EVALUATION OF RAW OR PARBOILED RICE OFFAL AS ENERGY SOURCE IN FATTENING BUNAJI BULLS.

By

Remilekun Tawakalit SANI, B. Agriculture (Ahmadu Bello University) 2010.

MSc/AGRIC/5361/2010-2011

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

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF A MASTER DEGREE IN ANIMAL SCIENCE.

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

AUGUST, 2014

DECLARATION

I declare that the work in this thesis entitled "Evaluation of raw or parboiled rice offal as energy source in fattening Bunaji bulls" 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 references provided. No part of this thesis was previously presented for another degree or diploma at this or any other Institution.

(Name)	(Signature)	Date

CERTIFICATION

This thesis entitled "EVALUATION OF RAW OR PARBOILED RICE OFFAL AS ENERGY SOURCE IN FATTENING BUNAJI BULLS" by SANI REMILEKUN TAWAKALIT meets the regulations governing the award of the degree of Master of Science (Animal Science) of the Ahmadu Bello University, Zaria, and is approved for its contribution to knowledge and literary presentation.

Chairman, Supervisory Committee (Name)	(Signature)	Date
Member, Supervisory Committee (Name)	(Signature)	Date
Head of Department (Name)	(Signature)	Date
Dean, School of Postgraduate Studies (Name)	(Signature)	Date

ACKNOWLEDGEMENTS

Foremost, I give thanks to uncreated creator (ALLAH) of all that exist. Moreso, I would like to express my heartfelt gratitude and indebtedness to my supervisors: Professor O.S. Lamidi and Dr. G.E. Jokthan for their mentorship in the undertaking of this project. They were instrumental to the success of this work by their meticulous and untiring effort in correcting, editing, constructive criticisms and proffering solution to lapses in the work.

I want to also thank the former Programme Leader, Beef Research Programme of the National Animal Production Research Institute (NAPRI), Prof. C.B.I. Alawa for his fatherly advice, encouragement and recommending my proposal for the Institute approval. Also, to the Management of the National Animal Production Research Institute (NAPRI), Shika for the opportunity given to me to conduct this research at the Institute. I want to thank the staff of Beef Research Programme, particularly Mrs. K.B. Adewuyi, Mr. D. Y. Goska, Mr. I.I. Madziga, Mr. A.L. Bashir A. L, Mal. M. Dalhatu, Mal. H. Ahmed, Mal. S. Ibrahim S, Mal. M. Salisu, Mr. Y. Abubakar for their support and good working relationship. I am also grateful to the Head of Data Processing Unit of NAPRI, Prof. I.A. Adeyinka for all his encouragements and for putting me through the Statistical Analysis of the data collected. I want to appreciate my Dear sister Prof. S.A. Sanni of the Department of Agricultural Economics and Rural Sociology (IAR) for her unflinching support throughout the course of this study and putting me through the Economic Analysis.

I like to appreciate the effort of the following staffs of NAPRI Central Laboratory: Mal. B. Ahmed, Mr. K. Mohammed, Mr. G. Falode and Mr. M. Agbonika for their technical assistance during the course of this work in the analysis of feed, faecal and urine samples. Also, my

appreciation goes to Mal. G. Mohammed, Mal. M. Idris and H.I. Danjumai of the Meat Laboratory for their efforts in processing the animals. I will also like to thank the Manager of PLS Feedmill, Jama'a, Samaru-Zaria, Dr. A.A. Adewuyi, who aided purchase of first batch of poultry litter from his farm. Also, the effort of staffs of Poultry Unit, NAPRI especially Mrs. F.B. Jaiyeoba is also appreciated for facilitating the purchase of poultry litter used in this experiment. My deepest appreciation goes to all staff of the Feedmill Unit, NAPRI, most especially Mr. D. Jang for mixing of the feed used in this experiment. Also, Dr. R. Yahya of Agronomy Department (IAR) for facilitating the purchase and transportation of rice offal used in this study from Kura in Kano State.

My sincere gratitude goes to all my Lecturers Dr. (Mrs) M. Orunmuyi, Prof. G. S. Bawa, Prof. J.J. Omage, Dr. S. Duru, Dr S.B. Abdu, Dr. P.A. Onimisi, Dr. T.S. Olugbemi, Dr. M.O. Daudu, Mal. M. R. Hassan, Dr. S.M. Yashim all of Department of Animal Science, Dr. M. Aminu and Prof. A. Lamido of Agronomy Department (IAR) and Dr. D. D. Dung (NAPRI) for impacting knowledge during my course work.

My heartfelt gratitude also goes to my father late Alh. U.A. Sanni of blessed memory and my mother Alhaja H.A. Sanni for her patience, understanding, moral support and prayer. Also, my siblings Mr. K. Ahmad, Mrs. A. Barakat, Mr. B. Bello, Mr. O. Tajudeen and Mr. O. Ilias. I will like to deeply appreciate the effort of my guardians Mr. and Mrs. O. Abdulfatia and their children. May Allah reward them abundantly Special thanks go to my father and mother in-law Mr. and Mrs. H.K. Amuda for their support and encouragement throughout the course of my study.

My unreserved gratitude goes to my beloved husband Mal. A.K. Abdulgafar and my three precious and wonderful gifts from Allah: A. Abdullah, A. Maryam and A. Aasiya . I would not have been able to get this far with this work safe with their understanding and support.

TABLE OF CONTENTS

TITLE PAGE…… ….i

DECLARATION ii

CERTIFICATION iii

ACKNOWLEDGEMENTS..... iv

TABLE OF CONTENTS vii

LIST OF TABLES x

LIST OF FIGURES xii

LIST OF APPENDIX xiii

ABSTRACT xiv

CHAPTER ONE 1

1.0 INTRODUCTION.....1

1.1 Aims and Objectives of Present Study.....3

1.2 Null Hypothesis (H_o).....3

1.3 Alternate Hypothesis (H_a) 4

CHAPTER TWO 5

2.0 LITERATURE REVIEW 5

2.1 Population, Breeds and Distribution of Beef Cattle in Nigeria 5

2.2 Beef Cattle Production Systems 10

2.3 Nutrient Requirements of Beef Cattle.....17

2.4 Feed Resources for Cattle Feeding in Northern Nigeria 21

2.5 Energy Metabolism in Ruminants 30

2.6 Nutritive Value of Different Rice Mill By-Products and their use in Cattle Feeding. 31

2.7 Feed digestion and physiology in Ruminants....34

CHAPTER THREE....36

3.0 MATERIALS AND METHODS....36

3.1 Experimental Site....36

3.2 Fattening Trial....36

3.3 Animal Management....38

3.4 Source of Rice Offal....38

3.5 Data Collection....38

3.6 Rumen Fluid Sampling....38

3.7 Digestibility Study....39

3.8 Carcass Evaluation....39

3.9 Chemical analysis....40

3.10 Economic analysis....41

3.11 Data analysis....41

CHAPTER FOUR....42

4.0 RESULTS....42

4.1 Chemical Analysis....42

4.2 Effect of Diet containing Raw or Parboiled Rice Offal on the Fattening Performance of Bunaji Bulls....43

4.3 Effect of Diet containing Raw or Parboiled Rice Offal on Digestibility and Nitrogen Balance of Bunaji Bulls....49

4.4 Effect of Diet containing Raw or Parboiled Rice Offal on Rumen Metabolites of Bunaji Bulls.... 53

4.5. Effect of Diet containing Raw or Parboiled Rice Offal on Carcass Yield of Bunaji Bulls…....59

4.6 Economic Evaluation 60

CHAPTER FIVE 68

5.0 DISCUSSION 68

5.1 Chemical Analysis 68

5.2 Effect of Diets containing Raw or Parboiled Rice Offal on the fattening Performance of Bunaji Bulls.....73

5.3 Effect of Diets containing Raw or Parboiled Rice Offal on Nutrient Digestibility and Nitrogen Balance of Bunaji Bulls 74

5.4 Effect of Diets containing Raw or Parboiled Rice Offal on Rumen Metabolites of Bunaji Bulls. 76

5.5 Effect of diet containing Raw or Parboiled Rice Offal on Carcass Yield of Bunaji Bulls. ----------79

5.7 Economic evaluation.....81

CHAPTER SIX.....83

6.0 SUMMARY, CONCLUSION AND RECOMMENDATIONS.....83

6.1 Summary 83

6.2 Conclusion.....84

6.3 Recommendation 85

REFERENCES 86

LIST OF TABLES

Table No		Page
Table 3.1:	Percent ingredient composition of concentrate diet	38
Table 4.1:	Chemical composition of individual feed ingredient and hay	45
Table 4.2:	Mineral composition of raw and parboiled rice offal	46
Table 4.3:	Chemical compositions of concentrate diets containing varying levels of raw or parboiled rice offal fed to fattening Bunaji bulls	47
Table 4.4:	Effect of feeding diet containing raw or parboiled rice offal on performance of fattening Bunaji bulls	48
Table 4.5:	Effect of feeding diet containing varying levels of raw or parboiled rice offal on performance of fattening Bunaji bulls	49
Table 4.6:	Effect of type and level of inclusion of raw or parboiled rice offal on performance of fattening Bunaji bulls	51
Table 4.7:	Effect of feeding diet containing raw or parboiled rice offal on digestibility and nitrogen balance of Bunaji bulls	52
Table 4.8:	Effect of feeding diet containing raw or parboiled rice offal on digestibility and nitrogen balance of Bunaji bulls	53
Table 4.9:	Effect of type and level of inclusion of raw or parboiled rice offal on digestibility and nitrogen balance of fattening Bunaji bulls	56

Table 4.10: Effect of feeding diet containing raw or parboiled rice offal on carcass yield of fattened Bunaji bulls 62

Table 4.11: Effect of feeding diet containing varying levels of rice offal on carcass yield of fattened Bunaji bulls 63

Table 4.12: Effect of type and level of inclusion of raw or parboiled rice offal on carcass yield of fattened Bunaji bulls 64

Table 4.13: Partial budget analysis for Bunaji bulls fed either Raw or Parboiled rice offal as energy source 65

Table 4.14: Partial budget analysis for Bunaji bulls fed varying levels of inclusion of rice offal as energy source 66

Table 4.15: Partial budget analysis for Bunaji bulls fed varying levels of Raw or Parboiled rice offal as energy source 68

LIST OF FIGURES

Figure		Page
Fig. 4.1:	Effect of feeding diet containing raw or parboiled rice offal on rumen pH, rumen ammonia nitrogen and rumen total volatile fatty acid of fattening Bunaji bulls	57
Fig. 4.2:	Effect of feeding diet containing varying levels of rice offal on rumen pH, rumen ammonia nitrogen and rumen total volatile fatty acid of fattening Bunaji Bulls	58
Fig. 4.3:	Effect of type and level of inclusion of raw or parboiled rice offal on rumen pH, rumen ammonia nitrogen and rumen total volatile fatty acid of fattening Bunaji Bulls	59

LIST OF APPENDIX

Appendix	Page
Appendix I: Mineral requirements and maximum tolerable concentration in beef cattle feed.	103
Appendix II: Light Brown raw rice offal with broken rice grains and fine hull	104
Appendix III: Brown Colour parboiled rice offal with coarse hulls	104
Appendix IV: Spectrum of mineral elements in parboiled rice offal with Silicon having the highest peak and intensity (cps) of K_α line energy	105
Appendix V: Spectrum of mineral elements in raw rice offal with Silicon having the highest peak and intensity (cps) of $K_\alpha - K_\beta$ line energy	106
Appendix VI: *Digitaria smutsii* forage used as basal diet	107
Appendix VII: Experimental animals in individual pens	107
Appendix VIII: Fortnight weighing of Bunaji bulls during fattening trial	108
Appendix IX: Rumen fluid sample collection using stomach tube	108
Appendix X: Rumen pH reading using pH meter	109
Appendix XI: Experimental animals (Bunaji bulls) in metabolic crates during digestibility trial	109
Appendix XII: Feacal and urine samples collected during digestibility trial	110
Appendix XIII: Blood collection after slaughtering	110
Appendix XIV: Hanging of animal in preparation for shrunk body weight measurement	111
Appendix XV: Hot carcass measurement with a weighing scale	111
Appendix XVI: Preparation of dissectible beef for weighing	112
Appendix XVII: Prepararion of offals for weighing	112

ABSTRACT

A study was conducted using 20 Bunaji bulls with a live weight range of 210-249kg, and age range of 2-3 years to evaluate the feeding value of raw or parboiled rice offal as energy source for bull fattening. Four bulls per treatment were allotted to five dietary treatments in a 2x2 factorial arrangement with a common control. Feeding and metabolism trials were conducted for 90 and 21 days, respectively. Rumen fluid was collected at 0, 2, 4 and 6hrs intervals to determine the rumen pH, rumen ammonia nitrogen and rumen total volatile fatty acid for all the bulls. A concentrate and basal diets of *Digitaria smutsii* were offered at 2% body weight. The proximate and mineral composition of the feed ingredients showed that raw rice offal (RRO) had 7.69% CP, 6.64% hemicellulose and 24.86% silica while parboiled rice offal had (PRO) 4.38% CP, 6.10% hemicellulose and 36.91% silica. In terms of mineral contents, RRO was only higher in magnesium. The CP contents of the experimental diets vary between 19.69 and 20.44% while the ME ranged from 10.86 to 11.16MJ/kg DM. The crude fibre varies from 14.59 to 17.84%. The result of the fattening trial showed that there was no significant ($P>0.05$) difference in concentrate, hay, total dry matter intakes and daily weight gain of bulls fed the control diet (NRO) and diets containing RRO and PRO. Inclusion level of rice offal had no significant effect ($P>0.05$) on intake of concentrate, hay and total feed intake. However, live weight gain of the bulls on the control diet was significantly ($P<0.05$) higher than bulls on 20 and 30% rice offal inclusion The intake of concentrate, hay, total feed and daily live weight gain of the bulls were similar ($P>0.05$) irrespective of type and inclusion levels of the rice offal. All the bulls experimented attained an average weight gain of between 1.11Kg to 1.29Kg which was above 1Kg. Rumen parameters were not significantly ($P>0.05$) affected by rice type but significantly ($P<0.05$) affected by inclusion level. The result showed that Rumen pH at 6hrs after feeding at 0% (6.63) and 30% (6.76) were similar ($P>0.05$), but differed ($P<0.05$) significantly from 20% (6.93) inclusion level. Total Volatile Fatty Acid (TVFA) was not significant at 0hr before feeding with 0% being similar to 20 and 30% inclusion levels. Bulls on diet containing 20% inclusion levels had the highest TVFA value (44.70 μmol) with the least (23.49 μmol.) being those on 30%. Varying the levels of inclusion of RRO and PRO was not significant ($P>0.05$) on rumen pH and TVFA at different sampling time. However, significant ($P<0.05$) difference was observed for Rumen Ammonia Nitrogen (RAN) at 2hrs post feeding. Bulls on 30% PRO had the highest value (22.41g/100g) while 20% PRO (14.80g/100g) had the least value. The result of the carcass evaluation showed significant ($P<0.05$) difference with rice type for legs, spleen, Empty stomach, Empty intestine, inguinal fat, abdominal fat with PRO being higher except for the spleen which is higher for RRO. At varying levels of inclusion of rice offal, there was significant ($P<0.05$) difference in dressing percentage, Beef percent of carcass, meat to bone ratio, legs, hide, tail, empty stomach, stomach with content, empty intestine, Inguinal fat, kidney fat, abdominal fat, depth of chest fat, testis and blood. Carcass evaluation for bulls on diets with varying levels of inclusion of raw or parboiled rice offal were significant ($P< 0.05$) for legs,

hide, empty stomach, empty intestine, inguinal fat and abdominal fat. Economic parameters such as cost per Kg gain, net benefit (NB) and return to naira invested on feed (RIF) were similar ($P>0.05$) for bulls on both RRO and PRO. Daily weight gain was significantly ($P<0.05$) affected by inclusion level with bulls on the control diet 0% having the highest(1.29Kg) while those on 20% (1.15 Kg) and 30% (1.14 Kg) were statistically ($P>0.05$) similar. Value of gain was significant ($P<0.05$) but decrease with increase in inclusion level. There was no significant ($P>0.05$) differences in the Value of weight gain (VWG), NB, RIF, Cost of feed and Cost per Kg gain for bulls on varying levels of inclusion of RRO or PRO. The inclusion of raw rice offal or parboiled rice offal lead to reduction in feed cost from N25,001.10 to a range of N22,115.50-N23,639.6 (about 5.45%-11.54% reduction in feed cost). It was therefore concluded from this trial that the meat from bulls fed 30% rice offal, (either raw or parboiled) were of better quality due to low fat. Similarly, rice offal of all kind (raw or parboiled) may be used to replace up to 30% of maize offal as source of energy in the diets of fattened Bunaji bulls without any detrimental effect on live weight. Hence it can be adopted by farmers.

CHAPTER ONE

1.0 INTRODUCTION

Nigeria's cattle population is put at 16 million (FAO, 2009). This is made up of two broad breeds, the Zebu breeds which include: Bunaji, Rahaji, Gudali etc and the Taurines breeds which include: Kuri, Keteku, N'dama etc (Blench, 1999). The breed mostly fattened by small holder cattle fattening operation is the white Fulani which constitute about 60% (Alawa *et al*., 2007), this breed is reported to have a higher dressing percentage when compared with other indigenous breeds of cattle (Adamu and Alawa, 2005). Bunaji is the most numerous and widely distributed breed of cattle in Nigeria (Ahamefule *et al*., 2007) representing about 51% of the national cattle population (Ikhatua, 2010) owned mainly by the normadic fulani people.

Cattle fattening is not a new practice in Nigeria, its practice has gained prominence as an important business in the livestock industry. It gives the farmer year round employment which provides him extra income and also provides a fast source of meat to meet the high demand for high quality protein needed in human diet. The Northern region of Nigeria is a home to most of the nation's ruminant livestock. The region is however, characterised by long and pronounced dry season of 6 -9 months, which is affected with serious feed shortage for ruminants.

Cheap and abundant agricultural by- products available to the farmer for fattening include maize stover, maize offal, rice straw, rice bran, wheat offal, sorghum panicle, groundnut haulms amongst others (Lamidi *et al*., 2008). Research efforts have been directed towards harnessing and enhancing the utilization of these abundant agricultural by-products and crop residues in the region for livestock feeding. Fetuga and Tewe (1985) have however, reported that livestock fed

with crop residues and agro-industrial by-products could achieve substantial weight gains. The utilization of these crop residues and agro-industrial by-products at reasonable cost could enhance production and reduce cost of compounded feeds, without adversely affecting the performance of the animals. This becomes more important considering the high cost and demand for conventional feedstuffs and the competition between man and livestock for the same feed resources (Iyeghe Erakpotobor *et al.,* 2002).

There is need therefore, to evaluate alternate source of cereal by product that is cheaper in price and abundant compared to maize offal for use as energy source for beef cattle fattening. Why looking for alternate energy source, one of such by product is rice offal. There is tendency that these by-product will be more available in future through the recent Presidential initiative on rice production in Nigeria which is aimed at encouraging local rice production in order to reduce overdependence of the country on imported rice (James, 2011)

Rice offal is an agro-industrial by-product that could contribute to livestock feeding. It is available in large quantities all year round in many towns and villages in the rice growing areas of Nigeria. It is a by-product of one step milling process of paddy rice which produces only two products; the rice seeds ready for human consumption and the waste product which is made up of rice husk, rice bran, rice polishing and small quantities of broken grains, it also has high content of silica and fibre (Dafwang, 2006). Rice offal constitutes 40% of paddy rice (Duru and Dafwang, 2010). In Nigeria the bulk of rice produced is being processed by small milling machines which produce large quantities of rice offal which until recently were often burnt off to reduce waste pollution (Dafwang and Damang, 1996). Nigeria current production of paddy rice is estimated at 475.52 million tonnes (NAERLS and NFRA, 2009), although the country has the

potential of producing about 190 million tonnes of rice offal thus pointing to the ready availability of rice offal as livestock feed resources.

1.1 Aims and Objectives of Present Study

The study is targeted towards reducing dependence on maize offal as energy source for fattening cattle.

Specific objectives are

1. To determine the effect of diet containing raw or parboiled rice offal and its level of inclusion on the fattening performance of Bunaji bulls.
2. To determine the economics of fattening Bunaji bulls on diet containing raw or parboiled rice offal
3. To determine the effect of diet containing raw or parboiled rice offal on the carcass yield of fattened Bunaji bulls.

1.2 Null Hypothesis (H_o)

1. Diet containing Raw or Parboiled rice offal and its level of inclusion has no attribute on the performance of the Bunaji bulls.

2. Fattening of Bunaji bulls with diet containing Raw or Parboiled rice offal has no economic benefit.

3. Diet containing raw or parboiled rice offal has no attribute on the carcass yield of fattened Bunaji bulls.

1.3 Alternate Hypothesis (H_a)

1. Diet containing Raw or Parboiled rice offal and its level of inclusion has an attribute on the performance of the Bunaji bulls.

2. Fattening of Bunaji bulls with diet containing Raw or Parboiled rice offal has economic benefit.

3. Diet containing raw or parboiled rice offal has effect on the carcass yield of fattened Bunaji bulls.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Population, Breeds and Distribution of Beef Cattle in Nigeria

There are over 800 breeds of cattle recognised worldwide (Wikipedia, 2010a) some of which were bred by human for specialized purpose. Scott (2008) reported that there are more than 250 breeds of beef cattle worldwide. The Nigeria cattle breed is broadly divided into two, the zebu breeds (*Bos indicus*) which include Bunaji (white fulani), Rahaji (red bororo) ,Sokoto Gudali (bokoloji), Adamawa Gudali, Azawak, Jali and Ambala while the Taurine breeds include Humpless longhorn (N'dama),West African Dwarf Shorthorn (Muturu), Borgu Keteku (shorthorn x Zebu), Lagos Keteku (N'dama x Muturu) and Kuri (Blench, 1999) and they are generally known to be trypanotolerant breeds of cattle.

2.1.1 White Fulani

White Fulani also called Bunaji or Yakanaji population in Nigeria, Cameroun and the Central Africa republic is estimated at about 9,645,000. Bunaji are the most numerous and widely distributed breed of cattle in Nigeria (Ahamefule *et al*., 2007) representing about 51% of the national cattle population (Ikhatua, 2010) the breed is owned mainly by the Normadic Fulani people.

The coat colour of white Fulani is commonly white on a black skin with black ears, eyes, muzzle, hooves, horn tips and tip of tail. Their thoracic or sometimes intermediate hump and dewlap are well developed. The head is long, wide across the forehead and with a straight or concave appearance; average adult wither height is 130 cm; the neck is strong providing an upward carriage for the head; horns are slender, medium to long (81 to 107 cm), lyre shaped:

curved outwards and upwards, with an outward turn at the tip (Faulkner and Epstein 1957). The White Fulani are generally taller and narrower bodied cattle; the rump is of good length but has a marked slope from hook to pin bones. The udder is well-developed, it has a good shape and strong attachment. Teats are well positioned and are of medium to reasonably large size (Tawah and Rege 1996). The general shallowness of the body and lack of width give the breed a leggy appearance. This characteristic of the breed has been described as an adaptation to long distance trekking in the pastoral management (Tawah and Rege 1996).

The breed is of interest in that it is more tolerant to heat as compared to N'Dama and Gudali, more resistant to dermatophilosis than the Muturu and N'Dama breeds, resistant to intestinal helminth parasites, and has low mortality rate. Although it is less resistant to trypanosomosis than the N'Dama, it is more tolerant than the Gudali and other Zebu types (Tawah and Rege 1996).

