietal factors, as well as environmental factors affecting photosynthesis, The large shelling per cent obtained in this experiment is in agreement with

60-75% as a normal range for shelling per cent reported by Faujdar (1993). Other studies reported similar values shelling percentage (66–70%, 48–61% and 54–66%) as this study (konlan 2013; Virender *et al*.,2007; Abdullah *et al.*, 2007, respectively) The large variation in shelling per cent in SAMNUT-22 and Maizabo in the current study is in concomitant with the statement which disclosed that factors affecting seed size have also been shown to reduce shelling per cent (Piggot, 1960 ;Ogundele, 1988; Abdullah *et al*, 2007). the finding here could be attributed to the thinner shells of the SAMNUT-22 and this is in agreement with the earlier report observed by Musa (2012).

5.2 Experiment 2: Effect of sowing dates and variety on pod and forage characteristics (On-station)

Pod yields obtained in the current study were fairly high and varied among the sowing dates the lowest value of 4437.5kg recorded in August the highest value of 5875Kg June which were lower than 6700kg/ha reported by Ishaq (1989) and 4587Kg/ha (Musa *et al* .,2012).

The highest pod yields were obtained in groundnut varieties sown in June. Pod yield declined consistently with delay in sowing from June to August. This result confirms the findings of several workers who reported consistent reduction in pod yield. In the present study SAMNUT- 22 had the highest pod yield of 5466.7 kg/ha compared to the Maizabo 4129.2kg/ha . The high yielding variety (SAMNUT-22) in this study when compared to highest yield of 3980 kg/ha reported by Dung (1998) for ICGV 86868 and 4587Kg/ha for Ex-dakar (Musa *et al.,* 2012) was higher but lower than the values reported by Gabasawa *et al.* (2011) for SAMNUT -23 (6,157.80 kg ha^{-1}) and early-maturing SAMNUT 22 (5,646.20 kg ha^{-1}). The large variation in yield for varieties in the present trial compared to other trials cited above may be attributed to differences in genetic material, ecological zones and probably cultural practices adopted, for instance seed size is known to affect pod yield in groundnut

The lowest and highest dry haulm yields recorded were 4687 and 9750 kg ha^{-1}, in mid-August and June respectively. The values of the current study are less than value of SAMNUTS 10 (12,138.90 kg ha^{-1}), and SAMNUT 22 (11,972.20 kg ha^{-1}) reported by Gabasawa *et al,* (2011) but higher than the values 7831 kg/ha for the highest yield reported by Dung (1998) and 6414kg/ha by Sokoto (2013).

.Yield declined in response to delay in sowing .The decline in haulm yield as sowing was delayed observed in the current study confirms the report stated that was significant declined

in haulm yield as sowing was delayed in groundnut, an observation that had been attributed to the shortening of vegetative cycle by delayed sowing (Morthy and Rao, 1986). This is in harmony with the earlier report by Bala *et al.* (2011) which stated that sowing date has a very strong influence on groundnut performance, particularly with respect to pod number per plant pod, seed and haulm yields.

Varietal differences in haulm yield per hectare observed between the two groundnuts varieties had earlier been reported in two groundnut varieties in India (Patel *et al*., 2005). However, a combination of early sowing and variety produced a significantly higher haulm yield. Similarly Bala *et al.* (2011) reported that response to sowing date by groundnut is also a function of cultivar as shown by the strong interactions between varieties and sowing date**.**

The number of pods plant-^{1} ranged from 25.75 (August) to 78.34 (June) which is higher than 32.4 to 47 .9 reported by Bala *et al.* (2011) and 28 -53 obtained in 2008 by Musa (2012) Current study showed that delaying of sowing groundnut until mid-August caused some reduction in number of pods per plant . Similar influence of sowing date on pod number had been reported in India by Morthy and Rao (1986) who attributed this to decrease in vegetative cycle and shortening of maturation. The present findings agree with those of Caliskan *et al*.(2008) who reported that number of pods per plant from all cultivars was significantly decreased in harvest from the June -August .

The number of pods plant^{-1} recorded in this study was 22.45 for Maizabo and 30 .32 for SAMNUT-22.The highest value was recorded in SAMNUT-22 (30.32 pods plant^{-1}) which is similar to 30.8 (2004) and higher than 20.4 (2005) for SAMNUT 22 both reported by Bala *et al*., (2011) .The variations observed in the present study, however, support the findings of Ahmad and Mohammad (1997) and Virk *et al*. (2005) who indicated that groundnut varieties differ significantly in the number of pods plant^{-1}Abdullah *et al*. (2007) reported between

18-24 pods plant^{-1} and Virender and Kandhola (2007) reported 24.1-28.7 pods plant^{-1}.The general variation in number of pods plant^{-1}within the locations was probably due largely to the genotypes of the varieties. However, between locations; the variations in number of pod could be attributed to both genetic and environmental effects, as well as interactions between the two, especially the weather, and availability of growth resources (Ogundele, 1988; Wright and Bell, 1992).

The leaf to stem ratio declined significantly ($P<0.05$) with early sowing. Leaf to stem ratio increased steadily as sowing was delayed from mid-June through mid-August. The results were statistically different ($P<0.05$) across the sowing dates.

Leaf to stem ratio per cent varied between varieties from 51.39% for Maizabo to 55.15% for SAMNUT-22 which are within the range 12% for 1CGV 86230 to 70% for RMP12 reported by Dung (1998). A high leaf to stem ratio adds value to the fodder. This is due to the fact that of all the botanical fractions, the leaf portion is generally more digestible and this was attributed to the higher concentration of lignified portions in the stem than in the leaves (Dung, 1998). The leaf/stem ratio also affects the hay quality since peanut leaf contain more than twice the nitrogen compared to either stem or root fractions (Arslan, 2005).

5.2.1 Chemical composition

The Ash content obtained in June and August in this study range between 8.55-8.79% respectively are lower compared to the value 9-17% reported by Faujdar (1993) 9-17%. but similar to 8.0 reported by Malau-Adulii (2003). The highest crude protein level was obtained in August 16.92% which is higher than 15.75% reported by Lamidi (2006). The ether extract contents of groundnuts have been reported as 4.12 % (Dung et *al.,* 2000) which was slightly higher than the highest value obtained in this study (3.97%).

The protein levels in the groundnut studied were higher than 15 .75% reported by Lamidi (2006). The high crude fiber content recorded in SAMNUT-22 was similar to the value 30.35% reported by Dung *et al.* (2000) and Lamidi (2006). Likewise, the highest ADF content is slightly lower than the mean values (50.2%) for the improved six dual purpose groundnut cultivar reported by Etela (2011) the lowest value of 2.13% in SAMNUT-22 of this experiment was slightly lower than 2.43% reported by Malau- Aduli (2003). The variations existing from the reports seem to reflect the difference in locations where the groundnuts were cultivated as well as differences in the cultivars/varieties. Nutritional value of the peanut haulm declines while the crop approaches physiological maturity. (Arslan, 2005) . Halevy and Hartzook (1998) stated that phosphorus and nitrogen content of groundnut haulm began to decline 37 and 64 days before harvest, respectively.

The Ash content reported in this study ranged between 6.53-6.56% (August and June) were higher compared of the report of Compos-Mondragon (2009) 2.0-2.2% and Aslam shad (2009) 2.70-3.03%. The highest Crude protein levels in the groundnut seeds of 19.48% in August reported in the current experiments are within the range reported by Asibuo *et al*. (2008) of 19.02-27.16% respectively.

The high protein levels recorded in SAMNUT-22 seeds are within the range of 17-31.0% reported by Oke *et al*. (1995) and lower than the values 30.24-32.37% CP reported by Aslam shad *et al.* (2009.).The ether extract contents of groundnuts have been reported as 32.7-53.1% (Musa *et al.,* 2010). This shows that the highest values reported in this study (40.09% in SAMNUT-22) are within the ranges found in the literature. The high Ether Extract content in groundnuts indicates high energy density that promotes fat soluble vitamin absorption without adding to the bulk of the diet (Atasie *et al.,* 2009). The variations existing from the

reports seem to reflect the difference in locations where the groundnuts were cultivated as well as differences in the cultivars/varieties evaluated in each study.

5.3 Experiment 3: The effect of different groundnut haulm on growth performance of Yankasa rams..

5.3.1 Chemical composition of the diets

Results on proximate composition showed that crude protein content (13.71-13.92%) of the experimental diet were within the values of 13-15% CP requirements for sheep stated by Aduku (2005). The CF content obtained from the present study met the minimum requirement recommended for ruminant by Banerjee (2007).

5.3.2 Dry Matter Intake (DMI)

The results of the feeding trial showed that DMI was highest (1113.23g) in rams fed 10%SAMNUT-22 followed by (1102.28g) 10% Maizabo level of inclusion in the supplement. The increased DMI of supplement diets containing 10% SAMNUT-22 could be an indication of increased palatability of groundnut haulm to sheep. This observation is in conformity with earlier works reported by Okafor *et al.* (2012) and Lamidi *et al.* (2009). They reported that groundnut haulms supplementation improved palatability of the feed to ruminant. Similarly, this result is in agreement with the work of Richard *et al.*(1994) who reported an increase in feed intake when crop residues with poor nitrogen levels were supplemented with legume forages. Brown and Pitman (1991) however, stated that in some case the use of legume supplement at between 10-20% had increased animal performance without significant increase in intake.

This improvement in DMI due to inclusion of groundnut haulm has also been reported by Ayoade *et al.* (1983) and Ikhatua and Adu (1984.) that the fodder could be fed fresh, as silage or as hay. Its high crude protein content which varies from 11.4- 16.7% in some cultivars (Alhassan, 1985) helps immensely in augmenting protein deficiencies in cereal residue based diets.

Since groundnut haulm of the present study had higher crude protein (14%CP) relative to *D smutsii* hay (6.78%CP). This apparent effect of increased dietary crude protein is in harmony with the report of Savadogo *et al*. (2000) who confirmed that groundnut haulms had high crude protein content and its inclusion in the feed lead to increased CP content of the diets. Horton (1979) Forero *et al*. (1980), Marston and Lusby (1995) Muinga *et al.(*1995), Matejovsky and Sanson (1995) and Adamu *et al.* (2013). They all demonstrated the influence of dietary crude protein or nitrogen level on DMI.

5.3.3 Live weight gain

The average daily weight gain (ADG) of 63.71, 65.77 and 68.88g/d for control, 10% Maizabo and SAMNUT-22 levels of groundnut haulm in concentrate diet, respectively are observed in this study. The ADG in this study were lower than the normal daily gains of150g/day (Aduku, 2011). It is also lower than 130.7g by lambs reported by Adu and Lakpini (1983) when lambs were fed chopped groundnut haulms. However, It was higher than the values (28 to 47g/hd/d) reported by Lamidi *et al.* (1998) for Yankasa sheep fed graded levels of *Ficus thonnigii* leaves as replacement for fresh *Hyparrhenia rufa.* The significant high ADG of rams fed concentrate diet containig 10% SAMNUT-22 was most likely because the diet provided energy and protein, which are critical for the growth of livestock.

