PERFORMANCE OF BUNAJI CATTLE FED DIETS CONTAINING GRADED LEVELS OF PALM KERNEL CAKE

BY

REMILEKUN TAWAKALIT SANI

DEPARTMENT OF ANIMAL SCIENCE,

FACULTY OF AGRICULTURE,

AHMADU BELLO UNIVERSITY,

ZARIA, NIGERIA

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BY

Remilekun Tawakalit SANI

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DEPARTMENT OF ANIMAL SCIENCE,
FACULTY OF AGRICULTURE,
AHMADU BELLO UNIVERSITY,
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NOVEMBER, 2018

DECLARATION

I declare that the work in this thesis entitled **"Performance of Bunaji cattle fed diets containing graded levels of Palm Kernel Cake"** was carried out by me in the Department of Animal Science, Ahmadu Bello University, Zaria. The information derived from the literature has been duly acknowledged in the text and a list of references provided. No part of this thesis was previously presented for another degree or diploma at this or any other Institution.

Tawakalit Remilekun SANI _____ _____

(Signature) Date

CERTIFICATION

This thesis entitled **"**PERFORMANCE OF BUNAJI CATTLE FED DIETS CONTAINING GRADED LEVELS OF PALM KERNEL CAKE" by Tawakalit Remilekun SANI meets the regulations governing the award of the degree of Doctor of Philosophy (Animal Science) of the Ahmadu Bello University, Zaria, and is approved for its contribution to knowledge and literary presentation.

Prof O.S Lamidi Chairman, Supervisory Committee	(Signature)	Date
Dr D.D. Dung Member, Supervisory Committee	(Signature)	Date
Dr M.R Hassan Member, Supervisory Committee	(Signature)	Date
Dr. M. Kabir Head of Department	(Signature)	Date
Prof.S.Z. Abubakar Dean, School of Postgraduate Studies	(Signature)	Date

DEDICATION

This work is dedicated to Almighty Allah, the Lord of the Universe. I also dedicate it to my husband, children and my siblings for their support.

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TABLE OF CONTENTS

TITLE PAGE.....i

DECLARATION.....ii

CERTIFICATION.....iii

DEDICATION.....iv

ACKNOWLEDGEMENTS.....v

TABLE OF CONTENTS.....vii

LIST OF TABLE.....xiv

LIST OF FIGURES.....xvi

LIST OF APPENDIXES.....xvii

ABBREVIATIONS/ACRONYMS.....xiv

ABSTRACT.....xxii

CHAPTER ONE

1.0 INTRODUCTION.....1

1.1 Justification.....2

1.2 Objectives of the Study.....4

1.3 Hypotheses (H_o and H_a) for the experiments.....4

CHAPTER TWO

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

2.1.1 White Fulani.....5

2.1.2 Sokoto Gudali.....7

2.1.3 N'dama.....8

2.1.4 Muturu.....10

2.1.5 Wadara/ Shuwa.....11

2.1.6 Kuri.....12

2.1.7 Azaouak.....13
2.1.8 Keteku.....14
2.2 Beef Cattle Production Systems.....14
2.2.1 Extensive System.....15
2.2.2 Semi-Intensive System.....18
2.2.3 Intensive (Feedlot) Fattening.....19
2.3 Nutrient requirements of beef cattle.....21
2.3.1 Protein requirement of beef cattle.....21
2.3.2 Enrgy requirement of beef cattle.....22
2.3.3 Mineral requirement of beef cattle.....24
2.3.4 Water intake of beef cattle.....24
2.4 Feed Resources for Feeding Cattle in Northern Nigeria.....25
2.4.1 Basal roughages.....26
2.4.2 Energy sources.....26
2.4.3 Protein sources.....30
2.4.4 Mineral sources.....36
2.5 Digestive Physiology of Ruminant.....38
2.6 Human Microbiology.....39
2.6.1 Acquisition of energy by rumen microbes.....41
2.7 Rumen Fermentation.....41
2.7.1Rumen Fermentation Microbiology and Chemistry.....41
2.7.2 Synthesis of high quality protein in the form of microbial bodies.....43
2.7.3 Synthesis of protein from non-protein nitrogen sources.....43
2.7.4 Synthesis of B vitamin.....43
2.7.5 Substrates for fermentation.....43

2.7.6 The product of fermentation.....44

2.8 Implication of Packed Cell Volume and some Biochemical Parameters in Ruminant Livestock.....45

2.8.1 Packed Cell Volume (PCV).....46

2.8.2 Blood Glucose.....47

2.8.3 Total Protein.....48

2.8.4 Blood urea.....49

2.9 Meat Processing and Evaluation of Quality.....49

CHAPTER THREE

3.0 MATERIALS AND METHODS.....52

3.1 Experimental Site.....52

3.2Experimental design and Animal Management.....52

3.2.1 EXPERIMENT 1: Effect of feeding diets containing graded levels of palm kernel cake on the growth performance of Bunaji weaner calves.....53

3.2.2 EXPERIMENT 2: Effect of feeding diets containing graded levels of palm kernel cake on the growth performance of Bunaji yearling bulls.....53

3.2.3 EXPERIMENT 3: Effect of feeding diets containing graded level of Palm Kernel Cake on the fattening performance of mature Bunaji bulls.....56

3.3Source of Palm Kernel Cake.....58

3.4 Data Collection for Experiments 1, 2 and 3.....58

3.4.1 Digestibility study.....58

3.4.2 Rumen fluid sampling.....59

3.4.3PCV and Serum biochemical analyses.....59

3.4.4 Analytical Techniques.....60

3.4.5 Economic analyses.....60

3.4.6 Carcass evaluation.....60

3.4.7 Data analyses.....61

CHAPTER FOUR

4.0RESULTS.....63

4.1 Chemical Analyses.....63

4.1.1 Proximate and cell wall composition of feed ingredients and hay.....63

4.2 EXPERIMENT 1: Effect of feeding diets containing graded levels of palm Kernel cake on the growth performance of Bunaji weaner calves.....65

4.2.1Proximate and cell wall compositions of concentrate diets containing varying levels of palm kernel cake fed to Weaner Bunaji calves.....65

4.2.2 Effect of palm kernel cake on Performance of weaner Bunaji calves..... 65

4.2.3 Effect of palm kernel cake on apparent digestibility of weaner Bunaji calves.....66

4.2.4 Effect of palm kernel cake on Nitrogen balance of weaner Bunaji calves.....73

4.2.5 Effect of palm kernel cake on Packed Cell Volume and Some biochemical parameterof weaner Bunaji calves.....78

4.2.6 Partial Budget of Analysis of Weaner Bunaji calves fed palm kernel cake.....86

4.3 EXPERIMENT 2: Effect of feeding diets containing graded levels of Palm Kernel Cake on the growth performance of Bunaji yearling Bulls.....93

4.3.1 Chemical compositions of concentrate diets containing varying levels of palm kernelcake fed to yearling Bunaji bulls.....93

4.3.2 Effect of level of PKC inclusion on the performance of yearling Bunaji. 93

4.3.3 Apparent nutrient digestibility of diets containing graded levels of Palm Kernel Cake fed to Bunaji yearling Bulls.....96

4.3.4 Nitrogen balance of Bunaji yearling Bulls fed graded levels of PKC.....96

4.3.5 Effect of palm kernel cake on the rumen metabolite of yearling Bunaji bulls.....99

4.3.6 Effect of palm kernel cake on Packed Cell Volume and Some biochemical parameter of yearling Bunaji bulls 102

4.3.7 Partial budget analyses of yearling Bunaji bulls fed diet containing varying levels of palm kernel cake.....108

4.4 EXPERIMENT 3: Effect of feeding diets with graded levels of Palm Kernel Cake on the fattening performance of Bunaji bulls.....110

4.4.1 Chemical composition of concentrate diets containing varying levels of PKC fed to finishing Bunaji bulls.....110

4.4.2 Effect of graded level of PKC on the performance of fattened Bunaji bulls.....110

4.4.3 Apparent nutrient digestibility of diets containing graded levels of PKC fed to fattened Bunaji bulls.....113

4.4.4 Nitrogen balance of fattened Bunaji bulls fed graded levels of PKC.....113

4.4.5 Effect of palm kernel cake on the rumen metabolite of fattened Bunaji bulls.....113

4.4.6 Effect of palm kernel cake on Packed Cell Volume and Some biochemical parameter of fattened Bunaji bulls 120

4.4.7 Partial budget analyses of fattened Bunaji bulls fed diet containing varying levels of PKC.....123

4.4.8 Effect of feeding diet containing varying levels of PKC on carcass yield of fattened Bunaji bulls.....124

CHAPTER FIVE

5.0 DISCUSSION.....128

5.1 Chemical Analyses.....128

5.1.1 Proximate and cell wall composition of feed ingredients.....128

5.2 EXPERIMENT 1: Effect of feeding diets with graded levels of Palm Kernel Cake on the growth performance of Bunaji weaner calves.....131

5.2.1 The proximate and cell wall compositions of concentrate diets containing varying levels of PKC fed to weaner Bunaji calves.....131

5.2.2 Effect of palm kernel cake on Performance of weaner Bunaji calves.....132

5.2.3 Effect of palm kernel cake on apparent digestibility of weaner Bunaji calves.....135

5.2.4 Effect of palm kernel cake on Nitrogen balance of weaner Bunaji calves.....136

5.2.5 Effect of palm kernel cake on Packed Cell Volume and some biochemical parameters of weaner Bunaji calves.....137

5. 2.6 Partial budget analyses of weaner Bunaji calves fed palm kernel cake.....142

5.3 EXPERIMENT 2 and 3: Effect of feeding diets with graded level of Palm Kernel Cake on the growth and fattening performance of Bunaji yearling and finishing Bulls.....143

5.3.1 The proximate and cell wall compositions of concentrate diets containing Varying levels of PKC fed to Yearling and finishing Bunaji bull.....143

5.3.2 Effect of experimental diets on the performance of yearling and finishing Bunaji Bulls.....145

5.3.3 Effect of feeding diet containing varying levels of PKC on the apparent digestibility of yearling and finishing Bunaji bulls.....148

5.3.4 Effect of feeding diet containing varying levels of PKC on the Nitrogen balance of yearling and finishing Bunaji bulls.....150

5.3.5 Effect of palm kernel cake on the rumen metabolite of yearling and finishing Bunaji bulls.....151

5.3.6 Effect of palm kernel cake on Packed Cell Volume and some biochemical parameter of yearling and finishing Bunaji bulls.....156

5.3.7 Partial budget analyses of yearling and finishing Bunaji bulls fed diet containing varying levels of PKC.....161

5.2.8 Effect of feeding diet containing varying levels of Palm Kernel Cake on carcass yield of fattened Bunaji bulls.....163

CHAPTER SIX

6.0 SUMMARY, CONCLUSION AND RECOMMENDATIONS.....165

6.1 Summary.....165

6.2 Conclusion.....168

6.3 Recommendation.....168

REFERENCES.....169

APPENDIXES.....196

LIST OF TABLES

Table 3.2.1 Percent Gross Feed Composition of Weaners's Concentrate Diets.....54

Table 3.2.2 Percent Gross Feed Composition of Yearling's Diets.....55

Table 3.2.3 Percent Growth Composition of Matured Bulls Concentrate.....57

Table 4.1.1 Proximate and Cell Wall Composition of Feed Ingredients.....64

Table 4.2.1 Chemical Compositions of Concentrate Diets Containing Varying Levels of Palm Kernel Cake Fed to Weaners Bunaji calves.....67

Table 4.2.2 Effects of Sex on the Performance of Weaner Bunaji Calves Fed Diet Containing Varying Levels of Palm Kernel Cake.....68

Table 4.2.3 Effects of Level of Inclusion of Palm Kernel Cake on Performance of Weaner Bunaji Calves.....69

Table 4.2.4 Effect of Sex and Levels of Inclusion of Palm Kernel Cake on Performance of Weaner Bunaji Calves.....70

Table 4.2.5 Effect of Sex on the Apparent Digestibility of Weaner Bunaji Calves Fed Diet Containing Varying Levels of Palm Kernel Cake.....71

Table 4.2.6 Effect of Levels of Inclusion of Palm Kernel Cake on the Apparent Digestibility of Weaners Bunaji calves.....72

Table 4.2.7 Effect of Sex and Inclusion of Palm Kernel Cake on the Apparent Digestibility of Weaner Bunaji Calves.....74

Table 4.2.8 Effect of Sex on Nitrogen Balance of Weaner Bunaji Calves Fed Diet Containing Varying Levels of Palm Kernel Cake.....75

Table 4.2.9 Effect of Levels of Inclusion of Palm Kernel Cake on Nitrogen Balance of Weaner Bunaji Calves.....76

Table 4.2.10 Effect of Sex and Levels of Inclusion of Palm Kernel Cake on Nitrogen Balance of Weaner Bunaji Calves.....77

Table 4.2.11 Partial Budget Analyses of Bull and Heifer Bunaji Calves.....90

Table 4.2.12 Partial Budget Analyses of Weaner Bunaji Calves Fed Diets Containing Graded Levels of Palm Kernel Cake.....91

Table 4.2.13 Partial Budget Analyses off Weaner Bull and Heifer Bunaji Calves Fed Diets Containing Graaded Levels of PKC.....92

Table 4.3.1 Chemical Composition of Concentrate Diets Containing Varying Levels of Palm Kernel Cake Fed to Yearling Bunaji Bull.....94

Table 4.3.2 Effect of Feeding Diet Containing Varying Levels of Palm Kernel Cake on Performance of Yearling Bunaji Bulls.....95

Table 4.3.3 Effect of Feeding Diet Containing Varying Levels of Palm Kernel Cake on Apparent Digestibility of Yearling Bunaji Bulls.....97

Table 4.3.4 Effect of Feeding Diet Containing Varying Levels of Palm Kernel Cake on Nitrogen Balance of Yearling Bunaji Bulls.....98

Table 4.3.5 Partial Budget Analyses of fattened Bunaji Bulls Fed Diets Containing Graded Levels of Palm Kernel Cake.....109

Table 4.4.1 Chemical Composition of Concentrate Diets Containing Varying Levels of Palm Kernel Cake Fed to Finishing Bunaji Bulls.....111

Table 4.4.2 Effect of Feeding Diet Containing Varying Levels of Palm Kernel Cake on Performance of Finishing Bunaji Bulls.....112

Table 4.4.3 Effect of Feeding Diet Containing Varying Levels of Palm Kernel Cake on the Apparent Nutrient Digestibility of Fattened Bulls.....114

Table 4.4.4 Effect of Feeding Diet Containing Varying Levels of Palm Kernel Cake on the nitrogen Balance of Fattened Bunaji Bulls.....115

Table 4.4.5 Partial Budget Analyses Fattened Bunaji Bulls Fed Diet Containing Graded Levels 0f Palm Kernel Cake.....126

Table 4.4.6 Effect of Feeding Diet Containing Varying Levels of Palm Kernel Cake on Carcass Yield of Fattened Bunaji bulls

LIST OF FIGURES

Fig 4.2.1: Effect of Sex on Packed Cell Volume and Some Biochemical Parameter of Weaner Bunaji.....79

Fig 4.2.2: Effect of Sampling Interval on Packed Cell Volume and Some Biochemical Parameter of Weaner Bunaji Calves Fed Graded Level of Palm Kernel Cake.....80

Fig 4.2.3: Effect of Levels of Inclusion of Palm Kernel Cake on Packed Cell Volume and Some Biochemical Parameter of Weaner Bunaji Calves.....81

Fig 4.2.4: Effect of Sex and Sampling Intervals on Packed Cell Volume and Some Biochemical Parameter of Weaner Bunaji Calves Fed Diet Containing Varying Levels of Palm Kernel Cake.....83

Fig 4.2.5: Effect of Levels of Inclusion and Sampling Intervals on Packed Cell Volume and Some Biochemical Parameter of Weaner Bunaji Calves Fed Diets Containing Palm Kernel Cake.....84

Fig 4.2.6: Effect of Sex and Levels of Inclusion on Packed Cell Volume and Some Biochemical Parameter of Weaner Bunaji Calves Fed Diets Containing Palm Kernel Cake.....85

Fig 4.2.7: Effect of Sex, Levels of Inclusion of Palm Kernel Cake and Sampling Duration on Packed Cell Volume.....88

Fig 4.2.8: Effect of Sex, Levels of Inclusion of Palm Kernel Cake and Sampling Duration on Some Biochemical Parameter of Weaner Bunaji Calves.....89

Fig 4.3. 1: Effect of Sampling Time on the Rumen Metabolite of Yearling Bunaji Bulls Fed Graded Levels of Palm Kernel Cake.....100

Fig 4.3. 2: Effect of Levels of Inclusion of Palm Kernel Cake on The Rumen Metabolite of Yearling Bunaji Bulls.....101

Fig 4.33: Effect of Levels of Inclusion and Sampling Interval on the Rumen Metabolite of Yearling Bunaji Bulls Fed Diets Containing Palm Kernel Cake.....103

Fig 4.3.4: Effect of levels of inclusion on Packed Cell Volume and Some Biochemicalparameter of yearling Bunaji bulls fed diets containing Palm Kernel Cake.....104

Fig 4.3.5: Effect of sampling interval on Packed Cell Volume and some biochemical parameter of yearling Bunaji bulls fed graded level of palm kernel cake.....106

Fig 4.3. 6: Effect of level of inclusion and sampling intervals on packed cell volume and some biochemical parameter of yearling Bunaji bulls fed diets containing PKC.....107

Fig 4.4.1: Effect of Sampling Time on the Rumen Metabolite of Fattened Bunaji Bulls Fed Graded Levels of Palm 116

Fig 4.4.2: Effect of levels of inclusion of palm kernel cake on the rumen metabolite of fattened Bunaji bulls.....118

Fig 4.43: Effect of levels of inclusion and sampling interval on the rumen metabolite of fattened Bunaji bulls fed diets containing palm kernel cake.....119

Fig 4.4.4: Effect of Treatment on Packed Cell Volume and Some Biochemical Parameter of Fattened Bunaji Bulls Fed Graded Levels of Palm Kernel Cake.....121

Fig 4.4. 5: Effect of Sampling Interval on Packed Cell Volume and Some Biochemical Parameters of Fattened Bunaji Bulls Fed Graded Levels of Palm Kernel Cake.....122

Fig 4.4. 6: Effect of Sampling Interval and Treatment on Packed Cell Volume and Some Biochemical Parameters of Fattened Bunaji Bulls.....125

LIST OF APPENDIXES

Appendix I: Palm Kernel Cake used as test ingredients for the formulation of experimental diets for weaner calves, yearling Bulls and finishing Bulls.....196

Appendix II: Digitaria *smutsii* hay used as basal diet for the weaner calves, yearling Bulls and finishing Bulls.....197

Appendix III: Mineral block offered to the weaner calves, yearling Bulls and finishing Bulls.....198

Appendix IV: Weaner Bunaji calves in individual pens.....199

Appendix V: Yearling Bunaji bulls in individual pens.....200

Appendix VI: Fattened Bunaji bulls in individual pens.....201

Appendix VII: Fortnight weighing of Bunaji bulls during the fattening trial.....202

Appendix VIII: Fattened Bunaji bulls in metabolic crate during digestibility trial.....203

Appendix IX: Weighing of experimental diets during digestibility trial.....204

Appendix VIII : (a) Feacal and (b) urine samples collected during digestibility trial.....205

Appendix IXI: Fattened Bunaji bulls waiting at the lairage prior to slaughter.....206

Appendix XI: Blood collection after slaughtering.....207

Appendix XII : Measurement of slaughter weight from carcass of fattened Bunaji bulls.....208

Appendix XIV: Hot carcass measurement with a weighing scale.....209

Appendix XV: Preparation of dissectible beef for weighing.....210

Appendix XIII: Prepararion of offals for weighing.....211

Appendix XIIII: Rumen fluid samples collection using stomach tube.....212

Appendix XIVIII: Animal being bled in a crush.....213

Appendix XVX : Measurement of Rumen pH using pH meter.....214

ABREVIATIONS/ACRONYMS

^{o}C Degree Celsius

% Percentage

A B U Ahmadu Bello University

ADF Acid Detergent Fibre

AOAC Association of American Analytical Chemists

ARC Agricultural Research Council

BDG Brewers' -*dried grain

CF Crude Fibre

CP Crude Protein

CSC Cotton Seed Cake

DAD-IS Domestic Animal Diversity Information System

DAGRIS Domestic Animal Genetic Resources Information System

EE Ether extract

FAO Food and Agriculture Organization

GNC Groundnut cake

hr Hour

Kcal Kilocalories

Kg Kilogram

L Litre

ME Metabolizable Energy

MJ Megajoule

Ml militres

Mmol/L Milimoles per litre

MO Maize offal

nNumber of animals

NAPRI National Animal Production Research Institute

NB Net Benefit

NDF Neutral Detergent Fibre

NH_3-N Ammonia-Nitrogen

NRCNational Research Council

PKC Palm kernel cake

PKM Palm kernel meal

RAN Rumen Ammonia Nitrogen

RIF Return to Investment on Feed

SAS Statistical Analyses System

SEM Standard error of the mean

TDN Total Digestible Nutrients

TVFA Total Volatile Fatty Acid

VG Value of Gain

ABSTRACT

Three experiments were conducted in this study to determine the performance of Bunaji weaner calves, yearling bulls and fattened bulls fed diets containing 0, 10, 20, 30 and 40% levels of Palm Kernel Cake (PKC) inclusion. The first experiment was conducted using thirty (30) Bunaji weaner calves (15 bulls and 15 heifer calves) with a live weight range of 85-94kg and age range of 7.5-9 months. The animals were balanced for weight and allotted to five (5) dietary treatments in a 2x5factorial arrangement laid in Completely Randomized Design. The second experiment was a growth trial conducted using 20 yearling Bunaji bulls with live weight range of 110-150kg and aged 1-1.5 years while In the third experiment, a fattening trial was conducted using 20 Bunaji bulls with a live weight range of 190-200kg and aged 2- 2.5 years. The yearling and finishing bulls were balanced for weight and allotted to five dietary treatments with four bulls per treatment in Completely Randomized Design. They were individually penned and fed diets containing graded levels of Palm Kernel Cake (PKC) and *Digitaria smutsii* (Wolly finger grass)hay at 2% of their body weight each. Feeding and metabolism trials were conducted for 90 and 21 days respectively for the three experiments. Blood samples were collected for PCV and biochemical parameters at the beginning, middle and end of the feeding trials. Rumen fluid were collected at 0, 3, 6 and 9hrs intervals to determine the rumen pH, rumen ammonia nitrogen and rumen total volatile fatty acid for the yearling and fattened bulls. The CP contents of the weaner diets vary between 13.88 and 18.00% while the ME ranged from 11.79 to 11.81MJ/kg DM. The crude fibre varied from 28.00 to 33.50%. The CP contents of the yearling diets varied between 14.19 and 17.75% while ME ranged from 11.79 to 11.81MJ/kg DM. The crude fibre varied from 26.36-38.77%. The CP of the fattening diets varied between 15.63 and 20.31% while ME ranged from 11.75 to 11.78MJ/kg DM. The crude fibre varied from 13.92 to 23.31%. The result of the weaner trial when effect of sex on performance was considered showed significant ($P<0.05$) difference in most of the parameters measured, it was higher in bull calves than heifer though FCR was more superior in heifer calves than bull calves.When the level of inclusion was considered, the result of the feeding trial showed significant ($P<0.05$) difference in most of the parameters measured except the initial weight. Animals on diets containing 30% PKC (0.58Kg) inclusion had the highest weight gain. Highest weight gain was obtained for bull at 30% PKC (0.65Kg) while the lowest weight gain was obtained for heifer at 0%PKC (0.38Kg). There were significant differences ($P< 0.05$) in all the digestible parameters measured and positive nitrogen

balance , when effect of sex and level of inclusion of PKC was considered. The PCV and biochemical parameters analysed when effect of sex, effect of PKC inclusion and combine effect of sex and PKC inclusion were considered all fall within the normal range. The economic analyses showed that cost per kg gain was highest at 0% PKC inclusion and lowest at 40% PKC. Weight gain and value of gain (VWG) was highest at 30% PKC inclusion and lowest at 0% PKC inclusion. There was positive Net Benefit (NB) and Return to Investment on feed (RIF) when sex, level of PKC inclusion and combine effect of sex and level of inclusion was considered hence it was concluded from the result of the performance, digestibility trial, blood analyses and economic analyses that PKC can be fed to weaner calves of both sexes at 30% PKC for optimum performance without any adverse effect. In the yearling trials, Average total feed intake (ATFI) ranged between 5.38-5.61Kg/day. Average daily weight gain was highest for animal on 0% PKC while those on 10, 20, 30, 40% PKC inclusion where similar ($P>0.05$). All the experimental bulls attained an average weight gain of between 0.66Kg to 0.75Kg. Rumen parameters were significantly ($P<0.05$) affected by sampling time, The result showed that Rumen pH at 0hr was highest (7.08) and lowest at 3hrs post feeding,(6.66),RAN value was similar at 0hr pre feeding (10.44 mg/100ml) and 3hr post feeding (9.93 mg/100ml) but differ at 6hr (8.25 mg/100ml) and 9hrs post feeding (8.34mg/100ml). Cost per Kg gain was similar at 0 and 20%PKC inclusion and lowest at 40% PKC. VWG were not significant ($P>0.05$) for bulls on 10, 20, 30 and 40% PKC inclusion. There was positive NB and RIF across treatments. The inclusion of PKC led to reduction in feed cost from ₦ 19598 to a range of ₦ 18761.00- ₦ 15609.00 (about 4.27%-20% reduction in feed cost). It was therefore concluded that PKC can be included in yearling diets at 40% for optimum performance.In the fattening study, ATFI ranged between 8.67-9.11Kg as fed /day with animals on 10, 20 and 40% PKC being statistically similar ($P>0.05$). The result showed that Total Volatile Fatty Acid (TVFA) was highest at 9hr post feeding (28.19)but differed at 0hr (23.80), 3hrs (24.15) and 6hrs(6.92) which were similar ($P>0.05$). At 3hr and 9hrs post feeding RAN was similar at 0,10,30 and 40%PKC. Blood glucose was highest for animals on diets containing 10%PKC inclusion (3.50mmol/l) and lowest for those on 30% PKC (2.88mmol/l).When sampling interval was considered, PCV value was highest at the end of the experiment (33.68%) and least value was obtained at the middle of the experiment.(31.86%) . The result of the carcass evaluation showed significant ($P<0.05$) difference in most of the measured parameters except for value obtained for longissimus muscle. Beef % of carcass was highest for bulls fed diets containing 0%PKC inclusion, followed by those on 10, 20 and 40% PKC but differ

for bulls on 30% PKC inclusion. Dressing % was highest for bulls fed 40%PKC inclusion which was similar to those on 30%PKC; the least value was obtained for animals on 20%PKC which was similar to those on 0% and 10%PKC inclusion. There was significant ($P<0.05$) difference in most of the parameters measured except the initial weight which was not significant ($P>0.05$) across treatment. live weight gain of the bulls was lowest for the control diet (1.14Kg) which was statistically similar with those on 20% (1.16Kg) and 40% (1.18Kg) while the highest weight gain was recorded for bulls fed diet containing 10% PKC inclusion (1.33Kg) which was not significant ($P>0.05$) to those on 30% PKC inclusion (1.31Kg). Bulls on 30%PKC has a more superior FCR (6.52)which was similar to those on 10%PKC (6.67) while animals on 0%PKC has the least FCR (7.57), Cost per kg gain was highest at 0% PKC inclusion and lowest at 40% PKC. NB and VWG were similar ($P>0.05$) for bulls on 10 and 30%PKC inclusion. There was positive NB and RIF across treatment. The inclusion of PKC lead to reduction in feed cost from ₦ 29389 to a range of ₦ 28857- ₦ 22099 (about 1.8%-24% reduction in feed cost) therefore it was concluded that PKC can be included in fattening diets at 30% for optimum performance.

CHAPTER ONE

1.0 INTRODUCTION

The dry season in Nigeria is a period of nutritional stress for ruminant livestock. Rangelands for animals to graze only blossom in the rainy season while in dry season they become standing hay (Bamigboye *et al*., 2013). Thus, animals will have abundant feed in the wet season and a shortage of feed in the dry season. The problem of nutritional stress is more prominent in the northern states where the dry season feed supply for stock is poor forage that is low in protein and energy. The result is that ruminant animals (cattle, sheep and goats) consume less of these forages and their intake cannot provide for maintenance let alone production. The animals therefore lose weight unless they are provided with supplementary feeds. Supplementary feeds therefore are additional feeds fed to livestock to make up for the shortfall of available feed, offered with the intention of increasing animal intake as well as preventing weight loss and enhancing weight gain.

The conventional protein sources of concentrate such as groundnut cake, soya bean cake and cotton seed cake are expensive and coupled with the fact that their prices fluctuate in the markets, especially when they are out of season. There is a need to circumvent the problem of this scarcity and increase the ingredient base for livestock feeds which will go a long way to decrease the overall cost of feed to farmers. Therefore, attention has been directed toward the search for agro-industrial by products and crop residues that have low inclusion rate in Monogastric feed formulation and are not directly consumed by human beings but relished by ruminants (Devendra and Sevilla, 2002 and AFRIS 2006) especially in cattle with the aim of reducing scarcity of feed.

One of such alternative by- product is Palm Kernel Cake (PKC). Palm kernel cake is an abundant and cheap source of protein compared to other conventional feed sources. It is one of the most

abundant protein meals in the country produced in more than one third of the country area with a current production of 400000 tonnes (USDA, 2014). Its production is all year round with a peakthat falls between the months of March and May, when all other conventional protein sources are scarce and expensive.

Palm kernel cake has been accepted as a useful component in animal feeds, especially in Asia and Europe and is also gradually gaining ground in Africa. It is a reasonably goodeconomic feed for both ruminant and monogastric feeding. Since it is an agro-industrial by-product that is being produced locally and within the West African sub-region in sizeable quantities, this feed resource should be fully utilized to reduce feed cost and also curb the problem of environmental pollution that accompanies its disposal (Boateng *et al.,* 2008).

1.1 Justification

Palm kernel meal is an important feed ingredient and the main by-product from the oil palm (*Elaeis guinensis*) extraction. Palm kernel meal is highly fibrous and has a medium grade protein content which is more suitable in feeding of ruminants and rabbits (Pickard, 2005). Palm kernel cake which is a by-product gotten by mechanical extraction of palm kernel contains 5-12% oil and 0.5– 3% oil in solvent-extracted (Chin, 2001). Most meal produced from palm kernel is used for animal feeding (FAO, 2012). Palm kernel cake contains 18.5-21.21% crude protein (Aduku, 1993), 9.06-10.31% crude fibre (Oyenuga, 1968 and Fetuga *et al.*,1973), 11.7MJ/Kg energy (Nwokolo *et al.*,1977) and has been used as energy and protein source in ruminants (Alimon 2004, Ehoche *et al.,* 1993, Silva *et al.,* 2013,Wan Zahari and Alimon (2004) and Wong *et al* (2010**)** . However, there are varied reports on its suitability and level of inclusion in the diets of cattle

Ehoche *et al.,* (1993) conducted an experiment with dairy cattle (Friesan x Bunaji Heifers) to determine the effect of supplementation of graded levels of palm kernel meal on intake compared with the utilization of maize stover. It was reported that the inclusion of palm kernel meal up to 30% resulted into comparable weight gain as those animals on maize stover ration. Rekwot *et al.*(1993) also carried out an experiment on the reproductive function of Friesan x Bunaji bulls grazing natural pastures and receiving supplements containing palm kernel meal. It was concluded that cotton seed cake can be replaced by up to 60% Palm kernel meal as supplementary feeds for grazing bulls to the maintenance of reproductive function. The performance of cross bred bulls grazing natural pasture and receiving supplement containing Palm kernel meal was studied by Adamu *et al.,*(1993). It was demonstrated that palm kernel meal can replace all the cotton seed cake in the supplements fed to cattle without significant loss in rates of live weight gain.

Although, some works have been done on its incorporation in the diets of beef cattle in Nigeria, especially on cross breed and indigenous breed reared mainly on semi intensive management system (Adamu *et al.,* 1993, Ehoche *et al.,* 1993 and Rekwot *et al.,*1993), not much has been done on its inclusion in the diets of indigenous breed of cattle under intensive system of management in Nigeria. Hence, the need to undertake this study, the aim of this study is therefore to determine the possibility of incorporating this cheap and relatively available protein source to replace cotton seed cake in the diet of weaner, yearling and finishing beef cattle.

1.2 Objectives of the Study

The study is targeted towards reducing dependence on cotton seed cake as protein source for feeding beef cattle.

The specific objectives for the experiments are to:

1. Evaluate the performance of weaner calves, yearling and finishing Bunaji cattle fed diets with graded levels of palm kernel cake (PKC).

2. Study the profitability of feeding diets with graded level of palm kernel cake to weaner calves, yearling and finishing Bunaji cattle

3. Determine the carcass yield of finishing Bunaji bulls fed diets with graded level of palm kernel cake.

1.3 Hypotheses (H_o and H_a) for the experiments

1. H_o: Diets containing graded levels of palm kernel cake have no effect on the performance of weaner calves, yearling and finishing Bunaji cattle.

H_a: Diets containing graded levels of palm kernel cake have an effect on the performance of weaner calves, yearling and finishing Bunaji cattle.

2. H_o: There are no differences in profitability of weaner calves, yearling and finishing Bunaji cattle fed diets containing graded levels of palm kernel cake.

H_a: There are differences in profitability of weaner calves, yearling and finishing Bunaji cattle fed diets containing graded levels of palm kernel cake.