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

2.1.2 Sokoto Gudali.

Gudali is a Hausa word for "short-horned and short-legged animals". They are also referred to as Fulbe or Peuhl zebu in West and Central Africa. Population estimate (DAD-IS, 2005) based on breed level survey in 1992 for the Sokoto Gudali in Nigeria and Ghana is 4 400 000 and 10 000, respectively. About 90% of the Sokoto Gudali are owned and managed by Fulani and Hausa pastoralists and transhumant herders (Ngere 1985), who feed their cattle on communally owned grazing lands and browse especially in the dry season (Tawah and Rege 1996). They account for 12% of Nigeria cattle population (Ikhatua, 2010) and are also known for their hardiness to the arid northernly environments.

The Sokoto Gudali has multiple coat colours although the most common one is black and white coating with light underside. The head is long and wide between the eyes and across the forehead, with a straight or slightly convex facial profile. Ears are long, large and convex, sometimes pendulous, although not to the same degree as in some of the Indo-Pakistan zebus. The hump is thoracic in position. The average height at withers ranges from 130-138 cm for males and 116-132 cm for females (Tawah and Rege 1996).

The Sokoto Gudali cattle are known for their meat and milk. Mature weights range from 495-660 kg for males and 240-355 kg for females. They are also reputed for their beef quality. Their slow and sluggish nature allows them to be used for draft, including ploughing and carting.

2.1.3 N'dama

The N'Dama, also known as Boenca, Boyenca, and Faouta Longhorn, it is a humpless Longhorn (*Bos taurus longifrons*). Population estimates by DAD-IS (2005) totals to 6, 618 713 head, distributed within the countries of West and Central Africa.

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

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

The N'Dama cattle are known for their beef conformation. The average adult weights range from 320 to 360 kg and 250 to 270 kg for males and females, respectively (Payne 1970; Starkey 1982; 1984; Maule 1990; Porter 1991; Mason 1996). The dressing percentage is around 50% and the meat has a very good flavour without much fat (Maule 1990; Rege and Tawah 1999).

2.1.4 Muturu

`Muturu', meaning humpless, is the Hausa name for the West African Shorthorn in Anglophone West Africa. The breed is a variety of West African Shorthorn and the Nigerian Forest Muturu is also called Kirdi. The number of Muturu cattle in 1990 in Nigeria was between 75 000 to 120 000: 25 000 to 40 000 for the Dwarf or Forest Muturu and 50 000 to 80 000 for the Savannah Muturu (DAD-IS 2005; Rege and Tawah 1999).

The Muturu is found in areas heavily infested with tsetse, as a result of which this breed has adapted and naturally selected to be tolerant to trypanosomosis, ticks and tick-borne diseases although it is susceptible to rinderpest. The breed is also reported to be trypanotolerant (Adeniji 1983).

The typical coat colour of forest Muturu is black and that of the Savannah Muturu is black and white. Height at withers is 95 cm for males and 88 cm for females (Maule, 1990). It is the smallest cattle breed known. They are used for socio-cultural purposes. In Igboland these cattle are traditionally sacred and considered as properties of the local deities or they are dedicated to a shrine. Muturu cows are seldom milked. As beef cattle they perform well, dressing out at 64%.The animals and their hides are used mainly for ritual sacrifices and ceremonies particularly funerals. They are also commonly kept as pets or, frequently, they are used for prestige or dowry purposes (Rege and Tawah , 1999).

2.2 Beef Cattle Production Systems

Beef accounts for 45% of total meat supply from domestic animals in Nigeria (Olayiwole, 1982). Beef cattle production is a strong animal industry throughout the world since beef cattle can graze forages on open range and pasture land. They serve a unique role in providing high quality protein for human. Considerable land in the world that will not support intensive crop production can often times sustain grasses and forages that conserve the land and produce feed that cattle can utilize.

Beef cattle production system is defined as all commercial cattle production system where the purpose of the operation includes some or all of the breeding, rearing and finishing of cattle intended for beef consumption (Terrestrial Animal Health Standards commission – TAHSC, 2009).

The primary purpose for the existence of beef cattle is to produce beef. The ultimate goal in a beef management programme is to produce large quantities of high quality beef efficiently and profitably. The basic conformation of the beef type animal is short, thick bones, thick muscles, long broad backs and square rumps carrying more of the valued flesh. The ideal beef conformation has been described as a "parallelogram" or a "block" conformation. Animals with long limbs, narrow flat sided barrels and small rumps are not desirable as beef animals. While the whole lot of cattle breeds and types can be used for beef production, certain breeds are specialized and possess the desired qualities with resultant maximum returns.

2.2.1 Extensive system

Extensive System or Range Feeding is the easiest and most unspecialized form of beef production and it is the traditional system in most of the tropics. Beef production in the Tropics is therefore based almost entirely on this system. The animals are produced solely on ranges using grass and herbage usually in areas where land is cheap and forage can be accessed for little or nothing or where the land, for one reason or the other is not used for any other form of profitable agricultural production. The young calves are left with their dams to suckle and there after maintained to slaughtered weight on pasture. All they are permitted to use from cultivated land are the residues of crops.

Transhumant pastoralist system in which animals receive most of their nutrients from natural range which is poor in quality (Blair, 1963; Kapu, 1975) is mainly the cattle production system in the country. The low quality of natural savanna grazing particularly during the dry season when the crude protein content of the grasses may be as low as 2%, suggests the potential role of supplementary feeding with concentrate mixtures rich.

The seasonality of rainfall and forage production invariably results in considerable nutritional stress on the animal. These restricted periods of forage growth result in abundance of feed during the rainy season, followed by period of relatively rapid deterioration and long period of stagnation. In some areas, the climate is so unfavourable that the land is infertile and there is practical starvation. In both cases the period of plenty is too short to allow young stock to complete sufficient growth to carry them to the condition where they may be profitably sold for meat.

During the unfavourable period the animals subsist on diets that are barely sufficient for the maintenance of essential, metabolic processes and have to draw on their body reserve for much needed energy. This not only results in a check on their growth but in an appreciable loss in body weight. Consequently, the appreciable gain made during the rainy season is lost in the dry season. This makes it impossible for the animal to reach slaughter weight until they are 4-6 years old, i.e. there is fluctuating growth of pasture and body weight in extensive system of management. In such circumstances not only is the production low, the carcass is also of low quality. Since grazing is uncontrolled, the tendency is for the animal to consume the available feed around low lying land and around water holes and wells first, they then have to go farther and farther in search of feed and water. In the process, a tremendous amount of valuable energy is thus expended (Powell, 1992).

Livestock production in Nigeria is largely in the hands of traditional rearers and can be rightly termed “subsistent”. Climate, rainfall, and disease determine the presence of certain livestock in a zone Over 80% of cattle, sheep, and goat populations are managed by traditional Fulani and Shuwa pastoralists. Most of the cattle, sheep, and goats are located in the semi-arid and sub-humid zones (Resource Inventory and Management, 1992).

Pastoralism, an age old system of livestock husbandry, entails grazing of animals as practiced in the ecological stratification of West Africa (Nuru 1988). Despite its dominance in the region, the traditional pattern of transhumance has been affected in recent years by a number of factors such as the drought in the Sahel and the increased arable farming in the semi-arid and sub-humid zones (Jabbar *et al*., 1995; Okoruwa *et al*., 1996).

The breeding, raising, growing and finishing activities are operated by the same people on virtually the same site in extensive systems of beef production, this occurs in most of the pastoralist areas of Africa. Under this system meat is often a by-product of milk production, and beef output may be as low as 7 kg per hectare per year on a carcass basis; acceptable carcass weights (equal to or above 150 kg) can only be achieved when steers are 5 years or older. The animals stay in good condition for only 3–4 months of the year following the end of the rainy season. The small gain accumulated in these months is often partly lost (up to 25 percent) when stock are trekked over several hundred kilometres to slaughter houses, which are usually located near large urban centres (McIntyre *et al*., 1992).

Traditional system of beef production cannot meet the future demand for beef production based on the numerous disadvantages enumerated. This is because in most areas the ranges is being overgrazed and reduce in size due to population and cropping pressure (Green Revolution Commission report, 1980).

A sensitivity analysis indicates that improved feeding will have a greater impact on livestock production than any other management strategy, while comparisons of various feeding strategies carried out by ILCA (1979) suggest that the most attractive approach in economic terms would be natural savanna grazing with supplementation (semi intensive system).

2.2.2 Semi-intensive system

Between the two extremes (extensive and intensive) lies a bridge which is known as semi-intensive system of animal production. The system consists essentially of partial rearing on pasture and supplemental feeds. The management practices adopted largely depend on the time of the year in which the calves are born i.e. whether wet or dry season. In situation where the

economics of production and the scale of development of beef industry do not justify intensive production, a semi-intensive system finds a ready acceptance.

Since the demand is mainly for quantity rather than quality, meat for the whole market must be cheap so that the low income group who incidentally forms the greater proportion of the population can afford it. In the semi-intensive beef production system, slaughter age varies from 2½ - 4 years depending on the breed. On the average:- N'dama reached slaughter weight (320kg) in 3 – 3½ years, Muturu – 200 – 220kg in about 3½ years, Zebu – 450kg in 3½ - 4 years (Jabbar *et al.*, 1995).

The semi-intensive system is mainly used on the Government and some private or corporation farms or ranches. On these ranches the cattle are either reared from birth or bought as "store cattle" and then fattened to slaughter weight (RIM, 1992). A supplementary feeding project was initiated in northern Nigeria in 1962/63 under the Fulani Amenities Programme in order to reduce weight loss in cattle during the dry season (Ogunfowora *et al.*, 1975).

The pattern of livestock production among the settled Fulani has been shaped over time by both environmental and historical factors. Apart from keeping livestock, the Fulani now grow crops, thereby giving rise to a system of mixed farming. Jabbar *et al.* (1995) reported that cattle owners who usually visit the humid zone for dry season grazing of their animals settle and become integrated crop/livestock farmers.

2.2.3 Intensive (feedlot) fattening

This is a system involving complete confinement of the animal and movement is restricted. All feed is carried to the animal (Clark and Jaime, 2005). A feedlot is a type of animal feeding

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

The feedlot is a technique or system which originated in tropical America and has gradually been adopted in such places as Ethiopia, Cote d' Voire, Kenya, Niger and Nigeria. This system of livestock production was first practised on a small scale in Mokwa cattle ranch in Nigeria between 1964 – 1977 under the Nigerian – German Technical Assistance. Performances of indigenous animal managed under this system have been very encouraging and comparable with those of animal reported in temperate regions. Essentially, these afford the animal the opportunity to exhibit the highest feed efficiency and best growth performance. Edible carcass yield under feedlot operation increased by 30-40% when compared to animals not fattened (Olayiwole *et al*., 1981). A proper system should afford the animal the opportunity to exhibit the highest feed conversion efficiency and best performance (Ikhatua and Olayiwole, 1982).

Creek (1972) showed that feedlots are viable commercial enterprises in Kenya while Wardle (1972) in Niger and Jespen and Creek (1976) in Ethiopia demonstrated that feedlots are very economically effective in improving carcass quality of indigenous cattle. In Nigeria, Olayiwole *et al,* (1981) have also shown that under feedlot conditions the performance of two indigenous breeds of cattle Bunaji and Gudali compared favourably with values reported for temperate

breeds of cattle. Cost and return analysis of a typical semi-intensive commercial feedlot operation at Shika, Nigeria by Olayiwole and Fulani (1980) indicated that feedlot operation is profitable and commercially viable in the country. Doubts about efficiency of feed conversion into meat by local cattle (Bunaji, Rahaji, Sokoto Gudali, Azawak, Wadara, Adamawa Gudali) are not justified, they are capable of achieving satisfactory growth rates with acceptable feed conversion efficiencies (Olayiwole *et al.*, 1981) for a profitable livestock enterprise.

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

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

2.3 Nutrient Requirements of Beef Cattle

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

Meeting the basic nutrient requirements of beef cows is a key component of meeting cow herd production and profitability goals for the beef cattle enterprise. Adequate nutrition is vital for adequate cow reproduction, cow and calf health, and growth of all classes of cattle (Mertens, 1997). Nutrient requirements of cattle change throughout the year based upon stage of the production cycle, age, sex, breed, level of activity, pest load and environment (Hersom, 2010). Each nutrient fulfils specific roles in growth, production and metabolism (Hamilton. 2007). Hersom (2010) noted that cost effective supplementation practices will be difficult to implement without the knowledge of cattle's adequate basic nutrient requirement.

2.3.1 Protein requirement of beef cattle

It is usually measured as percent Crude Protein (%CP) and is one of the main building blocks of the body (Hamilton, 2007). Crude Protein (CP) is a measure of protein content of any feedstuff and has been further characterised to indicate the amount of protein that is actually available for cattle to metabolize. Rutherglen (1995) noted that even though diet may be adequate in terms of Metabolizable Energy (ME) concentration, the desired level of production desired will not be

achieved if protein content is inadequate. Bulls with live weight of 150-300kg require a CP of 13% (Rutherglen, 1995) or 13-15% (Aduku, 2005). Growing cattle including replacement heifers and steers require from 10.5-14% of their daily dry matter intake to be protein (Rhinehart, 2006). The requirement of protein according to Hersom (2010) depends on the age, stage and level of production. Wahlberg (2005) concluded that to maximise forage intake and digestion therefore, cattle must meet its protein requirement.

2.3.2 Energy requirement of beef cattle

Energy usually account for the largest proportion of feed cost as it is required in large amounts in cattle. Protein, carbohydrates, and fats provide energy in beef cattle diets. Energy is often referred to as digestible energy, net energy for maintenance (NEm), net energy for gain (NEg), net energy for lactation (NEl), and total digestible nutrients (TDN),(Parish and Rhinehart, 2008). The primary sources of energy are cellulose and hemicellose from roughages and starches from grains (Hamilton, 2003). According to Rhinehart (2006) adequate energy concentration in the diets allows the cattle to utilize other nutrients such as protein, vitamins and minerals.

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

Because the rumen bacteria themselves require protein, just as the animal's body does, it is impossible to discuss ruminant energy requirements separately from ruminant protein requirements. With too little protein in the diet, the bacteria will not efficiently digest roughages,

while with too much protein in the diet, the protein will be deaminated (the nitrogen removed) and used as a very expensive energy source (Bodine and Purvis, 2003). Energy requirements are expressed in terms of TDN and net energy for maintenance (NEm) and (or) net energy for gain (NEg). Total digestible nutrient is the value most commonly used in simple ration balancing (Gadberry, 2007). TDN is the sum of the digestible starch, fiber, protein, and fat in a feed with a correction factor for the high energy content of fat and the amount of ash or mineral content. TDN requirements are expressed as a percent of the diet dry matter (Hersom, 2010).

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

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

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

2.3.3 Mineral requirement of beef cattle

These essentially are elements needed for structural integrity, metabolic function and immune function. They are classified as macro or trace minerals depending on the amounts needed (Gadberry, 2007). Wahlberg, (2005) noted that deficiency of mineral in certain feeds can be remedied with supplementation. Supplementation of minerals depends on the type of feed in the ration and the animal's requirement (Hamilton, 2007). Calcium is the most abundant mineral in the body and is an important component for bones, teeth, membrane permeability, muscle contraction, and many other metabolic functions (Hersom, 2010). Absorption of calcium is largely determined by the balance of requirement and intake. Skeletal reserves serve as a large repository of calcium that can be utilized to maintain blood concentrations.

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

NRC, (2000) recently revised the nutrient requirement for growing and finishing of beef cattle (including breeding bulls) and this is presented in Appendix I.

2.3.4 Water intake of beef cattle

Water is a fundamental constituent of all living cells. Its presence in adequate amount in the body tissues is an essential pre-requisite for the normal maintenance of life. It is so intimately connected with the transformation of nutrients and excretory matter between the digestive

system, the cells of the different body tissues and the excretory organ. To show its significance, French (1956) reported that starving animals may lose nearly all their glycogen and fatty resources, half of their body protein and about 40% of their body weight and still remain alive while the loss of only 10% of body water causes serious disorders and further losses may quickly lead to death.

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

2.4 Feed Resources for Cattle Feeding in Northern Nigeria

Beef cattle feed are derived from conventional and non-conventional sources to cover their energy, protein and mineral requirements.

Lamidi *et al*., (2008) noted the feed resources for smallholder fattening schemes in Northern Nigeria essentially includes basal roughages (rice straw, maize stover, sorghum stover leaves, millet stover, range grass hay, suger cane leave fresh) energy feedstuffs (maize offal, sorghum panicle), protein feedstuffs (groundnut haulms, cowpea haulms, soybean haulms, cowpea vine, whole cottonseed, cotton seed cake) and mineral supplement (kanwa and common salt).

Chemical, physical or microbial methods of treating straws to improve their low energy and protein content (Saadullah *et al,* 1981) are of little economic relevance to small-scale farmers. However, it is at this level that the problem of weight loss by animals during the dry season is most critical. There is thus a great need to prevent weight loss by the use of simple techniques applicable to farmers and involving readily available agro-industrial by-products and crop residues. Supplementation of poor quality roughages, including cereal crop residues, with legumes has been shown to increase digestibility in ruminants (Devendra, 1982) or intake (Minson and Milford, 1967) or both (McMeniman *et al.,* 1988).

Since the prices of conventional feed stuff has sky rocked, there is need to turn to agro-processing waste that are readily available, cheap, nutritionally adequate and at the same time not in direct use by humans with a view to lowering feed cost (Ocheja *et al*., 2011).

2.4.1 Basal roughages

Basal roughages used in fattening schemes in Northern Nigeria include rice straw, maize stover, sorghum stover leaves, millet stover, range grass hay, sugar cane leave fresh (Lamidi *et al.,* 2008). Grass hay is a conventional source while rice straw, maize stover, sorghum stover leaves, millet stover, sugar cane leave fresh.

2.4.2 Energy sources

Protein, carbohydrates, and fats provide energy in beef cattle diets (Parish and Rhinehart, 2008). Energy supplements are available in many forms. High quality forages, commodity co-product feedstuffs, range cubes, protein blocks, and liquid supplements are some examples. Diets containing non protein nitrogen (urea) must have sufficient carbohydrate levels (energy sources) available in them if the nitrogen in urea is to be effectively use (Parish and Rhinehart, 2008)

By-products of cereal milling processes are appealing because they often have considerable amounts of protein, starch and fat. Various cereal by-products have been investigated to be useful for livestock feeding. Brewers dried grain (BDG), wheat offal, maize offal, rice bran, broken rice have been widely tested and incorporated into livestock diets (Farinu, 2004; Ajayi *et al*., 2005; Aderemi *et al*., 2006; Afolabi *et al*., 2006).

Energy feedstuffs of agro-industrial origin include maize offal, wheat offal, wheat bran, Sorghum panicle, rice offal, Brewers' dried grain (BDG) and sorghum waste, millet bran e.t.c.

2.4.2.1 Maize offal

One of the envisaged alternative feedstuff is maize offal. In the manufacture of starch and glucose from maize, number of by-products are obtained, which are suitable for farm animals. The de-germ grain is finely ground and separated by wet screening (McDonald *et al.,* 1995). This process gives rise to three by-products, the germ, bran and gluten which are collectively referred to as maize offal (McDonald *et al.,* 1995). The offal has low energy and high fibre contents. Ayoade (1986) reported that supplementation with maize offal improved digestibility of dry matter and inorganic matter of pigean pea pods by goat. In a survey carried out by Lamidi *et al.,* (2008), it was reported that maize offal was the main energy source of choice for 95% of farmers engaged in cattle fattening in Katsina, Kano and Kaduna states of Nigeria. Fadugba (1990) also

reported that using by product such as maize offal in rations has often resulted in increased intake in compensation for the reduced energy concentration of the diets.

Lamidi *et al.,* (2008) reported that maize offal contain 9.6% CP, 26.31% ADF, 21.64% NDF and 5.48% Ash. Ayoade (1986) also reported that maize offal contain 88.9%DM, 9.6% CP, 2.4% Ash and 1.9MJ/Kg of energy. Lamidi *et al.,* (2007) supplemented a fattening diet of cattle with maize offal and obtained an intake of 3.84-3.98Kg/day.

2.4.2.2 Rice offal

Rice offal is the by-product of the one step milling process for paddy rice which produces only two products; the rice seeds ready for human use and the waste product which is made up of rice husk, rice bran, rice polishing and small quantities of broken grains (Duru and Dafwang, 2010). According to Myer (2008) it contains almost one third rice bran and two third hulls. Rice offal constitutes 40% of paddy rice. In Nigeria the bulk of rice processing is handled by small scale rice milling machines which produce large quantities of rice offal which until recently were often burnt off to reduce waste pollution (Dafwang and Damang, 1996). The current production of paddy rice in Nigeria is estimated at 475.52 million Tonnes (NAERLS and NFRA, 2009), which has the potential of producing 190 million Tonnes of Rice offal.

In spite of the abundance of rice offal, it has been neglected as animal feeds because it contains high level of fibre and low protein and energy (Ambashankar and Chandresekan, 1998). Salami *et al*., (2009) concluded that the feeding value of rice bran despite its high crude fibre content and low energy contents was improved when it was included to partially replace dietary maize proportion with enzyme added.

2.4.2.3 Millet bran

The protein content of millet grain compares favourably with that of wheat, barley and maize, varying from 8.6 to 17.45%, with the largest proportion found in bran (Rooney and McDonough, 1981). The lipid content of millet bran ranges from 3.0 to 14.45% with free fatty acid level of about 2 to 12% (Rooney and McDonough, 1981). No condensed tannin has been reported in millet bran (Sullins and Rooney, 1977).

2.4.2.4 Wheat bran

One of the most popular and important feed stuff is the wheat bran. It is highly palatable to stock and it has a mild laxative effect (Morrison, 1975). Wheat bran has 16.4% crude protein and 4.5% fat and usually does not contain more than 10% fibre (Morrison, 1975). Wheat bran has about 66.9% total digestible nutrients (TDN), the protein is of better quality than that of maize but it is not as good as the protein in feeds such as soybean meal (SBM), milk, meat by-products and fish by products, (Morrison, 1975). Wheat bran is the richest source of phosphorus (1.29%) and 0.13% calcium (Morrison, 1975).

2.4.2.5 Brewers' dried grain (BDG) and sorghum waste "Burkutu wastes".

The use of brewers' dried grains and sorghum wastes is gaining popularity especially now that the prices of cereal grains are increasing. Sorghum wastes are by-products obtained from the processing of sorghum to produce "Burkutu", a local beer. It is abundant all the year round in cities and villages where local beer is being made.

2.4.2.6 Sorghum panicle

This is a portion of the inflorescence that is left after the grain has been threshed out. Much of it is wasted though it has ocassionally been added to household wastes and fed to sheep and goats in northern Nigeria (Oyebanji, 1999). Ncube and Smith (1991) reported that heads of red

sorghum contains more nitrogen and crude protein than the white sorghum. They also found out that addition of cotton seed cake increased intake and digestibility of sorghum heads.

Al Hassan *et al.,* (1984) observed a voluntary dry matter intake of 1.9% of body weight for cattle and corresponding digestibility dry matter of 74.3% when it was fed and not supplemented. They also reported that sorghum panicle contains 95.6% DM, 3.2% CP and 0.09% phosphorus. The sorghum threshed head used by Oyebanji (1999) contains 98.27% DM, 2.38% CP and 26.98% CF while APRU (1980) gave values of 12% CF, 6.17% CP,0.038% Ca and 0.036% Phosphorus.

2.4.3 Protein sources

Lamidi (2005) reported that the most important conventional protein sources in Nigeria are the oil seed cakes which include cotton seed cake, ground nut cake, soybean cake and palm kernel cake.