The present result is in conformity with earlier works reported by Ikhatua and Adu (1984) In comparing *Digitaria smutsii* hay and groundnut hay, reported daily gains of 59g and 88g were reported in red Sokoto goats which was significantly better for groundnut haulm. It was concluded that groundnut haulm was better and had adequate protein to maintain ruminants.

The possible reason for the numerical decline in ADG in this study at 10%Maizabo level of haulm inclusion might be due to sudden fall in metabolizable energy at this level. Insufficient energy level in diet of high protein level leads to waste of protein and increased energy cost

of eliminating excess urea from the body (Huber *et al*. 1994). Growth rate in ruminant is highly correlated with the energy and protein intake; with energy intake being the major limiting factor affecting tissues deposition (Leng, 1990).

The improvement in feed conversion efficiency at 10% level of SAMNUT-22 in supplement diets meant that the efficiency of absorbed amino acids to energy VFA available from digestion corresponded to the animals' requirement needed for efficient utilization of poor quality resources (Preston and Leng, 1987).

5.3.4 Serum metabolites

Blood urea nitrogen values (1.4-9.3mg/100ml) reported in this study fall below the range of (8.3 - 52mg/100ml) for goats fed increasing amount of protein supplements (Kadzere and Charama,1993; Sahiu *et al*.1993) but were comparable with those reported by Adegbola (1988) for sheep (5.67-11.35mg/100ml) fed diets with varying levels of crude protein.. However, the higher blood urea concentration at 10% Maizabo groundnut level of inclusion in concentrates diets at 4 hours post feeding may have resulted in increased microbial degradation as a result of increased protein supplied to the rumen. Blood-urea nitrogen (BUN) concentration has been reported to be closely related to rumen NH_3-N. In addition, it was found that when dietary CP per cent increased, the concentration of BUN and the solubility and degradability of protein in the rumen of sheep also increased (Cressman *et al*., 1980).

The concentration of blood glucose in this study 0.4-3.8Mmol/L were higher than 2.11-2.90Mmol/L reported by Jonas and Vilma (2007) when fermented silage was fed to daily cows. However, they were within the normal range of (3.0-8.3 Mmol/l) reported by Woodman and Evans (1974). This supports the observation by Russel and Wright (1983) that blood glucose level is a poor indicator of nutritional status due to its sensitivity to stress and insensitivity to nutritional change. Report of studies on horse (Sticker *et al.,* 1995), sheep

(Ulyatt *et al*., 1970) and goats (Sahlu *et al*., 1993) also support this observation .The significant effects of the diets on blood glucose levels in the present study agreed with the previous reports of marked effects of diet on blood glucose levels. Schmidt and keith (1983) and Nacktomi *et al.* (1991) observed that increasing the energy fed by offering increasing amount of concentrate caused increased in blood glucose levels

Total protein reflects availability of protein and its concentration declines in the fate of protein deficiency. They were similar to the report of Ndlovu *et al*. (2007) but slightly higher than the range of 6.0-8.2g/100mg reported by Gleghorn *et al.* (2004). The high level of total protein noticed in this study indicates that the diet fed to the animals had adequate amount of crude protein in it agreed with the report of Oyedipe *et al.* (1984) which indicated that high protein intake in a diet results to high blood protein .

5.3.5 Rumen Metabolites

. There were no significant variation (P>0.05) in rumen pH between treatments and time of sampling. Jokthan (2007) obtained a pH of 7.1-7.31 when pigeon pea forages based diets were fed to sheep on rice straw basal diets. Reddy and Reddy (1999) have reported a normal pH range of 6.2-6.9. The slightly alkaline rumen condition in this study was probably due to increased concentration of ammonia in the rumen during these periods (Naik and Nengar, 1999). The peak mean pH values at 4 hours post-feeding agrees with the result of Adegbola (2002).

The findng is in conformity with the report of Lamidi (2005) who stated that the rise in pH was not detrimental to the bulls since the microbe's activity in the rumen was not affected. This was evidence by the production of rumen ammonia and volatile fatty acid across the times of sampling.

The total volatile fatty acid followed the same trend as the rumen nitrogen across time it increased with time in all. The increase in total volatile fatty acid noticed across the time of sampling means that the microbes in the rumen of the rams had enough time to act on the feed thereby producing TVFAs. The high TVFAs of 58 Mmol/100ml is probably the reason for lower pH concentration at 0 %level of groundnut haulms compared to the pH values obtained at10%LV and SAMNUT-22 haulm inclusion level in concentrate diets at 4-12 hours post feeding.

Volatile fatty acids are the main energy sources for ruminant feeding solely on roughages. Thus their concentration in the diet gave indication of their energy values .The value ranged between 28.8- 56.8 mmol/100 Ml in this study which was above 19.57-36.57mmol/l reported by Jokthan (2007) when pigeon pea forage was supplemented in sheep diet. The increase in rumen TVFA in this study is possibly due to increased digestibility of the feed material. This result was likely affected by numerically higher cellulolytic bacteria populations in control treatments. Based on this experiment, type of roughage could play an important role in VFA production. Wanapat *et al.* (2003) reported in a comparative trial with beef cattle and swamp buffaloes that rumen fermentation pattern of VFAs was relatively consistent and levels were low in both cattle and buffaloes fed on rice straw, but these values were increased by feeding *D smutsii hay*. It appeared that rumen function could be remarkably enhanced by dietary manipulation.

Ammonia nitrogen observed in this study shows that rumen NH_3-N concentrations were different ($P<0.05$) both across the treatment and time of sampling. This shows that groundnut haulms in concentrate diets were beneficial to rumen protein synthesis and that there was stable rumen environment needed for efficient rumen fermentation. The rumen NH_3-N concentration of 13.84 -29.34. mg/100ml in this study was higher than 11.42-14.43mg/100ml recorded by Jonas and Vilma (2007) and was slightly higher than 19-25mg/100ml observed

by Mehrez *et al.,(* 1977) needed to be adequate for forage digestion. Powel *et al.* (1981) reported that between 3.6-17mg/100ml NH_3-N concentration promotes microbial protein production which is an important factor in determining the utilisation of nitrogen in the rumen(Jokthan,2007).

However, the higher NH_3-N levels in 10% SAMNUT-22 and LV groundnut haulm level of inclusion in supplement were within the optimal range of ruminal NH_3-N (15-30 mg %) for low quality roughages (Pedro and Leng, 1990). It also should be noted that these rumen $NH._3$-N levels were within a suitable range for rumen ecology, particularly for further microbial protein synthesis (Kanjanapruthipong and Leng, 1998; Wanapat and Pimpa, 1999).

The effect of sampling time on total volatile fatty acids and NH_3-N concentration showed a similar pattern, it revealed an increase in the concentration of TVFA and NH_3-N as the sampling time increased from 4 hours post feeding up to 8 hours, thereafter, there was a decline. This indicates that there was efficient utilization of the ingested feed material leading to a favourable rumen environment and subsequent yield of rumen metabolites. Abouheif *et al*. (2010) reported that TVFA concentration in the rumen liquor of lambs fed concentrate was affected by sampling hours post feeding. They added that the concentration of TVFA increased gradually to attain its peak value before subsequently decreasing to the original concentration at 24 hours post feeding.

5.3.6 Nutrient digestibility and nitrogen retention

The increase in the apparent digestibility of dry matter, organic matter, crude protein ether extract, NFE, ADF and NDF as a result of SAMNUT 22 groundnut haulm supplementation is in agreement with the findings of Abule *et al.* (1995). This can be attributed to an increasing level of the crude protein that was ingested. This agrees with the previous study on the effect of increasing dietary crude protein level on nitrogen or crude protein digestibility (Sahlu *et al*.,1993) and Adamu, *et al.* (2013).

The most probable explanation for this phenomenon is in the fact that the diet contained SAMNUT 22 haulm might have resulted in high palatability and better utilization of the nutrients by the rams. The crude fibre digestibility decreased with inclusion of SAMNUT 22 haulm. These results are in agreement with the report of Garba *et al.* (2010) who observed a significant decrease in digestibility of crude fibre with increase in crude protein in the diet.

The results showed that all the rams had positive nitrogen balance irrespective of the haulm of groundnut varieties inclusion in the diets. There was a difference ($P<0.05$) in the urinary nitrogen with animals fed control diet (1.93g) being the highest and 10%LV, the lowest (1.62g). The significant high urinary N observed in the control diet compared to 10%LV can be explained by the fact that excess ruminal ammonia is absorbed and excreted in the urine in the form of urea (Murphy and Colucci, 1999).

Animals fed diets containing 10%SAMNUT-22 had highest nitrogen absorbed (13.37g) and nitrogen balance (11.68g) and nitrogen retained as percentage of intake (52.36g) in their body and significantly higher compared to other treatments .This is in agreement with the report of Sawar *et al*. (2003) and that nitrogen depends on good digestibility of nutrients and / or utilization. In some cases this effect is sufficient to maintain an adequate N balance (Woodward and Reed, 1997).

Nitrogen retention is the major indicator used to assess the protein nutrition status of ruminant livestock (Abdu *et al.,* 2012). It can be attributed to the additional supply by SAMNUT 22 groundnut haulm in the diet. Khan *et al.* (2009) reported a similar result when some selected leguminous tree leaves were used as replacement for cotton seed cake in dairy goats in Manshera, Pakistan.

However, the drop in nitrogen retained observed in diets containing 10 % Maizabo could be as a result of less efficient utilization of protein especially in view of the observation of some

authors like Tinnimit *et al.* (1972); Smith and Calvert (1976) and El-Sabban *et al*. (1970). They all observed decreased nitrogen retention when poultry litter made up more than half of the nitrogen in the diet. Umunna *et. al*. (1982) also reported that sheep fed soybean meal had higher nitrogen retention than those fed urea alone.

5.3.7 Cost benefit

The reduction in the cost of the concentrates diet with inclusion of 10%SAMNUT-22 is due to minimal cost of the SAMNUT-22 in replacing the cottonseed cake (CSC) as oil seeds cake are known to be expensive. Adegbola and Okonkwo (2000) reported that replacement of conventional feed ingredients reduces feed cost as Savadogo (2000) reported that industrial by- products oil seed cakes are not readily available or where they are available, they are so expensive.

The decrease in the cost of feed consumed is in line with the cost of the feed consumed as a result of the inclusion of SAMNUT 22 hay in the concentrate diet. This agrees with Richard (2001) who reported that high cost of oil seed cake protein supplements which are highly competitive as monogastric feedstuff and human being diets increase their cost and limit their use.