3. H_o: Diets containing graded levels of palm kernel cake do not enhance carcass yield of finishing Bunaji bulls.

H_a: Diets containing graded levels of palm kernel cake enhance carcass yield of finishing Bunaji bulls.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Population, Breeds and Distribution of Cattle in Nigeria

Nigeria's cattle population is put at 20.6 million (FAO, 2016). It is broadly divided into two, the first is the zebu breeds (*Bos indicus*) which include Bunaji (white fulani), Rahaji (red bororo) ,Sokoto Gudali (bokoloji), Adamawa Gudali, Azawak, Jali and Ambala while the second comprises of Taurine breeds which 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. The proportion of various breeds of cattle in Nigeria are 51%, 14%, 11.5%, 11.5%, 2.1%, 0.7%, 0.2% and 9% for Bunaji, Rahaji, Sokoto Gudali, Adamawa Gudali, Keteku, Muturu, N'dama and others, respectively (FAO, 1988 and Barje, 2006). Keteku, Muturu and Kuri/Chad cattle are predominantly found in the Southern-Western, Southern and North Eastern parts of Nigeria, respectively (Aregheore, 2009).

2.1.1 White Fulani Breed

White Fulani also called Bunaji or Yakanaji population in Nigeria, Cameroun and the Central Africa Republic. The population of this breed is estimated at about 9,645,000. There are two schools of thought about the origin of the White Fulani cattle breed. One is that the White Fulani are truly long-horned Zebus, and this assumption is due to appearance of a distinct hump in a newborn bull calf, and the characteristic nature of skull and thoracic vertebrae. The other one is that the breed resulted from interbreeding first between the short-horned zebu and the ancient Hamitic longhorn and/or shorthorn that results to a Sanga breed, and then interbreeding of Sanga

with Thoracic humped Zebu animals could have resulted in cattle with lyre-shaped horns including the White Fulani (Tawah and Rege, 1996).

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 Nomadic 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 Breed

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. There are about 5 strains of Gudali namely Sokoto Gudali, Adamawa Gudali, Banyo Gudali, Yola Gudali and Ngaundere Gudali. The Sokoto Gudali is the strain found in Nigeria, northern Benin, Ghana and Mali (Tawah and Rege, 1996). The Gudali are principally found in Nigeria, Cameroon and Central African Republic, but a small population also inhabits Ghana.

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 bulls and 116-132 cm for heifers (Tawah and Rege, 1996).

The Sokoto Gudali cattle are known for their meat and milk. Mature weights range from 495-660 kg for bulls and 240-355 kg for heifers. 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 Breed

The N'Dama, also known as Boenca, Boyenca, and Faouta Longhorn, it is a humpless Longhorn (*Bos taurus longifrons*). Humpless (*Bos taurus*) Hametic Longhorn cattle breeds are previously believed to have descended from the first domesticated cattle populations of the Humpless Hamitic Longhorn cattle in the region's so-called the 'Fertile Crescent', possibly 9000 BC (Payne and Hodges, 1997). They were said to be the first cattle to be introduced to Africa via the land connection with Asia by nomadic people and have spread to the west and south of Egypt. However, Archaeological findings have led to the new theory that there was an African centre of domestication in the Sahara from southern Libya and north-western Niger to southern Egypt. It has also been suggested by further genetic studies that the present-day humpless cattle populations are so divergent from similar cattle populations of Europe which implies that separate domestication could have occurred in Africa (Bradley *et al.*, 1996).

This was also supported by the genetic evidence from Hanotte *et al.* (2002), which indicated an exogenous but minor genetic influence of non-African origin from Europe and/or Near East in the breeds of north and northeast of Africa as well as localised areas of southern Africa. These African taurine cattle were also influenced by a slow genetic introgression by the zebu cattle (*Bos*

indicus) of Asian origin. There is now convincing genetic and archaeological evidences for the domestication within Africa of these African taurine cattle breeds. Presently, the Humpless Longhorn cattle are represented by two breeds; the N'Dama and the Kuri, though the two breeds are quite distinct in their morphology (Rege and Tawah, 1999). N'Dama cattle are believed to have originated from the Fouta Djallon plateau in Guinea, and are now found in the whole of coastal West and Central Africa: Senegal, The Gambia, Guinea-Bissau, Guinea, Sierra Leone, Cote d'Ivoire, western Mali, Ghana, Togo, Nigeria, Cameroon, Central African Republic, Gabon, Congo (Brazzaville), and Democratic Republic of Congo (former Zaire), particularly in the regions infested by tsetse fly (DAGRIS, 2005). 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 bulls and heifers, 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 MuturuBreed

`Muturu', meaning humpless, is the Hausa name for the West African Shorthorn in Anglophone West Africa. Since the second half of the first millennium B.C. Muturu cattle were the most widespread breed in Nigeria until the Fulani invasion, which started in 1820 (Felius, 1995). The breed is a variety of West African Shorthorn. Generally, two types of Muturu cattle have been identified: a larger Savannah-type and a Dwarf-Forest type, which appears to have evolved through adaptation to the humid forest environment. Most of the Muturu cattle of Nigeria belong to the Savannah type, spread over the Benue plateau, and smaller numbers are found further to the Southwest in Oyo and Kwara. This breed is also found in Southeastern coastal area of Ghana. The distinction between the strains of the breed is not yet clear, however, DAGRIS (2005) has classified the Muturu cattle breed into four separate cattle populations, namely Ghana Dwarf Muturu (also called Muturu or Forest Shorthorn), Liberia Dwarf Muturu (also called Liberian Muturu), Nigerian Forest Muturu (also called Kirdi), and Nigerian Savanna Muturu (also termed Muturu). Nigerian Forest Muturu is found along the coastline of Nigeria, from the border with Benin to the Cameroon border.

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 bulls and 88 cm for heifers (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).

2.1.5 Wadara / Shuwa Breed

Shuwa cattle are also known by the names Arab Shuwa, Arab Choa or Wadara cattle. They are called Arab cattle either with reference to their home country or the traders who introduced them into the Chad region. They are known to have been brought to the region by the migrant Shuwa Arab nomads. The estimated population of the Shuwa Arab was 4 092 000 in Chad, 50 000 in Cameroon indicating their abundance and not threatened.

The breed is owned by semi-nomadic people who move to good grazing lands and water in the dry seasons. Their usefulness under stressful environment is well appreciated. The Shuwa breed of cattle is used for work, meat and milk in that order of importance. They are also used for riding, as pack and draft animals. Shuwa are considered to be good dairy animals, with milk off-takes of 450-1820 kg in lactations lasting 240-370 days. The Animalls also give good beef

carcasses, although their size is as low as 17.9-18.8 kg at birth, and 250-300 and 350-475 kg at maturity for heifers and bulls, respectively (Tawah and Rege, 1996).

2.1.6 Kuri Breed

Kuri is a humpless longhorn (scientific name - *Bos taurus longifrons)*, the very pure form of which is found in the island region of Lake Chad i.e. Djibadala, Koremeron, Debada and Bagdal (Malbrant *et al.*, 1947). Other names of the breed at different locations are Baharie, Bare, Borrie, Boundouma, Dongole, Kouburi, Buduma, White Lake Chad, Boenca, and Boyenca. The Kuri cattle are predominantly white with pigmented mucous membranes; individuals with red, red pied, light grey, or dun, dark or black spots, reddish brown, greyish red or speckled markings are often present, white animals with occasional grey-coloured shoulders and dark spots with black or greyish black (Tawah *et al.,* 1997). The Kuri cattle are tall among African breeds with long back, shallow body and a large bony rump. The breed is adapted to the hot and humid climate, and in their original habitat, they are managed under traditional system feeding on grass on the small islands on the Lake Chad; they are excellent swimmers and follow their herdsmen through the water as they travel from an island to another; their bulbous horns are considered useful in floating (Rege and Tawah, 1999).

The 1991 estimate of Kuri population was 120 000 in Chad (which is ¾ of the total Kuri) and 2 350 in Cameroon (DAD-IS, 2005). More recent estimates give a lower figure of 110 000 for the total population (Rege and Tawah, 1999). The Kuri breed is said to be rapidly declining in numbers both in Nigeria and in Chad. Possible reasons for the declining trend include drought, protracted civil conflicts in the region, the retreating waters of the Lake and extensive crossbreeding with the zebus when they graze on the shores. Due to its inability to thrive outside its lake habitat, the Kuri is threatened (Rege and Tawah, 1999). The trend is exacerbated by lack

of improvement programmes for the breed and susceptibility to rinderpest. In early 1980s, a project was established to evaluate, select and distribute bull animals based on milk yield performance in Chad (Adeniji, 1983). There is no conservation programme for breed (Adeniji, 1983; Tawah *et al.*, 1997).

Tawah *et al.* (1997) indicated that the main use of Kuri cattle is milk and to a limited extent meat. Domestic Animals Diversity Information System (DAD-IS) puts the importance in the reverse order. Although it is said that there is milk let down problem, there is a record of 1260 kg of milk yield over an average lactation period of 280 days (Epstein, 1971). On the other hand DAD-IS indicates that the lactation milk yield range between 360 and 800 litres. It is also indicated that a Kuri cow is capable of producing as much as 6 kg of milk a day after feeding her calf, and fattens well on pasture and in feedlot. Meat quality of the Kuri is considered exceptionally good (Tawah *et al.*, 1997).

2.1.7 Azaouak

Azaouak also called Tuareg (in Burkina Faso), Adar, Shanun Adar (in Hausa), Tagana, Azawa, Azawal, Azawaje (in Fulani), Arab (in Niger), Azawak and AzaouakDamerghou. These sahelian west African zebubreeds are believed to have descended from the Indo-Pakistani Zebu, which entered the Horn ofAfrica by way of the Persian Gulf and South Arabia. Arabian immigrants spread the zebus to the south and west over the continent from 669 BC. Curiously, the name Arab is used to name cattletypes in the Sahel. The conformation (short horns and medium hump) suggest that these cattle have descended direct from the spread of short-horned zebu from eastern Africa, and remained in the arid environment of Niger, Mali, Burkina Faso and Nigeria. They are found mainly in the Azaouak valley in a vast, windy depression stretching 3'to 7'E Longitude and 15'to 20' N Latitude covering the arid eastern Mali in the Niger River bend through southern Niger to

parts of northern Nigeria. Very well adapted to drought; suitable for beef and draught; coat colour is usually a mixture of red and white, black and white or fawn with white patches.

2.1.8 Keteku

Keteku are Taurine x zebu cross. They are also called Borgu, Kaiama, Ketaku, Ketari, Kettije. A stabilized cross of Savannah Shorthorn (Muturu) of the south and White Fulani of the north of Nigeria, with some input from N'Dama Longhorn. It shows wide variation of intermediates in conformation between zebu and humpless forms (Rege et al., 1994; Felius, 1995). Its mainly Found in western Nigeria, in Kwara, Oyo, Niger and Ondo states; maintained by nomads and settled agriculturalists alike. White coat colour with black ears and nose and sometimes black speckled; body is long and muscled, but with poorly developed hindquarters; dished head profile (Felius, 1995).

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 practised 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 slaughter 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 rich concentrate mixtures.

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 unfavorable 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 analyses 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 Statesand 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 practiced 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 conversion ratio 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 favorably with values reported for temperate breeds of cattle. Cost and return analyses 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 analyses 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. The breed has been recorded to have higher dressing percentages of 52.2% (NAPRI, 2008), 52.5% (Buvanendran*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, Buvanendran*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 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, 2007). 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).

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 a.l* (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. Beef bulls with live weights 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).

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 in 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 Feeding Cattle 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 Nigeriaessentially includes basal roughages (rice straw, maize stover, sorghum stover leaves, millet stover, range grass hay, sugar cane leave fresh) energy feedstuffs (maize offal, sorghum panicle), protein feedstuffs (groundnut haulms, cowpea pods, soybean pods, 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 and 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. There is wide variability in the proximate composition of BDG depending on the brewery that produced it (Oyediji, 2001). Breweries inNigeria presently use maize and sorghum in combinations, which vary from one brewery toanother (Oluponna *et al*., 2002). This, therefore, has resulted in the production of BDG withvariable physical and chemical composition (Oluponna and Balogun, 1996). BDG containsabout 19-25% crude protein, 10-22% crude fibreand gross energyvalue of 3030-3170 kcal/kg (Oluponna *et al*., 2002). The protein value can be affected by theheat applied during the brewing process, which can be beneficial to ruminants but tend to bedetrimental for monogastric animals. Brewer's grain are also relatively rich in fibre (ADF 17-26% DM), which makes them suitable for ruminants fed concentrate-rich diets, but less suitable forpigs and poultry (Crawshaw, 2004).

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 occasionally 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

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 (Lamidi 2005). Oil seeds cakes and meals are the residues remaining after removal of the greater part of the oil from oil seeds. The residues are rich in protein and most are valuable feeds for farm animals. They often serve as protein supplements. Most oil seeds are of tropical origin. They include groundnut, cottonseed, soya beans and palm kernel. Other plant protein sources that are less frequently used include coconut meal, rapeseed meal, rubber seed meal, sesame (Beniseed) cake (Smith, 1993).

2.4.3.1 Palm Kernel Cake

Palm kernel cake (PKC) is a product of oil palm processing. It is obtained after oil extraction from Palm kernel. Protein content is between 18 - 25% (Onwuka *et al.,* 2014). The crude protein

content of palm kernel cake (PKC) ranges between 14 and 16% (ARC, 1980). Palm kernel cake is deficient in lysine, methionine, histidine and threonine. Palm kernel cake is dry, gritty, high in fibre content (at least 9%) and oil content. It is not readily acceptable by all classes of livestock. Adult cattle can be fed up to 2-3kg/head/day. The degradation of protein in Palm kernel cake is low (ARC, 1980).

Palm kernel cake varies considerably in chemical composition (protein, fiber or lipids), depending on the sources (Rhule, 1996), the methodology of oil removal, the proportion of endocarp remaining (Adesehinwa, 2007) and the efficiency of oil extraction from the kernel (Onwudike, 1986; Onuh *et al.,* 2010). The metabolizable energy (ME) of PKC reported previously by several researchers were varied, where Alimon (2004) reported that the ME was between 1553 to 1792 kcal/kg, but Sundu *etal.* (2006) reported 1479 and 2260 kcal/kg ME . Palm kernel cake produced through mechanical processing result in higher ME value compared to solvent extracted PKC as observed by Ezieshi and olumu 2007) where they found that the PKC obtained through mechanical extraction contained higher residual oil almost 8% compared to the palm kernel cake produced via solvent extraction (1%) while Marini *et al.* (2005) found that the oil content in the solvent-extracted PKC was low, around 0.5 to 3%, whereas the expeller-pressed PKC contained between 5 to 12% oil. The protein content of PKC had poor amino acid balance, with methionine (Rhule, 1996) and lysine, histidine and threonine content (Ezieshi and Olumu, 2007) being the major limiting amino acids. The fiber content of PKC was about 13-20% which is responsible for the grittiness and poor digestibility of PKC (Onuora and King, 1985; Alimon, 2004). The principal neutral sugar content in the cell wall of PKC fiber was mainly contributed by 56.4% of mannose, followed by 11.6% of glucose, 3.7% of xylose and 1.4% of galactose (Anon, 2002; Marini *et al.,* 2005).

In a study conducted by Ezieshi and olumu (2007) found that the composition of crude fiber (CF) of solvent extracted PKC was higher compared to mechanically extracted PKC, due to the degree of oil extraction in which, solvent extraction method provides a better oil removal efficiency, leaving PKC with higher CF contents. Besides that, the use of different varieties of oil palm, different methods of separating the shell from kernel and different processing methods employed before extraction of the oil is carried out may also affect the CF values of PKC. The nutrient values of PKC have been extensively studied and described by Alimon (2004) and Dairo and Fasuyi (2007).

2.4.3.2 Cotton seed cake (CSC)

Cotton seed cake (CSC) is obtained from cotton after the removal of the lint, followed by oil extraction from the seed. It is high in fibre containing about 10 - 13%. It is deficient in lysine, methionine, leucine and isoleucine (Onwuka *et al.*, 2014).

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).

2.4.3.3 Groundnut cake (GNC)

Groundnut cake (GNC) is the major plant protein supplement used in Nigeria. The residue remaining from extraction of oil from groundnut either by solvent or hydraulic method is the groundnut cake. This has a protein content of about 38 - 47% depending on the efficiency of oil extraction. Groundnut cake is palatable. It is however, deficient in lysine, methionine and threonine (Onwuka *et al*., 2014). This is much higher in crude protein (45%) than CSC but it is more expensive and scarce. GNC is highly degradable in the rumen with nitrogen degradable value range of between 0.71 and 0.90 (ARC, 1980). Lufadeju and Olorunju, (1986) also reported degradable value of 0.86 for GNC. However, the use of GNC as ruminant feed is also constrained by its popularity in monogastric diets, which makes the cake to be over priced and very uneconomical for ruminants.

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). Soya bean meal has about 40 - 48% protein depending on the efficiency of oil extraction and whether or not the beans were dehulled (Onwuka *et al*., 2014). The crude protein content of soybean meal is about 50%. The cake is considered to be one of the best protein sources because it contains all the essential amino acids, although the quantity of cystine and methionine are sub-optimal. Ruminants generally are not affected by some inhibitory and toxic factors (Trypsin inhibitor) present in soybean. In addition, the lack of Vitamin B12 associated with feeding soybean cake does not affect cattle.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 (Lamidi *et al.,* 2008).

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 hasCP 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.

2.4.3.6 Farm wastes (Crop residues or Crop aftermath)

Lamidi *et al.* (2008) noted thatthe protein feedstuffs for smallholder fattening schemes in the three Northern Nigerian states (Katsina, Kano and Kaduna) surveyed aregroundnut haulms, whole cotton seed, cowpea haulms and cotton seed cake.Farm wastes of protein origin include groundnut haulms, cowpea pod shell and leaves, lablableaves, soybean leaves and threshing. These feed resources and cereal straw constitute the mostimportant 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 from5.9 to10.4 percent while that of cowpea shell ranges from 6.9 – 7.1 % and groundnut haulmsbetween 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 *Digitariasmutsii* 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.

2.4.4.1 *Kanwa*

The Nigerian name for trona, particularly of the Hausa origin is 'Kanwa'. This name varies from one place to the other within the country. 'Kanwa' is a dry lake salt which is largely hydrated sodium carbonate ($Na_2CO_3NaHCO_3.2H_2O$) (Davidson et al 1974; Oyeleke and Morton, 1981). It is a mould, growing out of the soil during rain but scrapped off, dried in the sun and sold without further treatment. In Nigeria, 'Kanwa' occurs as a common deposit of saline lakes. The deposit is usually covered by shallow water, less than two feet deep (Makanjuola and Beetlestone, 1971). It mostly occurs in the northern part of the country, particularly in Kano and Maiduguri areas, extending to boarder countries like Chad and Niger is the second most commonly used salt in Nigeria. Hence, the next important table salt (Makanjuola and Beetlestone, 1971). It is erroneously called 'potash', although it contains very low amounts of potassium as compared to sodium (Ekanem, 1977). The level of potassium is quite below detection in most of the specimen analysed (Makanjuola and Beetlestone, 1971). This indicates that its chemistry is misunderstood by those describing it as 'potash'. There are basically two varieties of 'Kanwa' that are well known in Nigeria. The first contains 20% sodium carbonate and it is red-white. The other type contains 80% of sodium sulphate, which is whitish. Both varieties contain little or no potassium (Ekanem, 1977).

2.4.4.2 *Common Salt*

Salt is made up of sodium and chloride (NaCl) (Drovers 2011), but it's also an ideal carrier for a variety of essential trace minerals like calcium, magnesium, phosphorus and selenium. Using salt to supplement your livestock and animals' diets is essential to their health, as well as their production. Salt is made up of two vital nutrients: sodium and chloride. Sodium is necessary for the animals' nervous system, muscles, blood, and other required functions. Chloride also benefits the blood and aids in digestion (Pe´rez-Barberı`a*et al.,* 2001a). This basic mineral has a huge impact on the livestocks' production. Studies have shown that a producer will see a significant loss in production long before any symptoms of deficiencies are observed in the animal (Morris, 1980).

Many animals will regulate their own salt intake, as long as a source is available. However, there are certain times when more salt is required. For example, the heat will cause your animals to lose more salt through sweat and urine. The same loss of salt occurs during timesof extreme humidity. Especially when the animal is consuming more water, salt intake may need to be doubled (Surplus Salt, 2013).

2.4.4.3 *Limestone*

This is the most common source of calcium used in livestock feeding. It is almost pure calcium carbonate (McDowell*et al.,* 1993). Calcitic limestone contains 36-38% calcium and can safely be fed free choice (ad lib) mixed with salt. Dolomitic limestone contains at least 5 % magnesium carbonate and should not be used for poultry, but it is as good as calcitic limestone for other animals (Lall, 1987). Portland and natural cement can be used instead of limestone.

2.4.4.4 *Bone Meal*

Bone meal is a by-product of the slaughtering of livestock and rendering of dead animals. Often the sketetal system (bones) is separated from meat during the processing of meat. These bones can then be converted into bone meal using several different methods (Jędrejek, *et al.,* 2016).

2.5 Digestive Physiology of Ruminant

Ruminants are mammals that are able to acquire nutrients from plant-based food by fermenting it in a specialized stomach prior to digestion, principally through microbial actions (Clauss, *et al.*, 2010). The process typically requires the fermented ingesta (known as cud) to be regurgitated and chewed again. The process of rechewing the cud to further break down plant matter and stimulate digestion is called rumination. The word "ruminant" comes from the Latin ruminare, which means "to chew over again". The roughly 150 species of ruminants include both domestic and wild species. Ruminating mammals include cattle, goats, sheep, giraffes, yaks, deer, antelope and some macropods(Hume, 1985). Taxonomically, the suborder Ruminantia (also known as ruminants) is a lineage of herbivorous artiodactyls that includes the most advanced and widespread of the world's ungulates. The term 'ruminant' is not synonymous with Ruminantia. Suborder Ruminantia includes many ruminant species, but does not include tylopods and marsupials (Fowler, 2010).

Ruminants have a four-compartment stomach. The four parts are the rumen, reticulum, omasum, and abomasum. In the first two chambers, the rumen and the reticulum, the food is mixed with saliva and separates into layers of solid and liquid material (Hume, 1985). Solids clump together to form the cud or bolus. The cud is then regurgitated and chewed to completely mix it with saliva and to break down the particle size. Fiber, especially cellulose and hemicellulose, is primarily broken down in these chambers by microbes (mostly bacteria, as well as some protozoa, fungi

and yeast) into the three volatile fatty acids (VFAs): acetic acid, propionic acid, and butyric acid. Protein and non-structural carbohydrate (pectin, sugars, and starches) are also fermented (Hume, 1985, Clauss *et al.*, 2010).

Though the rumen and reticulum have different names, they represent the same functional space as digesta can move back and forth between them. Together, these chambers are called the reticulorumen. The degraded digesta, which is now in the lower liquid part of the reticulorumen, then passes into the next chamber, the omasum, where water and many of the inorganic mineral elements are absorbed into the blood stream (Clauss *et al.*, 2009e). After this, the digesta is moved to the true stomach, the abomasum. The abomasum is the direct equivalent of the monogastric stomach, and digesta is digested here in much the same way. Digesta is finally moved into the small intestine, where the digestion and absorption of nutrients occurs. Microbes produced in the reticulorumen are also digested in the small intestine. Fermentation continues in the large intestine in the same way as in the reticulorumen (Valtorta*et al.*, 2008).

Only small amounts of glucose are absorbed from dietary carbohydrates. Most dietary carbohydrates are fermented into VFAs in the rumen. The glucose needed as energy for the brain and for lactose and milk fat in milk production, as well as other uses, comes from nonsugar sources, such as the VFA propionate, glycerol, lactate, and protein. The VFA propionate is used for around 70% of the glucose and glycogen produced and protein for another 20% (50% under starvation conditions) (William, 2005; Valtorta*et al.*, 2008).

2.6 Rumen Microbiology

Microbiology is the study of microbes - microscopic living organisms. This group includes bacteria, fungi, and protozoa. Vertebrates lack the ability to hydrolyse the beta [1-4] glycosidic

bond of plant cellulose due to the lack of the enzyme cellulase. Thus, ruminants must completely depend on the microbial flora, present in the rumen or hindgut, to digest cellulose (Valtorta*et al.*, 2008). Digestion of food in the rumen is primarily carried out by the rumen microflora, which contains dense populations of several species of bacteria, protozoa, sometimes yeasts and other fungi - 1 ml of rumen is estimated to contain 10-50 billion bacteria and 1 million protozoa, as well as several yeasts and fungi (Li and Guan, 2017).

Since the environment inside a rumen is anaerobic, most of these microbial species are obligate or facultative anaerobes that can decompose complex plant material, such as cellulose, hemicellulose, starch, and proteins (Li and Guan, 2017). The hydrolysis of cellulose results in sugars, which are further fermented to acetate, lactate, propionate, butyrate, carbon dioxide, and methane. As bacteria conduct fermentation in the rumen, they consume about 10% of the carbon, 60% of the phosphorus, and 80% of the nitrogen that the ruminant ingests (Callewaert and Michiels,2010). To reclaim these nutrients, the ruminant then digests the bacteria in the abomasum. The enzyme lysozyme has adapted to facilitate digestion of bacteria in the ruminant abomasum (Irwin *et al.*, 1992). Pancreatic ribonuclease also degrades bacterial RNA in the ruminant small intestine as a source of nitrogen (Jermann*et al.*, 1995, Clauss *et al.*, 2009d).

During grazing, ruminants produce large amounts of saliva - estimates range from 100 to 150 litres of saliva per day for a cow. The role of saliva is to provide ample fluid for rumen fermentation and to act as a buffering agent. Rumen fermentation produces large amounts of organic acids, thus maintaining the appropriate pH of rumen fluids is a critical factor in rumen fermentation. After digesta pass through the rumen, the omasum absorbs excess fluid so that digestive enzymes and acid in the abomasum are not diluted (Clauss and Rossner, 2014, Li and Guan, 2017).

2.6.1 Acquisition of energy by rumen microbes

To obtain energy for growth and reproduction, organisms must break down large molecules into smaller ones, this process gives energy and is called catabolism. For growth to occur, larger molecules are made from smaller ones, using up energy, this process is called anabolism. Both processes are part of cellular metabolism.

When plant material, such as grass, enters a cow's stomach, microorganisms immediately get to work to break it down. They do this with enzymes. Ruminants are unable to synthesise the enzymes needed to digest cellulose and other plant compounds. The microbes in the rumen, however, are able to make the various enzymes needed to hydrolyse cellulose, proteins, sugars and other materials (Myer *et al.,* 2015).

Rumen bacteria need carbon dioxide, nitrogen, sodium, and volatile fatty acids to grow (Hungate*et al.,* 1964). Some bacteria use only one type of food, but others use a range of different types. Many bacteria are able to digest cellulose. Many can also digest xylan, a type of complex carbohydrate similar to cellulose. Others can digest proteins, or sugars such as amylose and lactose.

Glucose is released when cellulose is digested. Various microbes then ferment the glucose to produce short-chain fatty acids (SCFAs). The SCFAs are then taken up and used by the host animal. Carbon dioxide and methane gas are also produced by the microbes and are excreted by the host (e.g. in exhaled air & by belching) (Li and Guan, 2017).

2.7 Rumen Fermentation

2.7.1 Rumen Fermentation Microbiology and chemistry

Fermentation is supported by a rich and dense collection of microbes. Each milliliter of rumen content contains roughly 10 to 50 billion bacteria, 1 million protozoa and variable numbers of yeasts and fungi. The environment of the rumen and large intestine is anaerobic and, as expected,

almost all these microbes are anaerobes or facultative anaerobes. Fermentative microbes interact and support one another in a complex food web, with the waste products of some species serving as nutrients for other species(Myer *et al.*, 2015)..

Fermentative bacteria representing many genera provide a comprehensive battery of digestive capabilities. These organisms are often classified by their substrate preferences or the end products they produce. Although there is some specialization, many bacteria utilize multiple substrates.

Protozoa, predominantly ciliates, appear to contribute substantially to the fermentation process. Several experiments have demonstrated that lambs and calves deprived of their ruminal protozoa show depressed growth rates and are relative "poor-doers" compared to controls with both bacteria and protozoa. In general, protozoa utilize the same set of substrates as bacteria and, as with bacteria, different populations of protozoa show distinctive substrate preferences. Many utilize simple sugars and some store ingested carbohydrate as glycogen(Myer *et al.*, 2015).

An interesting feature of some protozoa is their inability to regulate glycogen synthesis: when soluble carbohydrates are in abundance, they continue to store glycogen until they burst. An additional feature of protozoa is that many species consume bacteria, which is thought to perhaps play a role in limiting bacterial overgrowth(Myer *et al.*, 2015, Li and Guan, 2017)..

Environmental conditions in the fermentation vat also can have profound effects on the microbial flora. Rumen fluid normally has a pH between 6 and 7, but may fall if large amounts of soluble carbohydrate are consumed. If pH drops to about 5.5, protozoal populations become markedly depressed due to acid intolerance. More drastic lowering of rumen pH, as can occur with grain engorgement, can destroy many species and have serious consequences to the animal(Myer *et al.*, 2015).

2.7.2 Synthesis of high quality protein in the form of microbial bodies.

Caudal fermentors cannot take advantage of this service, but in ruminants, bacteria and protozoa are constantly flowing into the abomasum and small intestine, where they are digested and absorbed. All vertebrates require certain amino acids which their cells cannot synthesize (the "essential amino acids"). Fermentative microbes can synthesize all the amino acids and thereby provide them to their host(Belanche*et al.,* 2012).

2.7.3 Synthesis of protein from non-protein nitrogen sources.

Fermentative microbes can, for example, utilize urea to synthesize protein. In some situations, ruminants are fed urea as a inexpensive dietary supplement. They also secrete urea formed during protein metabolism into saliva, which flows into the rumen and serves as another nitrogen source for the microbes (Belanche*et al.,* 2010b, Belanche*et al.,* 2012)..

2.7.4 Synthesis of B vitamins.

Mammals can synthesize only two of the B vitamins and require dietary sources of the others. Fermentative microbes are able to synthesize all the B vitamins, and deficiency states are rarely encountered (Belanche*et al.,* 2010b).

2.7.5 Substrates for fermentation

With few exceptions, all dietary carbohydrates and proteins can serve as substrates for microbial fermentation. Nonetheless, the crucial advantage of being a herbivore is the ability to efficiently extract energy from cellulose and other components of plant cell walls.

Cellulose fibers account for 40-50% of the total dry weight of stems, leaves and roots. These fibers are embedded in a matrix of hemicelluloses and phenolic polymers (lignin-carbohydrate complexes) that are covalently crosslinked. Cellulose itself is a linear polymer of glucose

molecules linked to one another by beta[1-4] glycosidic bonds and herein lies the problem for the vertebrate digestive system (Ozutsumi*et al.*, 2005; Pei *et al.*, 2010).

As far as is known, no enzyme able to hydrolyze beta[1-4] glycosidic bonds has evolved in vertebrates. However, a variety of such beta-glucanases are synthesized by microbes. Thus, the diverse population of bacteria and protozoa in the rumen or hindgut produce all the enzymes necessary to digest cellulose and hemicellulose. The glucose released in this process is then taken up and metabolized by the microbes, and the waste products of microbial metabolism are passed on to the host animal. Sugars derived from digestion of soluble carbohydrates such as starch are processed similarly (Ozutsumi*et al.*, 2005; Pei *et al.*, 2010)..

2.7.6 The products of fermentation

Fermentation occurs under anaerobic conditions. As a consequence, sugars are metabolized predominantly to volatile fatty acids (VFAs). Additional major products include lactic acid, carbon dioxide and methane (Ozutsumi*et al.*, 2005; Pei *et al.*, 2010)..

The principal VFAs are acetic, propionic and butyric acids, which collectively provide for the majority of a herbivore's energy needs. The ratio of these VFA does vary with diet, although the majority product is always acetate. On a diet high in fiber, the molar ratio of acetic to propionic to butyric acids is roughly 70:20:10 (Ozutsumi*et al.*, 2005; Pei *et al.*, 2010)..

As described above, proteins are also important substrates for fermentation. In caudal fermenters, much of the dietary protein is digested and absorbed prior to the large gut, but in ruminants, all dietary protein enters the rumen. The bulk of this protein is digested by microbial proteases and peptidases. The resulting peptides and amino acids are taken up by microbes and used in several ways, including microbial protein synthesis. However, large quantities of amino acids ingested by

fermentative microbes are deaminated and enter some of the same pathways used for carbohydrate metabolism. The net result is that much of dietary protein is metabolized to VFAs. Clearly, from the standpoint of the host animal, VFAs are the important product of fermentation. These small lipids are used for many purposes, but the paramount importance of VFAs to herbivores is that they are absorbed and serve as the animal's major fuel for energy production, serving much the same function that glucose does in human being (Ozutsumi*et al.,* 2005).

2.8 Implication of Packed Cell Volume and some Biochemical Parameters in Ruminant Livestock

Blood which is a vital special circulatory tissue is composed of cells suspended in a fluid intercellular substance (plasma) with the major function of maintaining homeostasis (Isaac *et al.*, 2013). Biochemical tests evaluate the body's internal condition, the function of different organs (including kidneys and the liver) and the course of metabolic changes in the body (Scamell, 2006).

Blood act as a pathological reflector of the status of the exposed animals to toxicants and other conditions. The examination of blood provides the opportunity to clinically investigate the presence of metabolites and other constituents in the body of animals and it plays a vital role in the physiological, nutritional and pathological status of an animal (Etim *et al.*,2014). Blood constituents change in relation to the physiological status of an animal. These changes are important in assessing the response of farm animals to various physiological situations. These changes are often caused by several factors; some of which are genetic and others, non-genetic. Age, sex, breed and management systems are among the factors that influence blood-based parameters of farm animals (Etim *et al.*,2014).