2.4.3.1 Cotton seed cake (CSC)

The most widely used oil seed cake for feeding ruminant availability and cost in relation to that of its closest competitor, groundnut cake. CSC is being traditionally used in the feed of dairy animals. The crude protein content of delinted decorticated CSC is about 26%. It is however low in cystine, methionine and lysine (Ikurior and Fetuga, 1984). Limited supply and seasonal availability of CSC can result in high price (Jabbar *et al.,* 2006). Cotton Seed Cake is a by-product of cotton ginnery industry and has sufficient feeding value to support average-high producing animals (Chandler, 1992). Moderate to high crude protein levels has been reported: 15.67 % (Wekesa *et. al.,* 2006), 24.63 % (Lamidi, 2005). The DM is high in fat and NDF (Lamidi, 2005).

2.4.3.2 Groundnut cake (GNC)

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

2.4.3.3 Palm Kernel cake

The crude protein content of palm kernel cake (PKC) ranges between 14 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. Another oil seed cake is sunflower (31% CP).

2.4.3.4 Soybean cake

It is characterized by the highest content of protein and amino acids and its good point are big consignments on homogenous nutritional value. In the regard of big quantity of soybean meal in mixtures the small difference in nutritional value in this feed may have influence on balance of nutrients in diets and animal performance (Kerley and Allee, 2003). Mechanically extracted soybean cake is the product obtained by grinding the chips which remain after removal of most of the oil from whole soybeans by a mechanical extraction process. It must contain no more than 7.0% crude fibers and not more than 12.0% moisture. Meals resulting from whole and dehulled soybeans contain 44% and 48% CP (as fed basis), respectively (Coppock, and Wilks, 1991). 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. However, soybean cake is highly priced making it uneconomical for feeding ruminants.

2.4.3.5 Agro - industrial by-products of animal origin and animal waste

According to Lamidi (2005) the non-conventional protein sources can be categorized into Agro - industrial by-products of animal origin, Farm wastes (crop residues or crop aftermath) and Animal wastes. By-products of animal origin 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).

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 (Lamidi, 2005).

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%. Broiler litter has higher CP content than layer litter (Lamidi, 1995). Adu and Lakpini (1983), Devendra and Roghavan (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). 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 and Roghavan (1978). Adu and Lakpini (1983) suggested 10% optimum level of inclusion in molasses based diets for sheep.

2.4.3.5 Farm wastes (Crop residues or Crop aftermath)

Lamidi *et al*., (2008) noted that the protein feedstuffs for smallholder fattening schemes in the 3 Northern Nigeria state (Katsina, Kano and Kaduna) surveyed are groundnut haulms, whole cotton seed, cowpea haulms and cotton seed cake. Farm wastes of protein origin 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 (Lamidi, 2005). 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 percent while that of cowpea shell ranges from 6.9 – 7.1 % and groundnut haulms between 11.40 and 16.70 (Alhassan *et al.,* 1984).

The use of these crop residues has led to improvement in animal performance. Adu and Lakpini (1983) recorded live weight gains of 90.20g/day and 130.7.0 g/day from Yankassa sheep when unchopped and chopped groundnut haulms was fed as sole protein sources. Ikhatua and Adu (1984) concluded from the performance of Red Sokoto goats fed groundnut haulms and *Digitaria smutsii* hay that the haulms is a better quality roughage with adequate protein to maintain ruminants than *Digitaria smutsii*.

2.4.4 Mineral source

It was reported by Lamidi *et al*., (2008) that the most common mineral supplement used for livestock in the survey northern state include kanwa and common salt. Other mineral supplement includes limestone and bonemeal.

2.5 Energy Metabolism in Ruminants

2.5.1 Carbohydrate metabolism

In farm animals, dietary carbohydrates provide well over one-half of the energy needs for maintenance, growth, and production (Baldwin, 1995). Glucose is a primary energy source for certain animal tissues and a precursor for lactose synthesis in the mammary gland. Consequently, understanding carbohydrate digestion and absorption, dietary glucose availability, and the involvement of gluconeogenesis in the regulation of glucose homeostasis is essential for the manipulation of the production and quality of agricultural foods (Nafikov and Beitz, 2007).

2.5.2 Carbohydrate digestion and rumen fermentation

In ruminants, fibrous feeds containing cellulose and hemicellulose and grains rich in starch are the primary carbohydrate sources. In swine, most dietary carbohydrates (e.g., starch) are hydrolyzed to monosaccharides in the small intestine, whereas ruminants have most of their dietary carbohydrates (e.g., starch and cellulose) fermented in the rumen by microorganisms, and only 5 to 20% of consumed dietary carbohydrates are digested in the small intestine (Huntington, 1997).

Work of Sutherland (1963) showed that starch and cellulose have the same energy value in cattle but not in swine. Numerous ruminant nutritionists have confirmed these observations and have shown that the major source of energy to the ruminant is the VFA absorbed from the rumen and other parts of the digestive tract. Later research documented that lesser proportions of VFA are also produced from dietary proteins, pentoses of nucleic acids, and glycerol of glycerophospholipids. Studies on the VFA production rates and metabolism have increased in number and sophistication as a result of the development of an artificial rumen (Donkin and Hammon, 2005)

Baldwin (1965), confirmed acetate as a major end product of fermentation, elucidated pathways for synthesis of each VFA and lactate, showed how diet composition (e.g., starch and cellulose ratios) influences proportions of each of the end products of fermentation, demonstrated that about half of butyrate is converted to β-hydroxybutyrate during absorption of butyrate from the rumen into blood, and showed that branched-chain organic acids are derived from amino acid fermentation.

2.6 Nutritive Value of Different Rice Mill By-Products and their use in Cattle Feeding.

2.6.1 Rice husk/hull

This is the outer covering of rice, yielding most of the ash values of rice offal (Duru, 2010). Various authors like McDonald *et al.,* (1975), Ensminger and Olentine (1978) have reported that majority of this ash is silica. The husk represents about 20% of the paddy; it has no nutritive value and has an irritant effect on the digestive tract because of high silica content. Cullison *et al.* (1976) reported that the feeding value of rice husk is a bulk factor of filler in ration. Ranjhana (1980) also reported that rice husk constitute nearly 20-25 % paddy and is the largest by product of rice milling industry.

FAO (1992) reported that rice hull is used in some countries as poultry litter that can later be fed to ruminants. It can be used in animal feeding in the following ways: as raw rice hull, low quality roughages like ground rice hulls can be included in small amounts (up to 15%) in high concentrate diets for feedlot cattle to help furnish bulk, stimulate appetite and decrease incidence of liver abscesses (Duru, 2010). Ground hull can be used instead of straw. The addition of ground hull has been found in some cases to increase feed intake, ammoniated rice hull have

been used up to 40% of the total ration for sheep without digestive or mastication problem (FAO, 1992).

2.6.2 Rice bran

It constitutes about 10% of brown rice and is used in animal feed (Farrell, 1994). The two main by-products obtained from rice milling are the hulls and rice meal. Bran is the coarse outer covering of grains separated during processing. They are obtained from the milling of wheat, maize and rice. Bran normally contains 9 to 18% crude protein and 10 to 14% crude fibre (Atteh, 2002). Rancidity is a major problem due to high oil content of the bran and the amino acid profile is generally superior to that of cereal grains (Farrell, 1994).

Rice bran is important rice by product which is a good source of B- vitamins and is fairly palatable to farm animals. About 90% of the phosphorus in the bran is the phytic acid and phytate (Ravindran, 1995). Not only is this phosphorus 18% available (Corley *et al*., 1980) but several other minerals in rice bran may be completed with phytate. Haghnazar and Rezaei (2004) reported that rice bran did not interfere with trace mineral availability.

2.6.3 Rice polishing

Rice polishing consists of rice kernels and polish after rice bran has been removed (Ensminger and Olentine, 1978). Scott *et al.,* (1976) gave a range of 12-13% protein for polishing. It is a good source of proteins, energy, vitamins and minerals (Saunders, 1990). It also contains better assortment of amino acids, particularly lysine and methionine, compared to other cereal grains, including corn and wheat (Khalique *et al.,* 2004). Rice polishing supplies as much total digestible nutrients as maize (Singh and Panda, 1988).

Rice polishing presents the same storage problem as the rice bran (Duru, 2010). It has a wider use than the bran because of lower fiber content. Polishing should be limited in the final week of fattening to avoid oily carcass. FAO (1992) reported that up to 5kg of polishing per day have been fed to dairy cattle without harmful effect or changes in performance.

2.6.4 Rice offal

Rice milling waste is the by–product obtained from small scale rice mills that process raw or parboiled rice through a mechanism which combines husk removal and polishing into one operation to produce the clean grains and rice offals which contain husk, bran, polishing and small quantities of broken grains (Dafwang and Shwarmen, 1996; Akinusi, 1999). Rice milling waste is readily available, cheap and usually discarded as waste product by burning to reduce pollution (Akinusi, 1999).

Essentially, rice offal is the mixture of all the by-product obtained in the milling of rice. It contains approximately 60% hull, 35% bran and 5% polishing (Gohl, 1975 and Duru, 2010). This product is low in feeding value because of the presence of hull (Idowu, 2011). The quality however depends on the method of milling. Rice offal obtained during the milling of either untreated or steam treated paddy seed are called raw and parboiled rice offal respectively (Duru, 2010). The offal obtained from one stage milling process is of similar composition and is often erroneously called rice bran. In Nigeria, rice offal is also called “rice mill feed” or “rice milling waste”.

Rice offal apart from its use as livestock feed resources, it has been reported by Isa (2003) that the raw rice offal is currently being used for the manufacture of ceiling boards, it is also been

used in rice producing areas as source of cooking energy and used by farmers to provide heat during cold season.

2.7 Feed digestion and physiology in Ruminants

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

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

The ruminant foregut or stomach has evolved into three pregastric fermentation chambers (rumen, reticulum and omasum) of which the rumen is by far the largest. Ingested plant material is hydrolysed and fermented in the rumen, and microbial cells and undigested plant particles pass into the abomasum where gastric digestion begins (Fig. 2.2). The most distinctive feature of

ruminants, rumination, where foregut digesta is regurgitated, rechewed and reswallowed in a frequent regular pattern repeated up to 500 times per day and enables reduction in particle size (comminution) and exposure of maximal surface area to microbial attack.

2.7.1 Role of rumen microbes in ruminant digestion.

The presence of microbes in the rumen makes it possible for ruminants to digest and metabolise feed materials that may otherwise be indigestible. The microbes are predominantly anaerobic and live in a symbiotic relationship with the animal. The rumen is a continuous anaerobic culture system in which the pH and temperature are maintained at between 5-7 and 39-40 oC respectively. Feed materials are fermented to volatile fatty acids which are absorbed, and ammonia which is either absorbed or incorporated into the microbial cells (Hungate, 1966).

Small-scale farmers are increasingly relying on browse and on crop residues and by-products to supplement roadside grazing during the dry season. Some of these materials are potentially good feed resources which degrade readily in the rumen (Krishna 1985; Odunlami 1988). Others have shown poor degradability so that they may require some treatment before they can contribute to animal nutrition (Smith and Calvert, 1976).

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

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Experimental Site

The experiment was conducted in the Experimental pens of the Beef Research Programme of National Animal Production Research Institute, Shika, Zaria, Nigeria. The study area falls within latitudes 11^{o} to 12^{o}N and longitudes 7^{o} to 8^{ol}E, with an altitude of 640m above sea level (Garmin Receiver, 2012). Shika is located within the Northern Guinea Savannah ecological zone with an average annual rainfall of 1,100 mm which starts from late April/early May and ends mid-October, the temperature range from 27-35°C depending on the season, while the mean relative humidity during the harmattan and wet seasons are 21%-72%, respectively (ovimap,2012).

3.2 Fattening Trial

A fattening trial was conducted using 20 Bunaji bulls with a live weight range of 210-249kg and average weight of 220kg with an age range of 2-3 years. The bulls were allotted to five dietary treatments in a 2x2 factorial arrangement with a common control to compare the effect of 2 levels of inclusion (20 and30%) of raw and parboiled rice offal on the fattening performance of Bunaji bulls. In the control diet (NRO), maize offal served as the main energy source and therefore had no rice offal. It contains 60% maize offal, 19.5% cotton seed cake, 19.5% poultry litter, 1% salt. The four test diets designated RRO contain 20 and 30 percent raw rice offal and PRO contain 20 and 30 percent parboiled rice offal. The TDN(%), ME(Kcal/Kg DM) and feed cost per Kg were calculated. There were four animals per treatment; the experimental diets were formulated to be isonitrogenous and isocaloric (Table 3.1). The trial lasted for 90 days.

Table 3.1: Percent feed composition of concentrate diets.

	Inclusion level				
Ingredient %	0	20RRO	30RRO	20PRO	30PRO
Maize offal	60	45	39	45.0	39.0
Rice offal	0	12	18	12	18
Cotton seed cake	19.5	24.9	29.7	24.0	29.0
Poultry litter	19.5	17.6	12.8	18.5	13.4
Salt	1	1	1	1	1
Total	100.0	100.0	100.0	100.0	100.0
Calculated analysis					
Crude protein(%)	15.16	15.15	15.11	15.17	15.15
TDN(%)	71.73	66.85	64.56	62.84	58.52
ME(Kcal/Kg DM)	2238	2090	2045	2145	2129
Feed cost (₦/Kg)	34.66	32.09	32.09	31.34	31.22

TDN = Total digestible nutrient, ME = Metabolizable energy, RRO = Raw rice offal, PRO = Parboiled rice offal.

3.3 Animal Management

The bulls were housed in individual pens and weighed every forth night. They were fed concentrate and hay (*Digitaria smutsii*) at 2% of their body weight respectively. The ration was adjusted at regular intervals of 2 weeks along with changes in live weight.

3.4 Source of Rice Offal

Parboiled and raw rice offal used for this experiment was sourced from a commercial rice mills at Kura in Kano State. The rice offal were sampled and analysed for proximate, cell wall and mineral analysis (Tables 4.1 and 4.2).

3.5 Data Collection

Parameters measured include: Initial body weight, Final body weight, Weight gain, Feed intake, Water intake, Feed to gain ratio, Feed cost per Kg gain, Rumen pH, Rumen ammonia nitrogen (RAN), Total volatile fatty acid (TVFA), Dissectible beef weight, Meat to bone ratio among others.

3.6 Rumen Fluid Sampling

Rumen fluid samples were collected from the bulls at the end of the feeding trial at 0hr, 2hrs, 4hrs and 6hrs after feeding. About 50mls of the rumen fluid was drawn from all the bulls in each treatment using stomach tube. The tube which is about 150cm with a metallic strainer attached to the end was passed through a pipe placed in the mouth of the bulls into the rumen and a suction pump which was used to draw out the rumen fluid was attached to the other end of the tube. The fluid was collected into a plastic bottles containing equal quantity of 0.1N H_2SO_4 to trap ammonia. The samples were frozen until analysed. Rumen ammonia concentration was determined by steam distillation into boric acid and back titrated with 0.01N hydrochloric acid,

according to the procedure described by Whitehead *et al.* (1976). Rumen pH fluid was determined using Philips digital pH meter (model 9409)

3.7 Digestibility Study

At the end of the fattening period, three bulls were randomly selected from each treatment and housed in metabolic crates for total faecal and urine collection. The animals were allowed 14 days for adjusting to the condition of the metabolic crates before the commencement of the collection period which lasted for another 7 days. The animals were fed experimental diets at 2% of their body weight daily and water intake was also measured. Daily faecal output was weighed and 10% of each day collection was sub sampled and oven dried at $60^{o}C$ for DM determination. This was later bulked and taken to the laboratory for proximate analysis, neutral detergent fibre and acid detergent fibre. Daily urine output was collected in a plastic container containing 100mls 0.1N H_2SO_4 placed under metabolic crates,10% of daily urine was taken from each bull and store in the refrigerator. At the end of the 7 day collection period, 10% of the urine taken from each bull was sub sampled and stored in the refrigerator pending Nitrogen determination (Osuji *et al.,* 1993).

3.8 Carcass Evaluation

Three bulls from each treatment were slaughtered to determine the carcass composition. The bulls were slaughtered after 24 and 12hrs of feed and water withdrawal, respectively to get shrunk body weight. After slaughter, the hot carcass was weighed using a calibrated hanging scale of 500kg (50Kg graduation). The external offal (head, limb, tail and hide) were removed and weighed separately using calibrated scale of 100kg (200g graduation). After evisceration the

internal offal (liver, spleen, kidney, heart and lungs) were removed and weighed individually using a calibrated weighing scale of 10Kg (50g graduation). The GIT was weighed with content using calibrated scale of 100kg (200g graduation) and reweighed after washing. Total lean meat (boneless) was separated and weighed. The bones were also weighed. Dressing percentage was calculated by dividing hot carcass by the fasted body weight expressed in percentage.

3.9 Chemical analysis

Analysis of individual feed ingredients (raw and parboiled rice offal, cotton seed cake, poultry litters and hay) and faecal samples were carried out by AOAC (2000) procedure. Also, Acid Detergent Fiber (ADF) and Neutral Detergent Fiber (NDF) were determined in all the feed ingredients according to Van Soest (1991) at the Central laboratory of National Animal Production Research Institute (NAPRI), Shika, Zaria. Metabolizable energy (ME) was determined by equation of Alderman and Cottrill, 1985. ME (MJ/Kg DM) = 11.78 + 0.0064 CP + $(0.000665EE)^2$ - CF (0.00414EE) - 0.0118A. Where ME = Metabolizable energy, DM = Dry matter, CP = Crude protein, EE = Ether Extract, CF = Crude fiber and A = Ash. Silica (SiO_2), sodium oxide (Na_2O), calcium oxide (CaO), Magnesium oxide (MgO), Aluminium oxide (Al_2O_3), phosphorus oxide (P_2O_3) analysis were carried out for raw and parboiled rice offal (using X-Ray Flourescence (XRF) techniques). Inner electronic structure of atoms was probed. The resultant spectrum generated aided qualitative estimation of elements. A quantitative estimate of chemical elements was established using a duly calibrated method with standard conditions at Multi-User Science Research Laboratory (MUSRL), Ahmadu Bello University, Zaria.

3.10 Economic analysis

The market price of the various feed ingredients as at the time of this study was used to compute the total cost of feed consumed within the fattening period and feed cost per Kilogram weight gain. This was used to determine how profitable or otherwise it was to fatten bulls with or without raw or parboiled rice offal as an energy source at various levels.

3.11 Data analysis

The data from the fatten, digestibility trials and rumen metabolites were analysed using General Linear Model procedure of SAS (2002) to see the response of the animals to measured parameters. Significant levels of difference among treatment means was separated using DMRT in the SAS package. The Model used is as follow:

$Y_{ijk} = \mu + P_i + G_j + (PG)_{ij} + E_{ijk}$

Where

Y_{ijk}= k^{th} observation of j^{th} graded level of rice offal inclusion and i^{th} type of rice offal.

μ=overall mean

P_i = effect of i^{th} type of rice offal on performance

G_j = effect of j^{th} graded level of rice offal on performance

$(PG)_{ij}$ = effect of interaction between i^{th} type of rice offal and j^{th} graded level of rice offal inclusion

E_{ijk} = random error .

CHAPTER FOUR

4.0 RESULTS

4.1 Chemical Analysis

4.1.1 Proximate and cell wall composition of feed ingredients.

Chemical compositions of the feed ingredients (Table 4.1) showed Dry Matter (DM) contents of the parboiled and raw rice offal are 93.36 and 91.35%, Crude Fiber (CF) of 34.73 and 33.99%, Neutral Detergent Fiber (NDF) of 61.22 and 53.49%, Crude Protein (CP) of 4.38 and 7.69 % and Metabolizable Energy (ME) of 10.57 and 9.76MJ/Kg DM, respectively. The values of CP, EE and hemicellulose were higher in raw rice offal than in parboiled. On the other hand, the DM, CF, Ash, NDF, Acid Detergent Fiber (ADF) and ME are higher in the parboiled rice offal than in the raw rice offal.

The CF, ADF, CP and ME of maize offal are as follows 8.28%, 10.33%, 11.88% and 11.37 MJ/Kg DM respectively. The cotton seed cake had 38.49 CF, 55.37 NDF, 47.31 ADF, 8.06 Hemicellulose, 23.69 % CP and ME of 9.14 MJ/Kg DM. The CF, NDF, ADF, Hemicellulose, CP and ME of poultry litter are 24.91, 60.15, 42.41, 17.70, 19% and 11.27% MJ/Kg DM respectively.

4.1.2 Mineral content of raw and parboiled rice offal

Silica content obtained in this study is higher in both raw (24.86 %) and parboiled rice offal (36.91 %) compared to other oxides (Table 4.2). Also, peak of silicon is high when compared with other chemical elements (see appendix I). Calcium oxide was higher for RRO (0.141) than PRO (0.043) while Phosphorus oxide follows opposite trend.

4.1.3 Chemical composition of experimental diets

The Dry Matter and Crude Protein of the Experimental diet ranged between 88.77 - 90.05% and 19.94 – 22.44% respectively (Table 4.3). Crude Fibre ranged between14.59 and 17.84% with treatment 1 having the lowest CF and treatment 2 with the highest. The Neutral Detergent Fibre and Acid Detergent Fibre ranged between 36.44 - 55.89 and 17.77 - 24.13% respectively. The ash content ranged between 9.12 and 13.02 while the Ether Extract ranged between 14.22 and 17.05. Metabolizable Energy for 30% RRO diet and 0% rice offal were higher than 20% RRO diet and 20% PRO. 30% PRO has the lowest ME.

4.2 Effect of Diet containing Raw or Parboiled Rice Offal on the Fattening Performance of Bunaji Bulls

The results of feeding raw or parboiled rice offal on the fattening performance of Bunaji Bulls is presented in Table 4.4.There was no significant ($P>0.05$) difference in all the parameters measured. Average concentrate intake, average feed intake, average dry matter intake and average weight gain is higher for raw rice offal diet than parboiled rice offal although average dry matter intake and feed efficiency was higher for parboiled rice offal diet than raw rice offal diet. The control diet was highest in all the parameters measured except for feed efficiency though not statistically significant ($P>0.05$).

Irrespective of rice offal inclusion level, there was no significant ($P>0.05$) difference in most of the parameters measured except in average daily weight gain (Kg/day) which was highest for the control diet (1.29) but similar for 20% (1.15) and 30% (1.14) level of inclusion (Table 4.5) though 30% level of inclusion has higher average (concentrate intake, hay intake and feed intake). However average dry matter intake was higher for 20% inclusion level compared to 30%.

Table 4.1 Chemical composition of individual feed ingredient and hay.

Parameters	Ingredient					
	D. smutsii	MO	CSC	LL	RRO	PRO
Dry matter	93.10	89.46	89.94	93.11	91.34	93.36
Crude protein	8.06	11.88	23.69	19.00	7.69	4.38
Crude fibre	41.28	8.28	38.49	24.91	33.99	34.73
Ether extract	8.39	16.07	17.84	8.63	15.74	10.75
Ash	9.95	5.41	3.87	21.28	14.40	24.21
Acid detergent fibre	50.59	10.33	47.31	42.45	46.85	55.12
Neutral detergent fibre	63.42	21.61	55.37	60.15	53.49	61.22
Hemicellulose	12.83	11.28	8.06	17.7	6.64	6.10
Metabolizable energy(MJ/KgDM)	10.52	11.37	9.14	11.27	9.76	10.57

CSC = Cotton seed cake, MO = Maize offal, LL = Layer litter, RRO = Raw rice offal, PRO = Parboiled rice offal, *D.smutsii* = *Digitaria smutsii*. ME for the feed ingredients was determined by equation of Alderman and Cottrill, 1985. ME (MJ/Kg DM) = 11.78 + 0.0064 CP + $(0.000665EE)^2$ - CF (0.00414EE) - 0.0118A. Where ME = DM = Dry matter, CP = Crude protein, EE = Ether Extract, CF = Crude fiber and A = Ash.