5.4 Experiment 4: The effect of different groundnut haulm on fattening performance of Yankasa rams

5.4.1 Chemical composition of the diets

Results on proximate composition showed that crude protein content (11.15-16.30%) of the experimental diet were within the values of 10.9-12.7% CP requirement for lamb fattening stated by Aduku (2005). Afzal and Ullah (2007) reported that crude protein from all diets experiment met the minimum requirements for production in ruminant animals(>7%) i.e. for maintenance, 10.0% for meat production and 11.9% for milk production (Humphreys, 1978) The CF content obtained from the present study met the minimum requirement recommended for ruminant by Banerjee (2007). The CF of diet has not exceed the minimum level of 17% required by ruminant NRC (2000).

5.4.2 Dry matter intake

The present study showed that the high DMI (1784.9g) was recorded in rams fed 10 % SAMNUT-22 level of inclusion in the supplement, which was higher compared to control and 10% Maizabo.. Godchild and Mcmeniman (1994) have indicated an increase in voluntary DMI of sheep when nitrogen and minerals were increased. The increased DMI of supplement diets could be an indication of palatability of groundnut haulm to sheep. This observation is in conformity with earlier works reported by Adebowale (1988) who reported that groundnut haulms supplementation improved palatability, increased minerals and vitamins, better rumen function and has a laxative influence on the gastrointestinal tract (GIT) of Yankasa sheep.

In the present study there was an increase in DMI as the 10% level groundnut haulm inclusion in concentrated diets, as a result of its high CP content; this is similar to the work of Savadogo *et al*.(2000) who reported that when ruminants are fed hay, intake is relatively low due to high fibre and low nitrogen content leading to insufficient nutrients to meet requirements of such animals. However, such deficiencies can only be met by supplementing

hay with low levels of CP or non – protein nitrogen, such as groundnut haulms used in this study. Similar results have been reported by several authors on different forage legume supplementations. Earlier, Moran *et al*. (1983), reported an increase in DM intake when rice straw was supplemented with *Leuceana leucocephala*. Similarly, Richards *et al.* (1994) and Adamu *et al.* (2013) reported increase in feed intake when maize stover with poor nitrogen levels were supplemented with legume forages. In addition, Muanyuchi *et al*. (1997) found that forage legume supplementation increased total feed intake up to a point beyond which intake declined.

5.4.3 Live weight gain

The daily live weight gains (59.72kg/day to 65.274kg/day) obtained in this study was higher than the value (31.086 kg to 54.92 kg) reported by Abdu (2011) in fattened rams on *Zizyphus Mauritania* leaf. The better performance of the rams on diets containing 0 and 10% SAMNUT-22 Level of inclusion could be as result of better feed intake and better feed utilization, which resulted in better feed efficiency and nitrogen retention, as compared to those on diets containing 10% Maizabo. Lower energy contents of the diets containing 10 % Maizabo was also responsible for the numerically lower average live weight gain of the rams. Lowman and Knight (1970) had attributed the lower daily gains of cattle on dry poultry litter to lower energy content of the diet. This observation is similar to those of Oliphant (1974) and Cullision *et al.* (1976).

The significantly higher ADG of rams fed concentrate diet at 0 and 10% Maizabo of groundnut haulms was most likely because the diet provided energy and protein, which are critical for the growth of livestock. The ADG of 65.27, and 59.72g were recorded 0, and 10% of SAMNUT-22 level of haulm in concentrate diet. Growth rate in ruminant is highly correlated with the energy and protein intake; with energy intake being the major limiting factor affecting tissues deposition (leng, 1990).

5.4.4 Carcass analysis

The rams on the control group achieved the highest dressing per cent (43.62 %) compared to other groups. The dressing per cent of carcass obtained in the current trial ranged from 42.07 to 43.62% which was slightly lower than 44 % reported by Intesar (2011) and 45% as optimal dressing's per cent for sheep reported by Aduku (1990). The higher dressing per cent obtained by the rams in the control diet may be attributed to the higher energy content of the control diets which is needed for fattening and higher body fat deposits and dressing per cent. (Nadaf, 1998). However, the least values obtained by rams fed 10% Maizabo were in line with those reported by Buhaif (1995) who found a lower dressing per cent (42.66%) using agricultural by-products for desert sheep fattening during drought season.

The results of non carcass component in Table 4.15 showed that rams fed the diets containing 10% SAMNUT-22 recorded the highest head, full stomach and lung weight (2.00, 4.55 and 0.22 Kg respectively). Flanagan [1990] reported that lambs on the fodder beet diet produced heavier carcasses compared to those on grass.

6 SUMMARY, CONCLUSION AND RECOMMENDATION

6.1 Summary

Assessment of two groundnut varieties for forage pod and seed yield characteristics and the effect of feeding the haulm to Yankasa rams were investigated. Four different experiments were conducted.

Experiment I: it was on- farm trials determined the effect of variety on pod yields, haulm yields seed yields and shelling per cent. The result of the on-farm trial revealed that SAMNUT-22 produced higher pod (5466.7kg/ha), haulm (11354.2kg/ha) and seed yields (1069.6kg/ha) than the Maizabo. SAMNUT-22 was superior to Maizabo with respect to all the parameters assessed.

Experiment II: It was on-station trials. It determined the effect of groundnut varieties and sowing dates on pod, haulm yield, number of pod plant^{-1} and leaf to stem . The results of the experiment showed that delaying of groundnut sowing till mid-August caused significant ($P<0.05$) increased in leaf to stem (62.43%) . Therefore, the early sowing enhanced positive response of pod (5875kg/ha) , haulm (9750kg/ha) seed yield (1069.6kg/ha) and number of pod plant^{-1} (78.34)

Experiment III: Growth trial, determined the effect of inclusion of different varieties of groundnut haulms in concentrate diets on growth performance of Yankasa rams, blood metabolites, rumen metabolites, digestibility and utilisation of nitrogen. The result of the growth trial showed that total dry matter intake was highest for the rams fed diet containing 10% SAMNUT-22 (1113.23g/d) followed by 1102.28g/d for 10% Maizabo level of inclusion in the supplement, which similar ($P>0.05$) but significantly higher than 1043.59g obtained on rams fed control diets. The live weight gain of the rams ranged from 5.74-6.2g/d and were statistically ($P<0.05$) different across the treatment. High ammonia nitrogen (NH3-N) levels were recorded in 10% SAMNUT-22 groundnut haulm level of inclusion in the supplement.

Blood urea nitrogen values varied between1.4 to 9.3mg/100ml.The result of the second trial depicted the apparent digestibility of dry matter was high ($P<0.05$) for animals fed 10% SAMNUT-22 (46.45g) and had the best digestibility of all nutrients and statistically different. Rams fed diets containing 10% SAMNUT-22 had highest nitrogen absorbed (13.37g), nitrogen balance (11.68g) and nitrogen retained as percentage of intake (52.36%) in their body compared to other treatments and were significantly different.

Experiment IV: fattening trial, evaluated the effect of inclusion of two varieties of groundnut haulms in concentrate diet on fattening Yankasa rams. The result of the fattening trial Indicated that highest ADG was obtained in rams fed 10% SAMNUT-22 (65.27g).The highest meat yield (5.5kg) was obtained in animals fed 10% SAMNUT-22. .

6.2 Conclusion

Based on the results of this study, it is concluded that

SAMNUT-22 haulm has a great potentiality to improve productivity of both crop and small ruminant, therefore Small-holder mixed crop-livestock farmers in Nigeria can introduce SAMNUT-22 for high pod yields and forage yield for their livestock.

Result obtained in this study indicated that 10% SAMNUT-22 in a concentrate diet enhances nutrients digestibility and nitrogen retention in Yankasa Rams without adverse effect on their health. It showed that the 10% SAMNUT-22 inclusion in concentrate diets of Yankasa rams increased their feed intake utilization and efficiency, and thereby, gaining high Average daily weight gain.

In order to improve the performance of Yankasa rams as well as the quality of their products particularly during the dry season 10% SAMNUT-22 can be included in their concentrate diet for better live weight gain, dressing percentage and meat yield.

6.3 Recommendations

The following recommendations have been made after a careful consideration of the research findings:

(i) In the light of the current practice of mixed crop-livestock system. Poor resource farmers be encouraged to adopt the SAMNUT -22 in mixed crop livestock enterprises to improve their income.

(ii) It is recommended to use SAMNUT-22 and early sowing June for better pod (5875 kg/ha) haulm (9750 kg/ha) Number of pod (78.34) and Shelling per cent (62.62%). The late sowing August could be best for good quality haulm for high leaf stem ratio (62.43%)

(iii) 10% SAMNUT 22 inclusion in supplementary diet for grower Yankasa rams can increase live weight gain of 68.88g daily, compared to 65.77 g/day and 63.71 g/day (10% Maizabo and control respectively)

(iv) The total value gain of N4,092.00 can be obtained by inclusion of 10% SAMNUT-22 in concentrate diets compared to N3,788.00 and N3,907.00 (control and Maizabo, respectively). With regard to Income over feed cost shows SAMNUT-22 making it the best choice of N357 Compare to N131 and N22 (10%Maizabo and control diets, respectively).

(v) 43.55% and 5.5 kg of dressing percentage and meat yield can be obtained by including 10% SAMNUT-22 in supplement of Yankasa rams

6.4 Future research directions

(i) Considering the findings of this research, further research of comparative study can be conducted to assess the performance of small ruminant especial Yankasa rams fed with the haulm of different improved varieties of groundnut such as SAMNUT- 10, 21 22 and 23.

(ii) The influence of harvesting time on quantity and quality of yield in the different agro- ecological zones should be investigated.

(iii) The graded level of inclusion of SAMNUT-22 which will give the best efficacy and potentiality on performance of Yankasa ram should be investigated

(iv) The degradability of SAMNUT-22 haulm in yankasa ram should be conducted.

(v) The effects of some Antinutritive factors (ANFs) present in SAMNUT 22 Haulm were not evaluated on the animal. It is therefore recommended that further studies should be conducted to evaluate the long term effect of feeding SAMNUT-22 haulm on the productivity of sheep.

7 REFERENCES

Abdel, M.B. and Ahmadi, E.l. (1994). Seed-Hull ratio and shelling percentage as indicators of groundnut maturity. *International Arachis newsletter*. 14, P.2

Abdu.S.B., Ehoche, O.W., Adamu, A.M., Bawa, G.S., Hassan, M.R., Yashim, S.M and Adamu, H.Y. (2012). Effect of varying levels of *Zizyphus mauritiana*) leaf Meal inclusion in Concentrate diet on performance of growing Yankasa Ram lambs fed maize stover basal diet. *Iranian Journal of Applied Animal Science* 2 (4) 253-256

Abdu,S.B. (2011). Effects of supplementing maize Stover with *Ziziphus mauritiana* leaf meal in Yankasa sheep. A Ph.D thesis submitted to the Department of Anim. Sci. Ahmadu Bello University. Zaria. 2, 10-50pp.