2.8.1 Packed Cell Volume (PCV)

Packed Cell Volume (PCV) which is also known as haematocrit (Ht or Hct) or erythrocyte volume fraction (EVF), is the percentage (%) of red blood cells in blood (Purves *et al.*, 2003). Packed cell volume (PCV) is also the volume of erythrocytes expressed as a percentage of the volume of whole blood in a sample. It is the most accurate means of determining red blood cell volume and can be used to deduce total blood volume and haemoglobin levels. According to Isaac *et al.* (2013) Packed Cell Volume is involved in the transport of oxygen and absorbed nutrients. Increased Packed Cell Volume shows a better transportation and thus results in an increased primary and secondary polycythemia.

Several factors affect PCV levels. Higher haemoglobin and PCV values than the reference values could be attributed to the differences in ages of the animals (Grunwaldt *et al.*,2005). However Otto *et al.* (2000) reported no age effect on PCV values. No breed effects were observed between Aberdeen Angus and the Criollo Argentino on PCV values (Grunwaldt *et al.*, 2005). Otto *et al.* (2000), however, observed a PCV value of 32% for Anguni cattle of Mozambique, which tended to be lower than Aberdeen Angus cattle thus showing breed differences. Reference levels for PCV and haemoglobin contents in indigenous cattle of Southern Africa raised under rural production conditions are largely unknown.Packed cell volume could indicate anaemia, haemorrhage,bone marrow failure, destruction of erythrocytes,leukaemia, malnutrition or specific nutritional deficiency, multiple myeloma and rheumatoid arthritis (Jain, 1993; Kaneko, 1997). Packed cell volume values higher than the reference values could indicate dehydration due to diarrhoea, erythrosis and polycythermiavera. Conditions that can result in a low haematocrit include vitamin or mineral deficiency, cirrhosis of the liver and malignances (Kaneko, 1997).

Packed Cell Volume, haemoglobin and mean corpuscular haemoglobin are major indices for evaluating circulatory erythrocytes, and are significant in the diagnosis of anaemia and also serve as useful indices of the bone marrow capacity to produce red blood cells as in mammals (Awodi *et al.*, 2005; Chineke *et al.,* 2006). Furthermore, Chineke *et al.* (2006) posited that high Packed Cell Volume (PCV) reading indicated either an increase in number of Red Blood Cells (RBCs) or reduction in circulating plasma volume.

In a study conducted by Olayemi *et al.* (2000) on the influence of management on the haematology of the white Fulani cattle. The intensively reared animals showed higher Packed Cell Volume (PCV), Red and White cell counts but lower Mean Corpuscular Haemoglobin than those under extensive management. According to Radostits *et al.* (1994) low nutritional grassland, pasture, stress, parturition, climatic factors among others greatly alter the blood values of goats and sheep, as well as other farm animals.

2.8.2 Blood Glucose

Blood glucose, beta-hydroxy butyrate and non-esterified fatty acids are the most common metabolites used to assess the energy status of cattle. Blood glucose has a moderate diagnostic value in the assessment of nutritional status of cattle as it varies moderately in blood. Insufficient nutrient intake can reduce circulatory glucose and cholesterol levels. In conditions of under nutrition, the blood levels of propionate and other precursors derived from the diet decreases thus causing a reduction in the rate of glucose synthesis (Reynolds *et al.,* 2003). Age affects glucose levels in cattle as has been shown by Doornenbal *et al.* (1988) where glucose levels in calves were lower than those for mature animals. In growing animals, glucose requirement is determined by growth rate, which is set by metabolizable energy intake (Reynolds *et al.,* 2003) whereas in

mature animals only maintenance energy is required. The physiological status of an animal also affects the glucose concentration (Otto *et al.,* 2000).

The percentage of total glucose supply oxidized is reduced in lactating compared to dry cows and tissue utilization of glucose decreases while there is an increase in use of lipid for energy (Reynolds *et al.,* 2003). Grunwaldt *et al.* (2005) reported an effect of season on glucose levels shown by a significant increase in blood glucose levels in autumn (February) as compared to summer (May). Glucose levels decreases with an increase in body temperature and respiration rate of animals normally experienced in hot summer season. Feed quality also affects blood glucose levels. For example, Chimonyo *et al.* (2000) observed a significant reduction of the levels of plasma glucose in winter in cows.Blood glucose concentration is one of the biochemical indicators on the basis of which one may draw conclusions pertaining to the body energy supply (Kupczynski and Chudoba-Drozdowska, 2002).

2.8.3 Total Protein

Serum proteins constitute a portion of the amino acid pool of the body and as such are believed to be indicative of the nutritional status of the animal (Doornenbal *et al.,*1988). Total protein levels are lower in young animals and higher in mature animals whilst albumin levels are lower at birth and then increases (Doornenbal *et al.,* 1988; Otto *et al.,* 2000). Malnutrition decreases albumin levels. Total protein and albumin reflect availability of protein and their concentration decline in the face of protein deficiency. Total protein levels are low in non pregnantnon-lactating cows (Otto *et al.,* 2000).Serum proteins constitute a portion of the amino acid pool of the body and as such are believed to be indicative of the nutritional status of the animal(Otto *et al.,* 2000).

2.8.4 Blood urea

Monitoring of blood urea levels can be used for measuring protein status in cattle from different feeding regimes and seasons (Hammond, 2006). Values for urea within the optimum range (< 3.6 mmol/l) in cattle indicate that the effective rumen degradable protein (ERDP) is adequate. High blood urea levels could indicate a high protein intake or the excessive mobilization of muscle (Chimonyo *et al.,* 2002). In ruminants a decrease in the blood urea concentration is related to low dietary intake of protein due to the recycling of urea from blood back to the rumen when dietary protein intake is low (Oulun,2005). Grunwaldt *et al.* 2005 observed similar levels of urea nitrogen in summer and in autumn.

The most common application of the use of blood urea nitrogen is as a retrospective diagnostic tool to analyze biological responses to protein or energy supplementation, change in pasture or forage on offer, or change in pasture management (Hammond, 2006). Serum urea concentration may also increase despite low-protein feeding if energy intake is restricted, which is thought to reflect increased breakdown of endogenous proteins for energy production, a decrease in renal reabsorption of urea and/or haemoconcentration (Oulun, 2005). High dietary protein (nitrogen) intake resulting in blood urea nitrogen of greater than 19 to 20 mg/dl has been associated with an altered uterine environment and decreased fertility (reduced conception rate, decreased pregnancy rate) in lactating dairy cows and heifers (Elrod and Butler, 1993; Butler *et al.,* 1998).

2.9 Meat Processing and Evaluation of Quality.

Meat is a very important commodity and it is an integral part of people's balanced and varied diet. Meat and meat products contain significant amounts of protein, vitamins, minerals, and trace elements that are essential for its growth and development. It used to be, and still is a sign of people's affluence. Meat quality is influenced by factors that function during the lifetime of an

animal, from birth, during breeding, to transport to slaughter house. After death, these factors are given by the slaughter and the entire slaughter processing, handling and end with storage of prepared foodstuff (Waritthitham*et al.*, 2010).

Meat quality is the term used to describe properties and perception of meat. It includes attributes such as carcass composition and conformation, eating quality of meat and health status (Maltin *et al.*, 2003). Cutrignelli *et al.* (2008) described meat quality as a set of attributes, related to hygienic, sensorial, structural, nutritional, and technological characteristics. Meat quality means different things to different people between or within countries/regions depending on their cultural background, personal experiences and location.

Pre-slaughter factors that include nutrition, breed, age, sex, live weight, days on feed and post-slaughter conditions such as rate of rigor development and length of ageing time are among the factors influencing meat quality (Waritthitham*et al.*, 2010). Days on feed (period of stay in feedlot) depends on the type and amount of feed as well as the age of the animals (Shirima *et al.*, 2014). The use of young animals is more efficient and produces high quality beef, although it may take longer time to reach slaughter weight. This has an implication on cost of feeding as more feed will be used to the finishing period. On the other hand, the use of too old animals in feedlot may take short time to reach slaughter weight but the high amount of connective tissue (collagen) may be a source of meat toughness consequently reducing the quality of meat (Hopkins *et al.*, 2006). Increasing the number of days on feed for young animals has been found to increase final weight, carcass weight, marbling and fat thickness (Waritthitham*et al.*, 2010; Sugimoto *et al.*, 2012) as well as rib eye area and tenderness (Van Koevering *et al.*, 1995; Stelzleni *et al.*, 2008; Shirima *et al.*, 2012)

Meat tenderness is the most important component of meat quality that influences consumers' satisfaction (Melody *et al.*, 2004; Pen *et al.*, 2012). Meat tenderness is mainly affected by post-mortem process including ageing, which is the practice of holding meat at low temperatures allowing proteolytic enzymes to break down muscle fibres (Miguel *et al.*, 2011). Most changes in meat tenderness occur during the first seven days of ageing, but extending time after one week further improves meat tenderness (Brewer and Novakofski, 2008). Ageing can be used to decrease shear force values during post-mortem storage (Sanudo *et al.*, 2004) indicating improved tenderness of meat.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Experimental Site

The three (3) experiments were conducted at the Experimental Pens of the Beef Research Programme of the National Animal Production Research Institute, Shika, Zaria, Nigeria. The study area falls within latitudes 11° 8′ 19.56″ N and longitudes 7° 45′ 51.22″ E, with an altitude of 640m above sea level (Google Earth, 2017). 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 (IAR, 2017) .

3.2 Experimental design and Animal Management.

The study comprises three experiments with 30 weaner (15 Bulls and 15 heifers) calves, 20 each of yearling and matured bulls for the feeding, growth and fattening trials respectively.

The animals were de-wormed with Albendazole 2500mg (Eagle Chemical Co. Ltd chungchongnamdo, Korea) and dipped in acaricides Amitix (Amitraz 12.5% by Alfasan) to control endo- and ecto- parasites a week to commencement of the experiments. They were also adjusted to the experimental diets and pen for a period of 14 days.They were individually penned and fed diets containing graded levels of Palm Kernel Cake (PKC) and *Digitaria smutsii* (Wolly finger grass)hay at 2% of their body weight each.The concentrate was offered first after which the hay was offered to the animals when the concentrate has been consumed.

They were allotted into five (5) treatments in a Completely Randomized Design. Palm Kernel

Cake was included in the formulated ration for Experiments 1, 2 and 3 at graded levels of 0, 10, 20, 30 and 40% and this constitutes Treatments 1 to 5.

3.2.1 EXPERIMENT 1: Effect of feeding diets containing graded levels of palm kernel cake on the growth performance of Bunaji weaner calves.

Thirty (30) Bunaji weaner (15 Bulls and 15 heifers) with age range of 7.5-9 months (85-94kg) were balanced for weight and allotted to five (5) dietary treatments in a 2x5factorial arrangement laid in Completely Randomized Design (CRD) with sex (bulls and heifers) constituting a factor and the 5 dietary levels of PKC is another. They were individually penned and fed diets containing graded levels of Palm Kernel Cake (PKC) and *Digitaria smutsii* (Wolly finger grass)hay at 4% of their body weight (2% for concentrate and 2% for hay). The animals were weighed fortnightly and the ration was adjusted in line with changes in their body weight. Water intake was also measured and evaporative loss was determined. The feeding trial was carried out for 90 days. The diet formulated were isonitrogenous and isocaloric (Table 3.2.1).

3.2.2 EXPERIMENT 2: Effect of feeding diets containing graded levels of palm kernel cake on the growth performance of Bunaji yearling bulls

A total of twenty (20) Bunaji yearling Bulls with age range of 1-1.5 years (110-150kg) were balanced for weight and allotted to five (5) dietary treatments in CRD. They were individually penned and fed diets containing graded levels of Palm Kernel Cake (PKC) and *Digitaria smutsii* (Wolly finger grass)hay at 4% of their body weight (2% for concentrate and 2% for hay). The animals were weighed fortnightly and the ration was adjusted in line with changes in their body weight. Water intake was measured and evaporative loss was also determined. The growth trial was carried out for 90 days. The diets formulated were isonitrogenous and isocaloric (Table 3.2.2).

Table 3.2.1: Percent GrossFeed Composition of Weaner's Concentrate Diets

Ingredient %	Levels of inclusion (%)				
	0	10	20	30	40
Palm kernel cake	0.00	10.00	20.00	30.00	40.00
Cotton seed cake	30.00	27.00	24.00	20.50	17.50
Poultry litter	20.00	18.00	16.00	14.00	12.00
Rice offal	12.00	12.00	12.00	12.00	12.00
Maize offal	37.00	32.00	27.00	22.50	17.50
Salt	1.00	1.00	1.00	1.00	1.00
Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
Calculated analyses					
Crude protein (%)	16.00	16.02	16.05	16.00	16.02
Crude fiber (%)	16.97	16.80	16.64	16.38	16.22
ME(MJ/KgDM)	11.80	11.81	11.79	11.81	11.81
TDN(%)	65.88	63.35	60.84	58.32	55.79
Cost /kg(₦)	40.21	35.82	31.43	26.96	22.58

Table 3.2. 2: Percent Gross Feed Composition of Yearling's Concentrate Diets.

Ingredient %	Levels of inclusion(%)				
	0	10	20	30	40
Palm kernel cake	0.00	10.00	20.00	30.00	40.00
Cotton seed cake	22.00	18.50	16.00	13.00	10.00
Poultry litter	25.00	23.50	21.00	19.00	17.00
Rice offal	12.00	12.00	12.00	12.00	12.00
Maize offal	40.00	35.00	30.00	25.00	20.00
Salt	1.00	1.00	1.00	1.00	1..00
Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
Calculated Analyses					
Crude Protein(%)	15.25	15.28	15.33	15.36	15.38
Crude Fiber (%)	15.04	14.74	14.71	14.55	14.38
Metabolizable Energy(MJ/KgDM)	11.81	11.80	11.80	11.81	11.79
Total Digestible Nutrients(%)	65.76	65.55	65.40	65.22	65.04
Cost/kg(₦)	38.07	33.47	29.29	24.9	20.51

3.2.3 EXPERIMENT 3: Effect of feeding diets containing graded level of Palm Kernel Cake on the fattening performance of mature Bunaji bulls.

Twenty (20) matured Bunaji bulls with age range of 2-2.5 years (190- 200kg) were balanced for weight and allotted to five (5) dietary treatments in Completely Randomized Design. They were individually penned and fed diets containing graded levels of Palm Kernel Cake (PKC) and *Digitaria smutsii* (Wolly finger grass)hay at 2% of their body weight each. The animals were weighed fortnightly and the ration was adjusted in line with changes in their body weight. Water intake was also measured and evaporative loss was determined. The fattening trial was carried out for 90 days. The diets formulated were isonitrogenous and isocaloric (Table 3.2.3).

Table 3.2.3: Percent Gross Feed Composition of Matured Bulls Concentrate Diets

	Inclusion Levels (%)				
Ingredients (%)	0	10	20	30	40
Palm kernel cake	0.00	10.00	20.00	30.00	40.00
Cotton seed cake	18.00	15.50	12.00	9.00	6.00
Poultry litter	24.00	21.50	20.00	18.00	16.00
Rice offal	12.00	12.00	12.00	12.00	12.00
Maize offal	45.00	40.00	35.00	30.00	25.00
Salt	1.00	1.00	1.00	1.00	1.00
Total	**100**	**100**	**100**	**100**	**100**
Calculated Analyses					
Crude Protein	14.65	14.70	14.70	14.72	14.74
Crude Fiber (%)	14.45	14.42	14.12	13.95	13.79
Metabolizable Energy(MJ/KgDM	11.75	11.76	11.78	11.77	11.76
Total Digestible Nutrients(%)	66.12	65.97	65.76	65.58	65..40
Cost/kg(₦)	37.75	33.58	28.97	24.58	20.19

3.3 Source of Palm Kernel Cake

The mechanically extracted palm kernel cake used for this experiment was purchased from Rebson Feedmil, Samaru, Zaria in Kaduna state.

3.4 Data Collection for Experiments 1, 2 and 3.

Parameters measured include: Initial body weight, final body weight, weight gain, feed intake, water intake, feed to gain ratio, feed cost per kg gain, packed cell volume, blood urea and serum total protein for the weaner, yearling and finishing trials. others include rumen pH, rumen ammonia nitrogen (RAN) and total volatile fatty acid for the yearling and finishing trials.

3.4.1 Digestibility study

At the end of the feeding, growth and fattening trials, six weaner calves (3 bulls and 3 heifers), three (3) each of yearling and finishing 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 7 days. The animals were fed experimental diets and hay at 2% of their body weight each 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 analyses, neutral detergent fibre and acid detergent fibre. Daily urine output was collected in a plastic container containing 100ml 0.1N H_2SO_4 placed under metabolic crates in which 10% of daily urine was taken from each bull and stored 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 at a temperature of - 4 ^{o}C pending Nitrogen determination (Osuji *et al.*, 1993).

3.4.2 Rumen fluid sampling

Rumen fluid samples were collected from the yearling and finishing Bunaji bulls at the end of the growth and fattening trials at 0hr, 3hrs, 6hrs and 9hrs after feeding. About 50mls of the rumen fluid was drawn from all the Bulls in each of the treatments using a 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 collected was poured into plastic bottles containing equal quantity of 0.1N H_2SO_4 to trap ammonia. The samples were stored in a refrigerator at -4^{o}c temperature until analyzed.

Rumen ammonia concentration was determined by steam distillation with boric acid and thereafter back titrated with 0.01N Hydrochloric acid (HCl), according to the Procedure described by Whitehead *et al.* (1976). Rumen fluid pH was determined using Philips digital pH meter (Model 9409).

3.4.3 PCV and Serum biochemicalanalyses

Ten (10ml) of blood samples were collected at the beginning, middle and end of the feeding, growth and fattening experiment through jugular vein puncture using a disposable syringe and sterile 18G needle. Five millilitres (5ml) of blood was put in vacutainer tubes containing Ethylene diaminetetraacetic acid (EDTA) as anti-coagulant. The remaining 5ml was placed in plain bottle for serum harvest.

The bloodsample in EDTA bottles was analyseed forPacked cell volume using micro hematocrit.Serum samples were analyzed for urea nitrogen level (BUN) using the procedure of Archer and Robb (1925), total protein was determined using refratometer as described in the routinelaboratory Procedures (Coles, 1986) while blood glucose was determined by collection of

a drop blood from the heparinized blood collection tubes and used to determine the fasting glucose concentrationusing a calibrated glucometer. The blood sample analyses were done at Ahmadu Bello University Teaching Hospital. Shika Zaria

3.4.4 Analytical Techniques

Proximate analyses of individual feed ingredients (Palm kernel cake, maize offal, rice offal, cotton seed cake, poultry litter and hay), concentrate diets and faecal samples were carried out according to 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).Gross Energy (GE) was also determined using an automated bomb calorimeter at the Central laboratory of National Animal Production Research Institute (NAPRI), Shika, Zaria.. Metabolizable energy (ME) was determined by the 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.

3.4.5Economic analyses

The market price of various feed ingredients as at the time of the studies were used in computing the total cost of feed consumed within the feeding period and feed cost per kilogram weight gain using the Procedure reported by Alimi and Manyong(2000).The Procedure was used to determine how profitable the inclusion levels of palm kernel cake in the formulated diets of weaners, yearling and finishing Bunaji bulls.

3.4.6 Carcass evaluation

Two bulls from each treatment were randomly selected and slaughtered to determine the carcass composition at the end of the fattening trial. 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 (1kg graduation). The external offal (head, limb, tail and hide) was removed and weighed separately using calibrated scale of 100kg (200g graduation). After evisceration, the internal offal (liver, spleen, kidney, heart and lungs) was removed and weighed individually using a calibrated weighing scale of 10kg (50g graduation). the gastrointestinal tract (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 was weighed and fats (depth of chest fat, inguinal, abdominal fat) were also measured. Dressing percentage was calculated by dividing hot carcass weight by the fasted body weight expressed in percentage (hot carcass weight /fasted body weight *100).

3.4.7 Data analyses

The data collected from the three (3) experiments 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 compared using Dunnett's test. The data from the feeding trials and digestibility trials of weaner calves were analysed using factorial arrangement.Data from feeding trials and digestibility trial of yearling and fattened bulls were analyzed using one way ANOVA, Carcass characteristic data was also analysed using one way ANOVA while rumen fluid and the blood samples data were analysed using repeated measure analyses. The models are as follow:

$Y_{ij} = \mu + t_i + E_{ij}$

Where

Y_{ij}= j^{th} observation of i^{th}graded levels of palm kernel cake inclusion.

μ=overall mean

t_i = effect of i^{th} graded levels of palm kernel cake inclusion on performance

E_{ij} = random error .

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

where:

Y_{ijk} = j^{th} observation of the i^{th}graded levels of palm kernel cake;

μ = the overall mean

τ_i = the effect of the i^{th} graded levels of palm kernel cake (i = 0, 10, 20, 30 and 40%);

t_k = the effect of k^{th} sampling period/sex (k= ohr before feeding,3hrs, 6hrs and 9hrs post feeding for rumen fluid,beginning, middle and end of experiment for blood / sex bull or heifer);

$(\tau*t)_{ik}$ = interaction effect between the i^{th} graded levels of palm kernel cake and the k^{th} sampling period/sex;

δ_{ij} = random error with mean 0 and variance $\sigma^2\delta$., the variance between animals (subjects) within treatment and it is equal to the covariance between repeated measurements within animals

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

CHAPTER FOUR

4.0 RESULTS

4.1 Chemical Analyses

4.1.1 Proximate and cell wall composition of feed ingredients and hay

The Chemical Composition of individual feed ingredients and hay used for this trial is shown in Table 4.1.1. Dry matter (DM) contents of palm kernel cake (PKC) is 96.4%, crude fibre (CF) of 55.89%, Neutral Detergent Fibre (NDF) of 71.08%, crude protein (CP) of 18.19% Gross energy(GE) 13.35MJ/Kg DM and Metabolizable energy (ME) of 11.85MJ/Kg DM.

The dry matter content for *Digitaria smutsii* was 95.65% while the crude protein, crude fibre, ether extract, ash, Acid Detergent Fiber (ADF), NDF, and Hemicellulose (HC) were 5.25%, 36.75%, 8.81%, 7.8%, 45.21% 70.54%, and 25.33%, respectively.

The CF, ADF, CP, GE and ME of maize offal were as follows 15.86%, 16.7%, 11.44% , 15.83 MJ/Kg DM and 11.93 MJ/Kg DM respectively. The cotton seed cake had 34.07 CF, 44.73 NDF, 35.29 ADF, 9.44 Hemicellulose, 30.75 % CP, 16.44 MJ/Kg DM for GE and ME of 11.84 MJ/Kg DM. The CF, NDF, ADF, Hemicellulose, CP,GE and ME of poultry litter are 18.86%, 43.49%, 24.59%, 18.9%,20.88%, 13.60 MJ/Kg DM and 11.75 MJ/Kg DM respectively.

Dry Matter (DM) contents of rice offal was 98.35%, Crude Fiber (CF) of 39.44%, Neutral Detergent Fiber (NDF) of 56.94%, Crude Protein (CP) of 5.25% and Metabolizable Energy (ME) of 11.57MJ/Kg DM.

Table 4.1. 1: Proximate and Cell WallComposition of Feed Ingredients.

Parameters (%)	Ingredients					
	PKC	MO	CSC	PLITTER	RO	*D. smutsii*
Dry Matter	96.4	97.70	95.04	97.62	98.35	95.65
Crude Protein	18.19	11.44	30.75	20.88	5.25	5.25
Crude Fibre	55.89	15.86	34.07	18.86	39.44	36.75
Ether Extract	12.38	15.63	13.26	12.48	10.59	8.81
Ash	3.98	1.31	4.11	13.53	20.49	7.8
Neutral Detergent Fibre	71.08	48.08	44.73	43.49	56.94	70.54
Acid Detergent Fibre	51.34	16.7	35.29	24.59	56.94	45.21
Hemi Cellulose	19.74	32.08	9.44	18.9	8.69	25.33
GE(MJ/KgDM)	13.35	15.83	16.44	13.60	13.93	21.10
ME(MJ/KgDM)	11.85	11.93	11.84	11.75	11.57	11.72

CSC = Cotton Seed Cake, MO = Maize offal, D.*smutsii* = *Digitariasmutsii*, Plitter=Poultry litter, PKC = Palm kernel cake, RO= rice offal, ME=Metabolizable Energy. 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 = Metabolizable energy, DM = Dry matter, CP = Crude protein, EE = Ether Extract, CF = Crude fibre and A = Ash.

4.2 EXPERIMENT 1: Effect of feeding diets containing graded levels of palm kernel cake on the growth performance of Bunaji weaner calves

4.2.1 Proximate and cell wall compositions of concentrate diets containing varying levels of palm kernel cake fed to Weaner Bunaji calves

The dry matter (DM) and crude protein (CP) of the experimental diet ranged between 97.3 - 97.96% and 13.88 – 18% respectively (Table 4.2.1). Crude fibre (CF) ranged between 28 and 33.5% with treatment 1 having the lowest CF and treatment 3 with the highest. The NDF and ADF ranged between 49.29 - 58.02% and 27.27 - 37.3% respectively. The ash content ranged between 5.74 and 7.48% while the EE ranged between 10.64 and 15.6%. Gross energy ranged between 12.68-15.11 MJ/KgDM and ME ranged between 11.79-11.81MJ/KgDM.

4.2.2 Effect of palm kernel cake on Performance of weaner Bunaji calves

Effect of sex on the performance of weaner Bunaji calves fed diet containing varying levels of palm kernel cake is shown in table 4.2.2. There was significant ($P<0.05$) difference in all the parameters measured between thebulls and the heifers. The initial weight is 100.07kg for the bulls and 86.20Kg for the heifers. Final weight is 156.27kg and 125.87kg, average weight gain is 0.62 and 0.44Kg/day, average feed intake is 4.6 and 3.80kg/day for both bulls and heifers respectively.

Table 4.2.3 shows effect of inclusion level on the performance of weaner Bunaji calves. Initial weight ranges between 92.50 - 94.00kg, final weight 137.50-144.67kg, average weight gain of 0.50-0.58 kg/day, feed conversion ratio ranged between 7.36-8.38 kg feed/ kg gain. Animals on diets containing 30% PKC inclusion levels had the highest weight gain which was also statistically similar ($P>0.05$) to those on diets with 10% PKC inclusion levels. Diets with 10, 20 and 40 PKC inclusions were not significantly ($P>0.05$) difference but differed from 30% inclusion level($P<0.05$).

The interaction effect of sex and level of inclusion is presented in Table 4.2.4. The parameters measured were significant (P< 0.05). Average feed intake was similar for bull calves on 10, 20 and 30% PKC inclusion level but differ from those on 0 and 40%PKC. Average water intake ranged from 10.77-14.29L, Average weight gain range from 0.38- 0.65Kg, FCR range from 7.13 - 9.62.

4.2.3 Effect of palm kernel cake on apparent digestibility of weaner Bunaji calves

When effect of sex on the apparent digestibility of weaner Bunaji calves fed diet containing varying levels of PKC was considered, there was no significant (P>0.05) difference in the apparent digestibilty of both bulls and heifers of Bunaji weaners except for CF and ADF as shown in table 4.2.5. The bullhas a higher numeric value than the heifer for DM, Ash and HC though not statistically significant (P>0.05). Heifer had higher digestibility value as show from EE digestibility of 56.13 and 61.74%, NDF of 70.59 and 73.09%, ADF of 67.55 and 71.38% for bull and heifer respectively.

Table 4.2.6 shows Effect of levels of inclusion of palm kernel cake on the apparent digestibility of weaner Bunaji calves. There was no significant (P>0.05) difference in Crude Prrotein (CP) digestibility at 10, 30 and 40% levels of inclusion of PKC. Crude Fibre digestibility (CF) was also similar for animals on diets containing 0, 10 and 40%. EE of 66.16, 60.44 and 59.02% for 0,10 and 20% levels of inclusion of PKC respectively. Hemicellulose at 10, 20 and 30 levels of inclusion of PKC are similar (P>0.05) but different from 0 and 40% PKC inclusion.

Table 4.2 1:Chemical Compositions of Concentrate Diets Containing Varying Levels of Palm Kernel Cake Fed to Weaners Bunaji Calves

	Treatment

Parameter (%)	0	10	20	30	40
Dry Matter	97.4	97.36	97.30	97.96	97.81
Crude Protein	16.75	18.00	13.88	16.31	16.06
Crude Fibre	28.00	29.00	33.50	31.00	32.50
Ether Extract	15.60	12.98	12.76	10.86	10.64
Ash	7.48	7.39	6.24	6.33	5.74
Neutral Detergent Fibre	49.29	53.14	58.02	52.65	54.2
Acid Detergent Fibre	35.11	37.30	33.97	35.21	27.27
Hemi Cellulose	14.18	15.84	24.05	17.44	19.18
GE(MJ/KgDM)	13.25	15.11	13.55	13.68	12.68
ME(MJ/KgDM)	11.80	11.81	11.79	11.81	11.81

Where ME = Metabolizable energy, GE= Gross energy DM = Dry matter, CP = Crude protein, EE = Ether Extract, CF = Crude fibre and A = Ash.,,NDF=neutral detergent fiber, ACF=Acid detergent fiber,HC=hemicellulose. ME=Metabolizable Energy. ME was determined by equation of Alderman and Cottrill, 1985. ME (MJ/Kg DM) = $11.78 + 0.0064\ CP + (0.000665EE)^2 - CF\ (0.00414EE) - 0.0118A$.

Table 4.2 2: Effectof Sex on the Performance of Weaner Bunaji Calves Fed DietContaining Varying Levels of Palm Kernel Cake

	Sex

Parameter	Bull	Heifer	SEM
Initial weight(Kg)	100.07[a]	86.20[b]	1.84
Final weight(Kg)	156.27[a]	125.87[b]	2.57
ACI(kg/day)	2.31[a]	1.90[b]	0.04
AHI(kg/day)	2.32[a]	1.92[b]	0.04
AFI (kg/day)	4.60[a]	3.80[b]	0.08
ADMI(kg/day)	4.50[a]	3.71[b]	0.08
AWI(L/day)	13.34[a]	11.50[b]	0.24
AWG(kg/day)	0.62[a]	0.44[b]	0.02
FCR	8.57[b]	7.30[a]	0.19

[abcd] means within the same row with different superscripts are significantly different (P<0.05)
where ACI=average concentrate intake, AHI=average hay intake, AFI=average feed intake, ADMI=average dry matter intake,AWI=average water intake, AWG=average weight gain, FE=feed conversion ratio,,SEM=Standard Error of mean, l=litre

Table 4.2 3: Effectof Levels of Inclusion of Palm Kernel Cake on Performance of Weaner Bunaji Calves

	Level of inclusion(%)

Parameter	0	10	20	30	40	SEM
Initial weight(Kg)	92.67	93.00	93.50	92.50	94.00	1.87
Final weight(Kg)	137.50 ^{c}	142.83 ^{ab}	140.83 ^{ab}	144.67 ^{a}	139.50 ^{bc}	2.37
ACI(kg/day)	1.99 ^{c}	2.17 ^{a}	2.13 ^{ab}	2.16 ^{a}	2.07 ^{bc}	0.04
AHI(kg/day)	2.04 ^{b}	2.18 ^{a}	2.13 ^{a}	2.16 ^{a}	2.11 ^{ab}	0.04
ATFI (kg/day)	3.99 ^{c}	4.33 ^{a}	4.24 ^{ab}	4.29 ^{ab}	4.15 ^{bc}	0.08
ADMI(kg/day)	3.89 ^{b}	4.21 ^{a}	4.12 ^{a}	4.20 ^{a}	4.05 ^{ab}	0.08
AWI(L/day)	12.25 ^{b}	12.77 ^{a}	11.99 ^{b}	12.83 ^{a}	12.17 ^{b}	0.24
AWG(kg/day)	0.50 ^{c}	0.55 ^{ab}	0.53 ^{b}	0.58 ^{a}	0.51 ^{bc}	0.02
FCR	8.38^{b}	7.65^{a}	8.04^{b}	7.36^{a}	8.25^{b}	0.19

^{abcd} means within the same row with different superscripts are significantly different (P<0.05)
where ACI=average concentrate intake, AHI=average hay intake, AFI=average feed intake, ADMI=average dry matter intake,AWI=average water intake, AWG=average weight gain, FE=feed conversion ratio,SEM=Standard Error of mean, l=litre

Table 4.2 4: Effect of Sex and Levels of Inclusion of Palm Kernel Cake on Performance of Weaner Bunaji Calves.