Table 4.2: Mineral composition of raw and parboiled rice offal

Analyte	Raw rice offal (%)	Parboiled rice offal (%)
SiO_2	24.860	36.910
Na_2O	0.023	0.057
CaO	0.141	0.043
MgO	0.118	0.040
Al_2O_3	0.004	0.008
P_2O_5	0.337	0.393

Table 4.3 Chemical compositions of concentrate diets containing varying levels of raw or parboiled rice offal fed to fattening Bunaji bulls.

	Level of inclusion				
Parameters	0	20RRO	30RRO	20PRO	30PRO
Dry matter	90.05	89.77	88.77	89.85	89.17
Crude protein	19.94	19.69	22.44	21.38	20.56
Crude fibre	14.59	17.84	14.91	16.77	17.40
Ether extract	16.28	16.21	14.22	17.05	16.22
Ash	10.19	13.02	9.81	10.74	9.12
Acid detergent fibre (ADF)	20.56	21.89	21.32	24.13	21.09
Neutral detergent fibre (NDF)	36.44	40.81	39.87	43.96	42.41
Hemicellulose	15.88	18.92	18.50	19.83	19.32
Metabolizable energy(MJ/KgDM)	11.05	10.87	11.16	10.86	10.85

RRO = Raw rice offal, PRO = Parboiled rice offal, ME for the feed ingredients was determined by equation of Alderman and Cottrill, 1985. ME (MJ/Kg DM) = 11.78 + 0.0064 CP + $(0.000665EE)^2$ - CF (0.00414EE) - 0.0118A. Where ME = DM = Dry matter, CP = Crude protein, EE = Ether Extract, CF = Crude fiber and A = Ash.

Table 4.4: Effect of feeding diet containing raw or parboiled rice offal on performance of fattening Bunaji bulls.

	Type of rice offal				
Parameters	NRO	RRO	PRO	SEM	LOS
Initial weight (Kg)	205.25	202.00	202.66	8.371	NS
Final weight (Kg)	321.25	311.17	308.17	10.66	NS
Average Concentrate intake (Kg/day)	5.21	5.13	4.97	0.153	NS
Average Hay intake (Kg/day)	3.59	3.47	3.52	0.128	NS
Average feed intake (Kg/day)	8.80	8.60	8.49	0.275	NS
Average DM intake (Kg/day)	8.05	7.79	7.70	0.250	NS
Average weight gain(Kg/day)	1.29	1.21	1.17	0.037	NS
Feed Efficiency	6.26	6.46	6.67	0.199	NS

NRO = No rice offal, RRO = Raw rice offal, RRO = Raw rice offal, PRO = Parboiled rice offal, SEM = Standard error of mean, LOS = Level of significance * = $P<0.05$, NS = Not significant ($P>0.05$)

Table 4.5: Effect of feeding diet containing varying levels of raw or parboiled rice offal on performance of fattening Bunaji bulls.

	Level of inclusion				
Parameters	0	20	30	SEM	LOS
Initial weight (Kg)	205.25	203.75	198.00	10.253	NS
Final weight (Kg)	321.25	307.50	300.25	13.058	NS
Average concentrate intake (Kg/day)	5.21	4.78	4.94	0.215	NS
Average hay intake (Kg/day)	3.59	3.43	3.46	0.157	NS
Average feed intake (Kg/day)	8.80	8.21	8.40	0.336	NS
Average DM intake (Kg/day)	8.05	7.68	7.62	0.306	NS
Average weight gain (Kg/day)	1.29^{a}	1.15^{b}	1.14^{b}	0.046	*
Feed Efficiency	6.26	6.71	6.72	0.244	NS

RRO = Raw rice offal, PRO = Parboiled rice offal, SEM = Standard error of mean
Means with different superscript along rows are significantly different at ($P<0.05$). LOS = Level of significance,* ($P<0.05$); NS = Not significant ($P<0.05$)

The result of interaction between type of rice offal (raw and parboiled) and level of inclusion showed no significant (P>0.05)effect in all the parameters measured, average concentrate intake decreases with increase in rice offal level for both raw and parboiled rice offal (Table 4.6.) The 20% RRO had the highest value for all the parameters measured except for average hay intake which was highest at 30% PRO inclusion though the control diet had higher values for average intake of (concentrate, hay, feed, dry matter) and average weight gain however these values were not statistically significant (P>0.05).

4.3 Effect of Diet containing Raw or Parboiled Rice Offal on digestibility and nitrogen balance of Bunaji bulls

There was significant (P<0.05) difference in result of feeding diet containing raw or parboiled rice offal on Dry Matter, Crude Protein, Ash and Acid Detergent Fibre but Crude Fibre, Ether Extract, Neutral detergent fibre and Hemicellulose showed no significant (P>0.05) difference. All the parameters measured for nitrogen balance were not significantly diffrent (P>0.05) (Table 4.7) though raw rice offal diets had higher value when compare to the parboiled rice offal with the exception of nitrogen retained (% N- intake).

There was significant (P<0.05) difference in the DM, Ash and ADF of the digestibility trial resulting from feeding diets containing varying levels of rice offal. All other parameters measured were not significant (P>0.05) though there was decrease in values obtained with increase in rice offal inclusion level. All the parameters measured for nitrogen balance were not significant (P>0.05) (Table 4.8) however, as rice offal inclusion increased, there was increase in urinary Nitrogen, nitrogen observed and nitrogen retained(%N -intake) which were higher at 20% inclusion level.

Table 4.6: Effect of type and level of inclusion of raw or parboiled rice offal on performance of fattening Bunaji bulls.

	Level of inclusion and Type of rice offal						
Parameters	0	20RRO	30RRO	20PRO	30PRO	SEM	LOS
Initial weight (Kg)	205.25	203.25	197.50	204.25	198.50	14.500	NS
Final weight (Kg)	321.25	310.75	301.50	304.25	299.00	18.467	NS
Average concentrate intake (Kg/day)	5.22	5.09	4.96	4.99	4.93	0.304	NS
Average hay intake (Kg/day)	3.59	3.44	3.39	3.43	3.53	0.222	NS
Average feed intake (Kg/day)	8.81	8.52	8.35	8.32	8.46	0.475	NS
Average DM intake (Kg/day)	8.04	7.77	7.56	7.59	7.68	0.433	NS
Average weight gain (Kg/day)	1.29	1.20	1.16	1.11	1.12	0.065	NS
Feed Efficiency	6.26	6.60	6.52	6.82	6.93	0.345	NS

RRO = Raw rice offal, PRO = Parboiled rice offal, SEM = Standard error of mean
LOS = Level of significance*=P<0.05; NS = Not significant (P>0.05)

Table 4.7: Effect of feeding diet containing raw or parboiled rice offal on digestibility and nitrogen balance of fattened Bunaji bulls.

	Type of rice offal				
Nutrient Digestibility (%)	NRO	RRO	PRO	SEM	LOS
Dry Matter	58.89[a]	53.63[b]	58.18[a]	0.908	*
Crude Protein	71.48[a]	68.31[b]	71.74[a]	0.818	*
Crude Fibre	47.53	42.57	58.48	3.994	NS
Ash	36.66[b]	30.61[c]	39.35[a]	1.296	*
Ether extract	76.39	71.01	74.21	2.607	NS
Acid Detergent Fibre	42.79[a]	35.23[b]	43.02[a]	1.787	*
Neutral Detergent Fibre	50.46	47.69	50.70	1.230	NS
Hemicellulose	69.11	67.91	66.55	4.033	NS
Nitrogen Balance					
Nitrogen intake (g/day)	12.54	13.10	12.26	0.417	NS
Urinary-N (g/day)	2.35	2.61	2.37	0.189	NS
Feacal-N (g/day)	3.59	4.04	3.48	0.188	NS
Total-N output (g/day)	5.94	6.65	5.84	0.324	NS
Nobserved(g/day)	8.95	9.06	8.78	0.267	NS
N-Retained (g/day)	6.60	6.46	6.42	0.223	NS
N-Retained (%N-intake)	52.92	49.44	52.39	1.466	NS

RRO = Raw rice offal, PRO = Parboiled rice offal, SEM = Standard error of mean Means with different superscript along rows are significantly different at ($P<0.05$).
LOS = Level of significance*=$P<0.05$; NS = Not significant

Table 4.8: Effect of feeding diet containing varying levels of raw or parboiled rice offal on digestibility and nitrogen balance of fattened Bunaji Bulls.

	Level of inclusion				
Nutrient Digestibility (%)	0	20	30	SEM	LOS
Dry Matter	58.89 [a]	56.86[a]	51.97[b]	1.112	*
Crude Protein	71.48	69.84	68.75	1.002	NS
Crude Fibre	47.53	54.97	43.08	4.891	NS
Ash	36.66[b]	42.32 [a]	25.96[c]	1.588	*
Ether extract	76.39	74.21	67.24	3.193	NS
Acid Detergent Fiber	42.79 [a]	41.54 [a]	33.03[b]	2.188	*
Neutral Detergent Fiber	50.46	49.53	47.59	1.506	NS
Hemicellulose	69.11	66.42	66.16	4.939	NS
Nitrogen Balance					
Nitrogen intake (g/day)	12.54	12.62	12.89	0.511	NS
Urinary Nitrogen (g/day)	2.35	2.57	2.54	0.231	NS
Feacal Nitrogen (g/day)	3.59	3.66	4.03	0.230	NS
Total Nitrogen Output (g/day)	5.94	6.23	6.56	0.396	NS
Nitrogen Observed (g/day)	8.95	8.96	8.86	0.327	NS
Nitrogen Retained (g/day)	6.60	6.39	6.33	0.273	NS
Nitrogen Retained (%N-intake)	52.92	50.61	49.19	1.795	NS

RRO = Raw rice offal, PRO = Parboiled rice offal, SEM = Standard error of mean
Means with different superscript along rows are significantly different at ($P<0.05$).
LOS = Level of significance*=$P<0.05$; NS = Not significant

The result of interaction between type of rice offal (raw and parboiled) and level of inclusion **on** Digestibility and Nitrogen Balance are presented in Table 4.9. There was no significant (P>0.05) differences in digestibility of DM, CP, CF, EE, ADF, NDF and hemicellulose with type and level of inclusion of rice offal except for Ash where 20%RRO was numerically higher than 30%RRO for DM, CF. EE and ADF. The parameters measured for nitrogen balance were also not significant (P>0.05) except for Urinary-N (g/day), N-Retained (g/day) and N-Retained (%N-intake) which were significant (P<0.05). Urinary-N (g/day) at 30%RRO was higher than 20%RRO, the reverse being the case for PRO, N-Retained (g/day) at 20%RRO was higher than 30%RRO while that of 30%PRO was higher than that of 20%PRO, the same trend was also observed for N-Retained (%N-intake).

4.4 Effect of Diet containing Raw or Parboiled Rice Offal on Rumen Metabolites of Bunaji bulls

Diets containing raw or parboiled rice offal had no significant effect (P>0.05) on rumen metabolites of the bulls in pH, RAN and TVFA irrespective of sampling time (Fig. 4.1). Raw rice offal had higher pH than parboiled rice offal at 0hr, 4hrs and 6hrs sampling time. Rumen ammonia nitrogen was however higher for parboiled rice offal than raw rice offal at 2hrs, 4hrs and 6hrs sampling time. Total volatile fatty acid on the other hand is higher than in raw rice offal than parboiled rice offal at 0hr, 2hrs, 4hrs and 6hrs sampling time

The result of the effect of feeding diet containing varying levels of raw or parboiled rice offal on Rumen Metabolites of fattened Bunaji Bulls are represented in Fig 4.2. Rumen pH was not significant (P>0.05) at 0hr, 2hrs and 4hrs of sampling but was significant at 6hrs post feeding (P<0.05), Rumen ammonia nitrogen (g/100g) was not significant (P>0.05) at 0hr, 2hrs and 4hrs

post feeding. However at 6hrs hour post feeding sampling time the RAN was significant at 0% inclusion level.

The result of interaction between type of rice offal (raw and parboiled) and level of inclusion on Rumen Metabolites of fattened Bunaji Bulls are represented in Fig 4.3. the result shows that the rumen pH was not significant ($P>0.05$) irrespective of hour of sampling, Rumen Ammonia Nitrogen was only significant ($P<0.05$) at 2hr post feeding while Total volatile fatty acid (µmol) was also not significant ($P>0.05$) irrespective of hour of sampling.

Table 4.9: Effect of type and level of inclusion of raw or parboiled rice offal on Digestibility and Nitrogen Balance of fattened Bunaji bulls.

	Level of inclusion and Type of rice offal						
Nutrient Digestibility%	0	20RRO	30RRO	20PRO	30PRO	SEM	LOS
Dry Matter	58.89	54.22	47.77	59.49	56.17	1.572	NS
Crude Protein	71.48	66.28	67.18	73.37	70.33	1.417	NS
Crude Fibre	47.53	43.69	36.50	66.25	47.66	6.918	NS
Ash	36.66^{b}	39.62^{b}	15.55^{c}	45.02^{a}	36.38^{b}	2.246	*
Ether extract	76.39	73.37	63.28	75.05	71.19	4.515	NS
Acid Detergent Fiber	42.79	37.62	25.27	45.46	40.80	3.095	NS
Neutral Detergent Fiber	50.46	45.43	47.18	53.64	47.99	2.129	NS
Hemicellulose	69.11	61.94	72.68	70.91	59.63	6.985	NS
Nitrogen Balance							
Nitrogen intake (g/day)	12.54	13.43	13.36	11.81	12.44	0.722	NS
Urinary-N (g/day)	2.35^{b}	2.28^{b}	3.19^{a}	2.87^{ab}	1.88^{b}	0.327	*
Feacal-N (g/day)	3.59	4.17	4.36	3.15	3.7	0.325	NS
Total-N output (g/day)	5.94	6.45	7.55	6.05	5.58	0.561	NS
Nitrogen observed (g/day)	8.95	9.26	8.99	8.66	8.74	0.463	NS
N-Retained (g/day)	6.60	6.98	6.79	6.80	6.86	0.387	NS
N-Retained (%N-intake)	52.92^{a}	52.19^{a}	43.19^{b}	49.03^{a}	52.92^{a}	2.538	*

RRO = Raw rice offal, PRO = Parboiled rice offal, SEM = Standard error of mean
LOS = Level of significance*=P<0.05; NS = Not significant

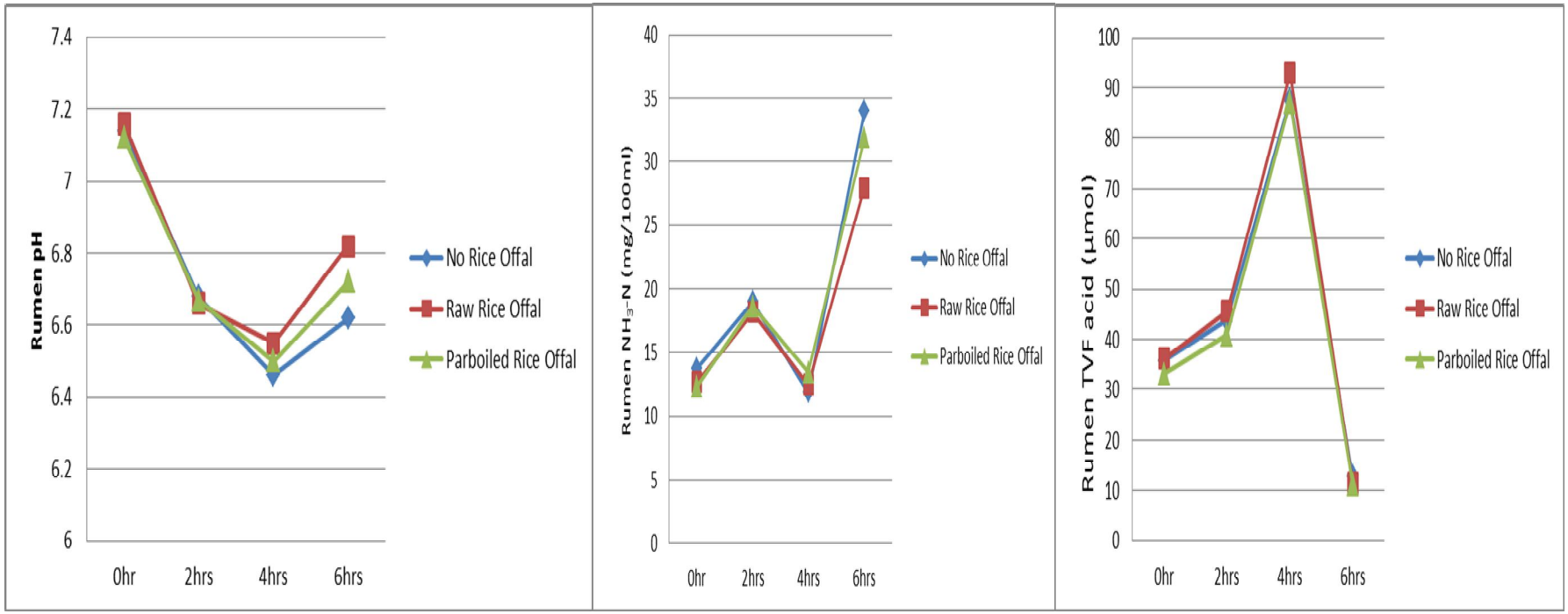


Fig. 4.1: Effect of feeding diet containing raw or parboiled rice offal on rumen pH, rumen ammonia nitrogen and rumen total volatile fatty acid of fattened Bunaji bulls

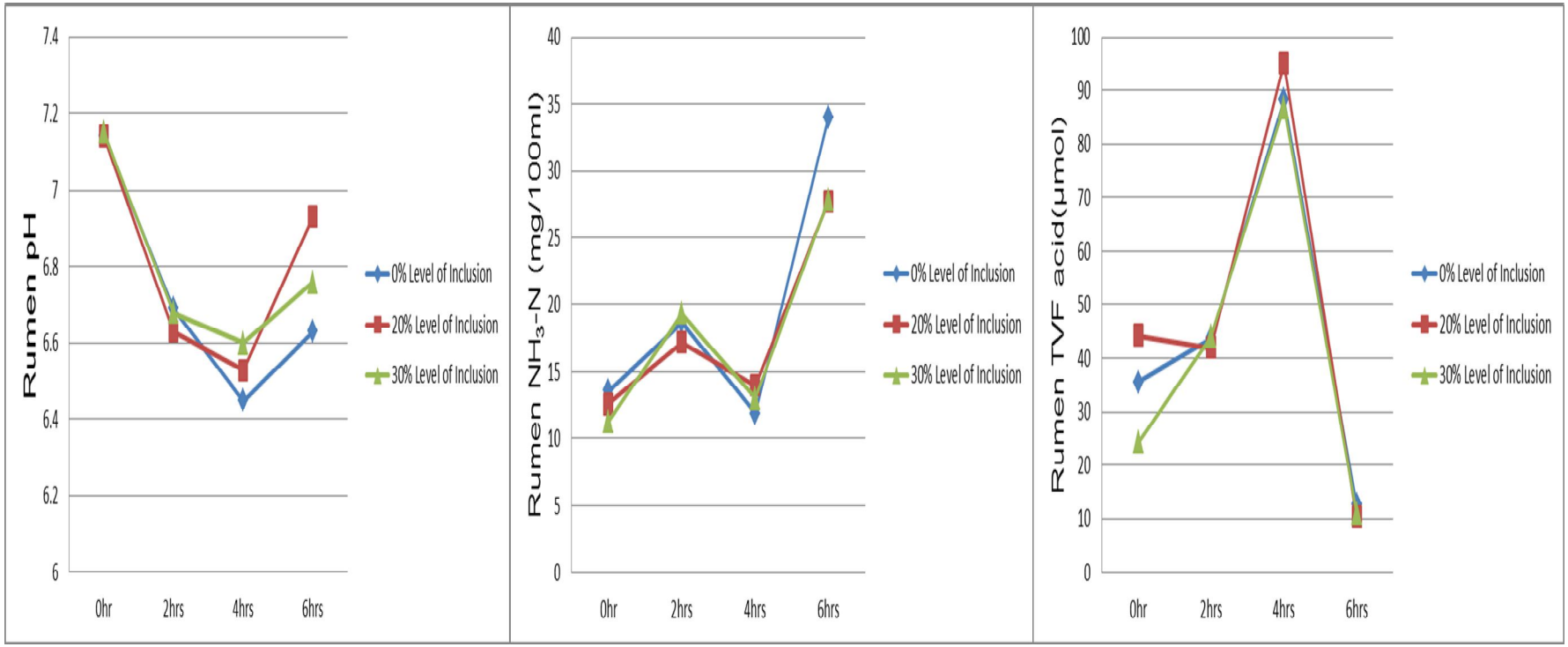


Fig.4. 2: Effect of feeding diet containing varying levels of rice offal on Rumen pH, Rumen ammonia nitrogen and Rumen total volatile fatty acid of fattened Bunaji bulls.

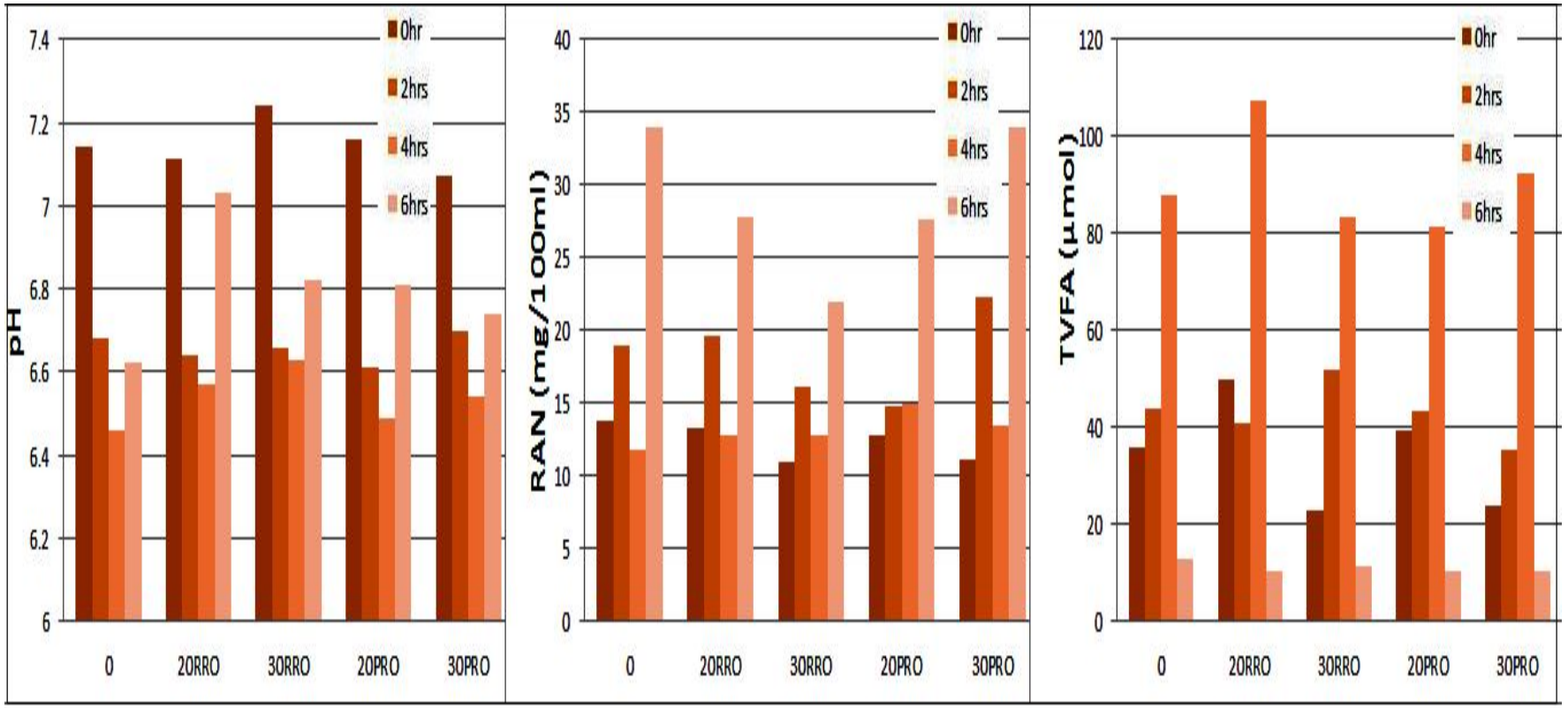


Fig. 4.3: Effect of type and level of inclusion of raw or parboiled rice offal on Rumen pH, Rumen ammonia nitrogen and Rumen total volatile fatty acid of fattened Bunaji bulls.