Abdu, S.B., Ehoche ,O.W., Adamu, A.M., Jokthan, G.E., Yashim, S.M. and Hanwa, Y.A. (2008) . The implication of secondary plant factors in animal nutrition: A review. *Proceedings of the 13th Ann. Conference of the Anim. Sci. Ass. Of Nigeria* . 15-19 sept 2008. In: Bawa G.S ., Akpa G.N., Jokhtan G.E., Kabir M. And Abdu S.B.(Eds) held in ABU, Zaria .Kaduna State of Nigeria.pp637-640.

Abule, E., Umuna,N.N., Nsahlai I.V.,Osuji, P.O. and Alemu, Y. (1995) . The effect of supplementing teff (*Eragrostis tef)* straw with graded levels of cowpea (*Vigna unguicuiculata*) and lablab lablab (*Lablab purpureus*) hays on degradation, rumen particulate passage and intake by crossbred (Friesian x Boran (zebu) calves . *Livestock Production Science* 44:221-228

Abdullah, T., Rahmianna, A. A., Hardaningsih, S. and Rozi, F. (2007). Increasing groundnut yield on dry land Alfisols inIndonesia. *Journal of SAT Agricultural Research* 5(1)

Abdoussalam, N.V., and Moamed, A.B.(2002).Impact of climate change on agricultural production in the Sahel-Part 2.Case study for groundnut and Cowpea in Niger, Climatic Change 24(3): 349-368.

Adamu, H.Y,, Lamidi, O.S., Ehoche, O.W., Abdu, S.B., Hassan, M.R. and Yashim, S.M 2013 Growth performance of yankasa rams fed varying proportions of *Gmelina aborea* leaves. *Nigerian Journal of Animal Science*, Vol. 15: 145-157

Adams , A. L., Harris , B. (Jr.), Van Horn, H. H. and Wilcox, C. J. (1995). Effect of varying forage types on milk production responses to whole cottonseeds, tallow and yeast. *Journal of Dairy Science*. 78:573-581.

Adu, I.F.(1982).Feedlot Fattening of Sheep and Goats ,Effects of energy and protein levels on feed intake and nutrient utilization by Yankasa lambs. *Nigeria Journal. Animal Production. 9* (2):90-93.

Adebowale (1988). The performance of goats fed maize straws treated with organic wastes 10th Annual Conference. *Nigerian Society for Animal of production* 29(1): 40-46

Adediran, A.S. (2002). Evaluation of the Nutritional value of Cowpea (*Vigna unguiculata* Linn) Shells using goats in Nigeria. A MS.C thesis submitted to the Department of Anim. SCI. A.B.U. Zaria.

Adegbola, T.A. (2002) . Nutrient intake, digestibility and rumen metabolites in bulls fed rice straw with or without supplements. *Nigeria Journal of Animal production* 29 (1):40-46.

Adegbola, A.A., Smith, O.R, and Asaolu, V.O.(1989).Response of the West African Dwarf sheep to diets based on processed cassava peels and *Gliricidia septium*. In: Said, A.N. and Dzowel, B.H.(Eds). Overcoming Constraints to the Efficient Utilization of Agriculture by-products as Animal Feed . *Proceedings of the Fourth Annual Workshop of the African Research Network for Agricultural By-products,* I.A.R., Mankon station, Bamenda, Cameroun. 20-27 October 1987. (ILCA) Addis Ababa, Ethiopia. Pp282-289

Adegbola, T.A.(1982).Forage resources and beef production in Nigeria. In: Osinowo,O.A, Ikhatua, U.j. and Ehoche, W.O .(Eds).Beef production in Nigeria. *Proceedings of the National Conference on Beef Production* , Kaduna, Nigeria, 27-30 July, 1982. NAPRI (National Animal Production Research Institute). Shika-Zaria, Nigeria

Ademosun, A.A., Bosman, H.G. and Jansen H.J. (1989) . Nutrional studies with west African Dwarf goats in the Humid tropics. In: Smith, O.B. and Bosman, H.G. (Eds).Goat production in the humid tropics. *Proceedings of a Workshop at the University of Ife, Ile-ife, Nigeria.* 20-24 July 1987. Centre for Agricultural Publishing and Decumentation (pudoc), Wageningen, The Neitherlands. Pp51-61

Ademosun, A.A. (1994). Constraints and prospects for small ruminant research and development in Africa . In: Lebbie , S.H.G., Rey, B. And Irungu, E.K. (Eds). Small Ruminant Research and development in Africa . *Proceedings of the Second Biennial Conference of the African Small ruminant Research Network , AICC. Arusha, Tanzania.* 7-11 December, 1992. ILCA (International Livestock Centre for Africa) CTA (Technical Centre for Agricultural and Rural cooperation) . Addis Ababa, Ethiopia. Pp 1-6.

Adu, I. F. (1982). Effects of energy and protein levels on feed intake and nutrient utilization byYankassa lambs. *Nigeria. Journal of Animal Production***.** 9(2). 90-93.

Adu, I. F. and Lakpini, C. A. M. (1983). Effect of feeding chopped and unchopped groundnut haulm (Harawa) on utilization and the production of some rumen metabolites in Yankasa lambs. *Nigeria. Journal of Animal Production*. 10: 110-113.

Aduku, A.O. (2005). Tropical Feeding stuff Analysis Table. Department of Animal Science, Ahmadu Bello University, Zaria-Nigeria.

Aganga, A.A. and Tshwenyane, S.O. (2003). Feeding values and Anti –Nutritive factors of forage tree legumes. *Pakistan Journal of nutrition .2(3):170-177.*

Agishi, E.C. (1985). Forage resources of Nigeria rangelands.In Adu, I.F., Osinowo,O.A.,Taiwo, B.B.A. and Alhassan, W.S (Eds). Small ruminant production in Nigeria. *Proceedings of National conference on Small Ruminant production Research Institute* (NAPRI) Shika- Zaria. Nigeria.Pp.115-140.

Aletor, V.A. (1993). Allechemicals in plant foods and feeding stuffs part 1, Nutritional, biochemical and physio-pathological aspects in animal production . *Veterinary Human toxical. 35 (1):57-67.*

Aletor, V.A. and Omodara, O.A. (1994). Studies on some leguminous browse plants with particular reference to their proximate, mineral and some endogenous anti-nutritional constitutes. *Animal Feed Science Technology 46 :343-34*

Ahmad, N., Mohammad, R. and Ulas K. (2007). Evaluation of different varieties, seed rates and row spacing of groundnut, planted under agro-ecological conditions of Malakand Division. *Journal of Interacademia*. 9(4):178-183.

Ahmad, N., Rahim, M. and Khan, U. (2007). Evaluation of different varieties, seed rates and row spacing of groundnut, planted under agro-ecological conditions of Malakand division. *Journal of Agronomy*., 6: 385-387.

Ahmed, M., (1992). Performance of groundnut (*Arachis hypogaea* L.) varieties as affected by date of sowing in Assam. *Indian Journal of Agronomy*., 37: 382-383.

Archer, H.E and Robb, G.D. (1925). Blood urea Analysis . In:Tarnoky A.L. (ED). *Clinical Biochemical Methods* .Hilger and watts Ltd, London pp203-205

Akpensuen. T.T. (2012) Evaluation of two maize accessions for forage yield, Nutrient composition and Digestibility. MS.C Thesis submitted to Animal Science Department, Ahmadu Bello University Zaria.

Alawa, J.P. and Umunna, N.N. (1993).Alternative feed formulation in the developing countries: prospects for utilization of agro-industrial by-products. *Journal of. Animal Production Research.*, 13: 63-98.

Alhassan WS, Ehoche OW, Adu IF, Obilara TA, Kallah MS. (1984). Crop residue potential of agricultural development projects: Nutritive value and residue management. NAPRIAnnual Report, National Animal Production Research Institute, Shika, Nigeria, 35-45

Alhassan , W.S. Ehoche, O.W., Adu, I.F. Obilan, A.T. and Kalian, M.S. (1985). Maize Stover potential of Agricultural Development projects (b) Nutritive value and residue management. National Animal Production Resarch Institute Annual Report, pp35-45, shika, Zaria, Ngeria

. Arkhipov, A. (1989).Nitrates and Nitrites in feeds. In Plant poisoning in animals. *A bibliography from the world literature*. No 3. 1983-1992. CABI. P21(Abstr.)

Ali N. and Malik N. S.(1992). Performance of short duration ground-nut lines suitable to increase cropping intensity in rainfed areas of Pakistan . In: Nigam S.N. (ed.), Groundnut - A Global Perspective. International Crop Research Institute for the Semi-Arid Tropics, Patancheru, India, p. 433.

Amodu JT, and SM Otaru, (2004). Forage and Crop Research Programme. A training Manual, National Animal Production. Research. Institute., Shika. Pp. 23-27.

Ani, F.O (1980). The value of sugsr cane molasses as an energy supplement in rations for fattening cattle, M.Sc. Thesi. Ahmadu Bello University, Zaria

AOAC (2000). Association of Official Analytical Chemists 17th Revised edition. In: Official methods of Analyses, Washington DC pp. 210 – 240.

ARC (Agricultural Research Council) (1980). The nutrient requirements of ruminant Livestock.Commonwealth Agricultural Bureaux, Farnham Royal, England.351 pp

Arslan, M. (2005). Effects of haulm cutting time on haulm and pod yield of groundnut. *Journal of Agronomy* 4:39-43.

Aslam Shad, M, Perveez, H, Na Waz H. Khan, H.and Amean Ullah, M. (2009). Evaluation of biochemical and phytochemical composition of some groundnut varieties grown in Arid zone of Pakistan. *Pakistan Journal of Botany*. 41, 2739-2749.

Atasie, V.N, Akinhanni, T.Fand Ojiodu, C.C. (2009). Proximate analysis and physic-chemical properties of groundnut (*Arachis hypogaea L.*). , *Journal of. Nutrition*. 8, 194-197.

Athanasiadou.S., Kyriazakis I., Jackson., F. And Coop, R.L. (2001). Consequences of long term feeding with condensed tannins on sheep parasitized with Trichostrongylus colubriformis. *International Journal for Parasitology* 99: 205-219.

Ayoade, J.A. Makhambera P.E. and BIdzalenki, M.Z. (1983) Evaluation of Crop residues as feed for goat part 1. Voluntary intake, digestibility and nitrogen utilisation of bean and groundnut haulm. *Herbage Abstract* 56:305.

Bailey, E. and Biosvert R.N. (1991). Yield response of groundnut to the amount and timing of water application. *Journal of Prod. Agric*. 4 (1): 1–9.