	Sex and level of inclusion										
	Bull					Heifer					
Parameter	0	10	20	30	40	0	10	20	30	40	SEM
IW(Kg)	95.33 ^{b}	101.33 ^{a}	102.33 ^{a}	100.00 ^{a}	101.33 ^{a}	90.00 ^{c}	84.67 ^{d}	84.67 ^{d}	85.00 ^{d}	86.67 ^{cd}	2.14
FW(Kg)	142.67^{b}	155.67 ^{a}	160.00 ^{a}	158.67 ^{a}	156.00 ^{a}	117.33^{d}	130.00 ^{c}	121.67^{d}	130.67 ^{c}	123.00^{d}	3.57
ACI(kg/day)	2.16 ^{bc}	2.38 ^{a}	2.40 ^{a}	2.38 ^{a}	2.25 ^{ab}	1.82 ^{c}	1.97 ^{c}	1.87 ^{c}	1.93 ^{c}	1.89 ^{c}	0.10
AHI(kg/day)	2.19 ^{c}	2.39 ^{a}	2.38 ^{ab}	2.37 ^{ab}	2.28 ^{bc}	1.89 ^{d}	1.98 ^{d}	1.89 ^{d}	1.96 ^{d}	1.93 ^{d}	0.05
ATFI (kg/day)	4.31 ^{b}	4.73 ^{a}	4.74 ^{a}	4.72 ^{a}	4.49 ^{b}	3.68 ^{d}	3.92 ^{c}	3.73 ^{cd}	3.86 ^{cd}	3.80 ^{cd}	0.10
ADMI(kg/day)	4.20 ^{b}	4.61 ^{a}	4.62 ^{a}	4.62 ^{a}	4.40 ^{b}	3.59 ^{d}	3.82 ^{c}	3.63 ^{cd}	3.78 ^{cd}	3.71 ^{cd}	0.10
AWI(L/day)	13.27 ^{b}	14.29 ^{a}	13.21 ^{b}	13.47 ^{b}	12.45 ^{c}	11.23 ^{d}	11.26 ^{d}	10.77 ^{d}	12.21 ^{c}	11.89 ^{c}	0.28
AWG(kg/day)	0.62 ^{ab}	0.60 ^{b}	0.64 ^{ab}	0.65 ^{a}	0.60 ^{b}	0.38 ^{d}	0.50 ^{c}	0.41 ^{d}	0.51 ^{c}	0.40 ^{d}	0.02
FCR	7.13 ^{a}	7.68^{c}	7.24^{abc}	7.19 ^{ab}	7.27^{abc}	9.62^{e}	7.63^{bc}	8.84^{d}	7.53^{abc}	9.22^{de}	0.46

^{abcd} means within the same row with different superscripts are significantly different (P<0.05). SEM=Standard Error of mean,
Where IW= Initial weight, FW= Final Weight ACI=average concentrate intake, AHI=average hay intake, AFI=average feed intake, ADMI=average dry matter intake, AWI=average water intake, AWG=average weight gain, FE=feed conversion ratio, l=litre

Table 4.2 5: Effect of Sex on the Apparent Digestibility of WeanerBunaji Calves Fed Diet Containing Varying Levels of Palm Kernel Cake

	Sex		
Apparent digestibility (%)	Bull	Heifer	SEM
Dry Matter	64.65	63.03	1.13
Crude Protein	57.75	60.46	2.39
Crude Fibre	65.53 [a]	62.57 [b]	1.23
Ether Extract	56.13	61.74	4.03
Ash	28.16	27.14	2.52
Neutral Detergent Fibre	70.59	73.09	1.30
Acid Detergent Fibre	67.55 [b]	71.38 [a]	1.57
Hemi Cellulose	54.77	54.72	2.31

[abcd] means within the same row with different superscripts are significantly different (P<0.05)
Where DM = Dry matter, CP = Crude protein, EE = Ether Extract, CF = Crude fibre and A = Ash.,NDF=neutral detergent fiber, ACF=Acid detergent fiber,HC=hemicellulose. .SEM=Standard Error of mean

Table 4.2 6: Effect of Levels of Inclusion of Palm Kernel Cake on the Apparent Digestibility of Weaner Bunaji Calves

	Level of inclusion(%)					
Apparent digestibility(%)	0	10	20	30	40	SEM
Dry Matter	61.69 [c]	63.07 [bc]	64.70 [ab]	66.03 [a]	63.70 [bc]	1.13
Crude Protein	54.63 [b]	65.44 [a]	51.95 [b]	62.13 [a]	61.37 [a]	2.39
Crude Fibre	59.13 [c]	61.20 [c]	66.59 [b]	70.58 [a]	62.76 [c]	1.23
Ether Extract	66.16 [a]	60.44 [a]	59.02 [a]	58.15 [ab]	50.87 [b]	4.03
Ash	29.13 [ab]	30.38 [a]	22.15 [b]	31.81 [a]	24.77 [b]	2.52
Neutral Detergent Fibre	67.77 [c]	72.59 [ab]	73.53 [a]	74.84 [a]	70.49 [b]	1.14
Acid Detergent Fibre	66.84 [b]	71.67 [a]	67.85 [b]	73.60 [a]	67.35 [b]	1.57
Hemi Cellulose	48.43 [b]	58.23 [a]	57.20 [a]	57.50 [a]	52.36 [b]	2.31

[abcd] means within the same row with different superscripts are significantly different ($P<0.05$)
Where DM = Dry matter, CP = Crude protein, EE = Ether Extract, CF = Crude fibre and A = Ash. SEM=Standard Error of mean,

When the effect of sex and levels of inclusion of palm kernel cake on the apparent digestibility of weaner Bunaji calves was considered, there was significant (P>0.05) difference in the apparent digestibility of weaner Bunaji calves at various levels of inclusion for both bulls and heifers as shown in table 4.2.7. DM range from 58.89 - 66.66%,CP range of 49.24 -67.44% and NDF value was similar for bull calves on 40% PKC, heifer calves on 20% and 30% PKC inclusions .

4.2.4 Effect of palm kernel cake on Nitrogen balance of weaner Bunaji calves

There was significant (P>0.05) difference in the Nitrogen balance measured from both bulls and heifers Bunaji weaners except for nitrogen retained as a percentage of nitrogen intake as shown in Table 4.2.8. The bull has a higher value than the heifer for Nitrogen intake (g/day) 97.26 and 81.37, Urinary Nitrogen (g/day) 1.44 and 0.97 respectively.

Table 4.2.9 shows the effect of levels of inclusion of palm kernel cake on Nitrogen balance of weaner Bunaji calves, it was observed that there was significant (P<0.05) difference in nitrogen balance across treatments. Nitrogen Intake was highest at 30%PKC inclusion (97.07g/day) but similar to the value of 95.56g/day for animals on 10%PKC. Urinary nitrogen loss was lowest for animals on 40%PKC inclusion and highest for those on 30%PKC levels but similar for animals on 0, 10 and 20%PKC inclusions. Faecal nitrogen loss was similar for animals on 0, 20 and 30% PKC levels but differ from those on 10% and 40% PKC inclusions.

Effect of sex and levels of inclusion of PKC on Nitrogen balance of weaner Bunaji calves is shown in table 4.2.10. There was significant (P<0.05) difference in nitrogen balance for animals of both sex and varying levels of inclusion of PKC. The nitrogen intake, Urinary nitrogen, nitrogen retained and total nitrogen ranged from 71.72-103.85 g/day, 0.77-1.81 .

Table 4.2 7: Effect of Sex and Levels of Inclusion of Palm Kernel Cake on the Apparent Digestibility of Weaner Bunaji Calves

	Sex and level of inclusion										
	Bull					Heifer					
Apparent digestibility (%)	0	10	20	30	40	0	10	20	30	40	SEM
Dry Matter	64.49^{c}	61.48^{e}	63.99^{d}	66.66^{a}	66.62^{a}	58.89^{g}	64.65^{c}	65.40^{b}	65.39^{b}	60.79^{f}	0.17
Crude Protein	49.24^{g}	63.44^{b}	49.72^{g}	63.64^{b}	62.71^{c}	60.03^{e}	67.44^{a}	54.19^{f}	60.61^{d}	60.03^{e}	0.48
Crude Fibre	64.02^{e}	60.24^{g}	66.37^{d}	69.48^{b}	67.54^{c}	54.23^{i}	62.17^{f}	66.81^{d}	71.68^{a}	57.98^{h}	0.25
Ether Extract	59.52^{e}	57.71^{f}	52.99^{h}	62.00^{d}	48.41^{i}	72.81^{a}	63.17^{c}	65.07^{b}	54.31^{g}	53.32^{h}	0.34
Ash	33.86^{a}	27.56^{d}	19.17^{g}	29.71^{c}	30.49^{b}	24.40^{f}	33.21^{a}	25.12^{e}	33.90^{a}	19.05^{g}	0.35
Neutral Detergent Fibre	67.96^{e}	69.51^{d}	69.83^{d}	72.42^{c}	77.26^{a}	67.58^{e}	75.67^{b}	77.23^{a}	77.26^{a}	67.74^{e}	0.22
Acid Detergent Fibre	67.46^{g}	68.31^{f}	62.89^{i}	70.17^{d}	68.93^{e}	66.23^{h}	75.03^{b}	72.81^{c}	77.04^{a}	65.77^{h}	0.23
Hemi Cellulose	47.64^{g}	54.23^{d}	53.17^{e}	57.29^{c}	61.52^{ab}	49.22^{f}	62.23^{a}	61.23^{b}	57.72^{c}	43.20^{h}	0.44

Where DM = Dry matter, CP = Crude protein, EE = Ether Extract, CF = Crude fibre and A = Ash. SEM=Standard Error of mean, ^{abcdef} means within the same row with different superscripts are significantly different (P<0.05)

Table 4.2 8: Effect of Sex on Nitrogen Balance of Weaner Bunaji Calves Fed Diet Containing Varying Levels of Palm Kernel Cake

	Sex		
Nitrogen balance	Bull	Heifer	SEM
Nitrogen intake (g/day)	97.26 [a]	81.37 [b]	1.95
Urinary Nitrogen (g/day)	1.44	0.97	0.06
Faecal Nitrogen (g/day)	40.97 [a]	31.89 [b]	2.33
Total Nitrogen Output (g/day)	42.41 [a]	32.87 [b]	2.34
Nitrogen Retained (g/day)	54.85 [a]	48.50 [b]	2.34
Nitrogen Retained (%N-intake)	56.28	59.23	2.40

[ab] means within the same row with different superscripts are significantly different (P<0.05) SEM=Standard Error of mean,

Table 4.2 9: Effect of Levels of Inclusion of Palm Kernel Cake on Nitrogen Balance of Weaner Bunaji Calves

	Level of inclusion(%)					
Nitrogen balance	0	10	20	30	40	SEM
Nitrogen intake (g/day)	84.74 [c]	95.56 [a]	80.24 [d]	97.07 [a]	88.96 [b]	1.95
Urinary Nitrogen (g/day)	1.12 [bc]	1.24 [b]	1.23 [b]	1.41 [a]	1.04 [c]	0.06
Faecal Nitrogen (g/day)	38.59 [a]	32.85 [b]	38.94 [a]	39.51 [a]	34.82 [b]	2.33
Total Nitrogen Output (g/day)	39.71 [a]	34.09 [b]	40.16 [a]	38.36 [ab]	35.86 [ab]	2.34
Nitrogen Retained (g/day)	45.03 [c]	61.47 [a]	40.08 [c]	58.70 [a]	53.10 [b]	2.34
Nitrogen Retained (%N-intake)	53.30 [b]	64.13 [a]	50.39 [b]	60.72 [a]	60.25 [a]	2.40

[abc] means within the same row with different superscripts are significantly different (P<0.05) SEM=Standard Error of mean

Table 4.2 10: Effect of Sex and Levels of Inclusion of Palm Kernel Cake on Nitrogen Balance of Weaner Bunaji Calves.

	Sex and level of inclusion										
	Bull					Heifer					
Nitrogen balance	0	10	20	30	40	0	10	20	30	40	SEM
Nitrogen intake (g/day)	96.86^{d}	99.40^{b}	88.76^{g}	103.85^{a}	97.42^{c}	72.62^{i}	91.72^{e}	71.72^{j}	90.29^{f}	80.51^{h}	0.29
Urinary Nitrogen (g/day)	1.36^{c}	1.52^{b}	1.21^{f}	1.81^{a}	1.31^{d}	0.88^{i}	0.97^{h}	1.24^{e}	1.01^{g}	0.77^{j}	0.20
Faecal Nitrogen (g/day)	48.79^{a}	34.51^{e}	45.04^{b}	38.14^{c}	37.76^{c}	28.39^{h}	30.19^{g}	32.83^{f}	35.76^{d}	32.28^{f}	0.27
Total Nitrogen Output (g/day)	50.15^{a}	37.03^{e}	46.25^{b}	39.95^{c}	38.67^{d}	29.27^{i}	31.16^{h}	34.08^{f}	36.77^{e}	33.05^{g}	0.27
Nitrogen Retained (g/day)	46.71^{g}	62.37^{b}	42.51^{i}	63.90^{a}	58.75^{d}	43.35^{h}	60.56^{c}	37.64^{j}	53.51^{e}	47.46^{f}	0.29
Nitrogen Retained (%N-intake)	47.84^{h}	61.88^{b}	48.34^{g}	61.95^{b}	61.41^{c}	58.76^{c}	66.38^{a}	52.45^{f}	59.49^{d}	59.08^{de}	0.28

SEM=Standard Error of mean, means seperated with letters within the same row with different superscripts are significantly different (P<0.05)

4.2.5 Effect of palm kernel cake on Packed Cell Volume and Some biochemical parameter of weaner Bunaji calves

Figure4.2.1 shows the effect of sex on Packed Cell Volume and Some biochemical parameter of weaner calves. The PCV(30.02% and 29.96%) and TP (75.36g/L and 68.65g/L) were higher ($P<0.05$) for bull than heifer while blood urea value(4.63mmol/L and 4.87mmol/L) was higher for heifer than bull. There was no significant difference ($P>0.05$) in glucose value for both bull and heifer weaner calves.

When effect of sampling interval on Packed Cell Volume and Some biochemical parameter of weaner Bunaji calves fed graded level of palm kernel cake was considered, the PCV was highest (30.77%) at the end of the experiment and lowest at the beginning (28.97%). Glucose value was lowest (2.69mmol/l)at the beginning but statistically similar value($P>0.05$) at the middle(4.16mmol/L) and end of the experiment (4.63mmol/L). Urea value was lowest (3.16mmol/L) at the middle of the trial and highest (6.72) at the end of the experiment. Highest TP value was obtained at the middle (78.47g/L) of the experiment, followed by the end (73g/L) and then the lowest value was obtained at the beginning (68.14g/L) of the trial (Fig 4.2.2).

Fig 4.2.3 shows the effect of levels of inclusion of palm kernel cake on Packed Cell Volume and Some biochemical parameter of weaner Bunaji calves,there was significant ($P<0.05$) difference across for PCV, urea and TP but glucose level was similar statistically across treatment. The PCV ranged from 28.39-32.17%, glucose range of 3.57-4.11mmol/L, Urea of 4.21-5.34mmol/L and TP of 68.83-76.67g/L.

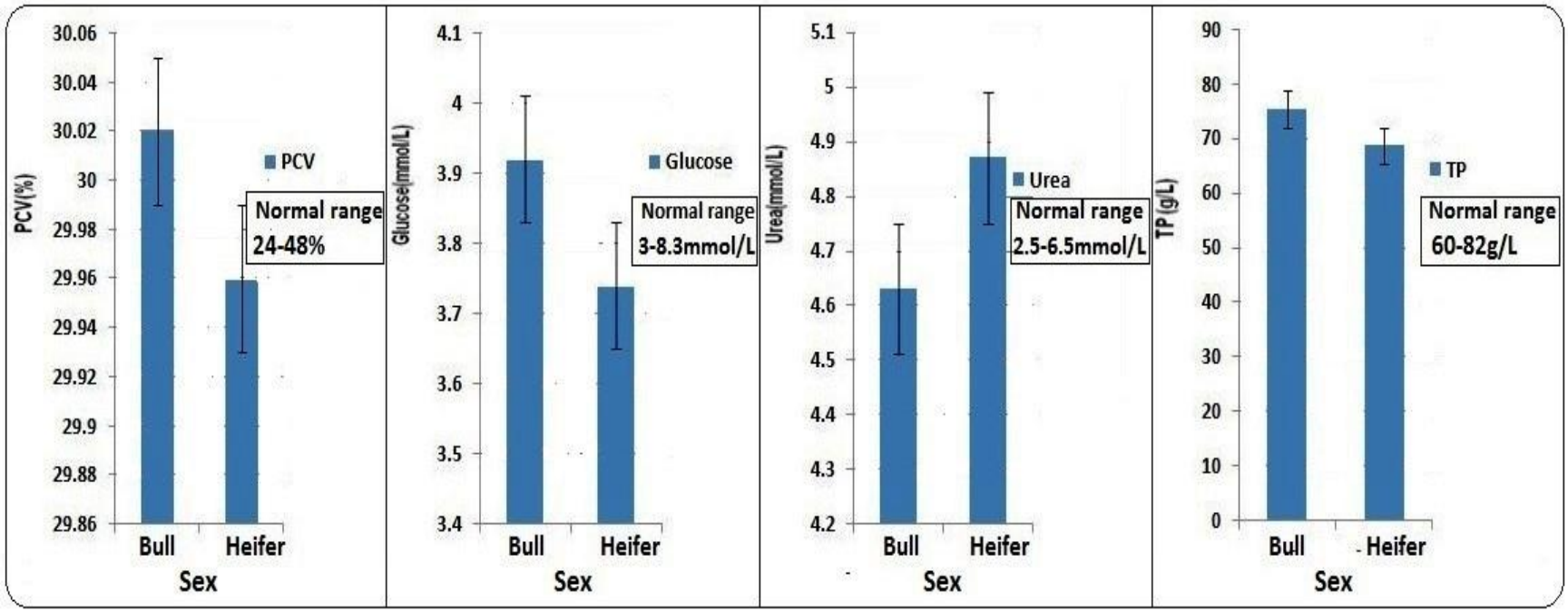


Fig4.2.2: Effect of Sex on Packed Cell Volume and Some Biochemical Parameter of Weaner Bunaji

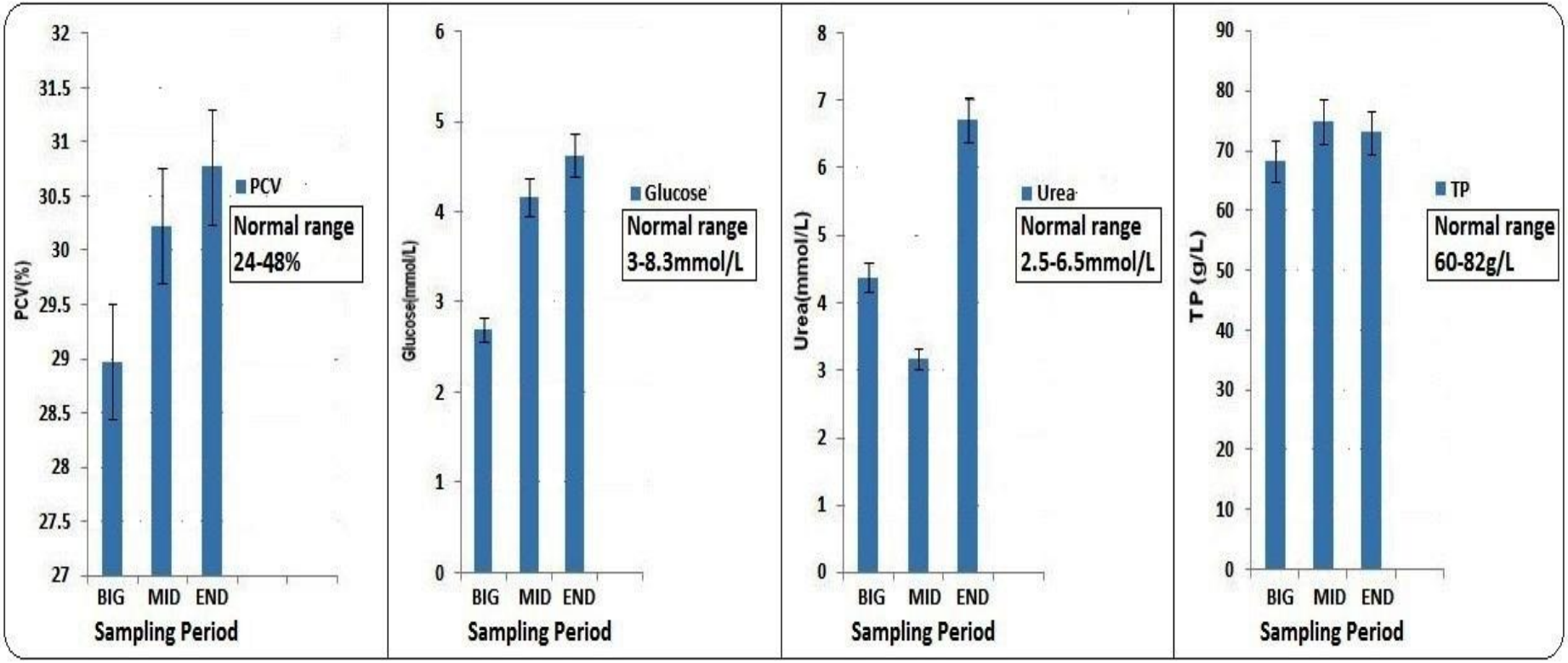


Fig 4.2. 2: Effect of Sampling Interval on Packed Cell Volume and Some Biochemical Parameter of Weaner Bunaji Calves Fed Graded Level of Palm Kernel Cake.

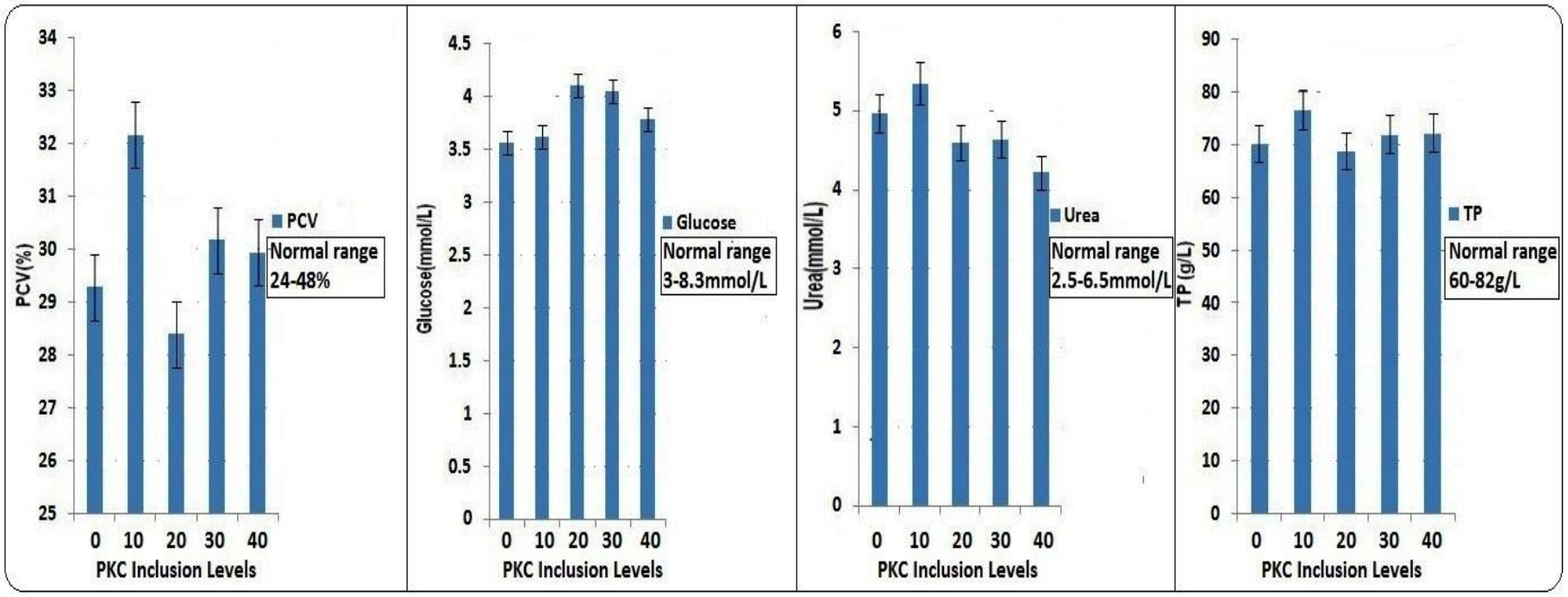


Fig 4.2. 3:Effect of Levels of Inclusion of Palm Kernel Cake on Packed Cell Volume and Some Biochemical Parameter of Weaner Bunaji Calves

Effect of sex and sampling intervals on Packed Cell Volume and Some biochemical parameter of weaner Bunaji calves fed diet containing varying levels of palm kernel cake is shown in Fig 4.2.4. PCV and glucose value at the beginning, middle and end of the experiment for both bulls and heifers where not significantly (P>0.05) different. The level of blood urea at the beginning and end of the experiment for both the bulls and heifers were not significant but differed significantly (P<0.05) at the middle of the experiment with the heifer having higher urea value than the bull.

Considering the effect of levels of inclusion and sampling intervals on Packed Cell Volume and Some biochemical parameter of weaner Bunaji calves fed diets containing palm kernel cake, the PCV range from 27-33.33, 28.17-31.33, 29-32.83%,Glucose range from 2.32-3.5,3.73-5.05,4.18-4.95mmol/L, Urea of 3.52 -4.80,2.58-3.52,5.62-7.17mmol/L and TP of 61.70-76.50,71.50-79.83,68-79.83g/L when the blood samples was taken at the beginning, middle and end of the experiment respectively and across treatment (Fig 4.2.5).

Figure 4.2.6 shows the effect of sex and levels of inclusion of palm kernel cake on Packed Cell Volume and Some biochemical parameter of weaner Bunaji calves, there was significant difference (P<0.05) in all the parameters at various level of PKC inclusion and between the bull and heifer. Glucose value was similar for the bulls at 10, 20 and 30% inclusion of PKC but differedfor animals fed diets containing 0% and 40% inclusion of PKC. Heifer animals had similar glucose value at 20, 30 and 40% inclusion levels of PKC, but differedfor animals fed diets containing 0% and 10% levels of PKC. The TP ranged from 68.44-80.89g/l and 64.57-72.44g/L for bull and heifer, respectively.

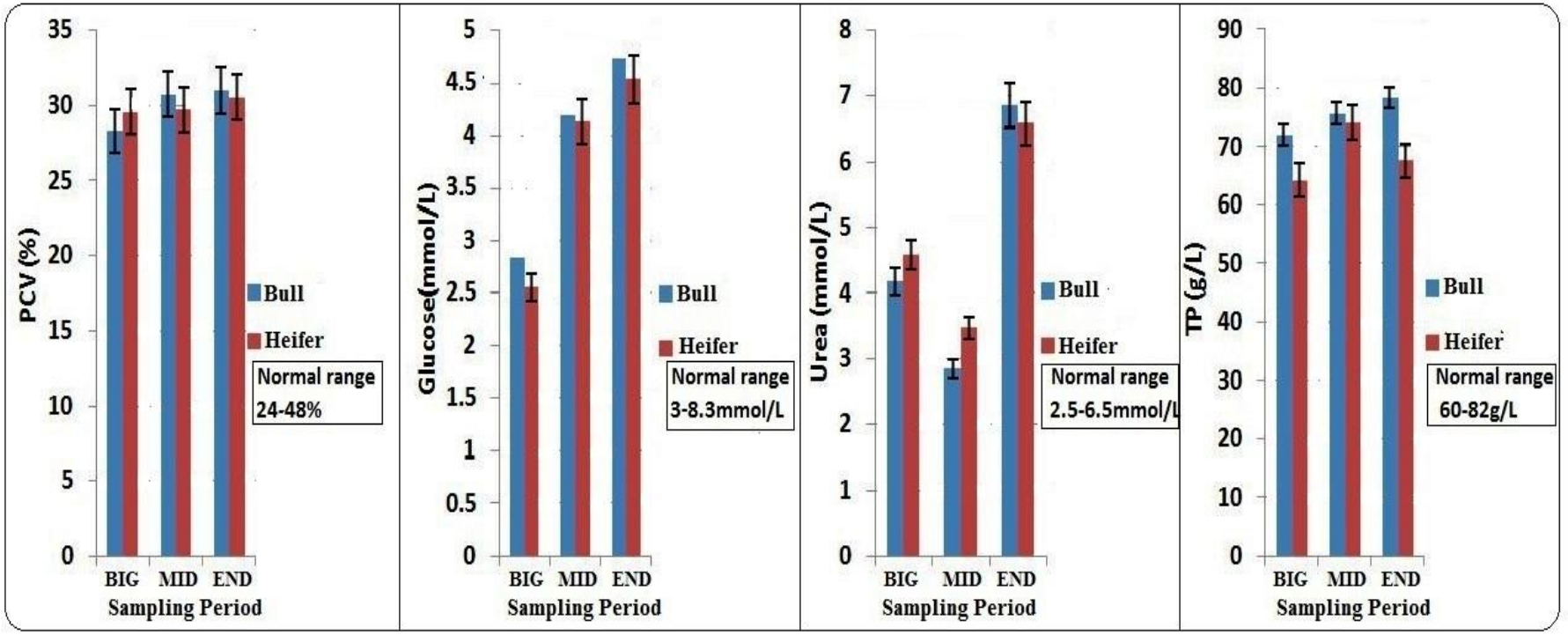


Fig 4.2. 4: Effect of Sex and Sampling Intervals on Packed Cell Volume and Some Biochemical Parameter of Weaner Bunaji Calves Fed Diet Containing Varying Levels of Palm Kernel Cake

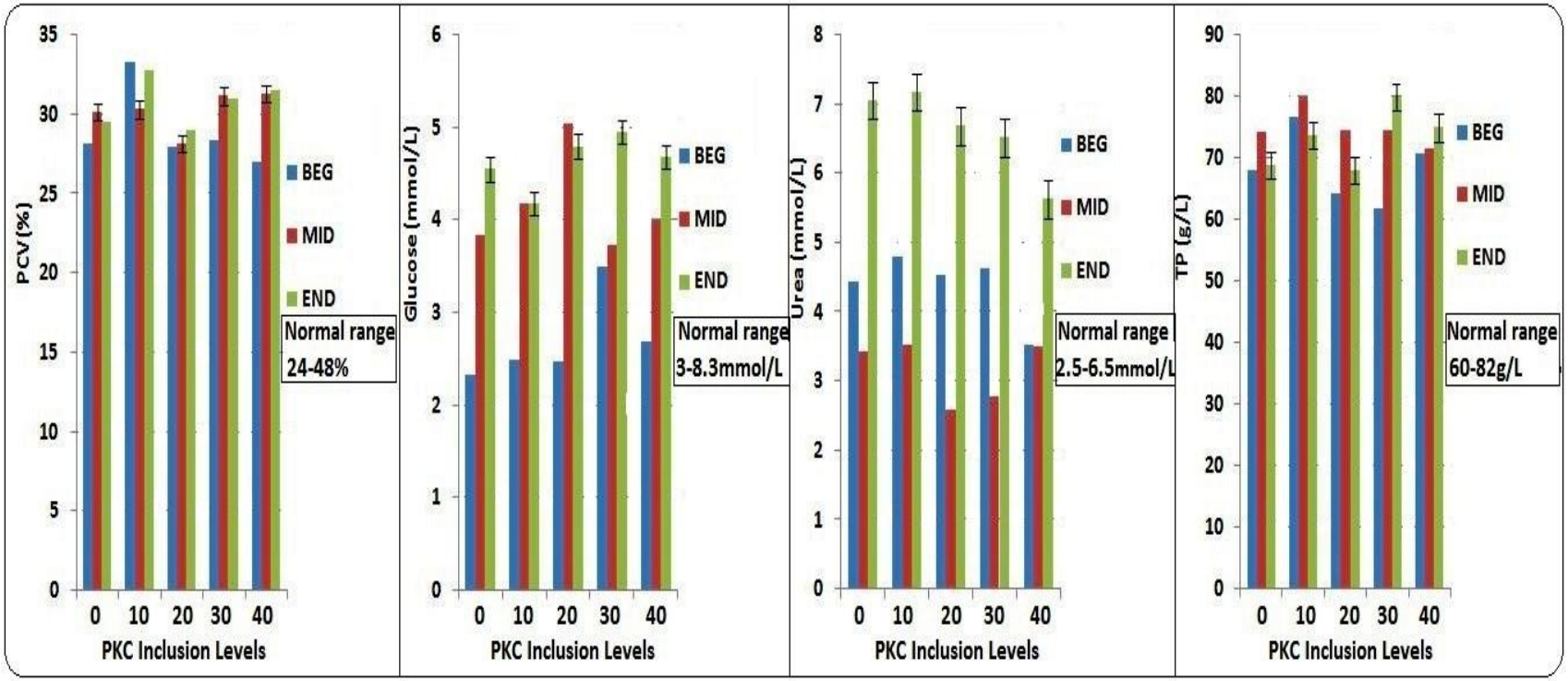


Fig 4.2. 5: Effect of Levels of Inclusion and Sampling Intervals on Packed Cell Volume and Some Biochemical Parameter of Weaner Bunaji Calves Fed Diets Containing Palm Kernel Cake.