4.5. Effect of Diet containing Raw or Parboiled Rice Offal on carcass yield of Bunaji bulls.

The result of feeding diet containing raw or parboiled rice offal on Carcass yield of fattened Bunaji Bulls is represented in Table 4.10. The result shows that type of rice offal had significant ($P<0.05$) effect on weight of legs, spleen, empty stomach, empty intestine, inguinal fat and abdominal fat of bulls fed raw and parboiled rice offal. However, there was no significant effect on all other parameters measured. Dressing percentage, weight of dissectible beef, beef (% of carcass), heart, spleen, kidney, intestine with content and rib muscles were numerically higher for animals on raw rice offal than parboiled rice offal while hide, head, liver, lungs stomach with content, kidney fat, intestinal fat, depth of chest fat, longissimus muscle and blood are higher for animals on parboiled rice offal than raw rice offal diet although these differences are not significant ($P>0.05$). From the result it was also observed that fat content was higher for animals on parboiled than raw rice offal diet.

The result of the effect of feeding diet containing varying levels of raw or parboiled rice offal on Carcass yield of fattened Bunaji Bulls is presented in Table 4.11. The dressing percentage, beef percent of carcass ,meat to bone ratio, legs, tail, empty stomach, intestine with content, empty intestine, inguinal fat, kidney fat, abdominal fat, depth of chest fat, Testis and blood are all significant ($P<0.05$) with varying level of inclusion of rice offal. However all other parameters measured were not significant ($P>0.05$). Bone yield, head, heart, lungs and kidney where higher at 30% inclusion than at 20%, reverse was the case for weight of dissectible beef, liver, Stomach with content, intestinal fat, longissimus muscle and rib muscle.

The result of interaction between type of rice offal (raw and parboiled) and level of inclusion on Carcass yield of fattened Bunaji Bulls is presented in Table 4.12. Most of the parameters

measured were not significant (P>0.05) except for the legs, hide, empty stomach, empty intestine, kidney fat and abdominal fat were significant (P<0.05). As the level of rice offal increases the dressing percentage reduces with 20% parboiled rice offal being the highest followed by 20% raw rice offal then 30% raw rice offal and lastly 30% parboiled rice offal, meat to bone ratio, stomach with content, intestinal fat, testis and rib muscle also follow similar trend although these differences were not significant P> 0.05. The control diet however gave highest beef yield expressed as percent carcass than other treatments though the differences were not significant (p>0.05).

4.6 Economic Evaluation

Table 4.13 shows that all the parameters evaluated in the partial budget analysis for bunaji bulls fed no rice offal, raw or parboiled rice offal diets were not statistically significant (P>0.05) except total and average weight gain. The lowest cost of feed was recorded for parboiled rice offal, then raw rice offal, the control diet however had the highest cost of feed. The control diet however had the least cost of feed per Kg gain although the differences are not significant (P>0.05).

Table 4.14 shows that most of the parameters evaluated in the partial budget analysis for bunaji fed varying level of inclusion of rice offal diet were not statistically significant (P>0.05). However, total weight gain, average weight gain and value of weight gain were significantly (P<0.05) different. 20% and 30% level of inclusion were similar but differ from the control diet (0%) for both total and average weight gain, 20% as a higher value of gain than 30% level of inclusion though the control diet as the highest value.

Table 4.10: Effect of feeding diet containing raw or parboiled rice offal on carcass yield of fattened Bunaji bulls.

	Type of rice offal				
Parameters	NRO	RRO	PRO	SEM	LOS
Fasted weight	317.00	314.83	329.00	8.952	NS
Slaughter weight	306.00	300.87	309.32	9.134	NS
Hot carcass weight	193.26	183.34	188.32	7.057	NS
Dressing %	60.88	58.07	57.21	0.726	NS
Weight of dissectible beef	123.00	112.67	111.00	4.851	NS
Beef (% of carcass)	63.50	61.27	58.87	0.946	NS
Bone yield	44.35	44.45	46.79	1.095	NS
Meat: bone ratio	2.78	2.53	2.39	0.091	NS
Legs	7.30^{c}	7.54^{b}	8.19^{a}	0.129	*
Hide	19.50^{b}	20.20	20.32	0.310	NS
Head	16.75	16.62	16.66	0.382	NS
Tail	3.40^{a}	3.27	3.27	0.045	NS
Liver	4.00	3.78	3.85	0.125	NS
Spleen	0.78^{b}	0.80^{a}	0.73^{b}	0.022	*
Heart	120	1.16	1.14	0.035	NS
Lungs	2.01	2.07	2.14	0.065	NS
Kidney	0.55	0.58	0.55	0.011	NS
Stomach with content	34.40	35.50	37.09	0.863	NS
Empty stomach	7.55^{b}	7.78^{b}	8.32^{a}	0.112	*
Intestine with content	12.10^{b}	13.97	13.74	0.437	NS
Empty intestine	6.10^{b}	6.12^{b}	7.01^{a}	0.165	*
Inguinal fat	2.85^{a}	2.39^{c}	2.77^{b}	0.117	*
Kidney fat	3.76^{a}	3.08^{c}	3.60^{b}	0.225	*
Abdominal fat	4.39^{a}	3.54^{b}	3.75^{b}	0.185	*
Intestinal fat	1.86	1.65	1.80	0.098	NS
Depth of chest fat	9.85	8.73	8.93	0.098	NS
Testis	0.50	0.58	0.57	0.029	NS
Longissimus muscle	1.25	1.34	1.35	0.078	NS
Rib muscle	2.17	2.19	2.14	0.080	NS
Blood	9.86	10.47	10.55	0.185	NS

NRO = No rice offal, RRO = Raw rice offal, PRO = Parboiled rice offal, SEM = Standard error of mean, Means with different superscript along rows are significantly different at ($P<0.05$).
LOS = Level of significance*=$P<0.05$; NS = Not significant ($P>0.05$)

Table 4.11: Effect of feeding diet containing varying levels of rice offal on carcass yield of fattened Bunaji bulls.

	Level of inclusion				
Parameters	0	20	30	SEM	LOS
Fasted weight	317.00	329.00	319.75	10.964	NS
Slaughter weight	306.00	310.56	298.73	11.187	NS
Hot carcass weight	193.26	187.38	176.86	8.643	NS
Dressing %	60.88^{a}	59.92^{b}	55.12^{b}	0.889	*
Weight of dissectible beef	123.00	108.50	104.00	5.942	NS
Beef (% of carcass)	63.50^{a}	57.91^{b}	58.80^{b}	1.159	*
Bone yield	44.35	44.63	47.88	1.342	NS
Meat: bone ratio	2.78^{a}	2.44^{ab}	2.17^{b}	0.111	*
Legs	7.30^{c}	7.79^{b}	8.50^{a}	0.158	*
Hide	19.50^{b}	20.18^{ab}	21.10^{a}	0.380	*
Head	16.75	16.43	16.73	0.468	NS
Tail	3.40^{a}	3.04^{b}	3.37^{a}	0.055	*
Liver	4.00	3.85	3.58	0.150	NS
Spleen	0.78	0.74	0.78	0.026	NS
Heart	120	1.12	1.13	0.043	NS
Lungs	2.01	2.12	2.18	0.077	NS
Kidney	0.55	0.56	0.58	0.013	NS
Stomach with content	34.40	37.80	36.68	1.057	NS
Empty stomach	7.55^{b}	7.78^{b}	8.83^{a}	0.138	*
Intestine with content	12.10^{b}	14.65^{a}	14.81^{a}	0.535	*
Empty intestine	6.10^{b}	6.63 ^{ab}	6.98^{a}	0.203	*
Inguinal fat	2.85^{a}	2.24^{b}	2.65^{ab}	0.143	*
Kidney fat	3.86^{a}	3.60^{ab}	2.79^{b}	0.275	*
Abdominal fat	4.62^{a}	3.75^{b}	3.52^{b}	0.226	*
Intestinal fat	1.86	1.80	1.53	0.120	NS
Depth of chest fat	9.85^{a}	8.50^{b}	8.15^{b}	0.205	*
Testis	0.50^{b}	0.69^{a}	0.54^{b}	0.036	*
Longissimus muscle	1.25	1.46	1.32	0.095	NS
Rib muscle	2.17	2.33	2.00	0.098	NS
Blood	9.86^{b}	10.81^{a}	10.87^{a}	0.227	*

RRO = Raw rice offal, PRO = Parboiled rice offal, SEM = Standard error of mean.
Means with different superscript along rows are significantly different at ($P<0.05$).
LOS = Level of significance*=$P<0.05$; NS = Not significant ($P>0.05$).

Table 4.12: Effect of type and level of inclusion of raw or parboiled rice offal on carcass yield of fattened Bunaji bulls.

	Level of inclusion and Type of rice offal						
Parameters	0	20RRO	30RRO	20PRO	30PRO	SEM	LOS
Fasted weight	317.00	308.00	319.50	350.00	320.00	15.505	NS
Slaughter weight	306.00	294.87	301.75	326.25	295.71	15.821	NS
Hot carcass weight	193.26	175.00	181.75	199.73	171.96	12.223	NS
Dressing %	60.88	56.79	56.77	57.05	53.69	1.257	NS
Weight of dissectible beef	123	101	114	116	94.00	8.403	NS
Beef (% of carcass)	63.50	57.79	62.53	58.03	55.07	1.639	NS
Bone yield	44.35	41.25	47.75	48.00	48.02	1.897	NS
Meat: bone ratio	2.78	2.45	2.37	2.42	1.97	0.157	NS
Legs	7.30	6.91	8.40	8.68	8.60	0.224	*
Hide	19.50	19.10	22.00	21.25	20.21	0.538	*
Head	16.75	16.25	16.85	16.60	16.62	0.662	NS
Tail	3.40	3.00	3.41	3.08	3.33	0.078	NS
Liver	4.00	3.85	3.48	3.85	3.69	0.213	NS
Spleen	0.78	0.83	0.80	0.66	0.76	0.037	NS
Heart	1.20	1.08	1.20	1.16	1.05	0.061	NS
Lungs	2.01	2.09	2.10	2.14	2.27	0.109	NS
Kidney	0.55	0.60	0.58	0.53	0.59	0.019	NS
Stomach with content	34.40	36.60	35.50	39.00	37.86	1.495	NS
Empty stomach	7.55	7.05	8.75	8.50	8.92	0.194	*
Intestine with content	12.10	15.05	14.75	14.25	14.88	0.757	NS
Empty intestine	6.10	5.75	6.50	7.50	7.42	0.287	*
Inguinal fat	2.85	1.87	2.45	2.60	2.85	0.202	NS
Kidney fat	4.95^{a}	2.78^{c}	2.85^{c}	3.60^{b}	2.73^{c}	0.389	*
Abdominal fat	6.00^{a}	3.24^{b}	3.63^{b}	3.75^{b}	3.42^{b}	0.320	*
Intestinal fat	1.87	1.60	1.50	2.00	1.56	0.170	NS
Depth of chest fat	9.85	8.00	8.35	9.00	7.95	0.290	NS
Testis	0.50	0.70	0.56	0.66	0.54	0.051	NS
Longissimus muscle	1.25	1.38	1.39	1.55	1.24	0.135	NS
Rib muscle	2.17	2.45	1.95	2.20	2.05	0.138	NS
Blood	9.86	10.33	11.23	11.28	10.50	0.321	NS

RRO = Raw rice offal, PRO = Parboiled rice offal, SEM = Standard error of mean
LOS = Level of significance*=P<0.05; NS = Not significant (P>0.05)

Table 4.13: Partial budget analysis for Bunaji bulls fed either Raw or Parboiled rice offal as energy source.

	Type of rice offal				
Parameter	NRO	RRO	PRO	SEM	LOS
Total weight gain (Kg)	116.00[a]	109.17[b]	105.5[b]	3.354	*
Daily weight gain (Kg)	1.29[a]	1.21[b]	1.17[b]	0.037	*
Value of gain (₦)	46400.00 [a]	43666.67 [b]	42200.00 [b]	1341.641	*
Concentrate intake (Kg)	469.63	457.75	451.07	15.804	NS
Hay intake(Kg) (Digitaria smutsii)	323.11	312.57	316.34	11.538	NS
Total feed intake (Kg)	792.73	770.32	767.42	24.702	NS
Cost of concentrate (₦)	16277.3	15091.5	14638.5	522.658	NS
Cost of hay (₦)	8723.8	8439.4	8541.3	311.522	NS
Total cost of feed (₦)	25001.1	23530.9	23179.9	753.324	NS
Cost/ Kg gain (₦)	216.07	216.54	220.48	6.463	NS
Net Benefit (NB)	21398.9	20135.72	19020.12	1060.123	NS
Return to investment on feed (RIF)	0.85	0.86	0.82	0.051	NS

Table 4.14: Partial budget analysis for Bunaji bulls fed varying levels of inclusion of rice offal as energy source.

	Level of inclusion				
Parameters	0%	20%	30%	SEM	LOS
Total weight gain (Kg)	116.00[a]	103.75[b]	102.25[b]	4.108	*
Daily weight gain (Kg)	1.29[a]	1.15[b]	1.14[b]	0.046	*
Value of gain (₦)	46400.00[a]	41500.00[b]	40900.00[b]	1643.168	*
Concentrate intake (Kg)	469.63	448.89	444.72	19.356	NS
Hay intake(Kg) (*Digiteria smutsii*)	323.11	308.81	311.46	14.131	NS
Total feed intake (Kg)	792.73	757.70	756.18	30.254	NS
Cost of concentrate (₦)	16277.3[a]	14239.7[b]	14078.2[b]	640.123	*
Cost of hay (₦)	8723.8	8337.9	8409.3	381.534	NS
Total cost of feed (₦)	25001.1	22577.6	22487.5	922.689	NS
Cost/ Kg gain (₦)	216.07	219.12	220.33	7.915	NS
Net Benefit (NB)	21398.9	18922.4	18412.5	1298.4	NS
Return to investment on feed (RIF)	0.85	0.85	0.83	0.063	NS

Table 4.15 shows that the partial budget parameters evaluated were not statistically significant (P>0.05). However, daily weight gain was higher at 20% RRO than at 30%RRO the reverse was the case for parboiled rice offal. Value of gain reduces with increase in raw rice offal while it increases with increase in parboiled rice offal; cost per kg gain was highest on diet containing 30%PROand lowest on the control diet. The differences were not significant (P>0.05).

Table 4.15: Partial budget analysis for Bunaji bulls fed varying levels of Raw or Parboiled rice offal as energy source.

	Level of inclusion and Type of rice offal						
Parameter	0	20RRO	30RRO	20PRO	30PR0	SEM	LOS
Total weight gain (Kg)	116.00	107.50	104.00	100.00	100.50	5.809	NS
Daily weight gain (Kg)	1.29	1.19	1.16	1.11	1.12	0.065	NS
Value of gain (₦)	46400.0	43000.0	41600.0	40000.0	40200.0	2323.790	NS
Concentrate intake (Kg)	469.63	457.68	445.94	440.09	443.51	27.373	NS
Hay intake (Kg)	323.11	309.36	305.26	308.27	317.66	19.984	NS
Total feed intake (Kg)	792.73	767.04	751.20	748.35	761.16	42.785	NS
Cost of concentrate (₦)	16277.3	14687.0	14310.2	13792.4	13846.2	905.271	NS
Cost of hay (₦)	8723.8	8352.6	8241.9	8323.2	8576.8	539.571	NS
Total cost of feed (₦)	25001.1	23639.6	22552.1	22115.5	22422.9	1304.795	NS
Cost/ Kg gain (₦)	216.07	217.39	216.16	220.85	224.50	11.193	NS
Net Benefit (NB)	21398.9	19960.4	19047.9	17884.5	17777.0	1836.187	NS
Return to investment on feed (RIF)	0.85	0.88	0.86	0.82	0.79	0.089	NS

CHAPTER FIVE

5.0 DISCUSSION

5.1 Chemical Analysis

5.1.1 Proximate and cell wall composition of feed ingredients.

The dry matter (DM) content 91.34% for RRO is lower than 94.94% reported by Duru (2010) . The DM of PRO (93.36%) in this study is close to 92.6% and 92.60% reported by Olomu (1995) and Ocheja *et al.,* (2011),it is lower than 97.20% reported by Adesote (2013) but higher than 89.90% reported by Garba *et al.,* (2012).

The crude protein (CP) of the raw rice offal (7.69%) was higher than that of the parboiled rice offal (4.38%). This is probably because of the heat treatment which must have denatured some of the protein during processing of parboiling the unthreshed rice. The CP content obtained in this study for raw rice offal (7.69%) is higher than 5.10% reported by Duru (2010).

Though higher, it is close to the values of 6.84% and 6.06% reported for regular rice offal by Ocheja *et al.,* (2008) and Duru (2010) respectively. The crude fibre (CF) content of RRO (33.99%) and PRO (34.73%) obtained in this study is close to 35.24% CF for RRO but lower than 42.48% CF for PRO (Duru, 2010). It is higher than values of 31.76%, 31.47%, 30.39% for Kwoi, Taime and Zaria city samples (Maikano, 2005). However, it is lower than values 38.0%, 44.94% and 40.06% reported by Aduku (1993), Oyeyiola (1991) and Dafwang and Shwarmwen (1996) respectively.

The Ether Extract content of RRO (15.74%) and PRO (10.75) are generally higher than values 5.35% and 5.31% obtained by Duru (2010) and Ocheja *et al.,* (2011) respectively. However, it is lower than 25.03% reported by Garba *et al.,* (2012) and slightly higher than 11.74% reported by

Adesote (2013). Fat content in the rice offal, which is of unsaturated nature, tends to develop rancidity readily upon heating (Singh and Panda, 1988). Oxidative rancidity of fat might be the factor for less percentage of EE in parboiled rice offal compared to raw rice offal. The ash content 11.33% and 13.48% reported by Duru (2010) for raw and parboiled rice offal are lower than values 14.40% and 24.21% obtained in this study.

The metabolizable energy (ME) of rice offal in the present study are generally higher for raw (9.76 MJ/Kg) and parboiled (10.59 MJ/Kg) rice offal than those reported by Duru (2010) for raw (8.92 MJ/Kg) and parboiled (7.56 MJ/Kg) rice offal.

The differences observed in the proximate value obtained in this study relative to previous workers could be primarily due lack of clear distinction between rice milling waste varieties (i.e mixture of raw and parboiled rice offal). Variation in results may also result from differences in seasons, variety, processing methods; proportion of broken grains in samples utilized and soil condition of rice crops.

The values of DM (89.46%), CP (11.88%) and CF (8.28%) of maize offal obtained from this study are lower than DM (91.82%), CP (12.80%) and CF (12.07%) reported by Ezieshi *et al.,* (2011). The CP, Ash, NDF (21.61%) and ME (11.37 MJ/Kg) are within range CP (10.93-11.98%), Ash (5.02-5.84%), NDF (22.75-26.37%) and ME (14.52-16.69 MJ/Kg) obtained by Lamidi (2005). CF value is lower than 12.38% and 12.07% reported by Olorunmisomo *et al.,* (2006) and Ezieshi *et al.,* (2011) respectively. Also, ADF (10.33) is low compared to range (20.28-22.84%) obtained by Lamidi (2005). EE of 16.01% is higher than range (9.24-9.57%) obtained by Lamidi (2005) and EE (11.72%) recorded by Ezieshi *et al.,* (2011). The DM is close to 88.9% and 88.9% by Ayoade (1986) and (Lamidi *et al.,* 2008). The CP of 11.88% falls within

the range of 11.26 -12.19% as reported by Fadugha (1990) and higher than 9.88% (Adesote, 2013) but lower than 12.69% and 14.31% reported by Idowu (2011) and Madziga *et al*, (2013). The NDF value 21.61% in present study is similar to 21.64% reported by (amidi *et al.,* 2008) but lower than 55.15% (Idowu, 2011), 33% (Olorunmisomo *et al.,* 2006) and 53.92% ((Madziga *et al*, 2013). The ash contents 5.41% in present study is close to 5.42% of Ezieshi *et al.,* (2011) and 5.48% reported by Lamidi *et al.,*(2008), it also fall within the range of 5.02 -5.84% given by (Lamidi, 2005).

The contents DM (89.94%), CP (23.69%) and ME (9.14 MJ/Kg) in cotton seed cake (CSC) are lower than the range DM (91.64-92.56%), CP (24.63-25.94%) and ME (21.97-23.05 MJ/Kg) obtained by Lamidi (2005). The DM, CP and ME are also lower than 92.99%, 30.88% and 11.51 (MJ/Kg) respectively reported by Madziga (2013). The value of CF, EE, NDF, ADF and Ash reported for CSC in this study is generally higher than values of CF (14.75-38.02%), EE (7.0-8.38%), NDF (50.31-54.28%), ADF (21.64-34.42%) and Ash (2.90-3.01%) reported by Lamidi (2005). However, the Ash content is also lower than value 4.98% reported by Madziga (2013) but the value Madziga (2013) reported for CF (37.23%) is lower than the present study. These variations probably result from difference in year of production and varieties used.

The CP (19.00%) obtained in this study is similar to CP (19.58%) reported by Lamidi (2005) while DM, CF, EE, NDF and ADF of layers litter (LL) is higher than those reported by Lamidi (2005). The EE is also higher than 4.40% reported by Madziga *et al*., (2013). The Ash (21.28%) and ME (11.48 MJ/Kg) are lower than values Ash (28.16%) and ME (16.90 MJ/Kg) reported by Lamidi (2005). The DM of present study is close to the value (92.71%) reported by Madziga

(2013). Also, CF and ADF in present study are higher than CF (21.05%) and ADF (35.95%) reported by Madziga (2013).

In general, the differences observed in the proximate composition of these by-product was in the line with the views of Oyediji, (2001) who reported that, the protein, fibre and energy of these by-products differ within themselves according to source and variety as well as processing methods.

The CP (8.06%), CF (41.28%), EE (8.39%), ADF (50.59%) and Ash (9.95%) in hay (*Digitaria smutsii*) of the present study are higher than values CP (5.86%), CF (41.09%), EE (4.05%), ADF (52.35%) and Ash (8.82%) but closer to DM (92.72%) reported by Madziga (2013). Also, the DM is lower than 96.38% reported by Sani (2010). On the other hand values of NDF (63.43%) and calculated ME (10.52MJ/Kg)) are lower than values NDF (68.89%) and ME (11.03 MJ/Kg) reported by Madziga (2013). Also, the Ash content is lower than the value 11.41% of (Omeiza, 2006) but higher than the values 7.89% reported by Sani (2010). The CP and EE were higher than 3.20% CP, 3.32%CP and 1.24% EE, 0.42% EE reported by Gohl (1981) and Sani (2010) respectively but lower than 9.76% CP (Omeiza, 2006).