Bala, H.M.B., Ogunlela V.B., Tanimu B. and Kuchinda, N.C. (2011). Response of two groundnut (*Arachis hypogaea* L.) varieties to sowing date and NPK fertilizer rate in a semi-arid environment 1. Growth and growth attributes. *Asian Journal of Crop Scence*

Banerjee, K., Sounda, G. and Mandal, A. (2005). Effects of different level of irrigation and cobalt on growth and nodulation of summer groundnut (*Arachis hypogaea* L.). *Journal of Interacademicia* 9(2): 235-241.

Beever, D.E. and Siddons, R.C. (1985) . Digestion and Metabolism in grazing ruminant in control of digestion and metabolism in ruminants prentice- hall, Eglewood Cliffs, U.J

Beddows, A.R. 1956 Observation on hoove , haven blown or bloat taken from agricultureal writings. *Journal of the Agricultural Society 33:12-15*

Bell, M., (1986). Effect of sowing date on growth and development of irrigated groundnuts (*Arachis hypogaea* L. cv. Early Bunch) in a monsoonal tropical environment. *Aust. Journal of Agriculture Research*., 37: 361-373.

Bhatti, M.B. and S. Khan (1996) *Fodder production in Pakistan* FAOPARC, Islamabad

Boote K.J. and Ketring D.L. (1990). Groundnut. In: Stewart B.A. and Nielson D.R. (eds), *Irrigation of Agricultural Crops*. ASA- CSSA-SSSA, Madison.

Brown, W.F. and Pitman, W.D. (1991). Concentration and degradation of fibre fractions in selected tropical grasses and legumes. *Tropical Grassland* 25: 305-311.

Bosman, H.G., Ayeni, A.oand Koper Limbourg, H.A.G. (1996), Farmers' response to a package of innovations in goat production in South- western Nigeria. *Trop. SCI*. 36:92-100.

Brown,W.F.and Pitman,W.N. (1991) Concentrate and degradation of fibre fraction in selected tropical grasses and legumes. *Tropical grassland* 25: 305-311.

Bunting, L.D., Howard, M.D., Muntifering, R.B., Dawson, K.A and Boiling, J.A. (1987). Effect of feeding frequency on forage fibre and nitrogen utilization in sheep. *Journal of Animal Science* 64:1170-1177.

Buhaif, M.A., (1995). *Husbandry and Production of Sheep* (in Arabic). First edition. Publication:

Caliskan, S., M.E. Caliskan, M. Arslan and H. Arioglu, (2008). Effects of sowing date and growth duration on growth and yield of groundnut in a Mediterranean type environment in Turkey. *Field Crops Research*., 105: 131-140.

Camberlin, P.and Diop, M.(1999). Inter-Relationships between groundnut yield in Senegal, interannual rainfall variability and sea surface temperatures. *Theoretical and Applied Climatology* 63(3&4): 163-181.

Campos-Mondragón, M.G, De La Barca AMC, Durán-Prado A, Campos-Reyes LC, Oliart-Ros RM, Ortega-García J, Medina-Juárez LA, Angulo O. (2009). Nutritional composition of new groundnut (*Arachis hypogaea* L.) cultivars. *Grasas Aceites* 60, 161-167.

Canavar, O. and Kaynak, M.A. (2008). Effect of different planting dates on yield and yield components of groundnut, (*Arachis hypogaea* L). *Turkish Journal of Agriculture. Forage*., 32: 521-528.

Canavar, O. and M.A. Kaynak, (2010). Growing degree day and sunshine radiation effects on groundnut pod yield and growth. *African. Journal of Biotechnology.*, 9: 2234-2241.

Carley, D.S., Jordan, D.L., Dharmasri L.C., Sutton T.B., Brandeburg ,R.L. and Burton, M.G. (2008). Groundnut response to planting date and potential of canopy reflectance as an indicator of pod maturation. *Agronomy Journal*., 100: 376-380.

Chung, S.H., Hwang, H.B., Lee, S.B. Choi, D.W. and Kang, K.H.(1989) Effect of sowing time on flowering and grain development of groundnuts in the sourthern region of korea. *Field crop Abstract*. 42: 105|

CIRAD-CORAF. 1988-1995. *Arachide-Info. Bulletin of the conference des responsables de reserche agronomique en Afrique de lOuest et du Centre* (CORAF) (eight issues). Dakar, Senegal and Montpellier, France.

.

Collinson, S.T., Sibuga, K.P., Tarimo, A.J.P. and Azam-Ali, S.N. (2000). Influence of sowing date on the growth and yield of bambara groundnut landraces in Tanzania. *Experiment. Agriculture*., 36: 1-13.

Coffelt, T.A. (1989). *Groundnut. In Oil Crops of the World: Their Breeding and Utilization*. . Robbelen, R.K. Downey, and A. Ashri, (eds.) Pp. 319-338. New York: McGraw-Hill Publishing Company.

Cressman, S. G., D. G. Grieve, G. K. McLoad, E. E. Wheeler and L. G. Young. (1980). Influence of dietary protein concentraion on milk production by dairy cattle in early lactation. *Journal of Dairy Science.* 63:1839-1847.

Cullision, A. E., McCampbell, H. C., Cunningham, A. C., Lowrey, R. S. Warren, E. P., McLandun, B. D. and Sherwood, D. H. (1976). The use of poultry manure in steer finishing ration. *Journal of Animal. Science*. 42 (1): 219-228.

Desire, T.V., Lillian, M.T., le prince, N.M, . Jonas, P.I. and Akoa, A. (2010) . Mineral nutrient status, some quality and morphological characteristic changes in groundnut (*Arachis hypogaea* L.) cultivars under salt stress. *African Journal of Environ. Science. Technology.*, 4: 471-479

Devendra, C.M., 1989. *Goat Production in the Tropics*. 92, 305-317.

Devendra, C. (1988). Forage Supplements: nutritional significance and utilization for drought, meat, milk production in buffaloes. *Indian Journal of Agriulturec Research*. 2 : 409-423.

David-west, K.B. (1985) . Role of government in small ruminant production . In: Adu I.F., Osinowo, O.A., Taiwo, B.B.A. and Alhassan, W.S. (Eds) small ruminant production in Nigeria. *Proceedings of National Conference and Small Ruminant, Zaria , Nigeria.* 6-10 October, 1985. NAPRI (National Animal Production Research Institute), Shika-Zaria, Nigeria. Pp 10-17.

Davies , A.T., and Onwuka, C.F.I. (1992).Conservation of forage for dry season feeding in the humid zone of Nigeria. *African Feed Resource Network* 32: 93-95

Donelly, E.D. and Anthoning, W.B. (1969) Effect of genotype and tannin on Dry matter digestibility in *Sericea cesdeza. Crop Science. 10: 200-202*

Duncan, B.D.(1955).*Multiple Range Test and Multiple F- Test Biometrics* 1:1-42.publishers Ltd. Pp.8

Dung D.D, Omokanye A.T and Lamidi.O.S. (2000). Short term intake and in sacco degradability of two tropical legumes. *Tropicultural* .18 (4) 164-166

Dung, D. D. (1998) Comparative assessment of yield, nutritive value and rumen degradation of groundnut (*Arachis hypogeal*). M.SC. Thesis submitted to the Department of Animal science, Ahmadu Bello University, Zaria

Dutta ,N.,Sharma, K.and Hassan, Q.Z . (1999).Effect of supplementation of rice straw with *leucocephala* and P*rosopis cineraria* leaves on nutrient utilization by goats *Asian – Australia Journal of Animal Science.* 12 (5)742-746.

Etela, I .and Dung, D.D (2011) utilisation of stover from six improved dual-purpose groundnut(*Arachis hypogeal*) cultivars by west African dwarf sheep *African journal of Food, Agriculture, Nutrition and Development* 11:.4538-4545

FAO. (1993).Food and Agricultural Organisation of the United Nations. *Production Year Book*, Vol. 47. Rome, Italy, ppi87-196.

FAO (2006) FAOStudies on ruminant animal livestock population WWW.fao.org/faostar. Food and agricultural organisation. Rome, Italy.

Folin, O. and Wu, H. (1990) .Protein measurement. *Journal of Biological Chemistry* 41:367

Faujdar Singh and Diwakar, B. (1993) Nutritive Value and Uses of Pigeonpea and Groundnut Skill Development Series no. 14 International Crops Research Institute for the Semi-Arid Tropics Patancheru, Andhra Pradesh 502 324, India

Flanagan, S.(1999). Early Lamb Production Systems. Teagasc Project Report No.3326.Sheep SeriesNo.6.http//www.teagasc.ie/research/reports /sheep/3326/eopr-3326.htm.

FLDPCS and RIM. (1992). Federal livestock Department and pest Control services/Resource . Inventory and management limited. Nigeria Livestock Resources . Volume ii *National Synthesis* .

Forera, C., Owens, F.N. and Lusby, K.J. (1980). Evalution of slow release of urea for winter supplementation of lactating range cows . *Journal of Animal Science. 50:532-538.*

Gabasawa, A.I, Yusuf, A.A, Iwuafor. E.N.O and Malgwi, W.B (2011). Groundnut Yield and as Affected by Biological Nitrogen Fixation at Samaru, Northern Guinea Savannah of Nigeria *www.abu.edu.ng/publications/2011-02-23-125821_1532.docx*

Garba, A., Abdul, S.D., Udom, G.N.and Auwal, B.M.(2005).Influence of variety and intra-rowspacing on cercospora leaf spot disease of groundnut in Bauchi, Nigeria. Global *Journal of Agricultural Sciences* 4(2): 177-182.

Getachew,G., Makhkor, H.P.S. and Becker,K. (2000). Tannins in tropical Browse: Effect on in vitro microbial fermentation and microbial protein synthesis on media containing different amounts of Nitrogen. *Journal of Agriulturec*. *Food Chemistry*. 48 :3581-3588.

Geo-positioning System (GPS) Garmin extres 12 channel Garmin

Gram, P. A. (1958). Recent developments in groundnuts production with special reference to Africa. *Field Crop Abstract.,* 11: 1-6, 75-84

Hagger, R. J. and Ahmed, M. B. (1970). Seasonal production of Andropogon gayanus. III. Changes in CP content and in vitro dry matter digestibility of leaf and stem proportions.*Journal of Agricultural Science. Cambridge***. 77**:47-52.

Hassan, M.R. (2014) Appraisal of Small holder irrigated forage production and performance of red Sokoto bucks fed lablab supplement. Ph.D thesis submitted to the Department of Animal science, Ahmadu Bello University, Zaria

Hassan, S.A. and Bryant, M.J. (1986). The response of store rams to dietary supplements of fish meal. 2. Effects of level of feeding. *Animal Production. 42 :233-240*

Haggar, R.J. and Ahmed, M.B (1971) . Seasonal production of *Andropogon gayanu*s . Iii changes in crude protein content and *in vitro* dry matter digestibility of leaf and stem proportions *Journal of Agricultural Science Cambridge. 77: 47-52.*

Halevy, J. and Hartzook A. (1988). Dry matter accumulation and nutrient uptake of high-yielding peanut (*Arachis hypogaea* L.). *Peanut Science*., 1: 5-8.