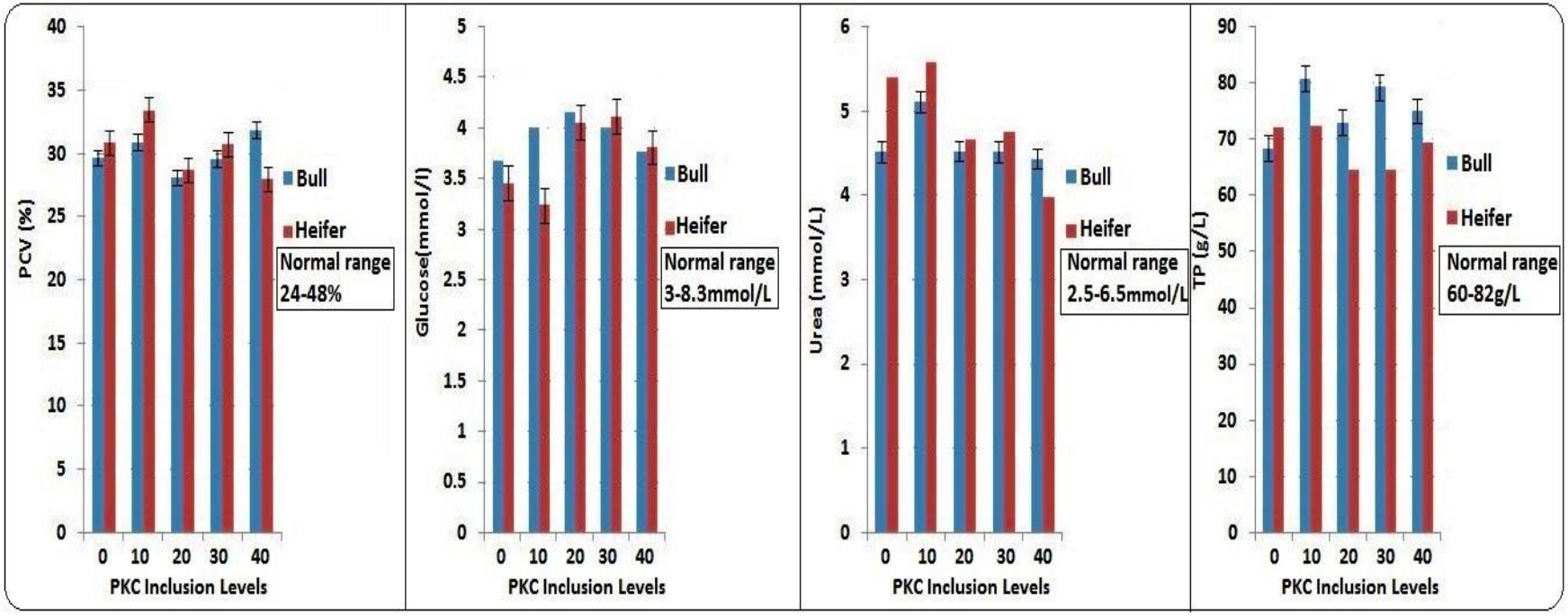


Fig 4.2.6: Effect of Sex and Levels of Inclusion on Packed Cell Volume and Some Biochemical Parameter of Weaner Bunaji Calves Fed Diets Containing Palm Kernel Cake

Effect of sex, levels of inclusion of palm kernel cake and sampling duration on Packed Cell Volume and Some biochemical parameter of weaner Bunaji calves is presented in Fig 4.2.7 and Fig 4.2.8 respectively. PCV is lowest for bulls (26%) at 40% PKC inclusion and highest for heifer (33.67%) at 10% PKC inclusion at the beginning of the experiment. At the middle of the experiment highest value was obtained for bull (35.33%) at 40% PKC inclusions while the lowest PCV value was obtained at 40% PKC inclusion for heifer (27.33%). The PCV value at the end of the experiment ranged from 28.67 -34.33% for bull weaners and 28.60-33.67%. Urea value ranged from 3.33-5.17mmol/l(40%PKC inclusion for bull weaner calves and 20%PKC inclusion for heifer weaner calves at the beginning of the experiment), 2.57-4.27mmol/l(20%PKC and 10%PKC for heifer weaner calves at the middle of the trials) and 4.57-7.77mmol/l(40%PKC inclusion for heifer weaner calves and 10%PKC inclusion for bull weaner calves at the end of the experiment).

4.2.6 Partial budget analyses of weaner Bunaji calves fed palm kernel cake

When sex was considered, there was significant difference ($P<0.05$) in all the parameters. The weaner bull calves have higher value than the heifers. Daily weight gain of 0.62 Kg and 0.44Kg was recorded for the bulls and heifers, Value of gain of ₦33720 and ₦ 23800, Net benefit of ₦ 18590 and ₦ 11263 for bull calves and heifers respectively as shown in Table 4.2.11.

Partial budget analyses of weaner Bunaji calves fed diets containing graded levels of palm kernel cake is presented in table 4.2.12. The highest daily weight gain (0.58kg) and value of gain ₦31,300 was obtained at 30%PKC inclusion which is statistically similar to the value (0.55kg and ₦29,900) obtained at 10% (0.50kg and ₦26,900) PKC inclusion. Net benefit was similar at 10% (₦14,777), 20% (₦14,464) and 40%(₦15, 276) PKC inclusion but differ at 0%

inclusion (₦12,104) though the highest value was obtained at 30%(=₦18,013) PKC inclusion (Table 4.2.12).

Table 4.2.13 shows Partial budget analyses of weaner bull and heifer Bunaji calves fed diets containing graded levels of palm kernel cake, there was significant difference (P<0.05) in all the parameters. The range of 0.38kg-0.65kg, ₦20,400-=₦35200, 969.27L-1286L,=₦10211.46-₦15532.65,=₦ 6790.67-=₦20642.47 and 0.49-1.55 for average weight gain, value of gain, total water intake, total cost of feed, net benefit and return to investment on feed respectively

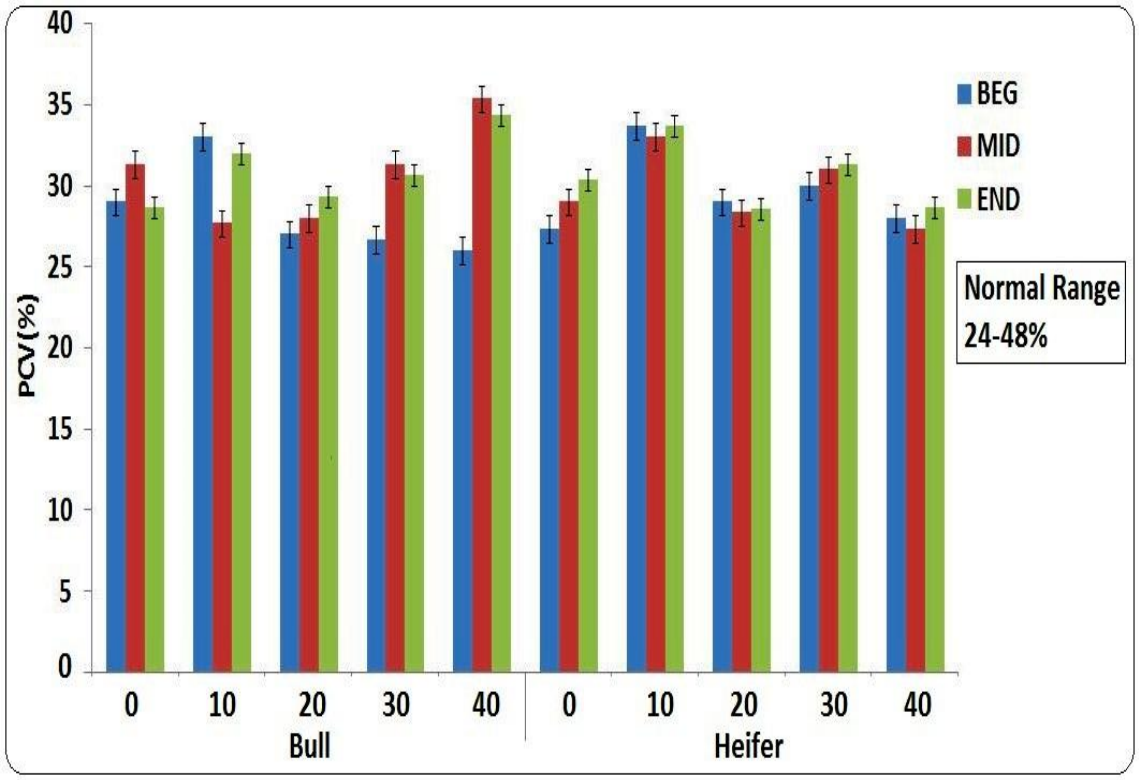


Fig 4.2. 7: Effect of Sex, Levels of Inclusion of Palm Kernel Cake and Sampling Durationon Packed Cell Volume

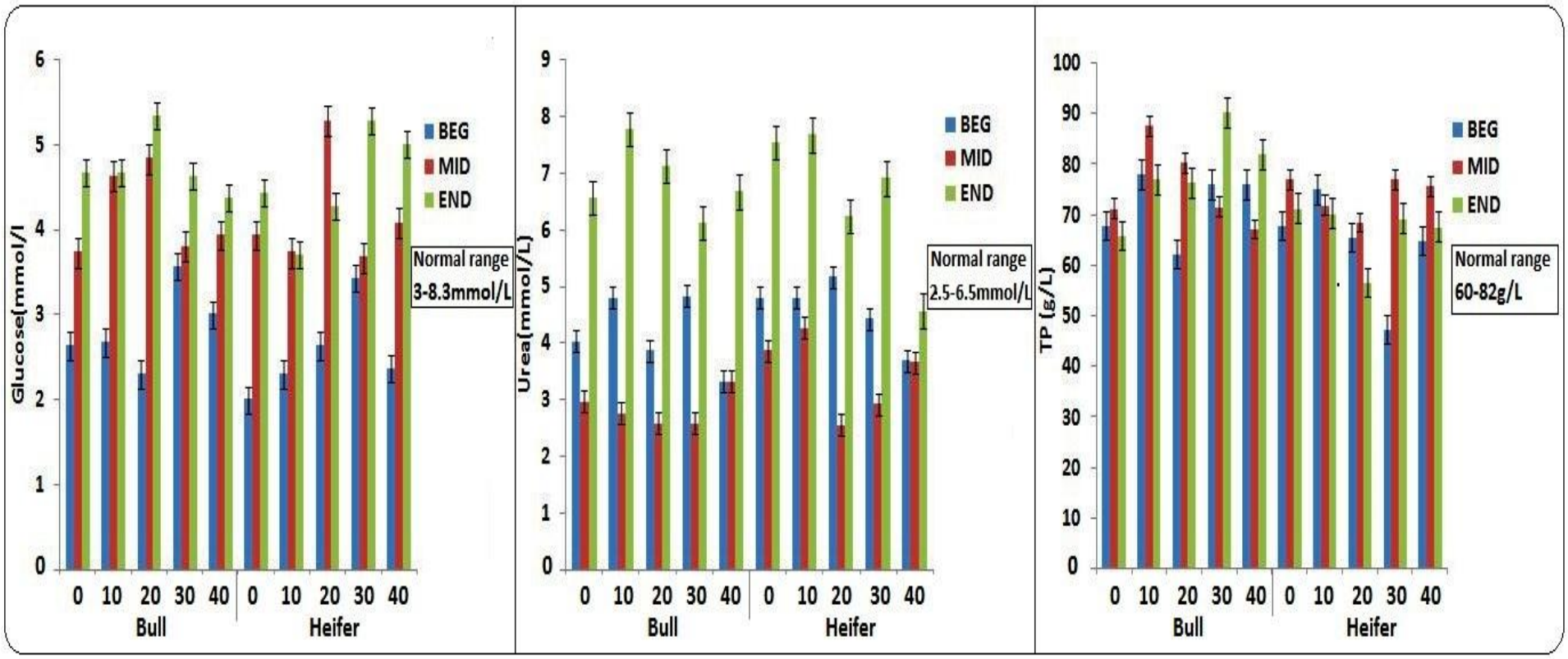


Fig 4.2. 8: Effect of Sex, Levels of Inclusion of Palm Kernel Cake and Sampling Duration on Some Biochemical Parameter of Weaner Bunaji Calves.

Table 4.2 11: Partial Budget Analyses of Bull and Heifer Bunaji Calves.

Parameter	Sex		
	Bull	Heifer	SEM
Total weight gain (Kg)	56.20 [a]	39.67 [b]	1.22
Daily weight gain (Kg)	0.62 [a]	0.44 [b]	0.02
Value of gain (₦)	33720 [a]	23800 [a]	891.07
Concentrate intake (Kg)	208.08 [a]	170.52 [b]	3.45
Hay intake (Kg)(*D. smutsii)*	208.70 [a]	173.61 [b]	3.51
Total feed intake (Kg)	413.96 [a]	341.87 [b]	6.88
Total water intake (Litres)	1200.49 [a]	1032.22 [b]	21.45
Total cost of concentrate consumed (₦)	6518.60 [a]	5346.30 [b]	112.66
Cost of hay consumed (₦)	7651.00 [a]	6364.6 [b]	128.50
Cost of feed consumed (₦)	14169.60 [a]	11710.90 [b]	238.83
Cost of water consumed(₦)	960.39 [a]	825.78 [b]	17.16
Total Cost of feed and water(₦)	15130.0 [a]	12536.6 [b]	251.99
Cost/ Kg gain (N/Kg gain)	322.86[a]	273.91	7.16
Net Benefit (₦)	18590	11263	790.81
Return to investment on feed (RIF)	1 .25 [a]	0 .91 [b]	0.06

[ab]means within the same row with different superscripts are significantly different (P<0.05), SEM=Standard Error of mean. , *Digitaria smutsii* hay=₦ 36.66/kg , price of water= ₦ 0.8/l, Price of weaner/liveweight=N600/kg. value of gain= total weight gain×N600,Net benefit=value of gain - total cost of feed and water consumed, Return to investment on feed-= net benefit/cost of feed and water

Table 4.2 12: Partial Budget Analyses of Weaner Bunaji Calves Fed Diets Containing Graded Levels of Palm Kernel Cake

Parameter	Level of inclusion(%)					
	0	10	20	30	40	SEM
Total weight gain (Kg)	44.83 [c]	49.83 [ab]	47.33 [bc]	52.17 [a]	45.50 [c]	1.49
Daily weight gain (Kg)	0.50 [c]	0.55 [abc]	0.53 [bc]	0.58 [a]	0.51 [c]	0.02
Value of gain (₦)	26900 [c]	29900 [ab]	28400 [bc]	31300 [a]	27300 [c]	891.07
Concentrate intake (Kg)	178.99 [c]	195.43 [a]	192.02 [ab]	194.05 [a]	186.02 [b]	3.45
Hay intake (Kg)	183.23 [b]	196.49 [a]	192.01 [a]	194.52 [a]	189.53 [a]	3.51
Total feed intake (Kg)	359.82 [c]	389.30 [a]	381.49 [ab]	385.96 [ab]	373.02 [bc]	6.88
Total water intake (Litres)	1102.11 [b]	1149.66 [a]	1079.40 [c]	1155.52 [a]	1095.08 [c]	21.45
Total cost of concentrate consumed (₦)	7197.00 [a]	7000.30 [a]	6033.30 [b]	5231.5 [c]	4200.2 [d]	112.66
Cost of hay consumed (₦)	6717.2 [b]	7203.3 [a]	7039.2 [a]	7131.1 [a]	6948.2 [ab]	128.50
Cost of feed consumed (₦)	13914.10 [a]	14203.60 [a]	13072.50 [b]	12362.60 [c]	11148.40 [d]	238.83
Cost of water consumed(₦)	881.69	919.73	863.52	924.41	876.07	171.16
Total Cost of feed and water(₦)	14795.80 [a]	15123.30 [a]	13936.00 [b]	13287.00 [c]	12024.5 [d]	251.99
Cost of concentrate/Kg (₦)	40.21	35.82	31.43	26.96	22.58	
Cost/ Kg gain (₦/Kg gain)	353.68	305.40	301.96	258.80	272.09	
Net Benefit (₦)	12104.00 [c]	14777.00 [b]	14464.00 [b]	18013.00 [a]	15276 [b]	790.81
Return to investment on feed (RIF)	0.78 [d]	0.98 [c]	1.01 [bc]	1.36 [a]	1.26 [a]	0.06

[abcd] means within the same row with different superscripts are significantly different (P<0.05) SEM=Standard Error of mean. , *Digitaria smutsii* hay=₦ 36.66/kg , price of water= ₦ 0.8/l, Price of weaner/liveweight=N600/kg. value of gain= total weight gain×N600,Net benefit=value of gain - total cost of feed and water consumed, Return to investment on feed-= net benefit/cost of feed and water

Table 4.2 13: Partial Budget Analyses of Weaner Bull and Heifer Bunaji Calves Fed Diets Containing Graded Levels Of PKC

	Sex and level of inclusion										
	Bull					Heifer					
Parameter	0	10	20	30	40	0	10	20	30	40	SEM
TWG (Kg)	55.67 ^{ab}	54.33 ^{b}	57.67 ^{ab}	58.67 ^{a}	54.67 ^{ab}	34.00 ^{d}	45.33 ^{c}	37.00 ^{d}	45.67 ^{c}	36.33 ^{d}	2.08
AWG(Kg)	0.62 ^{ab}	0 .60 ^{b}	0.64 ^{ab}	0.65 ^{a}	0.61 ^{ab}	0.38 ^{d}	0.50 ^{c}	0.41 ^{d}	0.51 ^{c}	0.40 ^{d}	0.02
V G (₦)	33400 ^{ab}	32600 ^{b}	34600 ^{ab}	35200 ^{a}	32800 ^{ab}	20400 ^{d}	27200 ^{c}	22200 ^{d}	27400 ^{c}	21800 ^{d}	1249.31
`CI (Kg)	194.03 ^{b}	213.93 ^{a}	215.91 ^{a}	214.42 ^{a}	202.10 ^{b}	163.94 ^{d}	176.93 ^{c}	168.13 ^{cd}	173.67 ^{c}	169.93 ^{cd}	4.69
HI (Kg)	196.81 ^{b}	214.66 ^{a}	213.90 ^{a}	212.95 ^{a}	205.18 ^{b}	169.65 ^{c}	178.31 ^{c}	170.13 ^{c}	176.09 ^{c}	173.88 ^{c}	4.48
TFI (Kg)	388.24 ^{b}	425.72 ^{a}	353.87 ^{c}	426.94 ^{a}	424.46 ^{a}	331.39 ^{d}	352.87 ^{c}	336.04 ^{cd}	347.46 ^{c}	341.58^{cd}	9.08
TWI (Litres)	1193.98 ^{a}	1286.22 ^{a}	1189.53 ^{b}	1212.37 ^{b}	1120.33 ^{c}	1010.23 ^{d}	1013.10 ^{d}	969.27 ^{d}	1098.67 ^{c}	1069.83 ^{c}	25.43
TCC (₦)	7802.08 ^{a}	7663.09 ^{a}	6783.79 ^{b}	5780.76 ^{c}	4563.42 ^{d}	6591.89 ^{b}	6337.51 ^{b}	5282.75 ^{c}	4682.14 ^{d}	3837.02 ^{e}	253.43
Cost of hay(₦)	7215.05 ^{c}	7869.56 ^{a}	7841.51 ^{ab}	7806.87 ^{ab}	7521.90 ^{b}	6219.25^{d}	6536.97^{d}	6236.97 ^{d}	6455.34 ^{d}	6374.44 ^{d}	164.32
Cost of feed (₦)	15017.13 ^{ab}	15532.65^{a}	14625.30 ^{b}	13587.63 ^{c}	12085.32 ^{e}	12811.14^{de}	12874.48	11519.72 ^{ef}	11137.48 ^{f}	10211.46 ^{g}	367.50
CW(₦)	955.19 ^{b}	1028.97 ^{a}	951.62 ^{b}	969.89 ^{b}	896.27 ^{c}	808.19^{d}	810.48^{d}	775.41 ^{d}	878.93 ^{c}	855.87 ^{c}	20.34
TCF and W(₦)	15972.32^{ab}	16561.62^{a}	15576.92 ^{b}	14557.53 ^{c}	12981.58^{de}	13619.33^{d}	13684.96^{d}	12295.13^{ef}	12016.41 ^{f}	12016.41 ^{f}	382.35
C/Kg G(₦/Kg gain)	301.097 ^{c}	306.94^{c}	271.28 ^{d}	251.54 ^{de}	238.70 ^{e}	406.26 ^{a}	303.85^{c}	332.65 ^{b}	266.05 ^{d}	305.47 ^{c}	10.30
Net Benefit (₦)	17427.68^{bc}	16038.38^{c}	19023.08^{ab}	20642.47^{a}	19818.42	6780.67^{f}	13515.04^{d}	9904.87^{e}	15383.59^{c}	10732.67^{e}	1046.03
RIF	1.07 ^{c}	0.97 ^{c}	1.23 ^{b}	1.44 ^{a}	1.55 ^{a}	0.49 ^{e}	0.98 ^{c}	0.81 ^{d}	1.29 ^{b}	0.97 ^{c}	0.07

where TWG=total weight gain, AWG =average weight gain, VG=value of gain, CI=concentrate intake, HI=hay intake,TFI= total feed intake, TWI= total water intake,TCC= total cost of concentraate, CW=cost of water, TCF and W= total cost of feed and water, CC/Kg = cost of concentrate /kilogram, C/ Kg G = cost per Kg gain, RIF = return to investment on feed. ^{abcde} means within the same row with different superscripts are significantly different (P<0.05) SEM=Standard Error of mean. *Digitaria smutsii* hay=₦ 36.66/kg , price of water= ₦ 0.8/l, Price of weaner/liveweight=N600/kg. value of gain= total weight gain×N600,Net benefit=value of gain - total cost of feed and water consumed, Return to investment on feed-= net benefit/cost of feed and water

4.3 EXPERIMENT 2: Effect of feeding diets containing graded levels of Palm Kernel Cake on the growth performance of Bunaji yearling Bulls

4.3.1 Chemical compositions of concentrate diets containing varying levels of palm kernel cake fed to yearling Bunaji bulls

Table 4.3.1 shows the chemical composition of concentrate diets containing graded levels of Palm kernel cake fed to growing Bunaji yearling bulls. The DM values ranged from 97.74 to 98.8% with diets containing 0% PKC inclusion having the lowest (97.74%) and 20% PKC inclusion diets having the highest (98.8%). The CP ranged from 14.19 to 17.75%, the crude fibre values ranged from 26.36 to 38.77% with 40% PKC inclusion having the highest crude fibre. The ether extract ranged from 11.36- 18.41% while ash ranged from 6.4 -7.46%. The ADF and NDF ranged from 27.27-36.45% and 44.52-57.78% respectively. The Hemicellose (HC) values ranged from 12.79- 24% while GE ranged between 13.47-15.71 MJ/KgDM and ME ranged from 11.79- 11.81 MJ/KgDM.

4.3.2 Effect of level of PKC inclusion on the performance of yearling Bunaji.

There was significant difference ($P<0.05$) on the performance of animals fed diets containing graded levels of PKC in some of the parameters measured (Table 4.3.2). The average concentrate intake (ACI) ranged from 2.71 -2.81Kg/day and the hay intake ranged from 2.27 - 2.79Kg/day. Average feed intake (AFI) and average dry matter intake (ADMI) were not significant ($P>0.05$) across treatment. The average weight gain (AWG) range from 0.66 - 0.75Kg/day. Animals on diets containing 0% PKC have an average weight gain of 0.75Kg/day which is the highest,0.70Kg/day which is same for both 10 and 40%, 0.66 and 0.68Kg/day for 20 and 30% though no significant difference ($P>0.05$) in weight gain between animals on 10,20,30% and 40%PKC inclusion. The Feed conversion ratio ranged from 7.11-8.08.

Table 4.3 1: Chemical Compositions of Concentrate Diets Containing Varying Levels of Palm Kernel Cake Fed to Yearling Bunaji Bulls

Parameter (%)	Levels of inclusion(%)				
	0	**10**	**20**	**30**	**40**
Dry Matter	97.74	97.81	98.25	98.13	98.8
Crude Protein	17.75	15.82	17.44	17.44	14.19
Crude Fibre	26.50	26.36	29.35	34.93	38.77
Ether Extract	18.41	20.57	13.31	12.46	11.36
Ash	6.43	6.79	7.46	6.75	6.40
Neutral Detergent Fibre	44.52	52.64	49.24	57.78	54.46
Acid Detergent Fibre	27.27	33.92	36.45	33.78	32.85
Hemi Cellulose	17.25	18.72	12.79	24.00	21.61
GE(MJ/KgDM)	14.86	14.36	13.47	14.34	15.71
ME(MJ/KgDM)	11.81	11.80	11.80	11.81	11.79

Where ME = Metabolizable energy, GE= Gross energy DM = Dry matter, CP = Crude protein, EE = Ether Extract, CF = Crude fibre and A = Ash.,„NDF=neutral detergent fiber, ACF=Acid detergent fiber,HC=hemicellulose. ME=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.

Table 4.3 2: Effect of Feeding Diet Containing Varying Levels of Palm Kernel Cake on Performance of Yearling Bunaji Bulls.

Parameter	Levels of inclusion(%)					
	0	**10**	**20**	**30**	**40**	**SEM**
Initial weight(Kg)	119.00	124.25	122.50	118.75	122.25	2.84
Final weight(Kg)	186.75	187.25	182.00	180.25	185.50	4.49
ACI(kg/day)	2.76 [b]	2.81 [a]	2.72 [bc]	2.71 [c]	2.81 [a]	0.02
AHI(kg/day)	2.71 [a]	2.78 [a]	2.68 [a]	2.27 [b]	2.79 [a]	0.07
ATFI (kg/day)	5.47	5.58	5.40	5.38	5.61	0.14
ADMI(kg/day)	5.35	5.46	5.30	5.28	5.54	0.14
AWI(L/day)	16.51 [a]	15.88 [ab]	15.61 [b]	16.51 [a]	16.43 [a]	0.32
AWG(kg/day)	0.75 [a]	0.70 [b]	0.66 [b]	0.68 [b]	0.70 [b]	0.02
FCR	7.11[a]	7.85[b]	8.08[b]	7.80[b]	7.98[b]	0.17

[abcd] means within the same row with different superscripts are significantly different (P<0.05).
where ACI=average concentrate intake, AHI=average hay intake, AFI=average feed intake, ADMI=average dry matter intake,AWI=average water intake, AWG=average weight gain, FCR=feed conversion ratio, SEM=Standard Error of mean, l=litre

4.3.3 Apparent nutrient digestibility of diets containing graded levels of Palm Kernel Cake fed to Bunaji yearling Bulls

The apparent nutrient digestibility of diets containing graded levels of PKC fed to Bunaji yearling Bulls is shown in Table 4.3.3. The dry matter digestibility ranged from 58.06% - 67.42%. There was significant difference ($P<0.05$) in crude protein digestibility and it ranged from 56.30% -69.11%. CF digestibility ranged from 51.70% to 67.48%. EE digestibility was highest in animals fed diets containing 40% inclusion of PKC and lowest in animals on 20% inclusion of PKC in their diet. There was significant difference ($P<0.05$) in ADF and NDF digestibility for animals fed diets containing graded levels of PKC with those fed 40% PKC diets having the highest digestibility values though statistically similar to those fed 30%PKC.

DM, CP, CF, EE, NDF, ADF and Hemicellulose ranged from 62.13-67.42,56.30-69.11,51.70-67.48,61.02-76.00, 56.53-74.14,42.03-66.39 and 75.98-88.10 respectively.

4.3.4 Nitrogen balance of Bunaji yearling Bulls fed graded levels of PKC

The result of nitrogen balance study is presented in Table 4.3.4. Total Nitrogen intake was significantly affected by inclusion level of PKC. Statistically similar value for nitrogen intake was observed in Bulls consuming diet containing 0% and 40% inclusion level of Palm Kernel Cake and the lowest on those on 20%PKC. The result showed a decrease in faecal nitrogen loss as the level of PKC increased in the diets. Urinary nitrogen loss was higher in the control than treatments with PKC. Nitrogen retained ranged from 70.06-93.78 g/day with the highest nitrogen retention value obtained for animals on diets containing 40% PKC inclusion.

Table 4.3 3: Effect of Feeding Diet Containing Varying Levels of Palm Kernel Cake on the Apparent Digestibilityof yearling Bunaji bulls.

Apparent digestibility(%)	Level of inclusion(%)					
	0	**10**	**20**	**30**	**40**	**SEM**
Dry Matter	62.13^{b}	62.15^{b}	58.06^{c}	65.33^{a}	67.42^{a}	1.20
Crude Protein	59.10^{b}	56.30^{b}	57.73^{b}	67.26^{a}	69.11^{a}	1.65
Crude Fibre	51.70^{d}	62.87^{b}	59.00^{c}	65.90^{ab}	67.48^{a}	1.83
Ether Extract	70.59^{b}	71.48^{b}	61.02^{c}	72.40^{b}	76.00^{a}	1.50
Ash	26.92^{b}	27.29^{b}	36.80^{a}	34.38^{a}	40.51^{a}	3.46
Neutral Detergent Fibre	58.29^{bc}	61.53^{b}	56.53^{c}	70.73^{a}	74.14^{a}	2.45
Acid Detergent Fibre	47.86^{bc}	51.93^{b}	42.03^{c}	59.77^{a}	66.39^{a}	3.70
Hemi Celloluse	75.98^{c}	78.78^{b}	88.10^{a}	88.16^{a}	86.46^{a}	1.30

Where DM = Dry matter, CP = Crude protein, EE = Ether Extract, CF = Crude fibre and A = Ash. SEM=Standard Error of mean, ^{abcd} means within the same row with different superscripts are significantly different (P<0.05)

Table 4.3 4: Effect of Feeding Diet Containing Varying Levels of Palm Kernel Cake on the Nitrogen Balance of Yearling Bunaji Bulls.

Nitrogen balance	Levels of inclusion(%)					
	0	**10**	**20**	**30**	**40**	**SEM**
Nitrogen intake (g/day)	140.82[a]	129.06[bc]	123.92[c]	131.44[b]	138.55[a]	3.36
Urinary Nitrogen (g/day)	2.16[a]	2.01[b]	1.26[e]	1.71[c]	1.41[d]	0.05
Faecal Nitrogen (g/day)	57.68[a]	56.17[a]	52.60[a]	43.97[bc]	43.36[c]	3.01
Total Nitrogen Output (g/day)	59.83[a]	58.18[a]	53.87[a]	45.68[bc]	44.77[c]	2.98
Nitrogen Retained (g/day)	80.99[c]	70.88[d]	70.06[d]	85.76[b]	93.78[a]	1.97
Nitrogen Retained (%N-intake)	57.57[b]	54.73[b]	56.70[b]	65.92[a]	68.08[a]	1.63

SEM=Standard Error of mean, [abcd] means within the same row with different superscripts are significantly different (P<0.05)

4.3.5 Effect of palm kernel cake on the rumen metabolite of yearling Bunaji bulls

Figure 4.3.1 shows the effect of sampling time on the rumen metabolite of yearling Bunaji bulls fed graded level of palm kernel cake. There was significant differences ($P<0.05$) at differrent sampling time across all the rumen metabolites measured. The lowest rumen pH recorded in this study is 6.66 at 3 hours post feeding and the highest was 7.08 at 0 hr before feeding.

Rumen ammonia nitrogen recorded in this study ranged from 8.25-10.44 mg/100ml with the highest value at 0hr before feeding and lowest value at 6 hours post feeding. TVFA obbserved in the study ranged from 25.95-34.10 µmol/l, its lowest at 0hr before feeding, it increased from 25.95 at ohr before feeding to 30.15 at 3 hrs post feeding, it reaches a peak at 6 hrs post feeding (34.10) then it drops to 28.80 at 9hrs post feeding.

Effect of levels of inclusion of palm kernel cake on the rumen metabolite of yearling Bunaji bulls is shown in figure 4.3.2. Rumen pH ranged between 6.89 -6.92 though there was no significant difference ($P>0.05$) across treatment. Rumen ammonia Nitrogen ranged between 8.41-10.15 mg/100ml, its highest at 30% PKC (10.15 mg/100ml) and lowest (8.41 mg/100ml) for animals on diets without PKC inclusion. Rumen TVFA was similar for animals on diets containing 10% (31.06 µmol/l) and 40% (31.31 µmol/l) PKC levels and the lowest value was obtained for the control (27.81 µmol/l).