5.1.2 Mineral content of raw and parboiled rice offal

Qualitatively (see appendix I and II) silicon (Si) had the highest peak in both raw and parboiled rice offals. The intensity of the peak is higher in parboiled (over 6500 count per seconds-cps) than raw (about 3500 cps) with K_α line energy (1.5-2.0 KeV) for parboiled and K_α to K_β line energy (1.8-3.0 KeV) for raw rice offal (see appendix I and II).

Quantitatively, silica is very high in raw (24.86%) and parboiled rice offal (36.91%) relative to other mineral elements. Valchev *et al.,* (2009) noted high silica (17.9%) content from rice hulls.

Ambreen *et al.,* (2006) worked on chemical composition of rice polishing from several sources and reported a range of (2.5-11% SiO_2). Since rice offal contains approximately 60% hull, 35% bran and 5% polishing (Duru, 2010), higher content of SiO_2 in the present study probably result from SiO_2 contents in rice bran. The calcium (Ca) content of RRO (0.10%) is higher than PRO (0.03%). This observation is similar to the value of (0.09%) RRO and (0.02%) PRO by Duru (2010) were higher Ca content was documented in the raw rice offal. The Phosphorus (P) content of 0.17% PRO is greater than 0.15% RRO. These values are lower than (0.29%) RRO and PRO (0.32%) reported by Duru (2010) and 0.49% reported by both Obeka (1985) and Aduku (1993). PRO gave higher values of Sodium (0.04%), Aluminium (0.004%) than raw with Sodium (0.02%), Aluminium (0.002%) except Magnesium (0.07%-RRO, 0.02%-PRO).EE normally has an inverse significant correlation with crude fibre, calcium and phosphorus (Ambreen *et al.,* 2006). This trend was confirmed in raw and parboiled rice offal used in the present study. The EE (15.74%) in raw is higher than parboiled (10.75%) hence an anticipated inverse proportional relationship with CF in raw (33.99%) to parboiled (34.73%), P in raw (0.17%) to parboiled (0.15%) and Ca in raw (0.10%) to parboiled (0.03%) was noted in present study.

5.1.3 Chemical composition of experimental diets

The ME of the diets was within the range of 10.85 - 11.16MJ/Kg DM. This is within the range of 10 - 11.6MJ/Kg DM recommended for Bulls (Rutherglen, 1995). The CP of the diets varies from 22.44% for diet containing 30%RRO to 19.69% for 20%RRO. These fall within the range of (19.00 to 22.91%) reported by Lamidi *et al* (2007) for fattening bulls, it is also similar to 19.63 reported by Madziga *et al* (2013) but higher than 13% and 13 - 15% reported by Rutherglen, (1995) and Aduku, (2005) respectively. CF ranged between 14.59% for control diet to 17.40 for 30% PRO. The CF of diets with no rice offal inclusion and 30% raw rice offal inclusion were

lower than the minimum level of 17% required for beef cattle (NRC, 2000). However the CF of diets with 20% raw rice offal inclusion, 20% parboiled rice offal inclusion and 30% parboiled rice offal inclusion are within the minimum level. The EE of all the diets also exceeded the maximum recommended level of 6% for matured cattle (Parish and Rhinehart, 2008). This increase might have resulted due to the presence of cotton seed cake in all the diets.

5.2 Effect of Diets containing raw or parboiled rice offal on the fattening Performance of Bunaji bulls

There was no significant difference ($P>0.05$) on the performance of the animal fed either raw or parboiled rice offal diet in all the parameters measured. This implies that performance was similar for all the parameters measured irrespective of the type of rice offal used. Average daily weight gain was higher for animal fed diet containing raw rice offal (1.21 Kg) than those on parboiled rice offal (1.17 Kg). Feed conversion efficiency was superior for animals on raw rice offal

There was no significant difference ($P>0.05$) on the performance of the bulls fed varying levels of raw or parboiled rice offal diet in most of the parameters measured. Performance was similar for most of the parameters measured in all the bulls irrespective of the rice offal inclusion level. Average daily weight gain was significantly ($P<0.05$) affected by level of rice offal inclusion in the diets. Bulls fed diet containing 0 level of inclusion had higher daily weight gain than those fed diets containing 20 and 30% rice offal inclusion.20% and 30% were statistically similar but 20% level of inclusion was numerically higher than 30% inclusion level. The 0% level of inclusion of rice offal had the highest Feed efficiency followed by 20% and lastly 30%.

There was no significant interaction effect between rice offal type and level of inclusion (P>0.05) on the performance of the bulls in most of the parameters measured. Average daily weight gain was numerically highest for 0%, 20% raw rice offal, 30% raw rice offal, 30% parboiled rice offal and 20% parboiled rice offal. Though they are all statistically similar (P>0.05). Feed efficiency was superior for 0%, 30% raw rice offal, 20% raw rice offal 20% parboiled rice offal and 30% parboiled rice offal respectively.

The average daily weight gain obtained in the present study irrespective of rice type (1.17-1.29Kg/day), inclusion level (1.14-1.29Kg/day) and interaction between type and inclusion (1.11-1.29Kg/day) is higher than those obtained in earlier studies reported by Olayiwole *et al*. (1981) 0.86Kg/day, Ikhatua and Olayiwole (1982) 1.07Kg/day, Scarr (1986) 0.5Kg/day, Lamidi *et al.* (2007) 0.69-0.91Kg/day, Idowu (2011) 0.4-0.66Kg/day and Madziga *et al.* (2013) 0.96-1.01Kg/day. Higher values obtained could probably be due to differences in experimental diets, age and live weight of the experimental bulls.

Feed Conversion Efficiency (FCE) based on rice type (6.26-6.67), inclusion level (6.26-6.72) and interaction between rice type and inclusion level (6.26-6.93) obtained in this study is superior to 9.04-9.55, 13.71-22.4 and 9.03-12.05 reported by Madziga *et al.* (2013), Idowu (2011) and Lamidi (2005) respectively. This could probably be as a result of differences in experimental diets, age and live weight of the experimental Animal.

5.3 Effect of Diets containing raw or parboiled rice offal on nutrient digestibility and nitrogen balance of Bunaji bulls

The non-significant (P>0.05) difference on the Digestibility observed on the bulls fed either raw or parboiled rice offal diet in most of the parameters measured suggests that the bulls utilized this

nutrient equally irrespective of the type of rice offal used. However there was significant difference ($P<0.05$) for dry matter , Crude Protein, Ash and Acid Detergent Fibre digestibilities with diet containing parboiled rice offal having higher digestibility . There was no significant difference ($P>0.05$) on the Nitrogen Balance.

The level of inclusion of rice offal in the diets of fattening did not have any effect on the digestibility of nutrient. It is indication that rice offal can be fed up to 30% in the diets of fattened bulls without any negative effect on nutrient utilization. However there was significant difference ($P<0.05$) for DM, Ash and ADF digestibilities. The DMD and ADF reduce with increase in level of inclusion of rice offal with 0% level of inclusion having higher digestibility value. However 20% level of inclusion as a better ash digestibility value, followed by 0% with 30% having the least value.

There was no significant interaction effect ($P>0.05$) on the Nutrient Digestibility of the animal fed varying levels of raw or parboiled rice offal diet in most of the parameters measured suggesting that the animals utilized this nutrient equally irrespective of the level of inclusion or the type of rice offal used . However there was significant difference ($P>0.05$) for Ash. The DMD and ADF values reduce with increase in level of inclusion of rice offal with 0% level of inclusion having higher digestibility value. However, 20% level of inclusion as a better ash digestibility value, followed by 0% with 30% having the least value.

All the bulls have positive nitrogen balance. This is an indication that the nitrogen was well metabolized and utilized by bulls in diet containing either raw or parboiled rice offal. This is also an indicated that there was no detrimental effect on feeding rice offal at 30% inclusion level. The lack of significant ($P>0.05$) difference on the Nitrogen Balance of the bulls fed varying level of

raw or parboiled rice offal diet in all the parameters measured. This implies that performance was similar for most of the parameters measured irrespective of the inclusion levels of rice offal type used. Hence rice offal can be utilized for fattening without adverse effect.

5.4 Effect of Diets Containing Raw or Parboiled Rice Offal on Rumen Metabolites of Bunaji bulls.

The pH of rumen fluid obtained in this study was not significantly ($P<0.05$) different among the bulls irrespective of the rice offal type in the diets. At 0hr the pH of the rumen fluid was slightly above the normal range 6-7 (Mould and Orskov, 1984). This could be due to a kind of conditioned reflex displayed by much salivation into the buccal cavity in expectation of the morning feeding regime. At 2hrs, 4hrs and 6hrs after feeding, the pH of the rumen fluid fall within the normal range of 6-7 (Mould and Orskov, 1984) and 6.2 – 6.9 (Reddy and Reddy,1999). So the pH is adequate for normal rumen function.

The critical Rumen Ammonia Nitrogen (RAN) level for optimum rumen function has been reported to be 5mg/100ml (Satter and Slyter, 1974). The RAN values obtained in this study is higher than what Satter and Slyter, 1974 reported but is within the normal range of 5-20mg/100ml (Leng and Nolan, 1984) for optimum Rumen Ammonia Nitrogen (RAN) level required for maximum rumen function. At 6hrs post feeding, the RAN recorded was similar to what Jonas and Vilma (2007) reported 11.42 -14.43mg/100ml and 19-25mg/100ml (Mehrez *et al.,* 1976). The high values obtained in this study could be due to low fermentable energy content of the diets especially at 6hrs post feeding. It could also be due to the fact that the poultry litter present in the diets is quite soluble in the rumen and rapidly converted to ammonia (Wohlt *et al.,* 1976). However there was no adverse effect on the performance of the bulls.

The non-significant difference (P>0.05) on the level of Total volatile fatty acid (TVFA) in the rumen fluid irrespective of the rice offal type in the diets is in line with the report of Orskov (1982). He stated that TVFA is the main source of energy to ruminants feeding solely on roughages. Thus, there concentration gave an indication of the energy value. It was lowest at 0hr before feeding, then increases at 2hrs post feeding, it reaches its peak at 4hrs after feeding probably due to increase in digestibility of the feed, then it drastically reduced at 6hrs post feeding.

There was no significant difference in pH of rumen fluid of all the bulls this study irrespective of the level of inclusion of the rice offal in the diet except at 6hrs post feeding (P<0.05), the pH was statistically similar at 0 and 30%level of inclusion but highest at 20%. At 2hrs, 4hrs and 6hrs after feeding, the pH values was above the minimum of 6.0 below which cellulolytic digestion in the rumen could be inhibited but it fall within the normal range of 6-7 (Mould and Orskov, 1984). This finding is also in agreement with the report of Lamidi (2005).

Similar pattern was observed for ammonia nitrogen at all the level of inclusion of rice offal. The RAN obtained in this study exceeded the value of 5mg/100ml (Satter and Slyter, 1974) for optimum rumen function.it is also higher than that reported by Lamidi (2005) but it within the normal range of 5-20mg/100ml (Leng and Nolan, 1984) for optimum Rumen Ammonia Nitrogen (RAN) level required for maximum rumen function except for the values obtained at 6hrs post feeding which was above this value. The high values obtained in this study could be due to low fermentable energy content of the diets especially at 6hrs post feeding with the highest value obtained at 0%level of inclusion even though not significant (P>0.05).

There was no significant difference (P>0.05) in the level of Total volatile fatty acid (TVFA) in the rumen fluid irrespective of the level of inclusion of rice offal in the diets except at 0hr before feeding (P<0.05). The value obtained in this study at 2hrs and 4hrs was higher than 19.57-36.57Mmol/L reported by Jokthan (2006) when pigeon pea forage was supplemented in sheep diets but it is lower at 6hrs post feeding. The TVFA reported in this study is within the normal range.

The rumen pH of all experimental animals measured at zero hour before feeding was either neutral or slightly above. At 2hrs, 4hrs and 6hrs after feeding, the pH values was above the minimum of 6.0 below which cellulolytic digestion in the rumen could be inhibited but it fall within the normal range of 6-7 (Mould and Orskov, 1984) and 6.2 – 6.9 (Reddy and Reddy, 1999) across all the treatment. The report in this study is similar to those of Lamidi (2005).

The RAN values obtained in this study is higher than this and that reported by Lamidi (2005) but it within the normal range of 5-20mg/100ml (Leng and Nolan, 1984) for optimum Rumen Ammonia Nitrogen (RAN) level required for maximum rumen function except for the values obtained at 6hrs post feeding which was above this value. the values obtained at 4hrs post feeding fall within the range of 11.42 -14.43mg/100ml reported by Jonas and Vilma (2007) except for 20% parboiled rice offal inclusion which was slightly above this value. The value of 19.54mg/100ml obtained for animals on 20% raw rice offal diet at 2hrs post feeding is within the range of 19-25mg/100ml (Mehrez *et al.,*1977) so also is the value of 22.41mg/100ml obtained for animals on 30% raw rice offal diet at 6hrs post feeding. The high values obtained in this study could be due to the fact that the poultry litter present in all the experimental diets is quite soluble in the rumen and rapidly converted to ammonia (Wohlt *et al.,* 1976).

The non-significant interaction (P>0.05) of the level of Total volatile fatty acid (TVFA) in the rumen fluid irrespective of the level of inclusion of the two rice offal type in the diets is in line with the report of Orskov (1982). These concentrations gave an indication of the energy value. The amounts and proportions of the TVFA produced are variable, depending on the nature of the diet, the time after feeding and the age of the animals (Stewart *et al.* 1958). The range of TVFA in this study at 0hr before feeding is within the value of 19.57- 36.57Mmol/L reported by Jokthan (2006) when pigeon pea forage was supplemented in sheep diets except for 20% level of inclusion of raw and parboiled rice offal which were higher than these values. Although all the values reported at 6hrs post feeding fall below that reported by Jokthan (2006). All the values obtained in this study is lower than 96.1 - 111.9Mmol/L reported by Jonas and Vilma (2007) except for the value of 107.90Mmol/L obtained for animals fed 20% raw rice offal at 4hrs post feeding which fall within this range.

5.5 Effect of diet containing raw or parboiled rice offal on carcass yield of Bunaji Bulls.

There was no significant differences (P>0.05) on carcass yield irrespective of the type of rice offal fed to the animal except for the legs, spleen, empty stomach, empty intestine, inguinal fat and abdominal fat which were significant (P<0.05) .

There was significant (P<0.05) differences on most of the carcass traits with varying levels of the rice offal fed to the animal. 0% as the highest value, closely followed by 20% level of inclusion and lastly 30%level of inclusion. Even though 20% and 30% level of inclusion of rice offal was statistically similar.

There was no significant effect of rice offal type and level of inclusion (P<0.05) on most carcass parts except for the legs, hide, empty stomach, empty intestine, Kidney fat and abdominal fat which were significant (P<0.05).The 0% level of inclusion had the highest dressing percent, followed by20% parboiled rice offal, 20% raw rice offal then 30% raw rice offal with 30% parboiled rice offal having the least value. Though these differences were not statistically significant (P<0.05).

The dressing percentage obtained in this study based on rice offal type (57.21-60.88), inclusion level (55.12-60.88) and interaction between rice offal type and inclusion level (53.69-60.88) were higher than the values of 52.50 to 53.98% reported by (Olayiwole *et al.,* 1979) and 50.2 to 53.6% (Olayiwole and Fulani, 1980) using intact Bunaji bulls. However, slightly higher dressing percentages (60.00%-61.00%) were reported by Cullision *et al.* (1976) for steers fattened on poultry litter, maize grain and soybean cake diets. The differences in dressing percentage between what is reported in the present study and those cited above could be due to high quality of the concentrate (maize grain and soybean cake) fed in those studies.

The weight of legs obtained in this study based on rice offal type (7.54 -8.19), inclusion level (7.30- 8.19) and interaction between rice offal type and inclusion level (6.91 – 8.68) obtained in this study is higher than the value reported by 6.3 -7.0Kg (Olayiwole and Fulani, 1980) and 6.35-7.25Kg (Lamidi, 2005). The weight of hide based on rice offal type (20.20 – 20.32), inclusion level (19.50-21.10) and interaction between rice offal type and inclusion level (19.10 -22.00) reported in this study is lower than values of 21.8 – 24.60Kg (Olayiwole and Fulani, 1980) and 21.30 – 22.15Kg (Lamidi, 2005). The value reported for head based on rice offal type (16.62-16.66), inclusion level (16.43-16.75) and interaction between rice offal type and inclusion level

(16.25-16.85) in this study is higher than 13.8-15.50Kg (Olayiwole and Fulani, 1980) but fall within the range of 16.53-18.87Kg as reported by Lamidi (2005). However, the meat to bone ratio obtained in this study is similar to 2.4-2.6% reported by Madziga (2013) except for the value of 1.97 gotten for animals on 30% parboiled rice offal diet.

5.7 Economic evaluation

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

The bulls on raw rice offal diet had their initial weights improved by 109.17Kg and feed cost per gain was also least on the diet but similar to the control diet though statistically not significant ($P>0.05$). The income over feed cost which was the most important economic factor for the farmers is also highest on the diet containing raw rice offal even though they are both statistically similar ($p>0.05$). Positive net benefit and rate of return to feed investment was observed for both rice offal types.

When level of inclusion is considered the bulls on 0%,20% and30% level of inclusion had their initial weights improved by 116Kg, 103.75Kg and 102.25 Kg respectively with 20 and 30% statistically similar ($P>0.05$) but differ from 0%. The income over feed cost which was the most important economic factor for the farmers and Feed cost per gain were also least at 0% followed by 20% and lastly 30% although no statistical difference ($P>0.05$). Net benefit and rate of return

to feed investment observed at the levels of inclusion were all positive. The return to naira invested on feed (0.85) for 0% and 20%level of inclusion are the same (Table 14).

The bulls on diets containing varying level of inclusion of raw and parboiled rice offal had their initial weights improved by 116Kg, 107.50 Kg, 104 Kg, 100.50 Kg and 100 Kg for 0%, 20RRO%, 30%RRO, 30%PRO and 20%PRO respectively. But all these values were statistically similar ($P<0.05$). Feed cost per gain was also least at 0% followed by 30%RRO, 20%RRO, 20%PRO and lastly 30%PRO although no statistical difference ($P>0.05$). The income over feed cost (net benefit) which is the most important economic factor for the farmers also follows this trend. Net benefit and rate of return to feed investment observed at the levels of inclusion were all positive

CHAPTER SIX

6.0 SUMMARY, CONCLUSION AND RECOMMENDATIONS

6.1 Summary

A fattening trial, digestibility trial and carcass evaluation were carried out in this study. The fattening trial was carried out to determine the use of varying levels of raw and parboiled rice offal as energy source in fattening of Bunaji bulls. The bulls were allotted to four dietary treatments in a 2x2 factorial arrangement with a common control. The control contain no rice offal (NRO), the four treatment designated 20%RRO, 30%RRO, 20%PRO and 30%PRO respectively.

The result of the experiment shows that raw and parboiled rice offal can be used as energy source to replace up to 30% of maize offal for fattening without any adverse effect on the fattening performance and rumen metabolite of the Bunaji bulls. When the performance of the bulls were accessed based on the type of rice offal irrespective of the level of inclusion, there was no significant ($P>0.05$) difference in the performance of Bunaji bulls fed raw and parboiled rice offal diet. But when the level of inclusion was considered irrespective of the type of rice offal used in fattening, it was observed that bulls on the control diet has the highest performance closely followed by those fed 20% and lastly 30% though the differences were not significant ($P>0.05$). However, when the bulls were accessed putting into consideration the type of rice offal constituting their diets and the level of inclusion of this rice offal types. It was observed that there was no significant ($P>0.05$) differences in the bulls performance.

The result of the digestibility trial showed that bulls on parboiled rice offal diet had higher digestibility value than those on raw rice offal, the reverse was however the case for nitrogen balance parameters with bulls on raw rice offal diet having higher value than those on parboiled rice offal. However, bulls on the control diet have the highest digestibility values, closely followed by those on 20% level of inclusion and lastly those with 30% inclusion level. Nitrogen intake and total nitrogen output were highest at 30% inclusion level, closely followed by 20% level of inclusion and lastly 0% inclusion level.

The experimental diet yielded high quality carcass (lean meat) because of low inguinal fat, kidney fat, abdominal fat and depth of chest fat compared with the control diets.

There is positive Net Benefit and Return to Investment on feed as the performance of the animals are similar ($P>0.05$) irrespective of the level of inclusion.

6.2 Conclusion

The following conclusions were made from these studies:

1. The incorporation of rice offal (raw and parboiled) can replace up to 30% of the maize offal in the diet for fattening Bunaji bulls.
2. Farmers can fatten their bulls with any of the rice offal types and still attain an average weight gain above 1Kg per day.
3. Fattening of bulls with diet containing up to 30% rice offal is capable of producing low inguinal fat, kidney fat, abdominal fat, depth of chest fat and lean meat
4. There were economic advantages in fattening with raw rice offal than with parboiled rice offal based diet though not significant ($P>0.05$). Therefore, farmers can fatten with either raw or

parboiled rice offal diets irrespective of level of inclusion and get an increased positive Net Benefit, return to investment on feed, superiority of feed conversion efficiency and average weight gain.

6.3 Recommendation

I hereby recommend the following:

1. The incorporation of rice offal into the fattening diet of bunaji bulls up to 30% replacement maize offal for production of lean meat.
2. A comparative study should be carried out using regular rice offal at the same level of inclusion to determine if similar result will be obtained.
3. The inclusion of rice offal at a higher rate to see its effect on performance and economics of fattening bulls.

REFERENCES

Adamu A.M. and Alawa C.B.I. (2005). Animal nutrition and cattle production in Nigeria. Invitedpaper at the National workshop on "Improving Productivity in Cattle Farming in Nigeria". Organised by the National Productivity Centre, Abuja and held at the Women Multipurpose Centre, Kaduna. 21st to 22nd Sept.

Adegbola, A.A., Smith O. B and Okendo N. J. (1990). Response of West African dwarf sheepfed cassava peel and poultry manure based diet. Proceedings of the first joined workshop held in Lilongwe., Malawi, between 16th -19th Dec. 1988. b*y the Pasture Network for Eastern and Southern* Africa (PANESA) and *African Research Network for Agricultural by-product* (ARNAB).

Adeniji K.O. (1983). Review of endangered cattle breeds of Africa. Animal Genetic Resources in Africa. OAU/STRC/IBAR, Nairobi, Kenya. Second OAU Expert Committee Meeting on Animal Genetic Resources in Africa. 24-28 November 1983: Bulawayo, Zimbabwe. pp. 29-31

Aderemi, F.A., Alabe, O.M. and Lawal, T.E. (2006). Utilization of whole cassava meal by egg- type chicken. *Proceedings of 11th Annual conference of Animal Science Association of Nigeria* (ASAN), Sept., 18th – 21st 2006, held at IAR and T, Ibadan, Nigeria. Pp: 73 – 75.

Adesote, A. (2013): Growth response of White Fulani Cattle feed *Gliricidia sepium* foliage as replacement for cotton seed cake. M.Sc theses, Department of Animal Science, Ahmadu Bello University, Zaria.

Adu. I. F. and Lakpini C.A.M. (1983). The utilization of dried poultry waste as protein supplement for growing Yankasa sheep. *Journal of Animal Production Resources*. 1 (13): 49-56.

Aduku, A.O. (1993). Tropical feedstuffs analysis table. Department of Animal Science. Faculty of Agriculture, Ahmadu Bello University, Zaria. Pp. 196.

Afolabi, K.D., Iyayi, E.A., Abu, O.A., Fakolade, P.O. and Adebiyi, O.A. (2006). Effects of solid substrate fermentation by *Aspergillus niger* and *Rhizopus* spp. on the nutritional value of cassava peel. *Proceedings of 11th Annual Conference of Animal Science Association of Nigeria* (ASAN), Sept., 18 – 21st 2006, held at IAR and T. Ibadan, Nigeria.Pp: 169–172.