Hammons, R.O., (1994). The origin and history of the groundnut. In J. Smartt (Eds). The Groundnut Crop. A Scientific Basis for Improvement. New York: Chapman and Hall.

Horton, G. M. J. (1979). Feed value of rations containing NPN or natural protein and ammoniated straw for beef cattle. *Journal of Animimal Scencei*. **48**: 38-44.

Hoolbook c.c. and Stalker, H.T. (2003) Groundnut breeding and Genetic resources *plant breeding Reviews* 22: 297-350

Hugo, O. (2010) Special Report on Desertification in Nigeria: The sun eats our land. Vanguard Newspaper

Humpreys, L.R. (1977) potential of humid and subhumid rangelands, In Winrock Foundation, *potential of world's forage for ruminant animal production.* Morrilton, Arkanas

ICRISAT-Patancheru (2010), Development of Sustainable Groundnut Seed System in West Africa. icrisat@cgiar.org,http://www.icrisat.org/

Ikhatua, U.J and Adu, I.F. (1984**)** A comparative evaluation of the utilization of groundnut haulms and *Digitaria smutsii* hay by Red Sokoto goats. *Journal of Animal Production Research.*, **4**: 145-152 in West Africa. icrisat@cgiar.org,http://www.icrisat.org/

Intesar Y. T. and Muna E. K. (2011). Effect of Feeding Fodder beet (*Beta vulgaris* L.var.Crassa) on Fattening Efficiency of Sudan Desert Sheep. *Advances in Environmental Biology*, 5(7): 1592-1596, ISSN 1995-0756

Ishaq, H.M. and Adu, I.P. (1984) A comparative utilisation of groundnut haulms and *Digitaria smutsii* hay by red Sokoto goats. *Journal of Animal Production. Research.* 4:145-152

Iwo, G. A. and Uwah ,D. F. (2010). On-Farm Evaluation Of Groundnut Varieties For Seed And Forage Yields In Southern Guinea Savannah Of Nigeria oar.icrisat.org/221/1/371_2010_WPS27_Farmer_preferences.pdf.

Jahnke,H.E.,(1982).Livestock production systems and livestock development in tropical Africa. *Kider Wissenschafrsverlag Vanx*. Pp253.

Jokhtan, G.E. (2007). Effect of supplementing Rice straw with pigeon pea forages on rumen and blood Metabolites of Yankasa sheep. A seminar paper presented at the Department of Animal Science ABU Zaria, 18th May 2006

Jonas, J. And Vilma, V. (2007).Effect of l.planetarium, pediococus Acdilactici,Enterococcus faectum and l. Lactis microbial supplementation of grass silage on the fermentation characteristics in rumen of dairy cows. V*eterinary Journal of Zootechnika*, p. 40(62) 29 pts@Igi.It

Jones , R.J. and Hegarty, M.P. (1984) . The effect of the different proportions of *leucaena leucocepHala* in the diet of cattle on growth, feed intake, thyroid function andUrinary excretion of 3-hydroxy-4(1h)-pyridone. *Australia. Journa.of Agricultural. Re*search. 35:317-325.

Jurgen, M.H. (1997). *Animal feeding and Nutrition* 8th edition. Kendaii/Hunt publishing company DDubuque., 6:lowa,USA.

Kabaija ,E. and Little, D.A.(1988).Nutrient quality of browses in Ethiopia with particular reference to mineral elements In:B.H. Dzowela ed posture Network for Eastern and southern Africa (Panesa) *Proceeding. Of 3rd Workshop, Arusha Tanzania* 27-30 April, 1987.440-448

Kallah, M.S. (1982) Grazing land management in Nigeria- The range management approach . In: Osinowo, O.A. Ikhatua, U.J. and Ehoche, W.O. (Eds).Beef production in Nigeria. *Proceedings of the National Conference on Beef production, Kaduna, Nigeria* , July 27-30, 1982. NAPRI (National Animal Production Research Institute) Shika-Zaria, Nigeria.pp213-225 .

Kallah, M.S.(2001). Livestock development in Nigeria: Re-orientation or priority setting ? *Journal of Nomadic Studies . 4: 40-47*

Kanjanapruthipong, J. and R. A. Leng. (1998.) The effects of dietary urea on microbial populations in the rumen of sheep. *Asian-Aust. Journal of Animal Science*. 11:661-672

Konlan S, Sarkodie-Addo J, Asare E, Kombiok JM.(2013) Groundnut (*Arachis hypogaea* L.) varietal reponse to spacing in the Guinea savannah agro-ecological zone of Ghana: growth and yield. *African Journal of Agricultural. Research*. ;8(22):2769-2777

Kowal, J.A. and Knabe, D.T. (1972). An Agroclimatological Atlas of Northern States of Nigeria with Explanatory Notes. Ahmadu Bello University Press. ABU, Samaru Zaria. Nigeria. 117p

Lamidi, O. S. (2005). The Use Of Some Non-Conventional Protein Sources For Fattening Cattle Poultry manure as supplement for cattle grazing the natural pastures, Ph.D Thesis. Ahmadu Bello University. Zaria, Nigeria.

Lamidi, O.S., Osinowo, O.A., Adamu, A.M. and Afolayan, R.A. (1998). Utilization of graded level of Ficus leaves by sheep. *Nigeria Journal of Animal Production*.25 (1)

Lamidi.O.S., Omokanye, A.T .and Dung, D.D. (2006) short term intake and in sacco degradability of mixture of groundnut haulm and *Gliricidia sepium* by ruminant in the northerm guinea savannah zones of Nigeria. *Journal of Animals and Vetenary Advance 5* (12) :1129-1132.

Lamidi, A.A., Aina,A.B.J., Sowande, S.O. and Johosho A.O (2009). Assessment of *Panicum maximum* (Jacq),*Gliricidia sepium* (Jacq) and *Gmelina arborea* (Roxb)- based diets as all year round for West Africa Dwarf goat. *Proceedings of 14th Annual conference ofAnimal Science Association of Nigeria* (ASAN),Sept. 14th -17th LAUTECH Ogbomoso, Nigeria

Le Houerou, H.N. (1980) .Browse in northern Africa, In: H.N. Le houerou (ed), *Browse in Africa; the current state of knowledge.* Paper presented at the international Symposium on browse in Africa, Addis Ababa, 8-12 April 1980.ILCA (International livestock Centre for Africa), Addis Ababa, Ethiopia. Pp.55-82 and 480 .

Lee, H. C., Berry, M. P., de Toledo, V. C., deffune, G., Haymes, R., Lopez R. J., Morrish, C. J., Rodigues, R., Scofield, A. M., Watt, T. A. and Wu, B. Z. (1994). Non-chemical weed management in major UK arable crops. In: Arable farming under 139 CAP reform. J. Clarke, A. Lane, A. Mitchel, M. Ramans and P. Ryans (Eds), *Aspects of applied Biology*. 40:317-324.

Leng, R.A (1990) Factors affecting the utilization of poor quality forage by ruminants particularly under tropical conditions *Nutritional Research Review* 3:277-303

Leng, R.A. (1991). Cited by Smith, O.B, (1993) . Partitioning of total tannins in some tree Fodders in condensed and hydrolysable forms.*Indian Journal of Animal Science. 53 (12):1333-1335.*

Loomis, W.D.and Battaile, J.(1960). Plant phenolic compound and the isolation of plant enzymes. *Phytochem*. 5:423-438

. Lowman, B.G. and O.W. Knight., (1971). A note on apparent digestibility of energy and proteinfrom dried poultry waste. *Animal. Production.* 12:525-528.

Lufadeju , E.A.(1988). Evaluation of Methods of improving Utilisation of mature *Digitaria smutsii* hay by Friesian Bunaji heifers. Ph.D. thesis. Ahmadu Bello University, Zaria.

Lufadeju, E. A. and Olorunju, S. A. S. (1986). The ruminal degradation of some agro Industrial by- products. *Journal of Animal. Production. Res*. 6: 161-170

Makembe N E T and Ndlovu L R (1996) *Dolichos lablab* (*Lablab purpureus* cv. 'Rongai') as supplementary feed to maize stover for indigenous female goats in Zimbabwe. Small *Ruminant Research.* 21:31-36

Makkar,H.P.S. and Becker, K. (1999). Do tannins in leaves of trees and shrubs from African and Himalayan regions differ in level and activity? *Agro-forestry systems, 40: 59-68.*

Malau-Aduli, B.S, Eduvie, L. Lakpini, C. and Malau-Aduli, E.O. (2003). Chemical compositions, feed intakes and digestibilities of crop residue based rations in non-lactating Red Sokoto goats in the subhumid zone of Nigeria. *Animal Science. Journal.,* 74: 89-94.

Mallory , R.J.(1972).An introduction to tropical Grassland Husbandary (2nd Ed). Oxford University press . Britain

Martiez, M.A. and Seifert, H.S.H. 1992. Investigations on the toxicity of leucaena leucocephala for goats in North-East Mexico. Herbage Abstract. 62 (80) : 329.

Matejovsky ,K.M.and Sanson, D.W.(1995).Intake and digestion of low –medium and high quality grass hays by lambs receiving increasing levels of corn supplementation *Journal.of Animal Science.* 73 (7):2156-2163.

McDonald, P., Edwards, R.A. and Greenhalgh, J.F.D.(1995). *Animal nutrition* 5th ed. Longman publishers, London UK.

Mehrez, A.z, orkskov, E.R. andMcdonald, I. (1977) Rates of rumen fermentation in relation to ammonia concentration. *British Journal Nutrition.* 38: 437-443

Merwe, P.J. Van der , A., and Swanevelder, C.J. (1989). A new runner groundnut. *Field Crop Abstract*. 42 : 223

. Min, *B.R.*, McNabb, W.C., Barry, T.N., Kemp, P.D., Waghorn, G.C. and McDonald, M.F. (1999) . The effect of condensed tannins in *Lotus corniculatus* upon reproductive efficiency and wool production in sheep during late summer and autumn. *Journal of Agriculture Science,* Cambridge . *132 :323-334.*

Morthy, P.S.S. and Rao, R.C.N. (1986). Physiological basis of variation in pod yield of rainfed groundnut (*Arachis hypogaea* L.) under different dates of sowings. *Indian Journal of Agronomy,* 31: 106-108.

Mosi ,A.K. and Butherworth, M. H. (1985). The voluntary intake and digestibility of cereal Crop residue and legume hay for sheep. *Anim. Feed Science. and Technology***. 12**; 241-251.