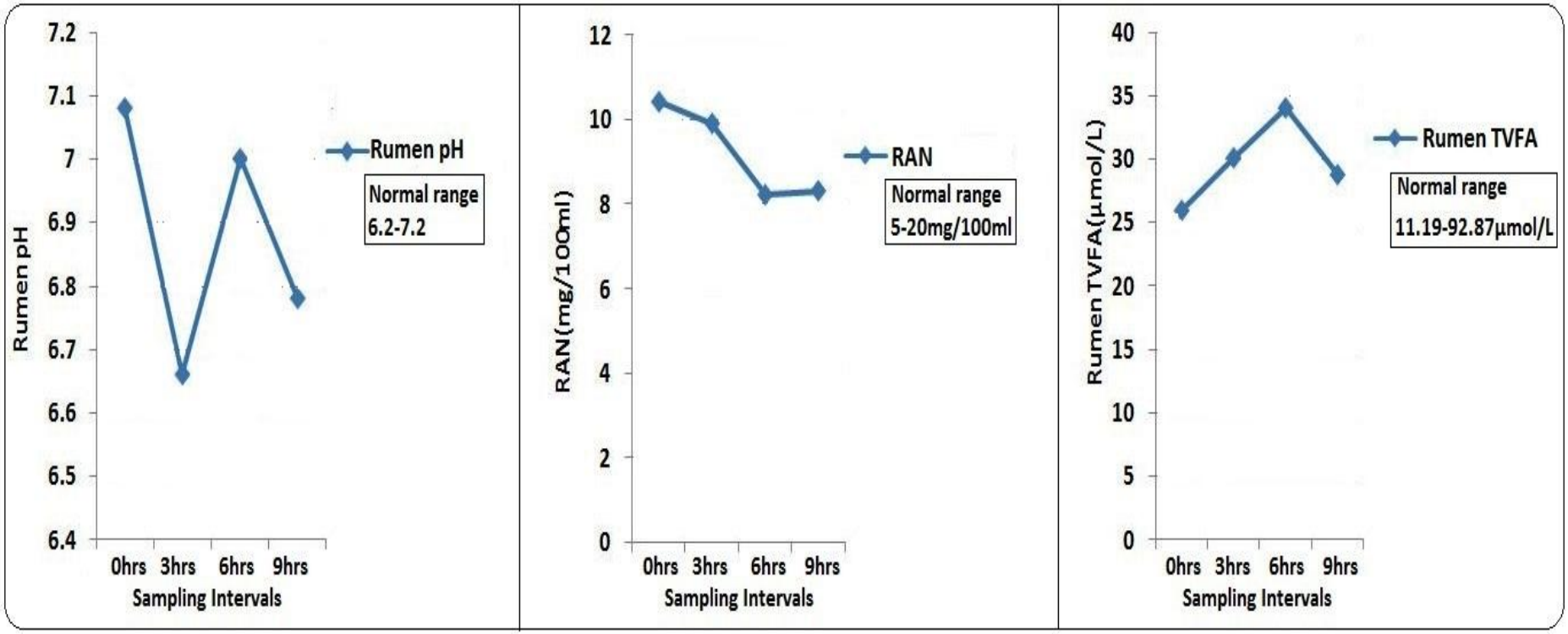


Fig 4.3. 7: Effect of Sampling Time on the Rumen Metabolite of Yearling Bunaji Bulls Fed Graded Levels of Palm Kernel Cake

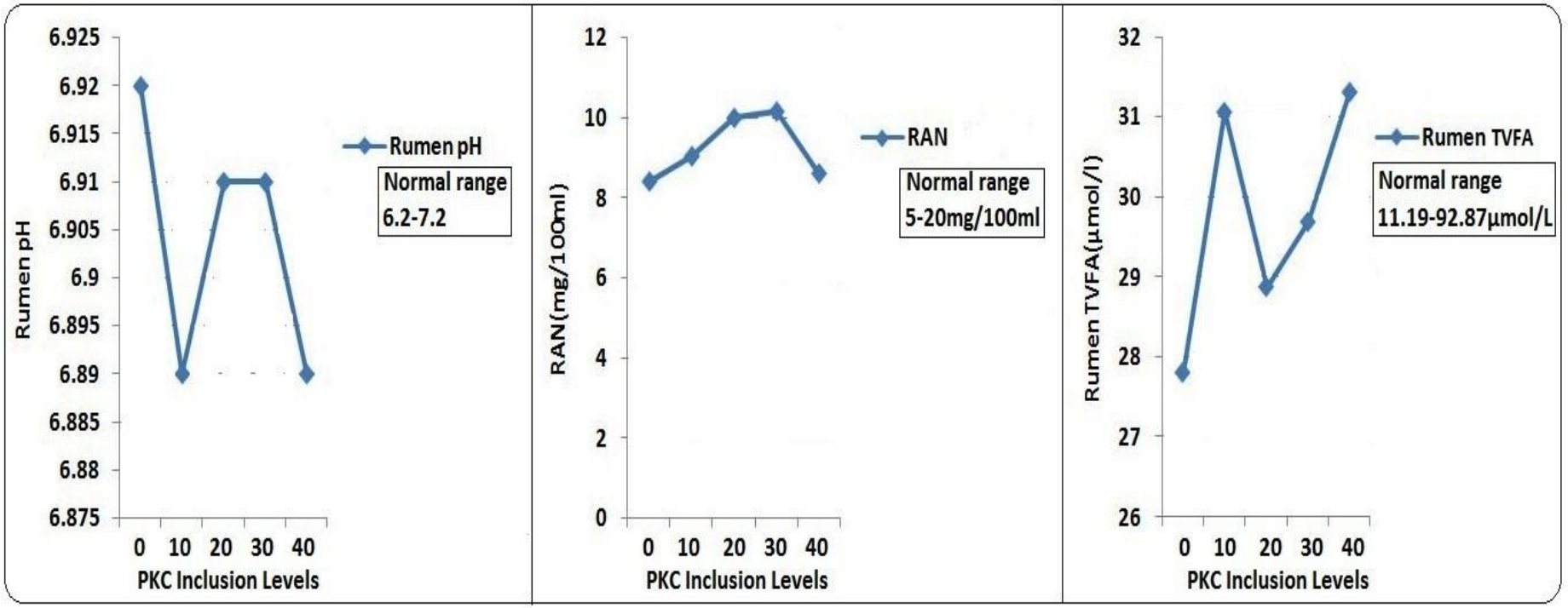


Fig 4.3. 8:Effect of Levels of Inclusion of Palm Kernel Cake on The Rumen Metabolite of Yearling Bunaji Bulls

Figure 4.3.3 shows the effect of levels of inclusion and sampling interval on the rumen metabolite of yearling Bunaji bulls fed diets containing palm kernel cake. There was no significant difference (P>0.05) in rumen pH across treatment at 0hr before feeding. At 3hrs post feeding, animals on 0 and 30% PKC inclusion have similar pH values but differ from those on diets containing 10, 20 and 40% PKC inclusion. At 6hrs post feeding, rumen pH was similar for animals on 0, 10 and 40% but differs for animals on 20 and 30% PKC inclusions. The highest pH was obtained for animals on 20% which differs significantly (P< 0.05) with those on 0, 10, 30 and 40% PKC inclusions at 9 hrs post feeding. Rumen ammonia nitrogen recorded in this study ranged from 9.56-11.65, 6.90-12.22, 7.41-9.92 and 7.26-10.34 for 0, 3, 6 and 9 hours respectively. TVFA in this study ranged from 21.75-27.75, 26.25-34.00, 29.00-37.50 and 26.25-34.00 for 0, 3, 6 and 9 hours respectively.

4.3.6 Effect of palm kernel cake on Packed Cell Volume and Some biochemical parameter of yearling Bunaji bulls

The result of the effect of levels of inclusion on haematological and biochemical parameter of yearling Bunaji bulls fed diets containing palm kernel cake is presented in figure 4.3.4. There was significant difference (P< 0.05) among treatment for all the haematogical and biochemical parameter measured. Packed Cell Volume ranged from 28.08-30.42%, Glucose ranged from 3.76-4.97mmol/L,Urea ranged 3.60-4.43mmol/L, highest urea value was obtained at 0% PKC inclusion, animals on diets containing 20,30 and 40%PKC where statistically similar (P>0.05) , Total protein ranged from 70.83 - 78.92 g/l highest value was obtained at 30% PKC inclusion, animals on diets containing 10% and 20%PKC where statistically similar (P>0.05) but differ from 40%.

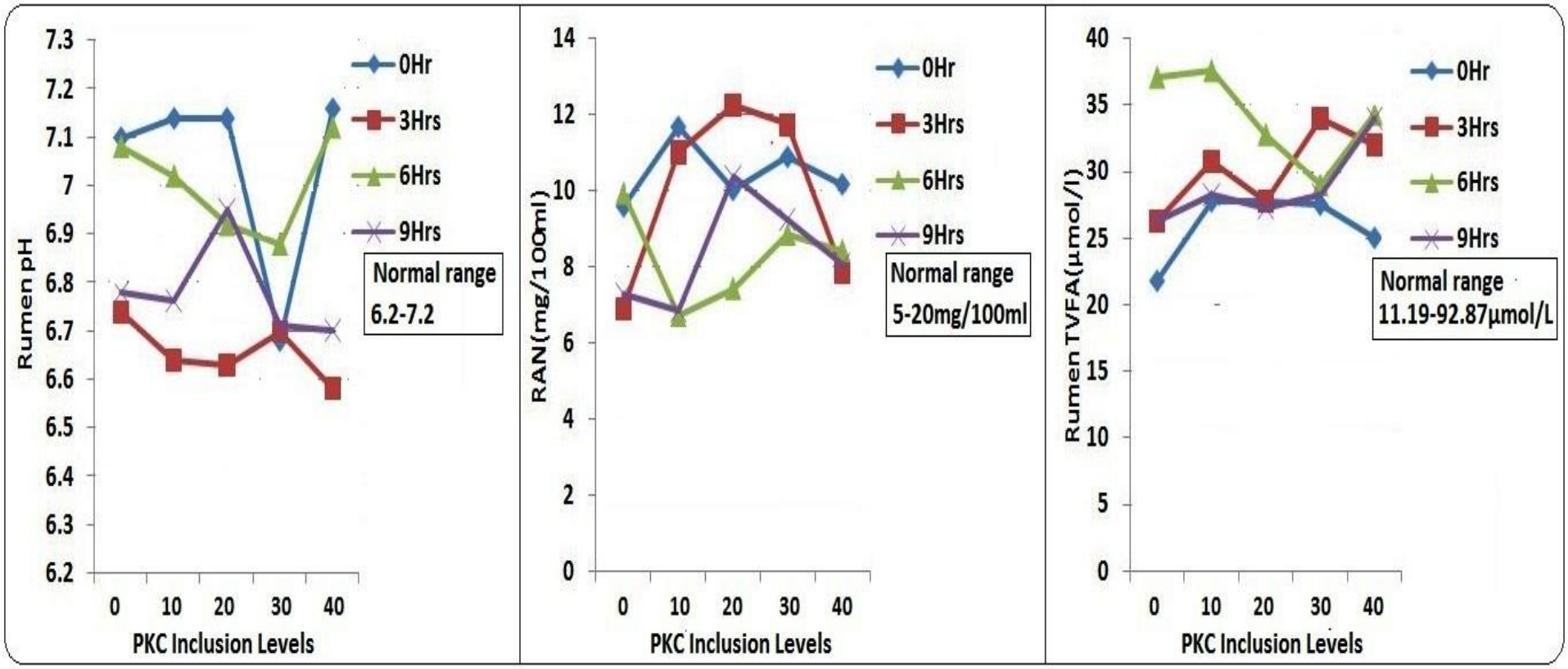


Fig 4.3. 9: Effect of Levels of Inclusion and Sampling Interval on the Rumen Metabolite of Yearling Bunaji Bulls Fed Diets Containing Palm Kernel Cake.

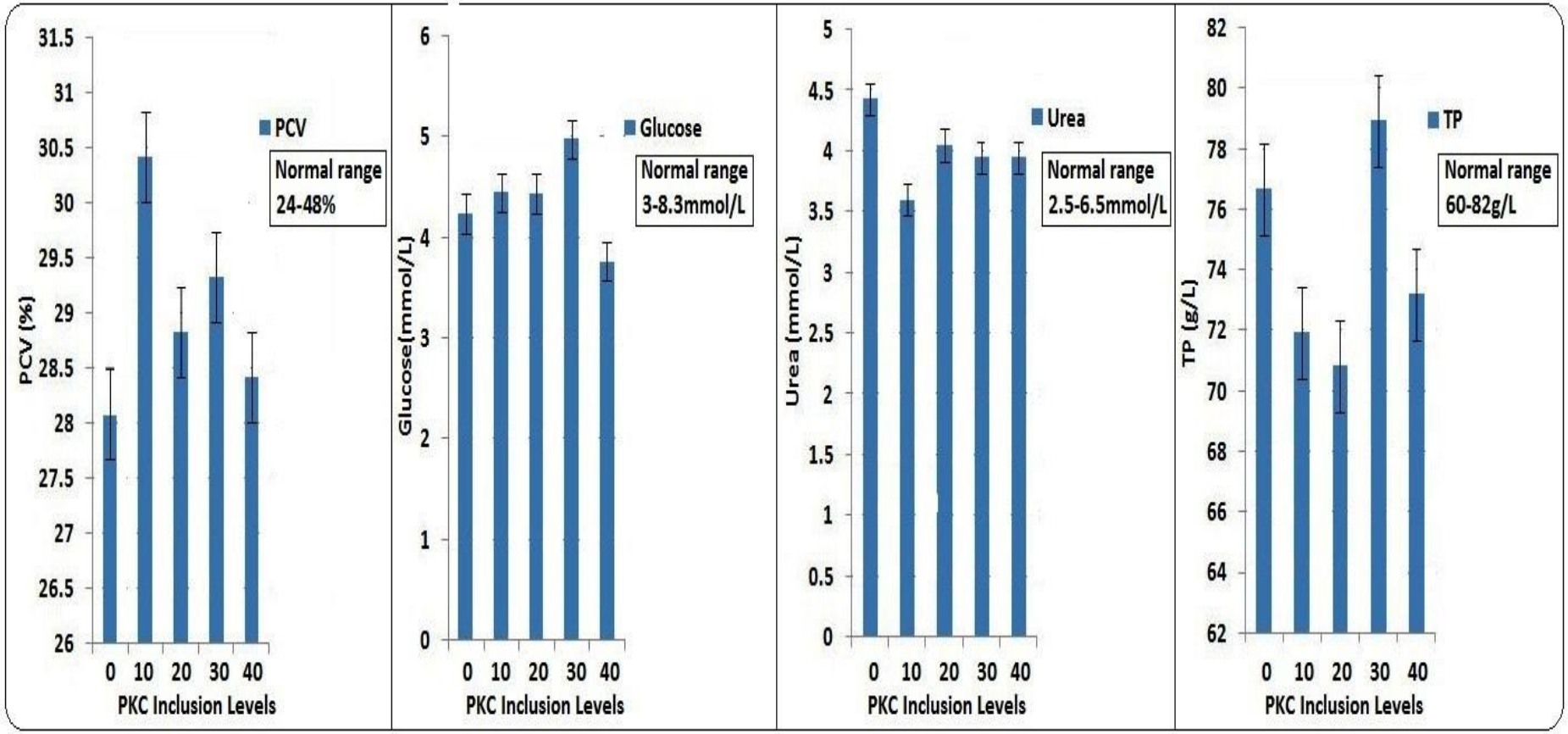


Fig 4.3. 10: Effect of levels of inclusion on Packed Cell Volume and Some biochemical parameter of yearling Bunaji bulls fed diets containing Palm Kernel Cake.

Figure 4.3.5 shows the effect of sampling interval on packed cell volume and some biochemical parameter of yearling Bunaji bulls fed graded level of palm kernel cake. The packed cell volume (PCV) ranged from 28.85-29.25%, glucose (2.61-5.49mmol/l), urea (2.74-5.90mmol/l) and Total protein (TP) of 69.45-78.25 g/l were significantly difference ($P< 0.05$) at the different sampling intervals.

Effect of level of inclusion and sampling intervals on packed cell volume and some biochemical parameter of yearling Bunaji bulls fed diets containing PKC is presented in figure 4.3.6. PCV was highest at the beginning of the experiment at 10%PKC inclusion (31.25) but was similar statistically at 0%, 20%,30% and 40% PKC inclusion. At the middle of the experiment, the PCV was similar at 0% and 30%PKC but differ from the value obtained at 20% and 40%PKC levels while the lowest value (27.25) was obtained for animals on control diets. The PCV at the end of the trial ranged from 28.00 -29.50.

The glucose value for the animals on diets containing varying levels of PKC ranged from 2.23-3.18mmol/l, 3.75-6.63mmol/l and 4.28-5.55mmol/l at beginning, middle and end of the experiment respectively. The urea value ranged from 2.65-3.90, 2.20-3.45, 5.50-7.18mmol/l for beginning, middle and end of the experiment respectively. Highest urea value was obtained for animals on control diets at the middle and end of the experiment. Total protein (TP) was significantly different ($P< 0.05$) among treatment and at different sampling time. TP ranged from 66.00-77g/l, 71.00-78.25g/l, 66.00-90.75g/l at beginning, middle and end of the experiment respectively.

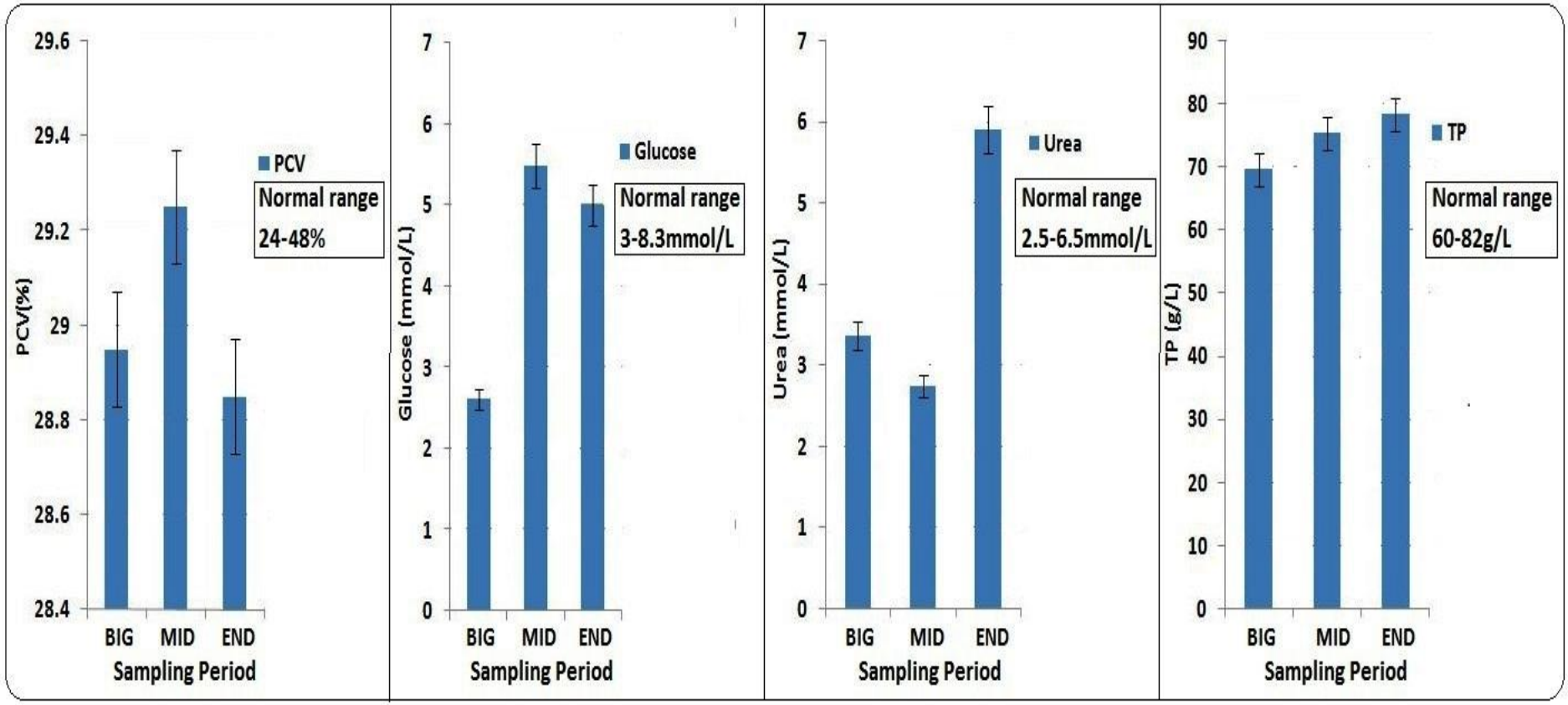


Fig 4.3. 11: Effect of sampling interval on Packed Cell Volume and some biochemical parameter of yearling Bunaji bulls fed graded level of palm kernel cake

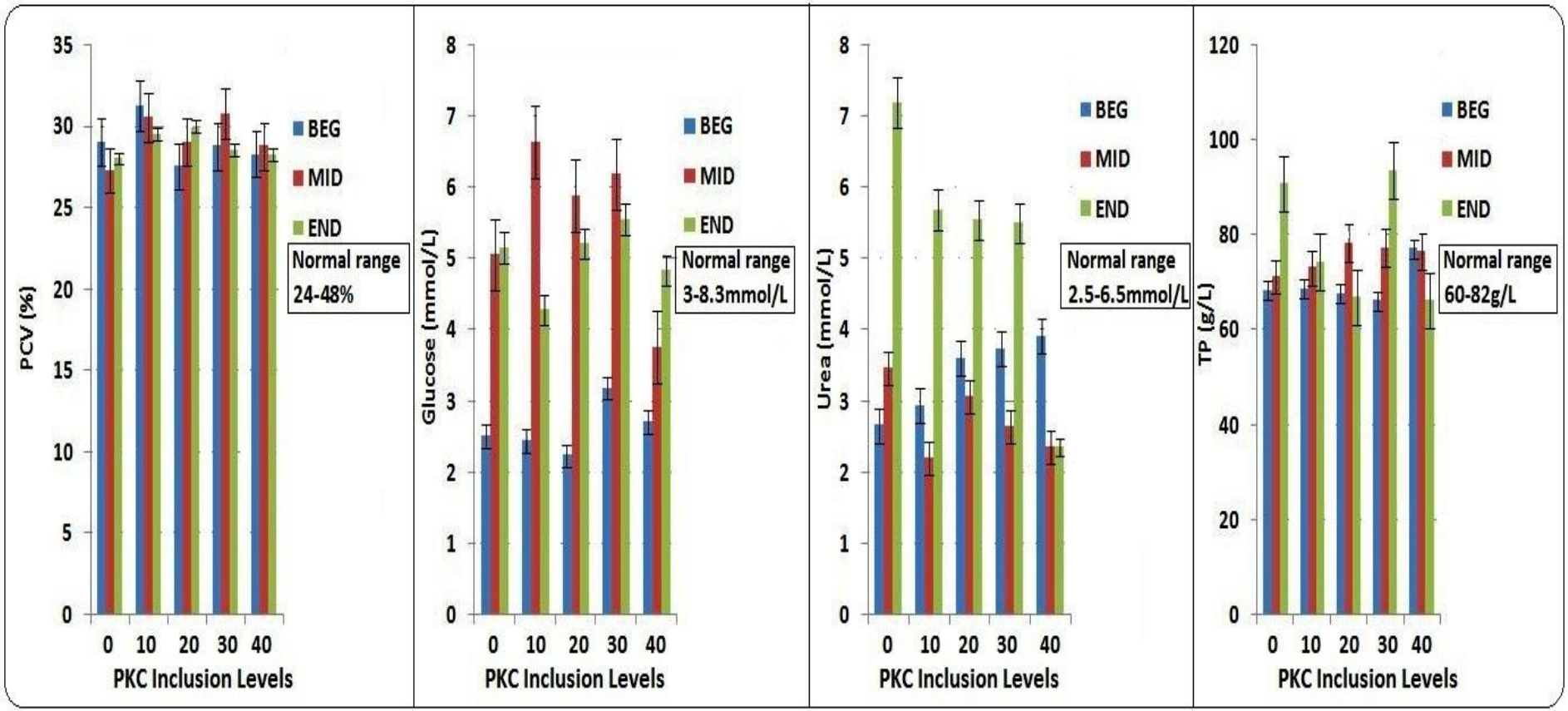


Fig 4.3. 12: Effect of level of inclusion and sampling intervals on packed cell volume and some biochemical parameter of yearling Bunaji bulls fed diets containing PKC

4.3.7 Partial budget analyses of yearling Bunaji bulls fed diet containing varying levels of palm kernel cake

The result of this study presented in table 4.3.5 shows that feed cost (concentrate) in ₦/kg declined with increase in PKC levels from ₦40.21/kg to ₦22.58/kg. The feed cost to gain ratio was higher at 10% inclusion level (₦ 299.75/ Kg live weight gain) and lowest at 40% PKC inclusion level (₦ 249.70/Kg live weight gain) which implies that the 40% inclusion was economically better than the control. The net benefits were ₦21052.00, ₦19039.00, ₦18585.00, ₦20835.00 and ₦22341.00 for feeding Bunaji yearling Bulls on 0, 10, 20, 30 and 40% PKC diets respectively. Net benefit was higher in the diets with 40% inclusion levels of PKC though statistically similar at 0 and 30%PKC inclusion. Average weight gain and Value of gain was highest for animals on 0% while those on 10,20,30 and 40% are statistically similar($P>0.05$).

Table 4.3 5: Partial Budget Analyses of Yearling Bunaji Bulls Fed Diets Containing Graded Levels of Palm Kernel Cake.

Parameter	Level of inclusion					
	0	10	20	30	40	SEM
TWG (Kg)	67.75 [a]	63.00 [b]	59.50 [b]	61.50 [b]	63.25 [b]	2.12
AWG(Kg)	0.75 [a]	0.70 [b]	0.66 [b]	0.68 [b]	0.71 [b]	0.02
V G (₦)	40650.00 [a]	37800.00 [b]	35700.00 [b]	36900.00 [b]	37950.00 [b]	1272.56
CI (Kg)	248.68	252.48	244.70	243.74	253.04	6.10
HI (Kg)	243.93	250.05	240.71	240.25	251.94	6.27
TFI (Kg)	492.61	502.54	485.41	483.91	504.98	12.37
TWI (Litres)	1485.72 [a]	1428.83 [a]	1404.51 [b]	1486.01 [a]	1478.51 [a]	28.64
TCC (₦)	9467.30 [a]	8450.60 [b]	7167.20 [c]	6069.10 [d]	5189.90 [e]	159.61
Cost of hay(₦)	8942.50	9166.90	8824.50	8807.40	9236.00	229.76
Cost of feed (₦)	18410.00 [a]	17618.00 [b]	15992.00 [c]	14876.00[d]	14426.00[d]	387.77
CW(₦)	1188.58 [a]	1143.06 [ab]	1123.60 [c]	1188.80 [d]	1182.80 [d]	22.91
TCF and W(₦)	19598.00 [a]	18761.00 [b]	17115.00 [c]	16065.00 [d]	15609.00 [d]	404.38
Cost of conc/Kg (₦)	38.07	33.47	29.29	24.90	20.51	
C/KgG(₦/Kg gain)	289.51 [ab]	299.75 [a]	289.90 [ab]	263.98 [b]	249.70 [c]	5.98
Net Benefit (₦)	21052.00[a]	19039.00 [bc]	18585.00 [c]	20835.00[ab]	22341.00 [a]	1000.64
RIF	1.07 [c]	1.02 [c]	1.10 [c]	1.29 [b]	1.42 [a]	0.05

Where TWG=total weight gain, AWG =average weight gain, VG=value of gain, CI=concentrate intake, HI=hay intake,TFI= total feed intake, TWI= total water intake,TCC= total cost of concentraate, CW=cost of water, TCF and W= total cost of feed and water, CC/Kg = cost of concentrate /kilogram, C/ Kg G = cost per Kg gain, RIF = return to investment on feed. [abcde] means within the same row with different superscripts are significantly different (P<0.05) SEM=Standard Error of mean. , *Digitaria smutsii* hay=₦ 36.66/kg , price of water= ₦ 0.8/l, Price of weaner/liveweight=N600/kg. value of gain= total weight gain×N600,Net benefit=value of gain - total cost of feed and water consumed, Return to investment on feed-= net benefit/cost of feed and water.

4.4 EXPERIMENT 3: Effect of feeding diets with graded levels of Palm Kernel Cake on the fattening performance of Bunaji bulls.

4.4.1 Chemical composition of concentrate diets containing varying levels of PKC fed to finishing Bunaji bulls

Table 4.4.1 shows the chemical composition of concentrate diets containing graded levels of PKC fed to fattened Bunaji bulls. The DM values ranged from 94.18 to 96.30% with 0% PKC inclusion having the highest (96.30%) and 10% PKC inclusion having the lowest (94.18%). The CP ranged from 15.63 to 20.31%, the CF values ranged from 13.92 to 23.31% with the diet without PKC inclusion having the lowest CF. The EE ranged from 9.50- 11.87% while ash ranged from 10.42 -11.38%. The NDF and ADF ranged from 26.38 -42.37% and 14.49-29.80% respectively. The HC values ranged from 10.72- 14.25% while GE ranged from 13.81- 15.74 MJ/KgDM and ME ranged from 11.75- 11.78 MJ/KgDM.

4.4.2 Effect of graded level of PKC on the performance of fattened Bunaji bulls

There was significant difference ($P<0.05$) on the performance of animals fed diets containing graded levels of PKC in all the parameters measured (Table 4.4.2). The average concentrate intake (ACI) ranged from 4.75-4.94 kg/day and the hay intake ranged from 3.95-4.22kg/day. The average weight gain (AWG) range from 1.14 - 1.33kg/day. Animals on diets containing 10% PKC have an average weight of 1.33kg/day the highest but statistically similar to 1.31kg/day obtained for animals on 30% PKC inclusion. AWG of 1.14kg/day,1.16kg/day and 1.18kg/day was obtained for fattened Bulls on diet containing 10, 20 and 40%PKC inclusions respectively. There was no significant difference ($P>0.05$) in weight gain between animals on diets contining 0,20 and 40%PKC inclusion. The Feed conversion ratio ranged from 6.52-7.57.

Table 4.4 1: Chemical Composition of Concentrate Diets Containing Varying Levels of Palm Kernel Cake Fed to Finishing Bunaji Bulls

Parameter (%)	Inclusion Levels (%)				
	0	**10**	**20**	**30**	**40**
Dry Matter	96.30	96.06	94.66	94.18	94.67
Crude Protein	15.63	16.13	20.31	19.56	17.13
Crude Fibre	13.92	15.33	17.52	23.31	21.96
Ether Extract	10.01	9.57	11.87	10.85	9.50
Ash	11.38	10.42	11.15	11.05	10.99
Neutral Detergent Fibre	26.38	32.63	27.32	39.03	42.37
Acid Detergent Fibre	14.49	18.38	16.60	25.37	29.80
Hemi Cellulose	11.89	14.25	10.72	13.66	12.57
GE[1]	15.26	15.64	13.81	15.64	15.60
ME[1]	11.75	11.76	11.78	11.77	11.76

[1] = MJ/KgDM; ME = Metabolizable Energy, GE= Gross Energy

Table 4.4 2: Effect of Feeding Diet Containing Varying Levels of Palm Kernel Cake on Performance of Finishing Bunaji Bulls

Parameters	Levels of Inclusion					
	0	**10**	**20**	**30**	**40**	**SEM**
Initial weight (kg)	196.50	198.00	192.25	197.50	197.75	3.16
Final weight (kg)	298.75 ^{cd}	317.75 ^{a}	296.25^{d}	315.00 ^{ab}	303.75^{bc}	5.14
ACI (kg/day)	4.75 ^{c}	4.94 ^{a}	4.76 ^{bc}	4.92 ^{ab}	4.83 ^{abc}	0.08
AHI (kg/day)	4.02 ^{b}	4.22 ^{a}	3.95 ^{c}	4.14 ^{ab}	4.04 ^{b}	0.08
ATFI (kg/day)	8.73 ^{bc}	9.11 ^{a}	8.67 ^{c}	9.02 ^{ab}	8.83 ^{abc}	0.15
ADMI (kg/day)	8.40 ^{bc}	8.75 ^{a}	8.20 ^{c}	8.49 ^{ab}	8.36 ^{bc}	0.14
AWI (L/day)	30.64 ^{d}	34.69 ^{a}	33.16 ^{c}	33.75 ^{b}	31.60 ^{d}	0.55
AWG (kg/day)	1.14 ^{b}	1.33 ^{a}	1.16 ^{b}	1.31 ^{a}	1.18 ^{b}	0.04
FCR	7.57^{c}	6.67^{a}	7.17^{bc}	6.52^{a}	7.12^{b}	0.20

^{abcd} means within the same row with different superscripts are significantly different (P<0.05)
SEM=Standard Error of mean. ACI = average concentrate intake, AHI=average hay intake, AFI=average feed intake, ADMI=average dry matter intake,AWI=average water intake, AWG=average weight gain, FCR=Feed Conversion Ratio, l=litre

4.4.3 Apparent nutrient digestibility of diets containing graded levels of PKC fed to fattened Bunaji bulls

The apparent nutrient digestibility of diets containing graded levels of PKC fed to fattened Bunaji bulls is shown in Table 4.4.3. There was no significant difference ($P>0.05$) in dry matter digestibility, ADF and NDF digestibility across treatment. However, there was significant difference ($P<0.05$) in CP digestibility and it ranged from 81.73 - 52.44%. CF digestibility also ranged from 78.43 to 83.30%.

4.4.4 Nitrogen balance of fattened Bunaji bulls fed graded levels of PKC

The result of nitrogen balance study is presented in Table 4.4.4. Total Nitrogen intake was significantly affected by inclusion level of PKC. Similar ($P>0.05$) nitrogen intake was observed in Bulls consuming diet containing 20 and 30% inclusion level of PKC. Total nitrogen output was higher in the control diets than treatments with PKC. Nitrogen retained ranged from 82.31-171.16 g/day with the highest nitrogen retention value obtained for animals on 20% PKC inclusion.

4.4.5 Effect of palm kernel cake on the rumen metabolite of fattened Bunaji bulls

Figure 4.4.1 shows effect of sampling time on the rumen metabolite of fattened Bunaji bulls fed graded level of palm kernel cake. The lowest rumen pH recorded in this study was 6.84 at 3 hours post feeding and the highest was 7.34 at 0 hr before feeding.

Rumen ammonia nitrogen (RAN) recorded in this study ranged from 13.28-15.55 mg/100ml with the highest value obtained at 9 hours post feeding and lowest value at 0 hours before feeding. Total Volatile Fatty Acid (TVFA) obtained in the study ranged from 23.80-28.19 µmol/l, its lowest at 0hr before feeding, with the highest value at 9hrs post feeding.

Table 4.4 3: Effect of Feeding Diet Containing Varying Levels of Palm Kernel Cake on the Apparent Nutrient Digestibility of Fattened Bunaji Bulls.