Ahamefule, F.O., Ibeawuchi, J.A., Okereke, S.N and Anyawu, A,C. (2007). Reproductive performance of White Fulani, Ndama and their crossbred in a hot humid environment. *Journal of Animal and Veterinary Advances.* 6(8):955-958.

Ajayi, F., Balogun, O.O., Ovuru, S.S. and Mgbere, O.O. (2005). Reproductive performance of rabbits fed maize milling waste-based diets. *African Journal of Biotechnology,* 4(5): 439 –443.

Ajayi, A.F., Farimu, G.O., Ojebiyi, O.O. and Olayemi, T.B. (2007). Performance Evaluation of male weaner rabbits fed diets containing graded levels of bloodwild sunflower leaf meal mixture. *World Journal of Agricultural Science.,* 3: 250-255.

Akinusi, O. (1999). Utilization of rice milling waste (RMW) in cockerel finisher ration. *Proceedings of the 26th Annual conference of Nigerian Society for Animal production* (NSAP), 21–25 March, 1999, Ilorin, Kwara state, Nigeria. Pp: 120 – 122.

Alderman, G. and Cottrill, B.R. (1985). Energy and protein requirements of ruminants. *An advisory manual prepared by the AFRC Technical Committee on Responses to Nutrients.* Wallingford, UK, CAB International.

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

Alawa C.B.I.,Aliyu B.S.,Okaiyeto P.O., Lamidi O.S and Adamu A.M. (2007). A survey of small holder cattle fattening operations in Kano, Katsina and Jigawa state of Nigeria . *Journal of Animal Production Resource.*20:53-63

Allen, M. S. 2000. Effects of diet on short-term regulation of feed intake by lactating dairy cattle. *Journal of Dairy Science*. 83:1598–1624.

Ambashankar, K. and Chandresekan, N. (1998) Chemical composition and Metabolisable energy value of rice waste for chicken. *Indian VeternaryJournal*. Pp 475-476.

Ambreen, N., Hanif, N.Q and Khatoon, A (2006). Chemical Composition Of Rice Polishing from Different Sources. *Pakistan Veterinary Journal,* 26: 190-192.

APRU (Annual Production Research Unit), (1980). Ten Years of Animal Production and Range Research in Botswana, Annual Production Research Unit, Ministry of Agriculture, Gaborone, Botswana.

ARC (Agricultural Research Council). (1980). The nutrient requirements of Ruminant Livestock.Commonwealth Agricultural Bureaux, Slough

Atteh, J.O. (2002). Principles and practice of livestock feed manufacturing. Adlek Printers. 64, Sabon-Line, Ilorin, Kwara state, Nigeria. Pp: 217.

Atsu, D.W. (2002). Contributory role of animal production in national development. Keynote address delivered at the opening ceremony of the *7th Annual Conference of Animal Science Association Nigeria (ASAN), pp: 16-18.*

AOAC. (2000). Official method of Analysis. Association of Official Analytical Chemists. Official Methods of Analysis, Washington, DC.

Ayoade, T.A. (1989). The effect of maize bran on voluntary intake and digestibility of pigeon pea (*Cajanus cajan*) pods by goats. FAO Coperative Document Repository.

Baldwin, R.L. (1965). Pathways of carbohydrate metabolism in the rumen. In: Daugherty RW, Allen RS, Burroughs W, Jacobson NL, McGilliard AD, (editors). *Physiology of digestion in the ruminant*. Washington, DC: Butterworth. p. 379–89.

Baldwin R.L. (1995). Modeling ruminant digestion and metabolism. London: Chapman and Hall

Baldwin, R.L. and Reichl, J.R. (1975). Rumen modeling: rumen input-output balance models. *Journal of Dairy Science. 58*:*879*–90.

Blench, R. (1999). Traditional livestock breeds: Geographical distribution and dynamics in relation to the ecology of West Africa. Nigerian Livestock resources survey: A narrative account. *Publication of overseas development institute portland house stag place London.* http://ilri.org/InfoServ/Webpub/fulldocs/AnGenResCD/docs

Blair, R. (1963). Grassland research in Northern Nigeria. *Samaru miscellaneou*s. Paper No1.

Bodine, T.N. and Purvis, H.T. (2003). Effects of supplemental energy and/or degradable intake protein on performance, grazing behavior, intake, digestibility, and fecal and blood indices by beef steers grazed on dormant native tallgrass prarie. *Journal of Animal Science*. 81:304–317.

Broderick, G.A., Wallace, R.J. and Orskov, E.R. (1991) Control of rate and extent of protein degradation. In "hysiological aspects of digestion and metabolism in ruminants" Academic Press, NY pp541-592

Buvanendran, V., Ikhatua, U. J. and Olayiwole, M. B. (1983). Carcass characteristic of indigenous breeds of cattle in Nigeria. *Journal of Agricultural Sciences. (Camb.)* 100:407- 411.

Calvert, C.C. (1979). Use of animal excreta for microbial and insect protein synthesis. *Journal of Animal Science* 48**:**178-182.

Chandler, P. (1992). Whole cotton seed has economic feeding value for dairy cattle. *Feedstuffs* 64 (53) 10-11.

Clark, G. and Jaime, M. (2005). "West Texas Feedlots: Reality and Perspectives". Texas Technical University.

Claxton, J. and Leperre, P. (1991). Parasite burdens and host susceptibility of Zebu and N'Dama cattle in village herds in Gambia. *Veterinary Parasitology*. 40:293-304.

Coles, E. H. (1974). Veterinary clinical pathology, Second edition. Saunders Company,Philadephia, London, Toronto.

Coppock, C. E., Moya, J. R., West, J. W., Nave, D. H., Labore, J. M and Gate, C. E. (1985). Effect of lint on whole cotton seed passage and digestibility and diet choice on intake of whole cotton seed by Holstein cows. *Journal of Dairy Science*. 68**:**1198-1206.

Coppock, C.E. and D.L. Wilks. (1991). Feeding whole cottonseed and cottonseed meal to Dairy and beef cattle. Proc. Alternative Feeds for Dairy and Beef Cattle, Natl. Invit. Symp., St. Louis, MO (Jordan, E.R., Ed.). pp. 43-48. Columbia, MO: Coop. Ext., Univ. of Missouri.

Corley, J.R., Baker, D.H and Easter, R.A. (1980). Biological availability of phosphorus in rice bran and wheat bran as affected by pelleting. *Journal of Animal Science*, 50: 286–292.

Creek, M.J. (1972): The Kenya Feedlot Project. *World Animal Review* 3: 23 - 27

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.

DAD-IS (Domestic Animal Diversity Information System of the Food and Agriculture Organization), (2005): http://dad.fao.org/

Dafwang, I.I. (2006). Meat, milk and eggs from farm wastes: Explorations in animal nutrition research and extension. An inaugural lecture. A publication of the University organized lectures committee, Vice chancellor's office, ABU, Zaria, pp:73.

Dafwang, I.I. and Damang, P. (1996). Rice offal in finishing diets for broilers. *Journal o Animal Production Resource.,15 and 16: 131-139.*

Dafwang, I.I. and Shwarmen, E.B.N. (1996). Rice offal/chaff of chickens, Nigerian *Journal of Animal Production*, 23:21 – 23.

DAGRIS (Domestic Animal Genetic Resources Information System (International Livestock Research Institute), (2005): http://dagris.ilri.cgiar.org

deLeeuw, P.N. (1978). The primary and secondary productivity of the Savannah in the Middle Belt of Nigeria. A paper presented at 4th Annual Conference of Nigerian Society for Animal Production, Ahmadu Bellow University, Zaria. March 22nd 1978.

Devendra, C. (1982). Goats In: *An Introduction to Animal Husbandry in the Tropics*, 3rd Edition, Longman, London; pages 463-483.

Devendra, C. and Roghavan, C.V. (1978). Agricultural by-products in south East Asia: Availability utilization and potential value. *World Review of Animal Production*. 14:11-27.

Donkin, S.S. and Hammon H. (2005). Hepatic gluconeogenesis in developing ruminants. In:Burrin DG, Mersmann HJ, editors. Biology of metabolism in growing animals. London: Elsevier;. Pages 375–90.

Duncan D.B. (1955). Multiple range and Multiple F-tests. Biometrics, 11: 1-42

Duru, S. (2010). Evaluation of three types of rice offal in broiler diets Ph.D Thesis. Department of Animal Science Ahmadu Bello University, Zaria. Nigeria.

Duru, S. and Dafwang I.I. (2010). Effect of Maxigrain Supplementation of Diets with or without Rice Offal on the Performance of Broiler Chicks International. *Journal of PoultryScience (8): 761-764.*

Dwinger, R.H., Clifford, D.J., Agyemang, K., Gettinby, G., Grieve, A.S., Kora, S. and Bojang M.A. (1992). Comparative studies on N'Dama and Zebu cattle following repeated infections with *Trypanosoma congolense. Research in Veterinary Science*. 52**:**292-298.

Ensminger, M.E. and Olentine, C.G. Jr. (1978). Feeds & nutrition complete. The Ensminger Publishing Company., Clovis, California.

El-Sabban, F.F., Bratzler, J.W., Long, T.A., Frear, D.F.H. and Gentry, R.F. (1970). Value of processed poultry waste as food for ruminants. *Journal of Animal Science,* 31: 107-111.

Ezieshi, E. V., Obazele, O.M and Olomu, J.M (2011): Performance and Energy Metabolism by Broiler Chickens Fed Maizeand Millet Offals at Different Dietary Levels. *Journal of Agriculture and Social Research (JASR)* Vol. 11, No. 1.

Fadugba, A.A. (1990) Evaluation of the nutritive value of maize offal in poultry diets. M.Sc. Thesis. Department of Animal Science, Ahmadu Bello University-Zaria.

Farinu, G.O. (2004). Effect of feeding a compound diet based of non-conventional feedstuffs on growth and carcass characteristics of rabbits. *World Rabbit Science,* 2(4): 123 – 126.

Farrel, D.J. (1994). Utilization of rice bran in diets of domestic fowl and ducklings. *World's Poultry Science Journal.* 50:115 – 131.

Faulkner D.E. and Epstein H. (1957). The indigenous cattle of British dependent territories in Africa. Colonial Advisory Council of Agriculture, Animal Health and Forestry. HiMSO,Lorndon. Publication No. 5, 186pp.

Feron A., Sheria M., Mulungo M., Pelo M., Kakiese O., d'Ieteren G.D.M., Durkin J., Itty P., Maehl J.H.H., Nagda S.M., Rarieya J.M., Thorpe W., Trail J.C.M. and Paling R.W. (1988). – Productivity of ranch N'Dama cattle under trypanosomiasis risk. In Livestock production in tsetse affected areas of Africa. International Laboratory for Research on Animal Diseases/International Livestock Centre for Africa, Nairobi, 246-250.

Fetuga, B. L. and Tewe, O.O. (1985) Potentials of Agro Industrial By-products and Crop residues as Animal Feeds, *Nigeria Food Journal 2 (2): 136 –141*

.

Fiennes, R. N. T. W. (1953). The therapeutic and prophylactic of antrycide in trypanosomiasis of cattle. *British Veterinary Journal.*109:330-344

FAO (Food and Agriculture Organization), **(**1992). Review of CGIAR priorities and strategies. Part 1: TAC. Rome, FAO. Pp 250.

FAO (Food and Agriculture Organization), (2009). FAO Statistics on Ruminant Animal Livestock population in Nigeria.

Fontenot, J. P. (1996). Feeding poultry waste to cattle. (A review). Department. of Animal and Poultry Science Virginia Polytechnics Institute And State University. Blacksbury, Virginia 24061 USA. Pg.38.

French, M.H. (1956). The effect of infrequent water intake on the consumption and digestibility of hay by zebu cattle. Empire: *Journal of Experimental Agriculture* 24:128-136

Gadberry, S. (2007). Nutrition Basics. Part I, Beef Cattle Nutrition Series. Coperative Extension Service. Agriculture and Natural Resources. FSA 3078.

Garba, M.G., Maigandi, S.A. and Muhammad, I.R (2012). Performance of Yankasa Ram lambs fed graded levels of RMW and SBMR combination in the semi-arid zone, Nigeria. *Scientific Journal of Animal Science.1: 146-153*

Gleghorn, J. F., Elam, N. A., Galyean, M. L., Duff, G. C., Cole, N. A. and Rivera, J. D. (2004). Effect of crude protein concentration and degradability on performance, carcass characteristics and serum urea nitrogen concentrations in finishing steers. *Journal of Animal Science*, 82: 2705-2707

Gohl, B. (1975). '' Tropical feeds,''Feeds information summaries and nutritive values. FAO feeds information centre FAO, U.N. Rome

Gohl, B. (1981). Tropical Feeds: feed information summaries and nutritive values. FAO *Animal Production and Health Series*, 12:529-585.

GRC (Green Revolution Commission report), (1980). 'A livestock production plan for Nigeria. A study conducted by World Bank and Nigeria consultant for federal Ministry of Agriculture committee on green revolution. Vol. 11, part 1.

Haghnazar A and Rezaei, M, (2004). To determine the metabolizable energy of rice bran and the use of it in layer ration. XII. World's Poultry Congo Istanbul. Turkey, pp: 8-13.

Hamilton, T. (2007) Basic Beef Cattle Nutrition. Factsheet No 1. Queen's Printer for Ontario.

Harris, P.A. (2000). Comparison of the Digestible Energy and Net Energy Systems for the Horse. WALTHAM Centre for Pet Nutrition, Leicestershire UK. *www.ker.com*

Hersom, M. (2010). Basic Nutrient Requirements of Beef Cows. Department of Animal Science Series, University of Florida. Florida Cooperative Extension Services, Institute of Food and Agricultural Sciences.

Hobson, P.N. and Stewart, C.S. (1997). The Rumen Microbial Ecosystem, 2nd edition. New York: Springer.

Hungate, R.E. (1966). The rumen and its microbes. Academic press. London.

Huntington, G. (1997) .Starch utilization by ruminants: from basics to the bunk. *Journal of Animal Science. 75:852–67.*

Idowu, O.O. (2011) Comparative Evaluation of some cereal by- product as energy source for fattening beef cattle. *M.Sc. Thesis submitted to Animal Science Department, Ahmadu Bello University Zaria, Nigeria.*

ILCA (International Livestock Centre for Africa), (1979): Livestock Production in the Sub-humid Zone of West Africa: A Regional Review. *Published by International Livestock Centre for Africa. P.O Box 5689 Addis Ababa, Ethiopia*. 184 pages.

Ikhatua, U.J. (2010): The Nigerian Livestock Industry – A Sleeping Giant?. *56th Inaugural lecture, University of Benin, Nigeria.*http://www.nuc.edu.ng/nucsite/File/Inugural%20Lecture/ILS-21.pdf

Ikhatua, U. I. 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 Resources*. 4: 145-152.

Ikhatua, U. J. and Olayiwole, M. B. (1982). Seasonal effect on performance of feedlot bulls. *Journal of Animal Production. Resources*. **2 (2)**:99-111.

Ikurior, S. A. and Fetuga, B. A. L. (1984). Some anti nutritional components in Nigeria Cottonseed and Cottonseed meals. *Nigeria Journal of Animal Production.* **11(2)**:110-116.

Isa, N. F. (2003). Analysis of energy minerals using thermatized neutron. Ph.D Dissertation, Physics Department, Ahmadu Bello University, Zaria Pp 47.

Iyeghe-Erakpotobor, G.T., Otchere, E.O., Tegbe, T.S.B., Jegede, J.O. and Abeke, F.O. (2002). A Review of some Agroindustrial by-products in the nutrition of pigs. *National Animal Production Research Institute Ahmadu Bello University Shika-Zaria, Nigeria.*

Jabbar, M.A., Reynolds, L. and Francis, P.A. (1995). Sedentarisation of cattle farmers in the derived savannah region of southwest Nigeria: Results of a survey. Tropical Animal Health and Production 27:55.64.

Jabbar, M.A., Anjum, M.I., Rehman, S and Shahzad, W. (2006). Comparative efficiency of sunflower meal and cotton seed cake in the feed of crossbred calves for meat production. *Pakistan Veterinary Journal.*, 26: 126-128.

James, U. (2011). Much Ado About Rice Production. *Publication of Nigeria Newsworld on 11th September 2011*. http://www.nigeriannewsworld.com/content/much-ado-about-rice-production

Jespen, O. and Creek, M. J. (1976). Comparative fattening performance of two types of cattle in Ethiopia. *World Review of Animal Production*. **12:** 83-90.

Jonas, J and Vilma, B. (2007): Effect *of L. Plantarum, Pediococcus Acidilactici, Enterococcus Faecium and L. Lactis* microbial supplementation of grass silage on the fermentation characteristics in rumen of Diary Cows. *Veterinarija Ir Zootechnika* T. 40 (62). 29 pts@lgi.lt

Jokthan, G. E. (2006). Effect of supplementing rice straw with pigeon pea forage on performance of Yankasa sheep. PhD Dissertation. Department of Animal Science, Ahmadu Bello University, Zaria, Nigeria152 pp,

Kapu, A. M. (1975). The natural forage of Northern Nigeria- 1. Nitrogen and mineral composition of grasses, standing hay from different savanna zones. *Nigeria Journal of Animal Production.* 2: 235- 246.

Kerley, M.S. and Allee, G.L. (2003). Modification in soybean seed composition to enhance animal feed use and value; Moving from a dietary ingredient to a functional dietary component. *AgBioForum,* Vol. 6, No. 1&2,14-17, ISSN 1522936X.Guest Editors: Henry T. Nguyen and GaryStacey Available on the World Wide Web:http://www.agbioforum.org.

Khalique, A., Lone, K.P., Pasha, T.N. and Khan, A.D. (2004). Amino acid digestibility of chemically treated and extruder cooked defatted rice polishing. *Malaysian Journal of Nutrition*., 10(2): 195-206.

Krishna, G. (1985). Nylon bag dry matter digestibility in agro- industrial by-products and wastes of the tropics. Agricultural Wastes 13:155-158.

Kunkle, U.J., Stewart, R.L. and Brown W.F. (2004). Using by-product feeds in Beef Supplementation Programs. Fact Sheet No. 1 Queens's Printer for Ontario.

Lamidi, O. S. (1995). Poultry manure as supplement for cattle grazing the natural pastures, M.Sc. Thesis. Department of Animal Science, Ahmadu Bello University. Zaria, Nigeria.

Lamidi, O.S. (2005). The use of some conventional non protein sources for fattening cattle. Ph.D. Thesis. Department of Animal Science, Ahmadu Bello University, Zaria, Nigeria.

Lamidi, O.S., Adamu, A.M., Ehoche, O.W. and Alawa J.P. (2007). Replacement value of Sun-dried broiler litter for cotton seed cake in the fattening diets for Bunaji bulls. *Journal of Animal Production Research* 20(1&2):99-112.

Lamidi, O.S., Adeyinka, I.A., Alawa, C.B.I., Balogun, A. R. and Barje, P.P. (2008). Survey of Dry season feed Resources for smallholder fattening schemes in Northern Nigeria. *Asian Journal of Animal and Veterinary Advances* 3(2): 92-97.

Leng, R.A. and Nolan, J.V. (1984). Nitrogen metabolism in the rumen. *Journal of Dairy Science*. 67:1072-1089.

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

Maikano, A. (2005). Effects of graded levels of rice offal in broiler diets M.Sc. Thesis, Department Animal Science, Ahmadu Bello University, Zaria. Nigeria.

Mason, I.L. (1996). A World Dictionary of Livestock Breeds, Types and Varieties. Fourth Edition. C.A.B. International. 273 pages.

Matt, H. and Carter, J.N. (2010): Total Protein Requirement of Beef Cattle. The Rumen and Microorganisms. Paper AN167, Department of Animal Science, Florida Cooperative Extention Service, Institute of Food and Agricultural Sciences, University of Florida.

Mattioli, R.C., Bah, M., Kora, S., Cassama, M. and Clifford, D.J. (1995). Susceptibility to different tick genera in Gambian N'Dama and Gobra Zebu cattle exposed to naturally occurring tick infections. *Tropical Animal Health and Production* **27**:95- 105.

Maule, J.P. (1990). The cattle of the tropics. Centre for Tropical Veterinary Medicine, University of Edinburgh, Great Britain. 225 pp.

Madziga, I.I., Alawa C.B.I., Lamidi O.S., Goska, D.Y., Adesote., A.A (2013). Feedlot assessment of four indigenous breeds of cattle in Nigeria. *International Journal of Life Science and Medical Research.* Volume 3, Issue 1, Pages 35-38.

McMeniman, N. P., Elliot, R. and Ash, A. J. (1988). Supplementation of rice straw with crop by-products. 1. Legume straw supplementation. *Animal Feed Science and Technology* 19**:** 43-53.

McDonald, P., Edward, R.A. and Greenhalgh, J.F.D. (1995). *Animal Nutrition*. 4th (ed.) Longman publishers Ltd., England. Pp: 453 – 455.

McIntyre, J., Bourzat, D. and Pingali, P. (1992). *Crop livestock interaction in sub-Saharan Africa*. Regional and Sectoral Studies Series. Washington, DC, USA, World Bank

Mehrez, A.Z. and Orskov, E.R. (1977). A study of the artificial fiber bag technique for determining the digestibility of feeds in the rumen. *Journal of Agricultural Science. (Cambridge.)* 88:645-658.

Mehrez, A.Z., Orskov, E.R. and McDonald, I. (1976). Rate of rumen fermentation in relation to ammonia concentration. *British Journal of Nutrition*. 28: 437-443.

Mertens, D.R. (1997). Creating a system for meeting the fiber requirements of dairy cows. *Journal of Dairy Sciences.* 80:1463-1481.

Minson, D. J. and Milford, R. (1967). The voluntary intake and digestibility of diets containing different proportions of legume and mature pangola grass *(Digitaria decumbens)*. *Australian Journal of Experimental Agriculture and Animal Husbandry* **7:** 545-551.

Moloney, A.P., Almiladi, A.A., Drennan, M.J. and Galfrey, P.J. (1994). Rumen and blood variables in steers fed grass silage and rolled barley or sugar cane molasses-based supplementation. *Animal Feed Sciences and Technology*. 50:37-54.

Moran, J.B., Satoto, K.B. and Dawson, J.E. (1983). The utilization of rice straw fed to zebu cattle and swamp buffalo as influenced by alkali treatment and *leucaena* supplementation Austrian. *Journal of Agricultural Resources*. 34:73-84.

Mould, F. L. and Orskov, E. R. (1984). Manipulation of rumen fluid PH and its influence on cellulosis in *in sacco* DM degradability and the rumen micro flora of sheep offered either hay or concentrate. *Animal Feed Science and Technology***.** 16:1-14.

Morrison, F.B. (ed.) (1975). *Feeds and feeding*. Morrison publishing company. Vail-Ballou press. Inc. Binghamton, New York, USA. Pages: 290 – 293.

Myer, R.O. (2008). Alternative feeds for Beef Cattle. AN128. *http//edis.ifas.uil.edu*

NAERLS (National Agricultural Extension and Research Liaison Services) and NFRA (National Food Reserve Agency). 2009. Annual Agricultural Performance Survey Report of Nigeria: 2009 Wet Season. NAERLS Press, Zaria, Nigeria. 134 p. ISBN: 978-978-904-447-4.

Nafikov, R.A. and Beitz, D.C (2007). Carbohydrate and lipid metabolism in farm animals. *Journal of Nutrition* 137: 702-705.

Nagaraja, T.G. and Titgemeyer, E.C. (2007). Ruminal Acidosis in Beef Cattle: The Current Microbiological and Nutritional Outlook. *Journal of Dairy Science*, 90 (E Suppl), E17-E38.