Muanyuchi, B., Deb havell, F.D., Ndlov, L.R., Topps, J.H. and Tigere, A. (1997). Napier or groundnut hay as supplements in diets of sheep consuming poor quality natural pasture hay I: effect on intake and digestibility. *Livestock Production Science.* 49: 33-41.

Muinga, R.W.Topps, J.H., Rook, J.A and Thorpe,W. (1995). The Effect of supplementation with *leucaena leucocepHala* and maize on voluntary food intake, digestibility, Liveweight and Milk yield of *Bos indicus* x *Bos taurus* dairy cows and rumen fermentation in steers offered *pennisetum purpureum* ad libitum in the semi – humid tropics. *Animal Science. (formally Anima. Production.), 60 (1)13-24*

Murphy, A and Colucci, P.E. (1999) A tropical forage solution to poor quality ruminant diets: A review of *Lablab purpureus*. *Livestock Resarch for Rural Development (11) 2 1999*. *http:/www.cipav.org.co/Irrd11/2/colu.htm*

Musa ,1.M., Singh, A., Abubakar 1.L., Noma,S.S. Alhassan J. and Haliru ,B.S. (2012). Influence of Cultivar and Sokoto Phosphate Rock Levels on the Yield and Yield Components of Groundnut (*Arachis hypogaea* L.) in Dry Sub-Humid Sokoto Area, Nigeria. *Nigerian Journal of Basic and Applied Science 20*(1): 49-54 http://www.ajol.info/index.php/njbas/index.

Nactomi, E., Halevi, A., Bruckental, I and Amir,S. (1991) . Energy-protein intake and its effect on blood metabolites of high-producing dairy cows. *Canadian. Journal of Animal Science.* 71: 401-407

Nadaf, S.K., Y.M. Ibrahim, M. Akhtar, M.G. El Hag and A.H. Al-Lawati, (1998b). Performance of Fodder beet in Oman. *Annals of Arid Zone*, 37 (4): 377-382.

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) PP 233-237

Ndjeunga J, Ntare BR, Abdoulaye A, Ibro A, Zarafi MA, Cisse Y, Moutari A, Kodio O, Echekwu CA, Mohammed SG and Micko I. (2010). Farmer preferences for groundnut traits and varieties in West Africa: Cases of Mali, Niger and Nigeria. *Working Paper Seriesno*. 27. Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics. 32 pp.

Ndlovu L R and Sibanda L M (1996) Potential of dolichos lablab (*Lablab purpureus*) and *Acacia tortilis* pods in smallholder goat kid feeding systems in semi-arid areas of Sourthern Africa. *Small Ruminant Research* 21:273-276

Ndlovu, L.R and Hove, L (1995). Intake, digestion and rumen parameters of goats fed mature veld hay ground with deep litter poultry manure and supplemented with graded levels of poorly managed groundnut hay. *Livestock Research Rural Development*.; 1995; 6, http://www.cipav.org.co/lrrd/lrrd6/3/ndlov.htm, 1995 Accessed on April 4, 2009*). Journal of Dairy Science* 74:3583-3597.

Nguyen, Thi Mui, Preston, T.R. Dinh van Binh, Le viet ly, and oblison, I. (1996a). Effect of management practices on yield and quality of sugar cane and on soil fertility. *Livestock research for rural development* 8(3): 51-60.

Nigam, S.N., Dwivedi S.L. and Gibbons R.W. (1991). Groundnut breeding, constraints, achievements and future possibilities. *Plant Breeding Abstract. 61*: 1127-1136.

Nworgu, F.C. and Ajayi, F.T. (2005). Biomass, dry matter yield, proximate and mineral composition of forage legumes grown as early dry season feeds.*livestock research for rural development* 17 (11) Retrieved on 20th March,2009 from http://www.lrrd.org19/9/ngon19129.htm

Nuru, S. (1985).Trends in small ruminant production in Nigeria In: Adu, I.F., Osinowo, O.A., Taiwo, B.B.A. and Alhassan. W.S. (Eds). Small Ruminant production in Nigeria.*Proceedings of National Conference in small ruminant production held in Zaria. Nigeria* 6-10 October, 1985. NAPRI (National Animal Production Research Institite) Shika,Zaria. Nigeria. Pp35-51

Ogundele, B. A. (1988). Variability for seedling vigour in cowpea (*Vigna unguiculata* l. Walp) evaluated in south western Nigeria. *Genetic Agraria*. 42(2): 133-140

Okafor EC, CAM Lakpini and A Fayomi, 2012. Dried gmelina *(Gmelina arborea roxb) l*eaves as replacement forage to groundnut haulms in the diet of fattening red sokoto bucks. *Internation Journal of Agriculture Bioscience*, 1(1): 5-10.www.ijagbio.com

Oke, D.B, Tewe, O.O and Fetuga, S.L. (1995). The nutrient composition of some cowpea varieties. *Nigeria. Journal of Animal. Production*. 22: 32-35.

Ong, C.K. (1984). The influence of temperature and water deficits on the partitioning of dry matter in groundnut (*Arachis hypogaea* L.). *Journal of Experiment. Botany*., 154: 746–753.

Orskov, E.R. 1982 *Protein Nutrition in Ruminants*.Academic press, London.

Osuji, P.O., Nsahlai, T.V. and Khalili, H. (1993). Feed evaluation. *ILCA Manual 5*. ILCA (International Livestock Center for Africa), Addis Ababa, Ethiopia. pp. 40.

Otchere, E.O, Tanko, R.J., Muhammad, I.R., Kallah, M.S., Ahmed, H.U., Mohammed, A.K., Gefu, J.O., Ajala, M.K. and Ndubuisi, A.H.(1994). Forage and cattle production under the traditional system of management in the savana zone of Nigeria. In O.A. Osinowo, E.O. Otchere, M.A. Adamu, D.V. Uza and J.O Agwu (eds) Strategies for improving livestock production for small scale farmers in Nigeria. *Proceedings of Workshop on Livestock Systems Research.* Organised by FDLPCS, Kaduna. 11-16thJuly, 1993. 77-88.

Ortega-García J, Medina-Juárez LA, Angulo O. 2009. Nutritional composition of new groundnut (*Arachis hypogaea* L.) cultivars. *Grasas Aceites* 60, 161-167. http://dx.doi.org/10.3989/gya.075008

Onwuka, C. F. I., Isah ,O.A. Oni, A.O.and Aderinboye R.Y.(2014) Ruminant Animal Nutrition Ann 503 lecture Note http://www.e-bookspdf/download/animalnutritionnotes

Oyedipe, E. O., Saror, D., Osori, D. I. K. and Akerejola, O. (1984). Hematologicaln parameters ofZebu cattle on different protein levels and their relationship to rate of gain. *Bulletin of Animimal. Health and production in Africa* ***32 (2)*** 129-139.

Oyedipe, E. O., Akerejola, O., Saror, D and Osori, D. I. K. (1984). Effects of dietary protein On some biochemical components of Zebu heifers. *Tropical. Veterinarian* 2: 137-144.

Pande, S. Bandyopa, R. Bliimmel, M. Narayana, R.J. Thomas, D. and Navi. S.S.(2003). Disease management factors influencing yield and quality of sorghum and groundnut crop residues. *Field Crops Research*., 84: 89-103. .

Parthasarathy, R.P. and Hal A.J . (2003).. Importance of crop residues in crop-livestock systems in India and farmers' perception of fodder quality in coarse cereals. *Field Crops Research.,* 84: 189-198.

Patel, D.P., G.C. Munda and C.H. Mokidulislam, (2005). Dry matter partitioning and yield performance of HPS groundnut. *Div. Agronomy*., ICAR Res. India, 30: 156-161.

Pauzenga, U. (1985). Feeding parent stock. Zoo-technician International conf. December Pp. 22-

Groundnut CRSP. (1997). Improving global production and use of groundnuts: *Annual report*, 1996. University of Georgia, Griffin, USA

Peoples, M. B., Faizah, A. W., Rerkasem, B. and Herridge, D. F. (1989). Methods for Evaluating Nitrogen Fixation by Nodulated Legumes in the Field. ACIAR, Camberra**.**

Pietrarelli J.R. (1980). Groundnut production, utilization, research problems and further research needs in Argentina. In: *Proceedure International. Workshop on Groundnuts*, 13-17 October 1980, Patancheru Andhra Pradesh, India

Pigott, C. J. (1960). The effect of fertilizer on yield and quality of groundnuts in Sierra Leone. *Journal of experiment. Agriculture*., 28: 58-64.

Powel, M.P. , Okorie, A.O, Okorie, A.U, Peter, J.B. Wilhain, H.Dyfed, L (1981) Amonia Concentration and protein Synthesis in the rumen. *Journal of science food Agriculture,* 32:759-763

Purseglove, J.W. (1968). *Tropical Crops Dicotyledons*. Vol L London, UK; Longmans Greens and Company Ltd. Pp 273-276.

Reddy, T.Y., Reddy, V.R.and Anbumozhi, V. (2003). Physiological responses of groundnut (Arachis hypogaea L.) to drought stress and its amelioration: a critical review. Plant Growth Regulation 41:75-88.

Reddish,P.M. and Scarr, M.J.(1987). Subsiding industries for the live stock subsector. *Proc. 11th Conf. Nigerian Soc. Anim Prod.,* Zaria. Pp12-23.

Reddy D.V. (2007) . Applied nutrition livestock, poultry, human, pet, rabbit and laboratory animal nutrition, 0xford and IBH publishing Co. Pvt. Ltd , new Delhi. Pp121.

Reed, J.D (1995). Nutritional toxicology of tannins and related polyphenols in forage legumes . *Journal of Animal Science 73: 1516-1528.*

Reed, J.D., Soller. H. and Woodward, A. (1990). Fodder tree and strw diets for sheep: intake, growth digestibility and the effects of phenolics on nitrogen utilisation . *Animal Feed Science Technology. 30: 39-50*

Rittenhouse, L.R., Clanto, D.C. and Steer, C.L. (1970). Intake and digestibility of winter-range forage by cattle with and without supplements . *Journal of Animal. Science. 31: 98-107.*

Robbins, C.T., Hanley, T.A., Hagerman, A.E., Hjelord, O., Baker, D.L., Schwartz, C.C. and Mautz , W.W. (1987). Role of tannins in defending plant against ruminants :reduction in protein availability. *Ecology, 68: 98-107*

Richard, D.E,, Brown W.F, Ruegsegger G. and Bates D.B. (1994). Replacement value of tre legumes for concentrates in forage based diets. *II* Replacement value of *leucaena leucocepHala and Gliricidia sepium* for lactating goats . *Anim. Feed Science Technology. 46 :53-65.*

Russel, A.J.F. and Wright, I.A. (1983). The use of blood metabolites in the determination of energy status in beef cows. *Anim. Prod*., 37: 335-343.