Apparent digestibility(%)	Level of inclusion(%)					
	0	10	20	30	40	SEM
Dry Matter	77.58	77.13	77.58	77.12	75.11	0.49
Crude Protein	52.44 ^{c}	64.03 ^{b}	81.73 ^{a}	78.03 ^{a}	63.37 ^{b}	2.64
Crude Fibre	80.11 ^{c}	78.43 ^{d}	81.80 ^{b}	83.30 ^{a}	80.07 ^{c}	0.70
Ether Extract	71.66 ^{c}	74.14 ^{b}	79.48 ^{a}	77.43 ^{a}	71.24 ^{c}	1.26
Ash	58.82 ^{ab}	57.72 ^{bc}	59.71 ^{ab}	61.15 ^{a}	55.96 ^{c}	1.31
Neutral Detergent Fibre	79.79	79.87	80.04	80.35	79.74	0.71
Acid Detergent Fibre	78.74	76.06	76.43	77.07	77.72	0.94
Hemi Cellulose	85.30 ^{a}	86.02 ^{a}	86.23 ^{a}	86.28 ^{a}	83.69 ^{b}	0.54

Where DM = Dry matter, CP = Crude protein, EE = Ether Extract, CF = Crude fibre and A = Ash. SEM=Standard Error of mean, ^{abcd} means within the same row with different superscripts are significantly different ($P<0.05$)

Table 4.4 4:Effect of Feeding Diet Containing Varying Levels of Palm Kernel Cake on the Nitrogen Balance of Fattened Bunaji Bulls

Nitrogen balance	Level of inclusion(%)					
	0	10	20	30	40	SEM
Nitrogen intake (g/day)	165.26^{d}	178.99^{bc}	215.49^{a}	212.51^{a}	175.13^{cd}	5.58
Urinary Nitrogen (g/day)	4.40	4.40	5.16	4.62	4.41	0.45
Faecal Nitrogen (g/day)	78.56^{a}	63.06^{b}	39.16^{c}	44.62^{c}	61.80^{b}	3.60
Total Nitrogen Output (g/day)	82.95^{a}	67.46^{b}	44.32^{c}	49.24^{c}	66.21^{b}	3.54
Nitrogen Retained (g/day)	82.31^{c}	111.53^{b}	171.16^{a}	163.27^{a}	108.92^{b}	8.40
Nitrogen Retained (%N-intake)	49.81^{c}	61.47^{b}	79.36^{a}	75.85^{a}	60.85^{b}	2.66

SEM=Standard Error of mean, ^{abcd} means within the same row with different superscripts are significantly different (P<0.05)

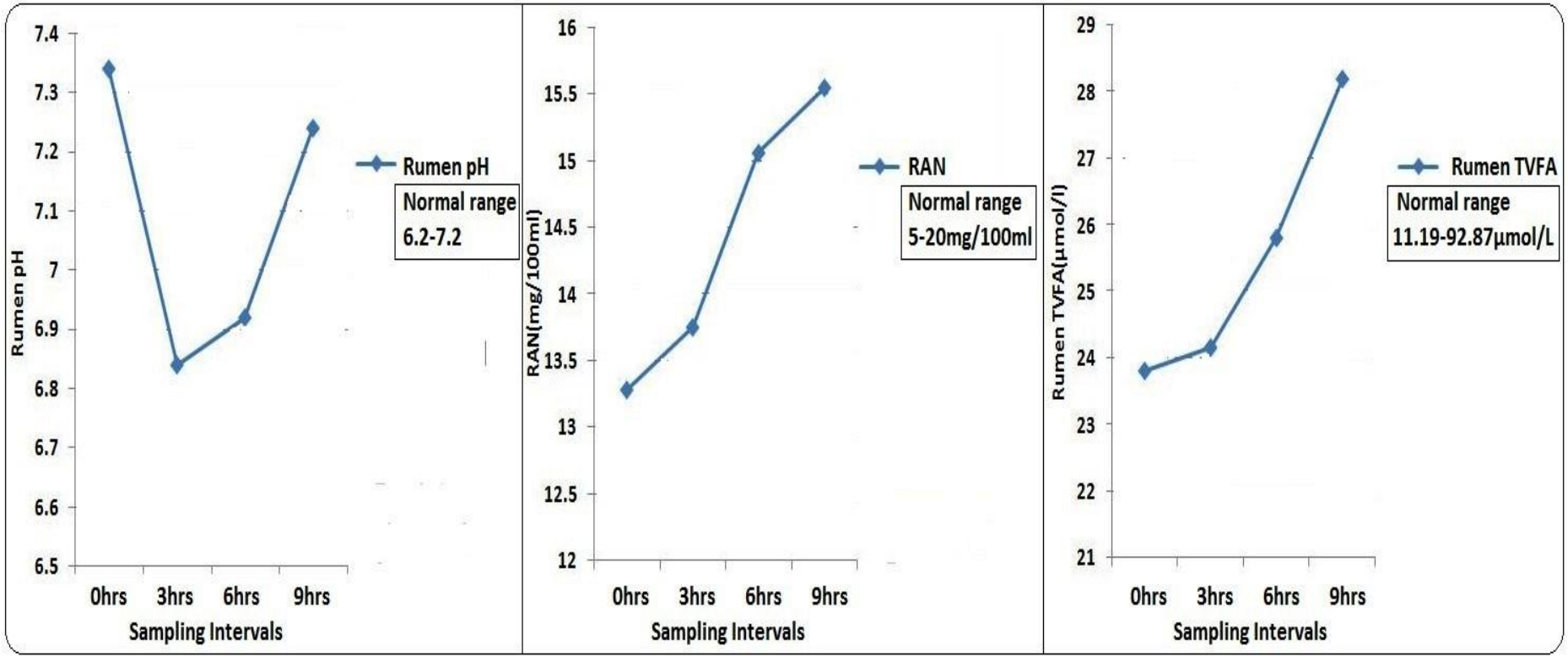


Fig 4.4. 7: Effect of Sampling Time on the Rumen Metabolite of Fattened Bunaji Bulls Fed Graded Levels of Palm Kernel Cake.

Effect of level of inclusion of palm kernel cake on the rumen metabolite of fattened Bunaji bull is shown in figure 4.4.2. There was no significant difference (P>0.05) in rumen pH, RAN and TVFA across treatment. Rumen pH ranged between 7.03 -7.15, RAN ranged from 13.51-15.30 mg/100ml. Rumen TVFA range from 24.63-25.94 µmol/l.

Figure 4.4.3 shows effect of levels of inclusion and sampling interval on the rumen metabolite of fattened Bunaji bulls fed diets containing PKC. There was no significant difference (P>0.05) in rumen pH of animals on 20, 30 and 40% at 0hr before feeding. At 3hrs post feeding, animals on 0, 10 and 30% PKC inclusion have similar pH values but differ from those on diets containing 10, 20 and 40% PKC inclusion. At 6hrs post feeding, rumen pH was similar for animals on 0, 10, 30 and 40% but differs for animals on 20 and 30% PKC inclusions. The highest pH was obtained for animals on 20% which differs significantly (P< 0.05) with those on 0, 10, and 40% PKC inclusions at 9 hrs post feeding. RAN recorded in this study ranged from 11.09-15.25, 12.28-13.90, 11.75 - 17.63 and 11.85-17.55 mg/100ml for 0, 3, 6 and 9 hours respectively.

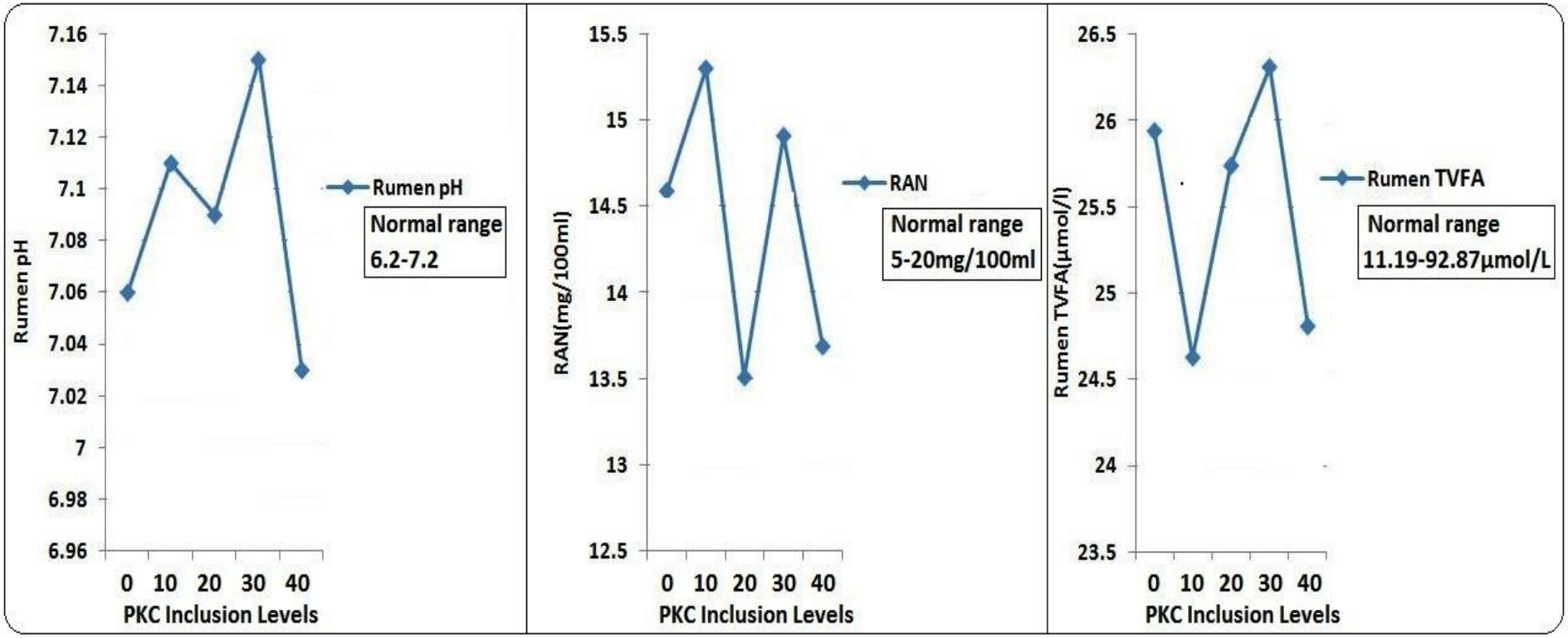


Fig 4.4. 8: Effect of levels of inclusion of palm kernel cake on the rumen metabolite of fattened Bunaji bulls.

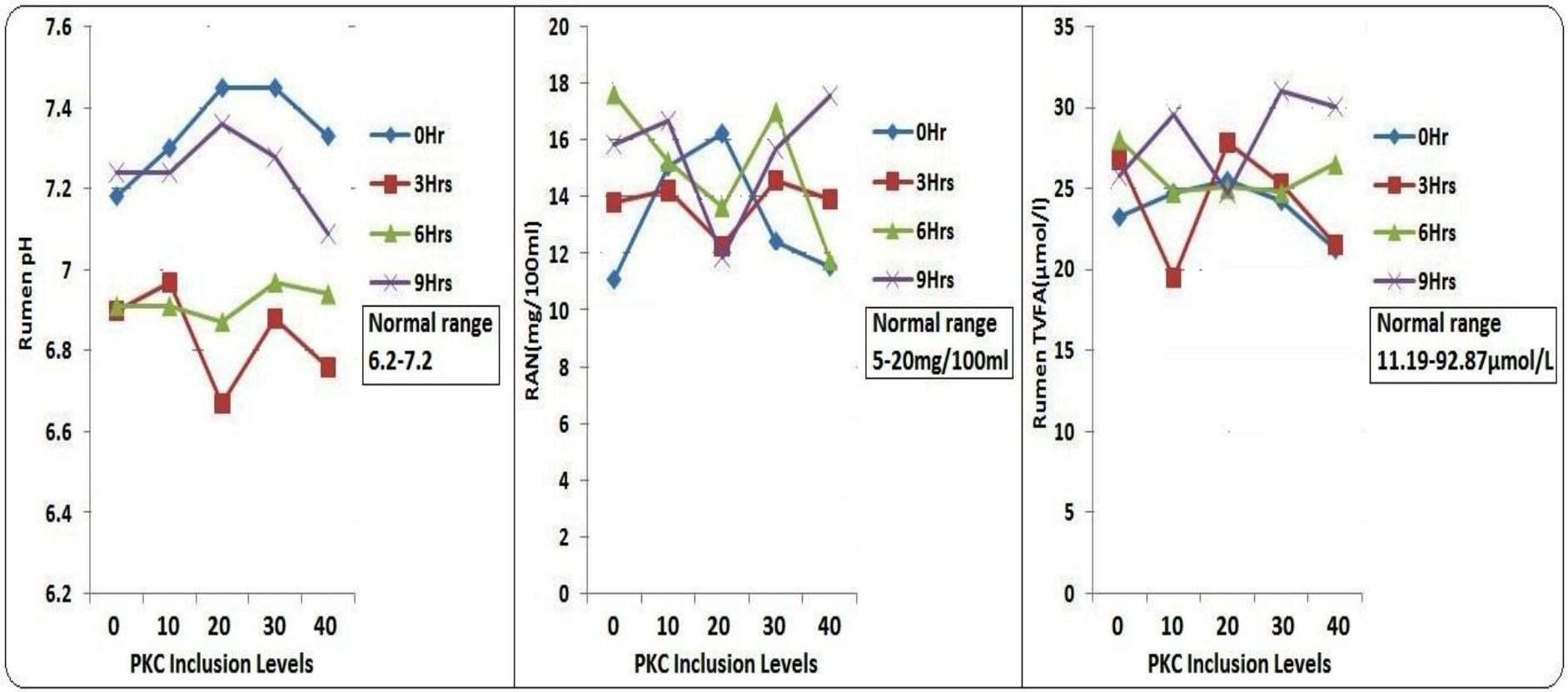


Fig 4.4. 9: Effect of levels of inclusion and sampling interval on the rumen metabolite of fattened Bunaji bulls fed diets containing palm kernel cake

4.4.6 Effect of palm kernel cake on Packed Cell Volume and Some biochemical parameter of fattened Bunaji bulls

The result of the effect of levels of inclusion on Packed Cell Volume and some biochemical parameter of fatttened Bunaji bulls fed diets containing PKC is presented in figure 4.4.4. There was significant difference ($P< 0.05$) among treatment for the Packed Cell Volume and all biochemical parameter measured. Packed Cell Volume (PCV) ranged from 31.86 -33.10%, Glucose ranged from 2.59-3.50mmol/L, Urea ranged from 4.31-5.04mmol/l, highest urea value was obtained at 10% PKC inclusion, Total protein (TP) ranged from 69.33-76.17 g/l highest value was obtained for animals on diets containing 30% PKC inclusion and lowest for animals on diets containing 40%PKC.

Figure 4.4.5 shows the effect of sampling interval on Packed Cell Volume and some biochemical parameter of fattened Bunaji bulls fed graded level of PKC. The PCV ranged from 31.86 -33.68%, glucose (1.88-4.25mmol/L), urea (2.37-6.43mmol/l) and TP of 63.00-79.55 g/l were significantly difference ($P< 0.05$) at the different sampling intervals.

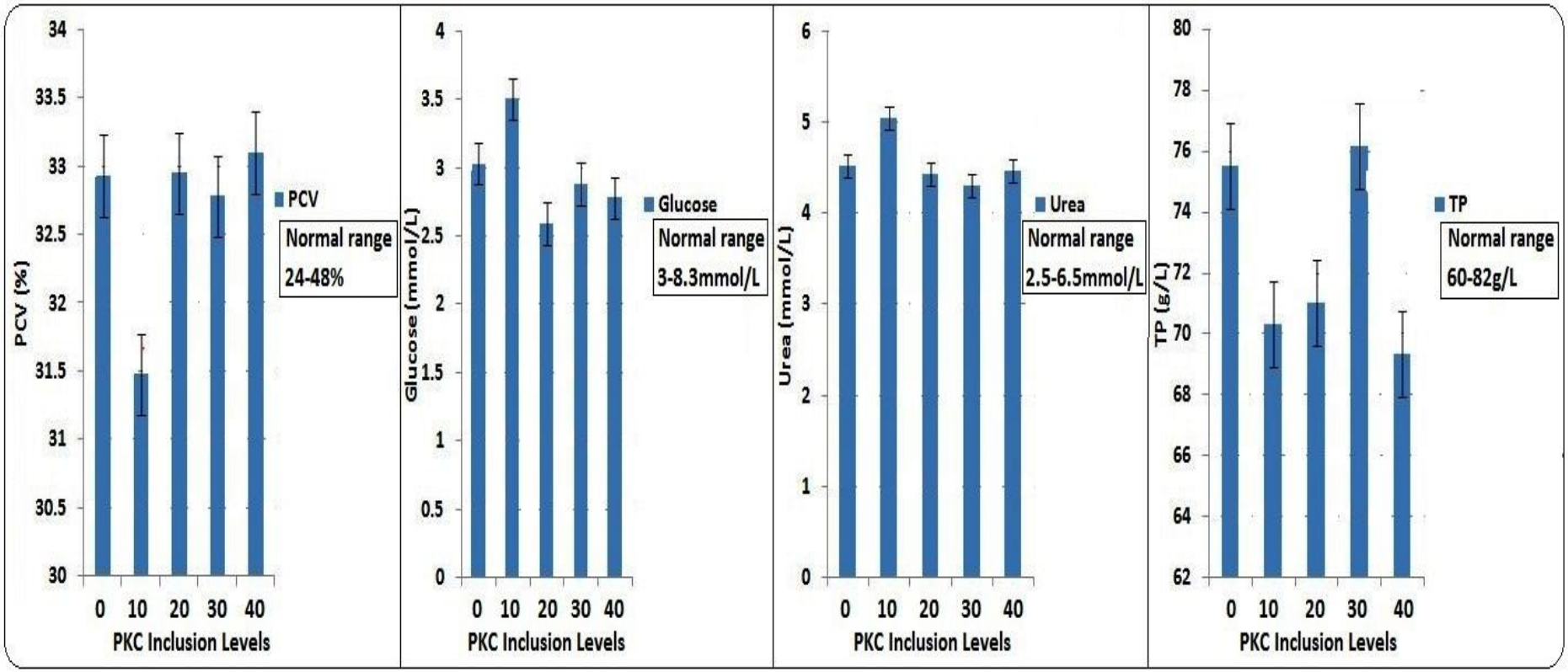


Fig 4.4. 10: Effect of Treatment on Packed Cell Volume and Some Biochemical Parameter of Fattened Bunaji Bulls Fed Graded Levels of Palm Kernel Cake

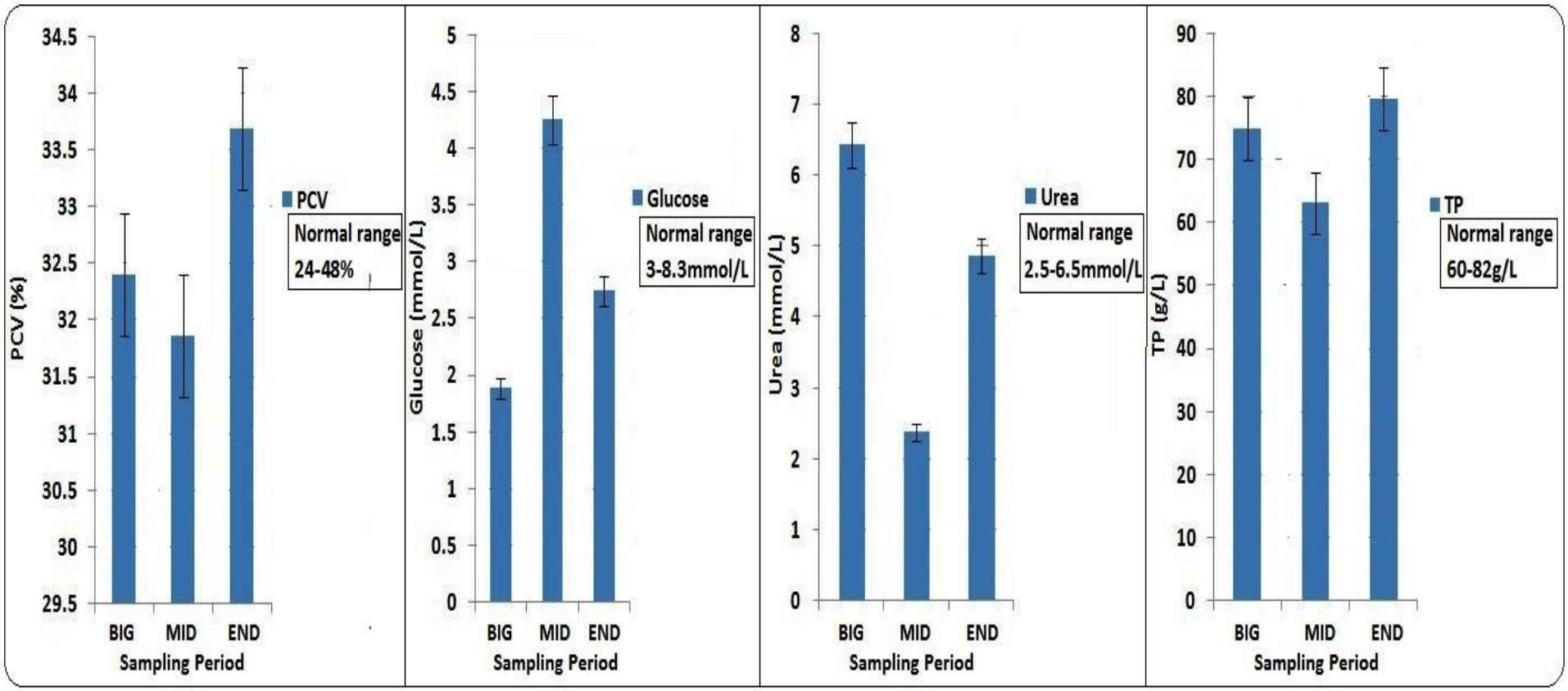


Fig 4.4. 11: Effect of Sampling Interval on Packed Cell Volume and Some Biochemical Parameters of Fattened Bunaji Bulls Fed Graded Levels of Palm Kernel Cake

Effect of feeding diet containing varying levels of PKC on the Packed Cell Volume and some biochemical parameter of fattened Bunaji bulls is presented in Fig. 4.4.6. Packed cell volume (PCV) was highest at the beginning of the experiment for bulls fed diets containing 40%PKC inclusion (31.25%) but was not significantly difference (P>0.05) at 0 and 30. 10, 20 and 30% PKC inclusion where also not significantly difference (P>0.05). At the middle of the experiment, the PCV was highest for animals on diets containing 20% PKC but similar at 0, 30 and 40%PKC but differ from the value obtained at 10%PKC levels which has the lowest value (29.95%). The PCV at the end of the trial ranged from 32.78 -34.85%.

The glucose value for the animals on diets containing varying levels of PKC ranged from 1.58-2.28mmol/l, 3.60-5.38mmol/L and 2.28-3.23mmol/L at beginning, middle and end of the experiment respectively. The urea value ranged from 6.10-6.60mmol/L, 2.00-2.30mmol/L and 4.03-5.45mmol/L for beginning, middle and end of the experiment respectively. There was no significant difference (P>0.05) in the urea values obtained for all the animals across treatment at the middle and end of the experiment. TP was significantly different (P< 0.05) across treatment and different sampling interval. The TP value at the beginning, middle and end of the experiment ranged from 69.25-80.00g/L,59.75-65.00 and 76.25-84.50g/L.

4.4.7 Partial budget analyses of fattened Bunaji bulls fed diet containing varying levels of PKC

The result of this study presented in table 4.4.5 shows that feed cost (concentrate) in Naira per Kg declined with increase in PKC levels from ₦37.75/kg to ₦20.19/Kg. The feed cost to gain ratio was higher at 0% inclusion level (₦ 315.84/ Kg live weight gain) and lowest at 40% PKC inclusion level (₦ 249.70/Kg live weight gain) which implies that inclusion of PKC up to 40% was economically better than the control. The net benefits were ₦29755.00, ₦40495.00, ₦34571.00, ₦43522.00 and ₦39226.00 for feeding fattened Bunaji bulls on 0, 10, 20, 30 and

40% PKC diets respectively. Net benefit was higher in the diets with 30% inclusion levels of PKC though not significantly difference (P>0.05) at 10%PKC inclusion. Average weight gain and Value of gain was highest for animals on diets containing 10% PKC level and similar to value obtained for animals on 30%PKC inclusion while those on 0%, 20% and 40% PKC inclusion are statistically similar (P>0.05).

4.4.8 Effect of feeding diet containing varying levels of PKC on carcass yield of fattened Bunaji bulls.

Table 4.4.12 shows the effect of feeding diet containing varying levels of Palm Kernel Cake on carcass yield of fattened Bunaji bulls. There was significant (P<0.05) differences on most of the carcass traits with varying levels of the Palm Kernel Cake fed to the animal. Fasted weight, slaughter weight and hot carcass weight were higher for animals on 10% and 30% .dressing % was higher for animals on 30 and 40% PKC levels. Beef (% carcass) was highest for animals on 0% PKC inclusion, closely followed by those on 10, 20 and 40% level of inclusion. Though 10, 20 and 40% level of inclusion of PKC werenot significantly difference (P>0.05). 20 and 40%PKC were also similar to animals on 30%PKC inclusion. Highest bone yield was obtained for animals on diets containing 30%PKC but similar to those on 10%PKC but differ for bulls on 0, 20 and 40%PKC inclusion. There was no significant difference (P>0.05) across treatments for longissimus muscle.

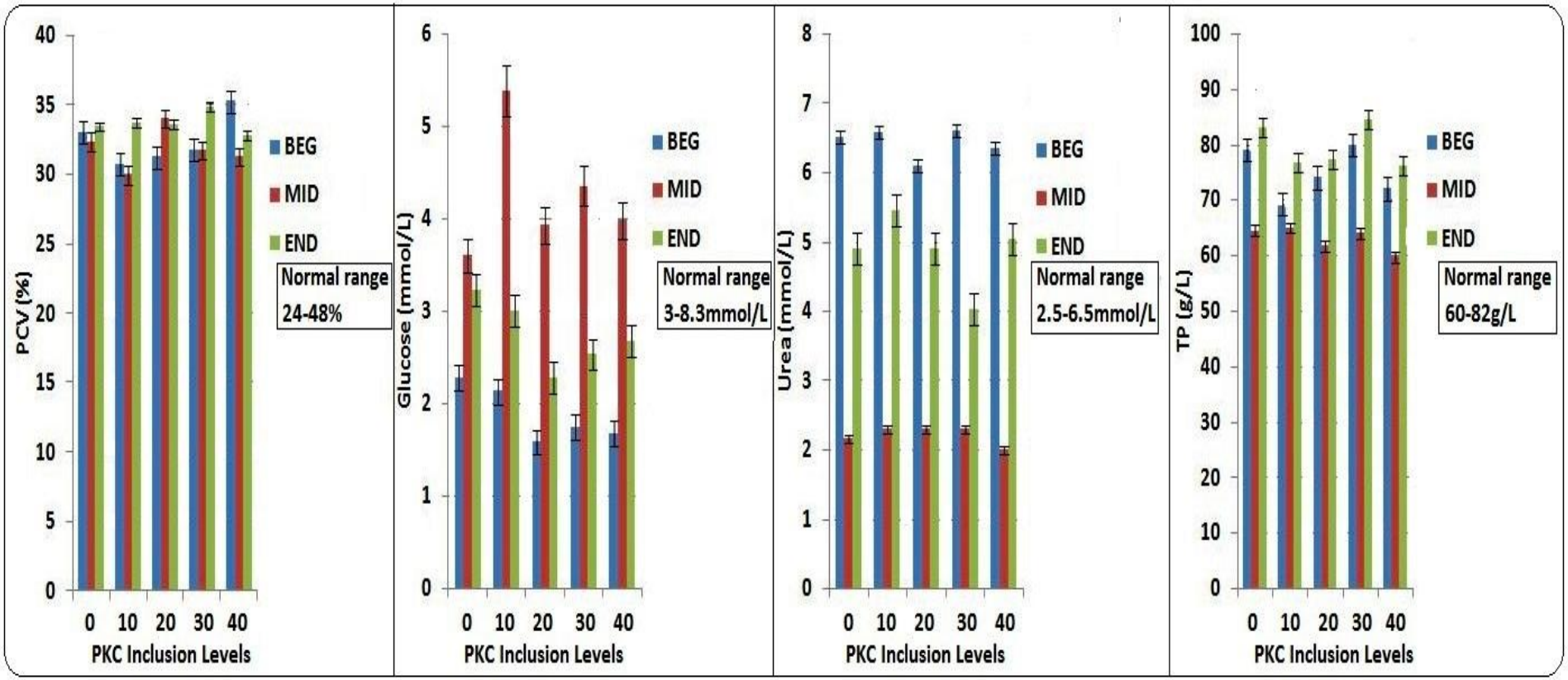


Fig 4.4. 12: Effect of Sampling Interval and Treatment on Packed Cell Volume and Some Biochemical Parameters of Fattened Bunaji Bulls

Table 4.4 5: Partial Budget Analyses of Fattened Bunaji Bulls Fed Diets Containing Graded Levels of PalmKernel Cake

	Levels of Inclusion(%)					
Parameters	**0**	**10**	**20**	**30**	**40**	**SEM**
TWG (Kg)	102.25 [b]	119.75 [a]	104.00 [b]	117.50 [a]	106.00 [b]	3.32
AWG (Kg)	1.14 [b]	1.33 [a]	1.16 [b]	1.31 [a]	1.18 [b]	0.04
V G (₦)	61350.00 [b]	71850.00 [a]	62400.00 [b]	70500.00 [a]	63600 [a]	1993.14
CI (Kg)	427.07 [b]	444.79 [a]	428.08 [b]	443.06 [a]	434.69 [ab]	7.06
HI (Kg)	361.90 [bc]	379.73 [a]	355.69[c]	372.55 [ab]	363.42 [bc]	6.90
TFI (Kg)	785.43	819.94	780.04	811.47	794.34	13.52
TWI (Litres)	2757.40	3122.50	2984.40	3037.10	2843.70	49.68
TCC (₦)	16122.00[a]	14936.00[b]	12401.60 [c]	10890.40 [d]	8776.30 [e]	200.41
Cost of hay (₦)	13267.20 [bc]	13920.80 [a]	13039.70 [c]	13657.80 [ab]	13322.90 [bc]	253.00
Cost of feed (₦)	29389.00 [a]	28857.00 [a]	25441.00 [b]	24548.00 [c]	22099.00 [d]	437.20
CW (₦)	2205.90 [c]	2498.00 [a]	2387.50 [b]	2429.70 [a]	2274.90 [c]	39.75
TCF and W (₦)	31595.00 [a]	31355.00 [b]	27829.00 [c]	26978.00 [d]	24374.00 [e]	461.87
Cost conc/Kg (₦)	37.75	33.58	28.97	24.58	20.19	
C/KgG (₦/Kg gain)	315.84 [a]	265.53 [b]	270.27 [b]	230.38 [c]	230.33 [c]	7.38
Net Benefit (₦)	29755.00 [d]	40495.00 [ab]	34571.00 [c]	43522.00 [a]	39226.00 [b]	1765.07
RIF	0.94 [c]	1.28 [b]	1.24 [b]	1.62 [a]	1.62 [a]	0.06

CI= concentrate intake,HI= hay intake, TFI=total feed intake, TWI=total water intake, TWG=total weight gain AWG=average weight gain, l=litre. [abcde] means within the same row with different superscripts are significantly different (P<0.05) SEM=Standard Error of mean., *Digitaria smutsii* hay=₦36.66/kg,price of water= ₦ 0.8/l, Price of weaner/liveweight=N600/kg. value of gain(VG)= total weight gain×N600,Net benefit=value of gain - total cost of feed and water consumed, Return to investment on feed-= net benefit/cost of feed and water.

Table 4.4 6: Effect of Feeding Diet Containing Varying Levels of Palm Kernel Cake on Carcass Yield of Fattened Bunaji Bulls.

	Levels of Inclusion(%)					
Parameters (Kg)	**0**	**10**	**20**	**30**	**40**	**SEM**
Fasted weight	311.00[b]	339.50[a]	310.00[b]	332.50[a]	317.50[b]	4.47
Slaughter weight	288.01[ab]	313.40[a]	280.70[b]	302.50[ab]	243.50[c]	13.20
Hot carcass weight	166.70[b]	180.25[a]	164.70[b]	178.60[a]	175.50[a]	3.01
Dressing %	53.64[bc]	53.14[bc]	53.05[c]	54.21[ab]	55.27[a]	0.56
Weight of dissectible beef	121.80[b]	128.68[a]	116.5[c]	125.52[ab]	124.10[ab]	2.60
Beef (% of carcass)	73.69[a]	71.39[b]	70.68[bc]	70.28[c]	70.69[b]	0.48
Bone yield	38.95[b]	40.45[a]	38.90[b]	41.11[a]	37.60[b]	0.68
Meat: bone ratio	3.13[bc]	3.18[bc]	3.37[a]	3.07[c]	3.29[ab]	0.08
Legs	8.03[a]	8.00[a]	7.75[ab]	7.45[b]	7.38[b]	0.22
Hide	19.38[d]	22.60[a]	19.73[cd]	20.35[c]	21.50[b]	0.32
Head	18.08[c]	19.50[a]	18.20[b]	19.50[a]	20.15[a]	0.34
Tail	2.68[b]	3.28[a]	2.73[b]	2.56[b]	2.65[b]	0.11
Liver	3.67[c]	4.10[ab]	3.10[d]	4.42[a]	3.92[bc]	0.18
Spleen	0.83[a]	0.69[c]	0.65[c]	0.79[ab]	0.76[b]	0.02
Heart	1.13[c]	1.28[a]	1.28[a]	1.24[ab]	1.18[bc]	0.04
Lungs	2.15[bc]	2.19[b]	2.03[d]	2.05[cd]	2.45[a]	0.05
Kidney	0.63[bc]	0.80[a]	0.73[ab]	0.63[bc]	0.58[c]	0.06
Stomach with content	32.00[c]	38.00[a]	32.50[bc]	37.75[a]	34.00[b]	0.85
Empty stomach	7.95[b]	8.77[a]	7.89[b]	8.27[ab]	7.85[b]	0.33
Intestine with content	15.25[a]	10.20[b]	7.85[c]	12.05[b]	10.35[b]	1.13
Empty intestine	6.80[b]	7.45[a]	5.15[c]	6.25[c]	5.64[d]	0.24
Inguinal fat	2.60[b]	3.00[a]	2.59[bc]	2.25[c]	1.85[d]	0.17
Kidney fat	2.53[d]	3.38[a]	2.77[cd]	2.98[bc]	3.08[b]	0.13
Abdominal fat	3.10[b]	3.08[b]	3.58[a]	3.70[a]	2.58[b]	0.18
Intestinal fat	1.41[b]	1.13[c]	1.48[b]	2.48[a]	1.35[b]	0.07
Depth of chest fat	5.50[a]	5.55[a]	5.65[a]	5.50[a]	4.70[b]	0.18
Testis	0.54[a]	0.48[ab]	0.46[b]	0.51[ab]	0.53[a]	0.03
Longissimus muscle	12.58	12.75	13.00	11.53	12.60	0.76
Rib muscle	15.25[c]	19.25[a]	17.20[b]	17.45[b]	18.50[ab]	0.76
Blood	9.00[bc]	9.00[bc]	9.05[b]	10.50[a]	8.00[c]	0.51

SEM = Standard error of mean. [abcd]Means with different superscript along rows are significantly different at ($P<0.05$).