NAPRI (National Animal Production Research Institute, (2008b). Micro Strategy Plan: Beef Cattle Research Programme. In: Agricultural Research Council of Nigeria. www.arcnigeria.org/research_institute/NAPRI microstrategy_plan_pdf.2008

Ncube, S. and Smith, T. (1991). The feeding value of crop residues from sorghum. Pearl and finger millet cultivars. Matopos Research Station, Zimbabwe.

Ngamuna, S., d'Ieteren G.D.M., Itty, P., Leak, S.G.A., Maehl, J.H.H., Minengu, M., Nagda, S.M., Paling, R.W., Rarieya, J.M., Thorpe, W. and Trail, J.C.M. (1988). Trypanosomiasis in N'Dama cattle under village management in Zaire. In: Livestock *Production in Tsetse Affected Areas in Africa. ILCA/ILRAD, Nairobi, Kenya,* pp 119-124.

Ngere L.O. (1985). The Gudali of Nigeria - Review. Animal Genetic Resources in Africa - High potential and endangered livestock. Proceedings of 2nd OAU Expert Committee Meeting, 24-28 November 1983, Bulawayo, Zimbabwe, pp. 77-81.

NRC (National Research Council), (1981).Nutritional Energetics of domestic animals and glossary of energy terms. National Academy of science., Washington, DC

NRC (National Research Council), (2000). Nutrient Requirements of Beef Cattle. 7th Revised Edition. National Academic, Press,Washington, DC, USA. Retrieved on 25th August, 2009 from http://www.nap.edu/books/0309069343/html

NAERLS (National Agricultural Extension and Research Liason Services) and NFRA (National Food Reserve Agency), (2009). Agricultural Performance Survey Report of Nigeria; *2009 wet season. NAERLS, ABU, Zaria and NFRA, Abuja.*

Ngere, L.O. (1985). The Gudali of Nigeria - Review. Animal Genetic Resources in Africa - High potential and endangered livestock. Proceedings of 2nd OAU Expert Committee Meeting, 24- 28 November 1983, Bulawayo, Zimbabwe, pp. 77-81.

Nuru, S. (1988) Research and development in pastoral production system in Nigeria: Past, present and future. In Proceedings of a National Conference on pastoralism in Nigeria, Kaduna.

Obeka, E.A. (1985). Nutritive Evaluation of Rice offal in the diets of growing pullet and Layers. M. Sc. Thesis, Department of Animal Science, Ahmadu Bello University, Zaria.

Ocheja, J.O., Daikwo S.I., Okpe A.A. and Ikusemoro, S.O. (2008): Performance of weaner Rams fed with varying proportions of a mixture of Bambaranut waste and Rice offal as supplement to natural pasture Proceedings of 4th International Conference of the Nigerian Society of Indigenous Knowledge and development 5-8th November 2008, Kogi State University, Anyigba.P.76-82.

Ocheja, J.O., Ebiloma S.O., Ukwuteno S.O., Oguche, H. G. E., Lalabe B.C and Akuboh, C.A. (2011). Performance and Heamatological Parameters of Grower Rabbits Fed With Some Browse Supplemented With A Mixture of Bambara Nut Waste and Rice Offal. *Journal of Production Agriculture and Technology*. Publication of Nassarawa State University, Keffi. Issue 7 (2): 37-47.

Odunlami, M.O. (1988) Energy supplementation of forage and browse based diets for West African Dwarf goats. MPhil. Thesis. Obafemi Awolowo University, Ile Ife, Nigeria.

Ogunfowara, O., Ademosun, A.A., Fetuga, B.L., Koopman, H., Offiong, A. and Akinola, J.O. (1975). Livestock Feed Study Report for Federal Livestock Department, Kaduna, Nigeria.

Okoruwa, V.O., Jabbar, M.A. and Akinwumi, J.A. (1996). Crop livestock competition in the west African derived savannah: Application of a multi-objective Programming model. Agricultual System 52: 439-453.

Olalokun, E.A. and Oyenuga, V.A. (1975). Observations on the White Fulani (Bunaji) Zebu cattle of Northern Nigeria in Southern Nigeria Environment., Blood values in relation to stage of lactation, milk production and nutrient intake of cows at Ibadan. *Ghana Journalof Agricultural Science.* 8: 37-43.

Olayiwole, M.B. and Fulani, J.J. (1980). Economics of commercial beef production under feedlot system of management. Monograph, pp. 1-14.

Olayiwole, M.B. (1982). Cattle feedlot operation in Nigeria. In Beef production in Nigeria.Proceedings of National Conference on Beef production. Pp 310-337.

Olayiwole, M.B., Buvanendran, V., Fulani, I.J. and Ikhatua. J.U. (1981). Intensive fattening of indigenous breeds of cattle in Nigeria. *World Review of Animal Production*, Vol. xvii, (2).71-77.

Olayiwole, M.B., Fulani, I.J., Buvanendran, V. and Ikhatua, U.J., (1979). Comparative performance of Bunaji and Sokoto Gudali bulls under feedlot management at Shika. NAPRI annual report of research in animal production. June 1978 - December 1979. pp 6-8

Olomu, J.M. (1995). *Monogastric Animal Nutrition - Principles and Practices*, a Jachem publication. Benin City. Pp 320.

Olorunnisomo, O.A., Adewumi, M.K and Babayemi, O.J. (2006): Effects of nitrogen level on the utilization of maize offal and sorghum brewer's grain in sheep diets. Livestock Research for Rural Development, 18 (1) http://www.cipav.org/irrd/irrd18/1/olor/18010.2006

Omeiza, S. (2006): Effect of varying levels of concentrates on feed intake and water consumption of Yankassa rams fed *Digitaria smutsii* as basal diet. B.Agric theses, Department of Animal Science, Ahmadu Bello University, Zaria.

Orpin, C.G. (1981). Fungi in ruminant degradation. In *Agricultural Science Seminar* Degradation of plant cell-wall material, Agricultural Research Council, London pp.37-46.

Orskov, E.R. (1982). *Protein nutrition in ruminants*. Academic press, London, UK. 160pp

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

Oyebanji, O.M. (1999). The use of sorghum panicle as a fiber source for growing rabbits. Bachelor of Agriculture Project. Department of Animal Science, Ahmadu Bello University, Zaria.

Oyediji, G.A. (2001): Improving Poultry feed production and supply in Nigeria Proceedings of One-day workshop on improving feed supply and litter management. Obafemi Awolowo – University,Ile-Ife, Nigeria.

Oyedipe, E.O., Saror, D., Osori, D.I.K. and Akerejola, O. (1985). Haematological parameter of zebu cattle on different protein levels and their relationships to rate of gain. *Bulletin of Animal Health and Production in Africa.* 32 (2): 129-139.

Oyeyiola, L. B. (1991) Utilization of rice offal by egg type chickens. M.S.c Thesis Deparment of Animal Science Ahmadu Bello Animal University Zaria, Nigeria.

Parish, J.A. and Rhinehart, J.D. (2008). Energy in Beef Cattle Diets.Mississipi Agricultural and Forestry Experiment Station. Retrieved on 12th September, 2010 from wwwthecattlesite.com/articles/1653/energy in beef cattle diets

Payne, W.J.A. (1970). Cattle Production in the Tropics. Volume 1. Longman Group Limited London. 336pp.

Philip, D. and Hubbs, M.A. (2010). The Origin and Consequences of the American Feedlot, Baylor University, History Department. August.

Portar, V. (1991). Cattle-A handbook to the breeds of the world. In christopher Helm Publishers (A. and C. Black), London, 400 pages.

Powell, (1975). The economics of winter feeding for beef production. *Journal of Britain Grassland Society.* 30:89.*Press Lancaster*. pp 611-662.

Powell, M.J. (1992). A Handbook for the Development of Grazing Reserves in Nigeria. National Livestock Projects Division of the Federal Department of Livestock and Pest Control Services, Federal Ministry of Agriculture and Rural Development, Kaduna, Nigeria.

Price, D.P. (1981). Beef production. Science and Economics appreciation and reality.Published by South West Scientific, U.S.A.

Ranjhana, S.K. (1980). Animal Nutrition in Tropics, Revised 2nd Edition.

Rasby, R and Martin, J. (2007). Understanding Feed Analysis. *www.beef.unl.edu/learning/feedAnalysis.html.*2007

Rasby, R.J. and Walz, T.M. (1996). Water requirement for beef cattle. University of Nebraska-Lincoln Extension, Institute of Agriculture and Natural Resources.

Ravindran, A. (1995). Phytase in poultry nutrition—an overview. *Proceedings of the Australian Poultry Symposium,* 7: 135–139.

Reddy, D.V. and Krishna, N. (2009). Precision animal nutrition: A tool for economic and ecofriendly animal production in ruminants. Livestock Research for Rural Development 21 (3)

Reddy, G and Reddy, M (1999). Utilization of expander extruded processed complete diet containing sorghum straw in Ongole bull calves. *Indian Journal of Animal Science* 69(1):49-50.

Rege, J.E.O. and Tawah, C.L. (1999). The state of African cattle genetic resources II. Geographical distributions, characteristics and uses of present-day breeds and strains. *FAO/UNEP Animal Genetic Resources Information Bulletin*. 26:1-25.

Rhinehart, L. (2006). Cattle Production: Considerations for pasture-based beef and dairy producers. ATTRA Publication #IP305.

RIM. (Resource Inventory and Management), (1992). Nigerian livestock resources. Four volume report to the Federal Government of Nigeria. I. Executive summary and atlas; II. National synthesis; III. State reports; IV. Urban reports and commercially managed livestock survey report.

Rooney, L.W. and McDonough, C.M. 1981. Food quality and consumer acceptance of pearl millet. *Proceedings of the International pearl mille workshop*, ICRI/SAT, Centre, India, Pages 45 – 49.

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

Saadullah, M., Haque, M. and Dolberg, F. (1981). Effectiveness of ammonification through urea In improving the feeding value of rice straw in ruminants. *Tropical Animal Production* 6:30-3.

Sani, R.T (2010): Manure production by Yankassa Sheep grazing native pasture in northern guinea savannah. B.Agric theses, Ahmadu Bello University, Zaria.

Salami, R.I., Akindoye, O. and Odunsi, A.A. (2009). Evaluation of rice offal as a substitute for maize in the enzyme–supplemented diets for finishing broiler chickens. Proceedings of the 14th Annual conference of Animal Science Association of Nigeria (ASAN), Sept. 14th 17th. Pages 240 243.

SAS (2002). INSTITUTE inc. SAS/STAT user's guide. 6.03 Edition, Gray NC, USA

Satter, L. D. and Slyter, L.L. (1974). Effect of ammonia concentration on rumen microbial protein production in vitro. *British Journal of Nutrition*. **32:** 199 -206.

Saunders, R.M. (1990). The properties of rice bran as foodstuff. Cereal Foods World, 35: 632-636.

Scarr M.J. (1986). The optimal use of agro-industrial by-products and crop residues in Nigeria. In: Little Said A.N. (eds). Utilization of Agricultural By-products as livestock feeds for Nigeria. Proceedings of workshop by African Research Network for Agricultural By-product

Scott, P.G. (2008). Beef Cattle Breeds and Biological Types. Virginia Cooperative Extension Virginia Tech. 400-803.

Scott, M.L., Neshheim, M.C. and Young, R.J. (1976). Nutrition of the chicken 2nd edition, M. L. Scott and Associtates, Cthaeq.

Spencer, W.P. and Eckert, J.B. (1988). Estimating liveweight and carcass weight in Gambian N'Dama cattle. *FAO, World Animal Review*. 65:18-23.

Starkey, P.H. (1982). N'Dama cattle as draught animals in Sierra Leone. *FAO, World Animal Review*. 42:19-26.

Starkey, P.H. (1984). N'Dama cattle - a productive trypanotolerant breed. *FAO, World Animal Review*. 50: 2-15.

Singh, K.S. and Panda, B. (1988). *Poultry Nutrition*. 1st Ed., Kalyani Publishers, New Delhi, India. Pages 282-293.

Smith, I.M. (1959). The blood picture of normal Zebu in Uganda**.** *British Veterinary Journal*.115: 89 -96.

Smith. R.H. and Calvert C.C. (1976). Dehydrated poultry excreta versus soybean meal as nitrogen supplements for sheep. *Journal of Animal. Science*. 43 **:**1.286- 1292.

Sullins, R.O. and Rooney, L.W. (1977). Pericarp and endosperm structure of peal millet (*Pennisetum typhoides*). *Proceedings of International symposium on millet and sorghum grains,* ICRISAT, Niamey, Niger. Pages 120–124.

Sutherland, T.M. (1963) The metabolism of short chain fatty acids in the ruminant. In *Progress in Nutrition and Allied Sciences* [Edited by D.P.Cuthbertson] Oliver and Boyd: Edinburgh and London. Pp. 159-170

TAHSC (Terrestrial Animal Health Standards Commision), (2009). Animal Welfare and Beef Cattle Production Systems. TAHSC Report. www.animalagalliance.org

Tawah C.L. and Rege J.E.O. (1996). White Fulani cattle of west and central Africa. *Animal Genetic Resources Information Bulletin*. 17:137–158.

TradeInvest(2009). Easy Meat Invest in Beef Production.www.tradeinvestnigeria.com/investment_opportunities/742678.html.

Valchev, L., Lasheva, T. and Josifov, N. (2009): Silica Products from Rice Hulls, Journal of the University of Chemical Technology and Metallugy, 44(3), 257-261.

Van Soest, J.P. (1991). The use of detergents in the analysis of fibrous feeds. Determination of plant constituents. *Journal Association of Agricultural Chemistry.50:50-55.*

Vecchiettini, M. and Giardini, A. (2000). Cattle fattening: The Italian example. CIHEAM Options Mediterraneennes. www.ressources.ciheam.org/om/pdf/a35

Wahlberg, M.L. (2005). Alternative feeds for beef cattle. *Journal of Animal Science* 69:940-946.

Wardle, C. (1972). Small holder fattening of beef cattle in Niger World Animal Review. 32, 14-17.

Whitehead, R., Cooke, G.H.,Chapman.B.T.(1976). Automation in analytical chemistry technicon syrup. Vol.2,Pg 377.basingstoke intants, Technicon instruments company limited.

Wekesa, F. W., Abdulrazak, S. A. and Mukisira, E. A. (2006). The effect of supplementing Rhodes grass hay with cotton seed cake and pyrethrum marc based rations on the performance of Sahiwal female weaners. *Livestock Research for Rural Development.* 18: 157-162

Wikipedia. (2010a). List of Breeds of Cattle. www.absoluteastronomy.com/topics/list of breeds_of_cattle.

Wohlt, J.E., Sniffens, C.J., Hoover, W.H., Johnson, L.L. and Walker, C.K. (1976).Nitrogen metabolism in wethers as affected by dietary protein solubility and amino acid profile *Journal of Animal Science*. 42:1280-1286

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

LIST OF APPENDIX

Appendix I: Mineral requirements and maximum tolerable concentration in beef cattle feed.

Mineral	Units	Growing and finishing	Maximum Tolerable Level
Magnessium	%	0.10	0.40
Pottasium	%	0.60	3.00
Sodium	%	0.06-0.08	- -
Sulfur	%	0.15	0.40
Cobalt	Ppm	0.10	10.00
Copper	Ppm	10.00	100.00
Iodine	Ppm	0.50	50.00
Iron	Ppm	50.00	1000.00
Manganese	Ppm	20.00	1000.00
Selenium	Ppm	0.10	2.00
Zinc	Ppm	30.00	500.00

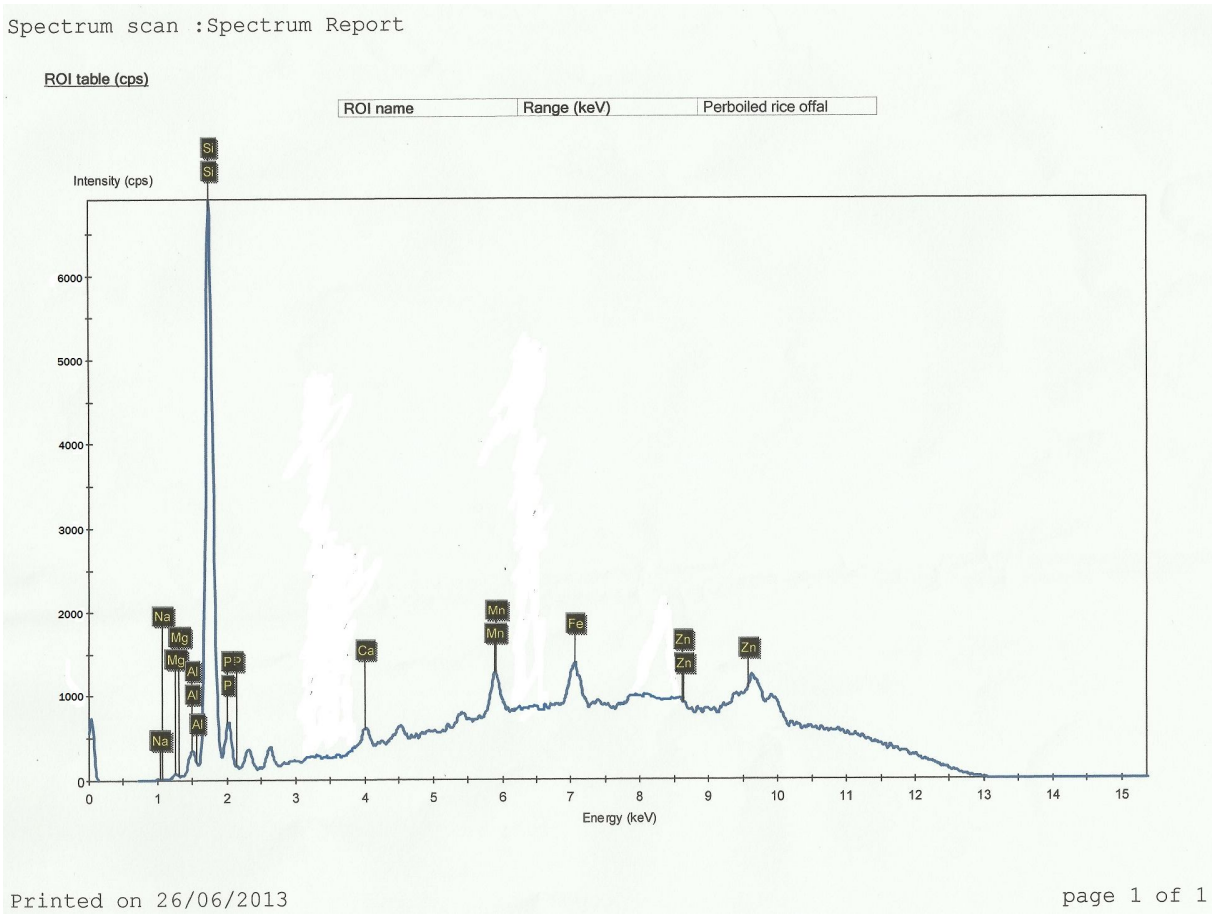
Source: NRC, (2000).



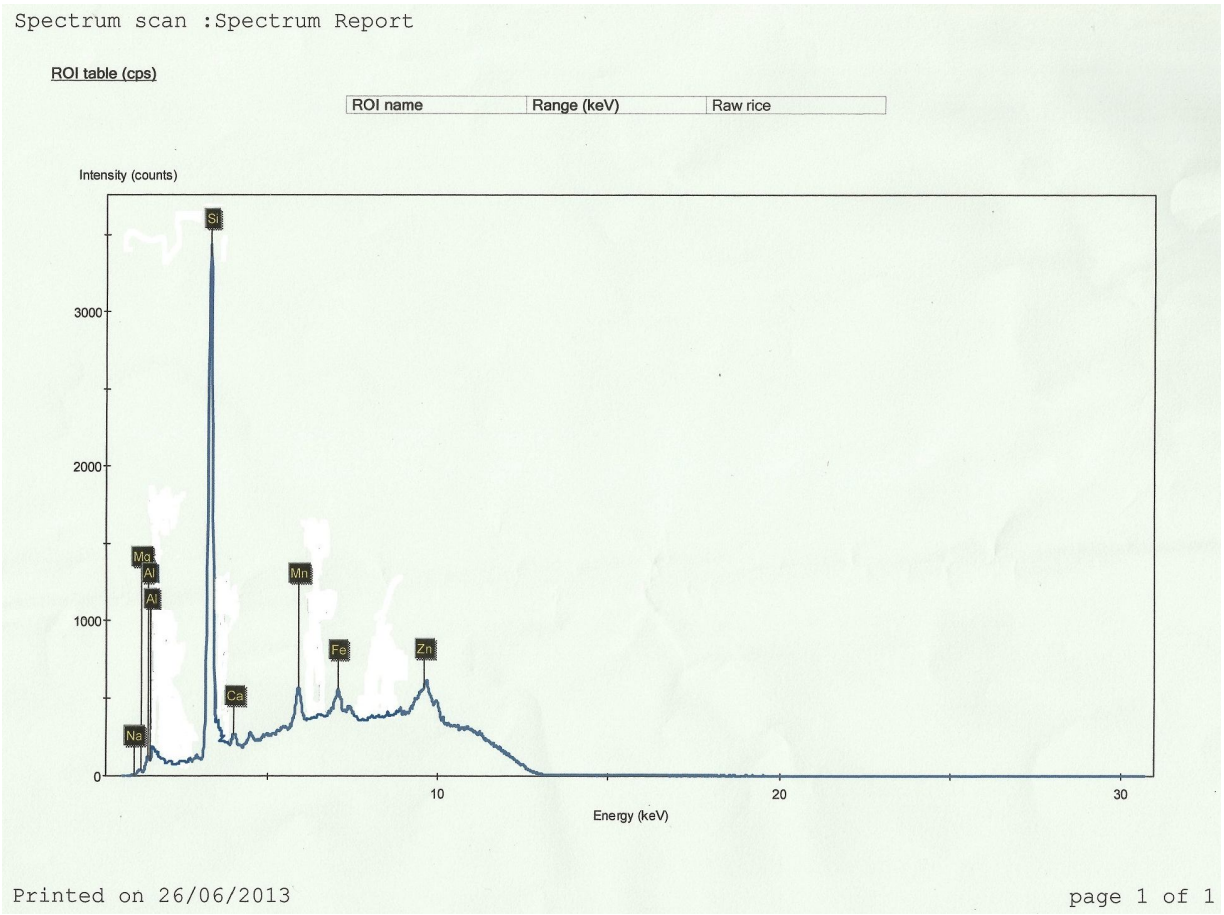
Appendix II: Light Brown raw rice offal with broken grains and fine hull



Appendix III: Brown Colour parboiled rice offal with coarse hulls



Appendix IV: Spectrum of mineral elements in Parboiled rice offal with Silicon having the highest peak and intensity (cps) with K_{α} line energy.



Appendix V: Spectrum of mineral elements in raw rice offal with Silicon having the highest peak and intensity (cps) with $K_{\alpha} - K_{\beta}$ line energy.



Appendix VI: Digitaria *smutsii forage* used as basal diet



Appendix VII: Experimental animals in individual pens



Appendix VIII: Fortnight weighing of Bunaji bulls during the fattening trial



Appendix IX: Rumen fluid samples collection using stomach tube



Appendix X: Measurement of Rumen pH using pH meter



Appendix XI: Experimental animals (Bunaji bulls) in metabolic crate during digestibility trial



Appendix XII: Feacal and urine samples collected during digestibility trial.



Appendix XIII: Blood collection after slaughtering



Appendix XIV: Hanging of animal in preparation for shrunk body weight measurement



Appendix XV: Hot carcass measurement with a weighing scale



Appendix XVI: Preparation of dissectible beef for weighing



Appendix XVII: Prepararion of offals for weighing