Rutherglen, D C (1995). Energy and Protien Requirements of Beef cattle. Victoria Stat Government Agricultural Notes. AG0374 ISSN 1329-8062

Sahlu,T., Hart, S.P.and Fernandez, J.M.(1993).Nitrogen metabolism and blood metabolites in three goats breed fed increasing amount of protein. *Small Rum.Res. 10: 281-292*

Shaib,B. Aliyu , A. And Bakshi, J.S.(1997). *Nigeria National Agricultural Research Strategy* . (1997).

Sardana, V. and Kandhola,S.S. ,(2007). Productivity of semi-spreading bunch type varieties of groundnut as influenced by sowing date. *Journal. SAT Agriculture Research*., 5: 1-3.

Schilling, R.and Misari, S.M.(1992). Assessment of groundnut research in the Savanna region of West Africa, In: Nigam, S.N (ed.), *Groundnut – A Global Perspective*, International Crops Research Institute for the Semi-Arid Tropics, Patancheru, India, pp.97-112

Schmidt, S.P. and Keith, R.K (1983) Effects of diet and energy intake on kinetics of glucose metabolism in Steers. *Journal of. Nutrition. 113:2155*

Silanaikove, N., Perevolosky, A and Provenza F.D. (2001) Use of tannin binding chemicals to assay for tannin in and their negative post-ingestive effects in ruminants. *Animal Feed Science and Technology* 91:69-81

Sticker, L. S., Thompson, D. L, Fernandez, J. M., Bunting, L. D, and DePew, C. L. (1995) Dietary protein and(or) energy restriction in mares: plasma growth hormone, IGF-I, prolactin, cortisol, and thyroid hormone responses to feeding, glucose, and epinephrine. *Journal Animal Science.* 73:1424 1432.http://www.journalofanimalscience.org/content/73/5/1424

Savadogo, M., Zemmelink, G. and Nianogo, A. J.(2000). Effect of selective consumption on voluntary intake and digestibility of sorghum (*Sorghum bicolor* L. Moench) stover, cowpea (*Vigna unguiculata* L. Walp.) and groundnut (*Arachis hypogaea* L.) haulms by sheep. *Animal. Feed Science Technology.*, 84 (2000),pp. 265–277.

Smith, O.B. (1992). Small ruminant feeding systems for small scale farmers in humid West Africa . In: stare, J.E.S., Said, A.N. and Kategile, J.A(Eds). The Complementarity of feed Resources for Animal Production in Africa. *Proceedings of the joint feed Resources Network. ILCA. Gaborone, Botwana*4-8 march, 1991.African feeds research Network. ILCA (International Livestock Centre for Africa), Addis Ababa Ethiopia. Pp363-37

Smith, O.B. (1993). Feed Resources for intensive small holder systems in the tropics: The role of Maize Stover In :Baker, M.J. Crush J.R. and HumpHreys, L.R.(Eds) *Proceedings of the 17th international grassland congress*; Australia/New Zealand. 8-21 February, 1993. Vol. lll:1969-1976.

Smith, A.F. 2002 Groundnuts: The Illustrious History of the Goober Pea. Chicago: University of Illinois Press.

Ssali, H. and Keya, S.O. (1980). Nitrogen levels and cultivar effects on nodulation, dinitrogen fixation and yield of grain legumes. *East African Journa of Agriculture and Forestry.* 45(4): 247-254

Sokoto, M.B. Bello, I. and Osemuahu, E. A (2013).Effects of Intra-Row Spacing on Herbage Yields of Two Groundnut (*Arachis hypogaea* L.) Varieties in Sokoto, Semi-Arid Zone, *Nigeria International Journal of Applied Agricultural and Apicultural Research* ,9 (1&2): 11-17.

Summerfield, R. J. and Roberts, E. H.(1985). *Grain Legume Crops*. Collins, London.

Summerfield, R. J. and Bunting, A. H. (1978). Advances in legume science: Volume 1 of the *International Legume Conference*, 31 July-4 August 1978, Kew, Uk

Tarimo A. J. P. (1997). Physiological response of groundnut to plant population density. *African Crop Science Journal, Vol. 5. No. 3, pp. 267-272.*

Tariq, M. 1`988 . Effect of urea-treated wheat and rice straws on nitrogen fractions of ruminal fluid. M.Sc. Thesis, University of Agriculture, Faisalabad

Taru,V.B.,Kyagya,I.Z.,Mshelia,S.I and Adebayo,E.F. (2008*).* Economic Efficiency of Resource Use in Groundnut Production in Adamawa State of Nigeria *World Journal of Agricultural Sciences* 4 (S): 896-900, 2008ISSN 1817-3047.

Tsigbey, F. K., Brandenburg, R. L. and Clottey, V. A. (2003). Groundnut production methods in northern Ghana and some disease perspectives. *Online Journal of Agronomy.* 34 (2): 36-47.

Tinnimit, P., Y. and K. W. Thomas. K. W. (1972). Dried poultry waste as protein supplements for sheep. *Journal of Animal Science* **35:** 431-435

Ulyatt, M.J.. Whitelaw.F.g. and Watson, F.G. (1970) .the effect of diet on glucose entry rates in sheep. *journal of Agricultural Science . Camb. 75:565-570*

Umunna N N, Osuji P O, Nsahlai I V, Khalili H and Mohamed-Saleem M.A. (1995) Effect of supplementing oat hay with lablab, *sesbania*, *tagaste* or wheat middlings on voluntary intake, N utilisation and weight gain of Ethiopian Menz sheep. *Small Ruminant Research.* 18:1130-120.

Valentim, J.F., Rueike, O.C and Prine, G.M. (1987). Yield and quality responses of tropical grasses, a legume and grass legume associations as affected by fertilizer nitrogen. *Herbage Abstract*

Van Soest, P.J., Robert, J.B. and Lewis, B.A. (1991) Method for dietary , fibre, neutral detergent fibre and non-starch polysaccharides in relation to animal nutrition. *Journal of Dairy Science* 74: 3583-3597

Vance, C.P. (2001). Symbiotic Nitrogen Fixation and Phosphorus Acquisition. Plant Nutrition in a World of Declining Renewable Resources. *Plant Physiology* . 127**:** 390-397.

Virender S, Kandhola SS. (2007) Productivity of semi-spreading and bunch type varieties of groundnuts as influenced by sowing date. *Journal of Semi-Arid Tropical Agricultural. Research. ;5(1)*

Waghorn, G.C. Reed, J.D., Ndlovu, L.R. (1999). Condensed tannin and herbivore nutrition. In *proceedings of the xvll*th *International grasslands Congress* 3:153-156 .

Walshe ,M.J., Grindle, J.N., and Bachmann,M.,(1991). Dairy Development in Subsaharan Africa: A study of issues and options Wold Bank, Washinton DC.

Wanapat, M. (1985). Improving rice straw quality as ruminant feed by urea-treated in Thailand. In: *Proc. of Relevance of crop residues as animal feeds in developing countries* (Ed. M. Wanapat and C. Devendra) Funny Press, Bangkok, Thailand.

Wanapat, M. (1999). *Feeding of ruminants in the tropics based on local feed resources*. Khon Kaen Publishing Company Ltd., Khon Kaen, Thailand. p. 236.

Wanapat, M. (2003). Manipulation of Cassava Cultivation and Utilization to Improve Protein to Energy Biomass for Livestock Feeding in the Tropics. Asian-Aust*. Journal of Animal Science.* 16(3):463-472.

Wanapat, M. and Pimpa O. (1999). Effect of ruminal N[H.sub.3]-N levels on ruminal fermentation, purine derivatives, digestibility and rice straw intake in swamp buffaloes. *Asian-Aust. Journal of Anim. Sci. 12:904-907.*

Wang, Y., Douglas, G.B., Waghorn, G.C., Barry, T.N., Foot, A.G. and Purchas, R.W.(1996). Effect of condensed tannins upon the Weight Change on rams grazing *Lotus corniculatus* and lucerne (Medicago sativa) . *Journal Agriculture Science (Cambridge) 126:87-98*.

Weiss, E. A. (2000). *Oilseed Crops*. London: Blackwell Science

Wikipedia. (2013). Nigeria Google Satellite Maps. Retrieved May 6, 2013 from www.maplandia.com/../samaru

Woodman, H F and Evan, R F (1974). The nutritive value of fodder cellulose when fed to ruminants and pigs. *Agricultural Science*, XXXVII 202 -223

Yayock, J.Y., Ajayi,O., Karikari, S.K.and Owonubi, J.J. (1987). Improvement in the productivity of food grains in drought-prone areas of Nigeria .In Menyonga,J.M., Bezunch,A. (Eds).Food Grain Production in Semiarid Africa: *International Drought Symposium*. OAU/STRC. Ougadougou

Zeyong, X.(1992). Groundnut production and research in East Asia in the 1980s .In: Nigam, S.N.(ed.), Groundnut-A global perspective, *Proceeding of International Workshop*, Patancheru, A.P., India, 25-29 November 1991,ICRISAT Center, India, pp.157-165

8 APPENDICES

Appendix 1: Temperature relative humidity and rainfall distribution for 2012 and 2013

rainy seasons for Shika and Samuru.

Months	**R/Humidity (%)**		Max **Air Temperature (C^0)**		**Rainfall (Mm)**	
	2012	2013	2012	2013	2012	2013
April	52	38	39.03	38.45	73	73
May	68.25	68.19	33.77	35.35	263.4	94.4
June	76.09	73.06	31.54	32.56	120.7	166.1
July	82.61	81.96	30 29	30.32	165.3	315.2
August	82.32	81.75	29.06	29.78	426.7	163.0
September	77.23	78.92	30.36	31.12	270.3	226.8
T/Annual Rainfall					1358	1049.9
25 years Average Rainfall						1133.2mm

Source IAR(2013) Meteorological Unit ,A.B.U .Zaria.

Appendix 2: Weight-Unit Conversion Factors

Units Given	Units Wanted	For Conversion Multiply by
Lb	G	453.6
Lb	Kg	0.4536
Oz	G	28.35
Kg	Lb	2.2046
Kg	Mg	1,000,000.
Kg	G	1,000.
G	Mg	1,000.
G	µg	1,000,000.
Mg	µg	1,000.
mg/g	mg/lb	453.6
mg/kg	mg/lb	0.4536
µg/kg	µg/lb	0.4536
Mcal	Kcal	1,000.
kcal/kg	kcal/lb	0.4536
kcal/lb	kcal/kg	2.2046
Ppm	µg/g	1.
Ppm	mg/kg	1.
Ppm	mg/lb	0.4536
mg/kg	%	0.0001
Ppm	%	0.0001
mg/g	%	0.1
g/kg	%	0.1