CHAPTER FIVE

5.0 DISCUSSION

5.1 Chemical Analyses

5.1.1 Proximate and cell wall composition of feed ingredients

The Dry Matter (DM) contents of palm kernel cake (PKC) was 96.4% which was similar to value of 95.90and 95.12% reported by Chanjula *et al.* (2010) and Daudu (2007) respectively but higher than 94%, 93.21 and 91.66% reported by Sundu *et al.*(2006), Wallace *et al.*(2010) and Akinyeye *et al.*(2011) respectively. Crude protein (CP) of 18.80% reported by Aduku (1993) was similar to 18.19% obtained in this study but higher than 14.12% reported by Sundu *et al.* (2006),14.71% by Adesehinwa.(2007) and 14.10-16.42% CP reported by Carvalho *et al.*, (2005) but lower than 23.33 and 20.15% reported by Daudu (2007) and Akinyeye *et al* .,(2011) respectively. The differences could be as a result of the method of oil extraction as this affects the residual oil content of the cake and its CP content. The CP content is a reasonable estimate of a feed ingredient to supply and or meet dietary protein requirement for a given class of animal, the amino acid profile and proportion(which impact protein quality) is critical determinant in the evaluation of nutritional potential of feed ingredient.

The Ether extract (EE) of 12.38% obtained was similar to 12% reported by Perez *et al* (2000), higher than 7.83-9.40% reported by Carvalho *et al.*, (2005) but lower than 22.48% reported by Wallace *et al.*(2010) and 19.50% by Adesehinwa *et al.*,(2007). The ash of 3.98% reported in this trial was similar to the value of 3.89% obtained by Daudu (2007), 3.60% by Sundu *et al.* (2006) and 3.29% by Wallace *et al.*(2010), higher than 3.06% reported by Adesehinwa.(2007) but lower than 5.69% obtained by Akinyeye *et al.*(2011). Acid detergent fiber of 51.34 is higher than 43.7% reported by Sundu and Dingle (2003). These variations probably result from differences in processing methods to get the cake, source of cake e.t.c.This is in-line with the

observationof previous authors that reported thatPKC varies considerably in chemical composition (protein, fiber or lipids), depending on the sources (Rhule, 1996), the methodology of oil removal, the proportion of endocarp remaining (Adesehinwa, 2007) and the efficiency of oil extraction from the kernel (Onwudike, 1986; Onuh et al., 2010).

The CP of 11.44% reported for maize offals in the study falls within the range of 11.26 -12.19% reported by Fadugha (1990), 11.88% by Sani (2014) and 10.93-11.98% by Lamidi (2005) but higher than 9.88% (Adesote, 2013). It is lower than 12.69 and 14.31% reported by Idowu (2011) and Madziga *et al.* (2013) respectively. The NDF value of 48.08% was higher than 21.61% reported by Sani (2014), 21.64% by Lamidi *et al.* (2008), 33% (Olorunmisomo *et al.*, 2006) but lower than 55.15% (Idowu, 2011) and 53.92% by Madziga *et al.* (2013). The values of DM of 97.70% was similar to 97.01% (Adesote, 2013) but higher than 89.46% reported by Sani (2014), 91.82% by Ezieshi *et al.* (2011). The ME of 11.93 MJ/Kg obtained in this study was similar to 11.37 MJ/Kg (Sani, 2014) and 14.52-16.69 MJ/Kg reported by Lamidi (2005). ADF of 16.7% was similar to 17% Adesote (2013). The EE of 15.63% was similar to 16.01% by Sani (2014) but higher than range (9.24-9.57%) obtained by Lamidi (2005) and EE (11.72%) recorded by Ezieshi *et al.* (2011).

The DM (95.04%), CP (30.75%) and ME (11.84 MJ/Kg) in cotton seed cake (CSC) was similar to 92.99%, 30.88% and 11.51 (MJ/Kg) reported by Madziga*et al.* (2013) but higher than DM (89.94%), CP (23.69%) and ME (9.14 MJ/Kg) reported by Sani (2014), DM (91.64-92.56%), CP (24.63-25.94%) and ME (21.97-23.05 MJ/Kg) obtained by Lamidi (2005). The DM of 94.82% reported by Yusuf (2016) was similar to 95.04% reported in this trial. ADF of 35.29% was similar to 34.17% reported by Yusuf (2016) and 21.64-34.42% by Lamidi (2005). Ash content of 4.11% was similar to 4.37 reported by Adesote (2013) and 4.98% by Madziga*et*

al(2013). NDF of 44.73 was similar to 44.40 reported by Adegun and Aye (2013). These variations probably result from difference in year of production and varieties used.

The CP (20.88%) obtained in this study for layer litters was similar to CP of 19.58% and 19.00% reported by Lamidi (2005) and Sani (2014). It is also similar to crude protein value of 21.88% reported by Bello and Tsado (2013) lower than 26.60% reported by Ndubueze et al. (2006); 28.20% reported by Abdul *et al.* (2008), but higher than 15.40, 20.3% reported by Lanyasunya et al. (2006), Onimisi and Omage (2006) and Owen et al. (2008) respectively.The EE of 12.48 is higher than 4.40% reported by Madziga *et al.* (2013). The Ash of 13.53 is lower than (21.28%) by Sani (2014) and (28.16%) reported by Lamidi (2005). The ME of 11.75 MJ/Kg was similar to the value of 11.48 MJ/Kg reported by Sani (2014) but lower than values of ME (16.90 MJ/Kg) reported by Lamidi (2005). The DM of present study (97.62%) was similar to the value (97.39%) reported by Adesote (2013) but higher than (92.71%) reported by Madziga *et al*(2013). Hemicellulose (HC) of 18.9% reported by in these trials is close to the value of 17.7% reported by Sani (2014). The variations in the crude protein values of the poultry manure may be attributed to type of bird, the age of the manure and level of feeding the birds.

The CP content of 5.25% obtained in this study for rice offal was similar to 5.33% (Adesote, 2013) and 5.10% reported by Duru (2010) but lower than 6.84 and 6.06% by Ocheja *et al.* (2008) and Duru (2010) respectively. The dry matter (DM) content 98.35% was similar to 97.20% reported by Adesote (2013) but higher than 92.6% and 92.60% reported by Olomu (1995) and Ocheja *et al.*(2011). EE of 10.59% % was similar to 10.75% by Sani (2014),it is lower than 25.03% reported by Garba *et al.* (2012) and slightly higher than 11.74% reported by Adesote (2013). 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.

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.

DM of 95.65 reported for *Digitariasmutsii* was similar to 95.2% reported by Barje (2006), 94.29% (Yusuf, 2016), 94.42% (Abu, 2014) and 96.38% reported by Sani (2010) but higher than 93.1% (Sani, 2014) lower than 97% (Hassan, 2007). The CP of (5.25%) was similar to 5.36% reported by Yashim (2014) and 5.86% by Madziga *et al.* (2013) but lower than CP (8.06%) and (9.36%) by Sani (2014) and Yusuf (2016). EE of 8.81% was similar to 8.6% by Barje (2006) and 8.39% by Sani (2014). Ash of 7.8% was similar to the values 7.89% reported by Sani (2010) but lower than 9.95% by Sani (2014), 8.82% by Madziga *et al.* (2013), 11.41% (Omeiza, 2006) and 10.8% by Barje (2006).

5.2 EXPERIMENT 1: Effect of feeding diets with graded levels of Palm Kernel Cake on the growth performance of Bunaji weaner calves

5.2.1 The proximate and cell wall compositions of concentrate diets containing varying levels of PKC fed to weaner Bunaji calves.

The CP contents of the diets containing graded levels of PKC (0, 20 , 30 and 40%) fell within the range of 15.38-16.18% reported by Yusuf (2016), 13-16% Aduku (2005) and 16% CP recommended by NRC (1989) for growing bulls. However it was higher than 13% reported by Rutherglen (1995) but lower than the value of 19.64- 22.44% reported by Sani (2014), (19.63%) by Madziga *et al.* (2013) and 19.00% to 22.91% reported by Lamidi *et al.* (2007) for mature

bulls.This could be as a result of the fact that the feed was formulated to meet the requirement of different classes of animal. The CF content of the experimental diets ranged from 28 to 33.5% which are higher than the minimum level of 17% CF required for maintenance in beef cattle (NRC, 2000) . This could probably have been because of the high CF content of the PKC in the experimental diets .The ether extract of all the diets were higher than the maximum recommended level of 6% for mature cattle (Parish and Rhinehart, 2008). This increase might have resulted due to the presence of residual oil after the mechanical extraction of cotton seed cake and palm kernel cakeused in the formulation of all the diets. mechanically extracted cakes tend to contain more oil than solvent extracted ones. The ME of the diets was within the range of 11.79- 11.81MJ/Kg DM. This is slightly above the range of 10.85-11.16MJ/Kg DM reported by Sani (2014) and 10-11.6MJ/Kg DM recommended for Bulls (Rutherglen, 1995). The differences observed in the proximate composition of the experimental diets used in this study as compared with the results obtained by other authors could be as a result of the differences in feed ingredients, source of grains,method of extraction (Mechanical or solvent) of certain feed ingredient(PKC and CSC).

5.2.2 Effect of palm kernel cake on Performance of weaner Bunaji calves.

There was significant difference ($P<0.05$) between the bull and the heifer weaner calves in all the parameter measured. The bull has a higher value than the heifer. The average ACI of 1.90 - 2.31Kg/day and average hay intake of 1.92-2.32Kg/day is lower than 2.55-2.76Kg/day, 2.54 - 2.78Kg/day reported by Yusuf (2016), Adesote (2013) for concentrate and 3.49-3.71Kg/day reported by Yusuf (2016) for hay. The differences observed in hay and concentrate intake observed in this study compare with other studies such as Yusuf (2016) and Adesote (2013) could be as a result of the differences in the stage of development of the animal and feed

composition such as fiber content, the amino acid profile and quality. Post weaning adjustment might also be responsible for the differences.

The AWG range from 0.44 and 0.62 Kg/day for heifer and bull respectively was similar to 0.45-0.61Kg/day Yusuf (2016) higher than 0.22-0.35Kg/day by Adesote (2013) and Gonzalez *et al.*(2002) but lower than 0.70Kg/day reported by Abdulrazak *et al.*(1996). The average weight gain of 0.62kg/day reported for the weaner bull calve was similar to 0.623kg/day reported by Sharif *et al.*(2014) for calves fed CSC based diet and 0.61kg/day and 0.616kg for calves fed Guar meal(GM) and Cotton seed cake + Guar meal (CSC+GM) based diet. The weaner bull calves has a higher weight gain than the heifer. The differences in average weight gain could be due to differences in the season the experiment was carried out, concentrate quality fed, temperature differences, differences in the classes of animal used, sex of the animals and also individual differences among animals used. Feed conversion ratio (FCR) of the heifer weaner calves (7.30) is more superior to that of the bull calves (8.57). This could probably be as a result of difference in the sex of the experimental Animal.

When level of inclusion of PKC was considered,the average feed intake reported in this study is 3.99-4.33 Kg/day which is lower than 6.04-6.47Kg/day reported by Yusuf (2016). Average Concentrate Intake (ACI) of 1.99 -2.17 Kg/day is lower than 2.55-2.76Kg/day and 2.54 -2.78Kg/day reported by Yusuf (2016) and Adesote (2013). The AWG ranged from 0.50 -0.58Kg/day which is higher than 0.22-0.35Kg/day by Adesote (2013) and gonzalez *et al.*(2002) lower than 0.70Kg/day reported by Abdulrazak *et al.* (1996) but within the range of 0.45-0.61Kg/day reported by Yusuf (2016). Animals on 30%PKC has the highest weight gain but there is no significantly different at ($P>0.05$) for those on 10%PKC inclusions while the lowest weight gain was obtained for the control diet. The differences in average with gain reported in this study and that reported by other authors could be due to differences in the season the

experiment was carried out, concentrate fed, temperature differences, age and individual differences of the animals used.

The FCR of 7.36-8.38 obtained in this study is superior to 9.04-9.55, 13.71-22.4, 9.03-12.05,14.58%-21.81 and 10.6-13.71 reported by Madziga *et al.* (2013), Idowu (2011), Lamidi (2005), Adesote (2013) and Yusuf (2016) respectively. It is less superior when compared with FE based on rice type -raw and parboiled (6.26-6.67), inclusion level (6.26-6.72) and interaction between raw/parboiled rice type and inclusion level (6.26-6.93) reported by Sani (2014) for fattened Bulls. This could probably be as a result of differences in experimental diets, age and live weight of the experimental Animal.

The ACI of 1.82 -2.40Kg/day obtained when effect of sex and level of inclusion was considered is lower than 2.55-2.76Kg/day and 2.54 -2.78Kg/day reported by Yusuf (2016) and Adesote (2013). Also the hay intake of 1.89 -2.39Kg/day was lower than 3.49-3.71Kg/day by Yusuf (2016). The differences in average hay and concentrate intake in this study compared with previous study could be as a result of differences in the age and size of the animal. The AWG range from 0.38- 0.65Kg/day was similar to 0.45- 0.61Kg/day reported by Yusuf (2016) and lower than 0.70Kg/day reported by Abdulrazak *et al.*(1996), higher than 0.22-0.35Kg/day by Adesote (2013) and Gonzalez *et al.*(2002). The average weight gain of the control diet was similar with the value of 0.62kg/day reported for sahiwal calves fed cotton seed cake based diets by Sharif *et al.*(2014). The differences in average weight gain in this study and that reported by previous workers could be due to differences in the season the experiment was carried out, CP and energy content of the concentrate fed, age and size of the weaner calves used.

FCR of 7.13-9.62 obtained in this study is superior to 9.04-9.55, 13.71-22.4, 9.03-12.05,14.58%-21.81 and 10.6-13.71 reported by Madziga *et al.* (2013), Idowu (2011), Lamidi

(2005), Adesote (2013)and Yusuf (2016). This could probably be as a result of differences in experimental diets, age and live weight of the experimental Animal.

5.2.3 Effect of palm kernel cake on apparent digestibility of weaner Bunaji calves

There was no significant (P>0.05) difference in most of the digestibility parameters except in digestible crude fibre where those of the bull is higher than what is obtained from the heifer and ADF where the value obtained from the heifer is higher than those of the bull. The crude protein digestibility falls within the range of 61.37- 68.48% reported by Youssuf *et al (*2013) for goat fed increasing concentrate supplementation. Nutrient digestibility in animals is the classical and direct method for estimating feed digestion by ruminants; hence studies on digestibility of ruminant feeds are very important as they allow for the estimation of nutrients actually available for ruminant nutrition (Yashim *et al.,* 2016).

Animals on 30% PKC inclusions had the highest digestibility values for all the parameter measured, this might have resulted to the higher weight gain obtained at 30% inclusion of PKC when compared to other PKC inclusion levels (0%, 10%, 20% and 40%).

The digestibility values obtained in this trial for most of the parameter was higher than those obtained by Yusuf (2016) and Sani (2014) . The digestible crude fibre range obtained in this study is within the range of 54.06-73.22 obtained by Goska (2016) when he fed diets cotton cotton seed cake and groundnut halum to Bunaji bulls. this is an indication that palm Kernel cake can be fed up to 40% in the diets of Bunaji weaners without any negative effect on nutrient utilization. The digestibility of feed was reported to be influenced by the composition, available energy and retention time in the gastrointestinal tract (Abdu *et al*., 2012).

5. 2.4 Effect of palm kernel cake on Nitrogen balance of weaner Bunaji calves

The bull weaners had a higher digestibilty values than the heifer in most of the parameters except nitrogen retained as a percentage of nitrogen intake where the heifer has a higher values. Nitrogen intake depends on nitrogen content of the feed and dry matter intake (Mohamed *et al.*, 2001).

Nitrogen retained of 54.85 and 48.50g/day obtained in this study for bull and heifer weaner calves is lower than 72.01-79.48 g/day reported Yusuf (2016), this differences could be because palm kernel cake was fed in this study as against the brewer dried grain fed by yusuf (2016) to bunaji bulls while Nitrogen retained as a percentage of intake of 56.28 and 59.23 obtained in this study was within the normal range of 52.8-64.6% reported by Prakash *et al.* (2003).

All the weaner calves had positive nitrogen balance irrespective of the sex of the animals. This is an indication that the nitrogen was well metabolized and utilized by the animals. Hence PKC can be utilized for weaner calves without any adverse effect because Nitrogen retention is a major indicator used to assess the protein nutrition status of ruminant livestock (Abdu *et al.*, 2012).This is in agreement with the report of Sarwar *et al.* (2003) who stated that nitrogen depends on good digestibility of nutrients and or utilization. In some cases this effect is sufficient to maintain an adequate N balance (Woodward and Reed, 1997).

When level of inclusion of PKC was considered, the nitrogen intake is lower than the value of 130-180 and 146.67-206.6g/day reported by Lamidi (2005) when Bunaji bulls were fed sundried layer and broiler litters respectively. This could be as a result of differences in the age of the animal and feed composition.

All the weaner calves had positive nitrogen balance irrespective of the level of PKC in their diet. This is an indication that the nitrogen was well metabolized and utilized by the animals because Nitrogen retention is a major indicator used to assess the protein nutrition status of ruminant livestock (Abdu *et al.*, 2012). All the weaner calves had positive nitrogen balance irrespective of sex of the animals and the level of PKC in their diet. This is an indication that the nitrogen was well metabolized and utilized by the weaners. This is in agreement with the report of Sarwar *et al*. (2003) who stated that nitrogen depends on good digestibility of nutrients and or utilization. In some cases this effect is sufficient to maintain an adequate N balance (Woodward and Reed, 1997).

There were significant differences ($P<0.05$) in nitrogen intake at different levels of PKC inclusion for the bull and heifer weaner calves. This is in line with the report by Philips and Rao (2001) who reported that differences in nitrogen intake could be due to the variation in the amount of DM consumed and N concentration in the diets. Al-Asfoor, (2010) also reported that the nitrogen concentration of faeces strongly depends on the N concentration of the diet.

5.2.5 Effect of palm kernel cake on Packed Cell Volume and some biochemical parameters of weaner Bunaji calves

The packed cell volume of the bull and heifer calves obtained in this study fell within the normal range of 24 – 46% for healthy calves as reported by Merck Veterinary Manual(2016), it also falls within the normal range of 24- 48% reported by Research Animal Resource (2009) and 26-30% reported by Radkowsk and Herbut (2014). The PCV is higher for the bull calves than the heifer calves, similar result was obtained for Red Sokoto goats in Nigeria (Tambuwal *et al*., 2002) in which bucks had higher values than does. This is in agreement with the report of Daramola *et al*. (2005) which states that age and sex of farm animals affect haematological

parameters.The PCV values recorded for weaner calves at different sampling intervals (28.97-30.77%)were higher than 27.40 to 28.00% reported by Finangwai *et al.* (2013) for crossbred bulls and but fell within the normal range of (24-46 %) reported for healthy cattle (Coppock *et al.*,1985, Oyedipe *et al.*, 1985) but lower than the range of 39.79 to 41.42% reported by Moloney *et al.* (1994), this could be as a result of differences in class of animal used and differences in experimental diets fed. A normal PCV value reported in this study implies that the formulated feed was able to meet the nutrient requirement of the animals and hence the animals where not anaemic as a result of low PCV nor where they dehydrated as a result of high PCV.

The PCV values of the experimental animals obtained across the dietary treatments in this study was lower than the range of 39.79 to 41.42% reported by Moloney *et al.* (1994)but higher than 27.40 to 28.00% reported by Finangwai *et al.* (2013). It however fell within the normal range of (24-46%) reported for healthy calves (Merck Veterinary Manual., 2016, Coppock *et al.*, 1985, Oyedipe *et al.*, 1985).This shows that all of the diets can be fed to the animals without any adverse effect hence it implies that the inclusion of palm kernel cake in the diets of calves was ideal and adequate and the animals were not anaemic. Increased PCV shows a better transportation and thus results in an increased primary and secondary polycythemia (Isaac *et al*., 2013).Furthermore, Chineke*et al.* (2006) and Etim *et al.* (2014a) reported that high PCV values indicated either an increase in number of red blood cells or reduction in circulating plasma volume. Bello and Tsado (2013) stated that PCV within the normal range suggests that there wasno toxic factor (such as haemaglutinin) in the feed of the animal which may adverselyaffectblood formation. The PCV values observed in the experimental animals at the beginning, middle and end of thestudy for both bull and heifer weaner calves were within the normal range of 24-48% reported by Etim *et al* (2013).

The PCV irrespective of sex and levels of PKC inclusion in the diets falls within normal range of 24-46 % reported for healthy cattle (Merck Veterinary Manual, 2016). This shows that all of the diets can be fed to the animal without any known adverse effect. This result is in agreement with the finding of Lamidi (2005). The PCV of experimental animals reported at the beginning, middle and end of this study for both bull and heifer weaner calves fell within normal range (24-46 %) reported for healthy cattle by Coles (1974), Coppock *et al.*, (1985), Oyedipe *et al.*, (1985). Olalokun and Oyenuga (1975) reported PCV values of 29.5 – 32.8% for white Fulani in Nigeria. Whereas Smith (1959) and Fiennes (1953) reported values of 32.88 – 38.00% for Zebu breed in East Africa. This shows that all of the diets can be fed to the animal without any known adverse effect. This result is in agreement with the finding of Lamidi (2005) and Sani *et al.*, (2014).

Blood glucose concentration is regarded as one of the indicators of energy status in ruminants (Ganong, 2005). The liver is the pre-dominant site of glucose synthesis in the ruminant. Glucose supply is crucial for maintenance and productive functions in growing ruminants (Hagawane *et al.*, 2009).The glucose value obtained in this study was higher than the 2.11- 2.90 reported by Jonas and Vilma (2007) but within the normal range of 3.0-8.3mmol/l (Woodsman and Evans, 1974).Blood glucose concentration is one of the biochemical indicators on the basis of which one may draw conclusions pertaining to the body energy supply (Kupczynski and Chudoba-Drozdowska 2002). The values for blood glucose reported in this study at the beginning of the experiment fell within the values of 2.11- 2.90mmol/L reported by Jonas and Vilma (2007) for dairy cow and of 40.00 to 49.75mg/dl (2.22-2.76 mmol/L) reported by Roy *et al.* (2016), while the blood glucose values recorded in weaner calves at the middle and end of the experiment fell within the normal range 3.0-8.3mmol/l reported by Woodsman and Evans (1974) and 4.4 and 4.5mmol/L reported by Doornenbal *et al.* (1988) for 7.5 month old bull and steer respectivly.

The blood glucose values at various PKC inclusion levels fell within the normal range of 40 – 100 mg/dl (2.22-5.55mmol/L) reported by Merck Veterinary Manual (2016) for healthy calves but higher than the 2.11- 2.90 reported by Jonas and Vilma (2007). The blood glucose values obtained at the beginning of the feeding trial for both bull and heifer calves were within the values of 2.11- 2.90 reported by Jonas and Vilma (2007), while those obtained for both sexes at the middle and end of the experiment,those obtained irrespective of sex and levels of PKC inclusion, blood glucose values obtained irrespective of sex, levels of PKC inclusion in the diets and sampling interval in the diets all fell within the normal range of 3.0-8.3mmol/L (Woodsman and Evans, 1974) and 5.5- 8.3mmol/l reported for healthy cattle by Slanina (1999). Similar trend was observed by Sani *et al.* (2014) graded level of raw and parboiled rice offal to Bunaji bulls.

The range of 2.5-6.5 mmol/l of blood urea nitrogen was reported by Mehrez *et al* (1976) and Woodsman and Evans (1974). The BUN values obtained in this study were within the normal range for healthy calves. When rumen ammonia is absorbed into the systemic blood, it is converted to urea by the liver thus, the moderate levels of serum urea with inclusion of PKC in the diet could be a pointer to better urea nitrogen utilization. The blood urea level reported for weaner calves in this study at different sampling time was within the range of 2.5-6.5 mmol/l reported by Mehrez *et al.* (1976). It also fall within the normal range of 10 – 25mg/dl (3.57-8.93mmol/L) reported by (Merck Veterinary Manual, 2016) for healthy calves. Mehrez *et al.* (1976) and Woodsman and Evans (1974) reported the range of 2.5-6.5 mmol/l as normal blood urea values for healthy animals which is in line with the range of values obtained across treatments in this study. Calves on 30% PKC also have similar urea value as 4.6mmol/l reported by Cozzi *et al.,* (2011) as reference value for Holstein dairy cow. The urea value reported in this study for both bull and heifer and at different sampling intervals fell within the normal range of blood Urea for healthy calves as reported by Merck Veterinary Manual (2016)which range

between 10 – 25mg/dl (3.57-8.93mmol/l). It also fell within the range reported by Sani *et al.*(2014) when rice offal based diets was fed to bulls. Similar results were obtained by Finangwai (2013) who fed concentrate diets containing varying levels of groundnut haulms to Friesian x Bunajiheifers.

The urea value reported in this study at different levels of PKC inclusion in the diets and for both bull and heifer weaners falls within the normal range of blood urea for healthy animals reported by Mehrez *et al* (1976) which range between 2.5-6.5 mmol/L. Similar report was obtained by Finangwai (2013) who fed Friesian x Bunaji heifers with concentrate diets containing varying levels of groundnut haulms. The urea value reported at the beginning and middle of this study for both bull and heifer and at varying PKC inclusion in the diets all fall within the normal range of Blood Urea for healthy animals reported by Mehrez *et al.,* (1976) which range between 2.5-6.5 mmol/L while a slightly higher value was reported at the end of the experiment.

The total protein values of 75.36g/l and 68.65g/l reported for bull and heifer weaner calves in this study fell within the normal range of 60-82 g/l reported by Gleghorn *et al.* (2004).The total protein obtained at the beginning, middle and end of this study fell within the normal range of6.7 – 7.5 g/dl (67-75g/L) reported by Merck Veterinary Manual (2016) for healthy animals.This is in line with the reports of Hagawane *et al.* (2009) who indicated that TP concentrations are usually used as an appraisal of nutritive status of animals reflecting improved feed intake and metabolism.The values for total protein obtained in this study at graded levels of PKC were within the range of 60-82 g/l reported by Gleghorn *et al.* (2004). This could be attributed to the fact that the animals received adequate levels of protein from the diets and this translated into adequate production of microbial proteins by the microbes to the animal. This

result is in agreement with the finding of Sani *et al.*(2014) who reported TP value within the range of 60-82g/l for Bunaji bulls fed diets containing graded level of raw and parboiled rice offal

The values for total protein obtained in this study for bull and heifer calves at the beginning, middle and end of the study, those reported irrespective of sex and levels of PKC inclusion in the diets all fell within the normal range of 60-82 g/l reported by Gleghorn *et al.* (2004). This shows that the animals protein requirements were adequately met.Ndlov *et al.* (2007) reported that total protein reflect the availability of protein and that total proteinconcentration decline in the phase of protein deficiency.It could also mean that the animals received adequate levels of protein from the diets and this translated into adequate production of microbial proteins by the microbes to the animal. This result is in agreement with the finding of Sani *et al.*(2014).

5. 2.6 Partial budget analyses of weaner Bunaji calves fed palm kernel cake

Feed cost was the major cost monitored during the study; the economic returns were based on this. The calculations of other costs such as capital required for pens, depreciation and purchase of stock and labour were not considered. The result of this study showed that the bull weaner calves have higher economic values than the heifer weaner calves though the income over feed cost (net benefit) which is the most important economic factor for the farmers and rate of return to feed investment observed for both the bull and heifer were all positive.

When level of inclusion of PKC was considered, the result of this study shows that feed cost (concentrate) in Naira per kg declined with increase in PKC levels from ₦40.21/kg to ₦22.58/kg. The feed cost to gain ratio was higher at 0% inclusion level (₦ 353.68/ Kg live weight gain) and lowest at 30% PKC inclusion level (₦ 258.80/Kg live weight gain) which

implies that the 30% inclusion was economically better than the control. Net benefit was higher in the diets with 30% inclusion levels of PKC, it was though statistically similar at 10, 20 and 40% PKC inclusion but lowest value was obtained for the control diets. The income over feed cost (net benefit) which is the most important economic factor for the farmers and rate of return to feed investment observed at the levels of inclusion were all positive.

The result of this study when sex and level of inclusion was considered showed that feed cost (concentrate) in Naira per kg declined with increase in PKC levels for both bull and heifer weaner calves. The value of gain and net benefit was higher at 30% PKC inclusion for bull weaner calves. The heifer weaner calves at 30% also had higher NB than other heifer animals at other PKC inclusion levels. Though the income over feed cost (net benefit) which is the most important economic factor for the farmers and rate of return to feed investment observed at the levelsof inclusion were all positive.

5.3 EXPERIMENT 2 and 3: Effect of feeding diets with graded level of Palm Kernel Cake on the growth and fattening performance of Bunaji yearling and finishing Bulls.

5.3.1 The proximate and cell wall compositions of concentrate diets containing varying levels of PKC fed to Yearling and finishing Bunaji bull.

The CP of the yearling diets ranged from 14.19-17.75% which falls within the range of 15.38-16.18% reported by Yusuf (2016),13-16% Aduku (2005) and 16% CP recommended by NRC (1989) for growing Bulls. However, it is higher than 13% reported by Rutherglen (1995) but lower than the value of 19.64- 22.44% reported by Sani (2014),19.63%by Madziga *et al.* (2013) and 19.00 to 22.91% reported by Lamidi *et al.* (2007) for matured Bulls. The CF ranged from 26.36% for diet containing 10% PKC inclusion to 38.77% for the treatment with 40% inclusion level of PKC which are higher than the minimum level of 17% required for maintenance by beef

cattle (NRC, 2000). The increased in crude fibre as the level of PKC increases could be as a result of higher fibre content in PKC compared with CSC. The ether extract of all the diets were higher than the Maximum recommended level of 6% for mature cattle (Parish and Rhinehart, 2008) This increase might have resulted due to the presence of cotton seed cake and Palm Kernel Cake in all the diets since the efficiency of oil extraction in these ingredient affect its fat profile. Despite this high EE level, there were no negative effects such as diarrhoea observed on the animals fed these diets. The ME of the diets was within the range of 11.79- 11.81MJ/Kg DM. This is within the range of 10.85 - 11.16MJ/Kg DM reported by Sani (2014), 10 - 11.6MJ/Kg DM recommended for Bulls (Rutherglen, 1995). NDF of 44.52-57.78% was similar to 43.61-52.78 reported by Yusuf (2016)

The CP of the fattening diets range from 15.63% to 20.31% . These falls within the range of (19.00 to 22.91%) reported by Lamidi *et al.*, (2007) and 19.69%-22.44% reported by Sani *et al.* (2015) for mature bulls but higher than 13% reported by Rutherglen (1995). The CF of 20%, 30% and 40% PKC inclusion met the minimum level of 17% required for beef cattle (NRC, 2000). The ME of the diets ranged between 11.75-11.78MJ/KgDM which is slightly above the range of 10-11.6MJ/Kg DM recommended for Bulls (Rutherglen, 1995) and 10.85 - 11.16MJ/Kg DM reported by Sani (2014). This implies that these diets have adequate energy content and can be used for fattening of cattle.

Differences in the feed ingredients used could have been why the chemical composition of concentrate diets used in this studies differed from other authors. Feed composition affects rumen fermentation hence the supply of energy (VFA) and Protein in thee form of microbial crude protein (MCP) to the host. Also, feed composition affects rumen residence time that in turn has regulatory effects on feed intakes.

5.3.2 Effect of experimental diets on the performance of yearling and finishing Bunaji Bulls.

There was significant difference (P<0.05) on the performance of animals fed diets containing graded levels of PKC in some of the parameters measured. The ACI of 2.71 -2.81Kg/day is higher than 2.55-2.76Kg/day and 2.54 -2.78Kg/day reported by Yusuf (2016) and Adesote (2013) while the hay intake of 2.27 -2.79Kg/day is lower than 3.49-3.71Kg/day by Yusuf (2016). AFI and ADMI were not significant across treatment. The AWG range from 0.66 - 0.75Kg/day which was similar to 0.70Kg/day reported by Abdulrazak *et al.*(1996) but higher than 0.45- 0.61Kg/day Yusuf (2016), 0.22-0.35Kg/day by Adesote (2013) and Gonzalez *et al* (2002) but lower than 0.75 - 0.85 reported for Nili Ravi buffalo calves fed PKC by Tipu *et al.* (2014). Animals on 0%PKC has the highest weight gain but there is no significantly different (P>0.05) between those on 10, 20, 30 and 40% PKC inclusions. The differences in average weight gain could be due to differences in the season the experiment was carried out, quality of concentrate fed such as crude fiber, amino acid profile and quality used. The data indicate that inclusion level of PKC had no effect on feed intake for bulls. All diets were accepted well by the yearling bulls, as evidenced by similar DMI among bulls receiving diets containing varying inclusion of PKC though weight.gan was different These data support earlier studies (Hutagalung and Mahyuddin, 1985; Jelan et al., 1991) in which inclusion of PKC-based diets or supplements generally resulted in satisfactory animal performance and no negative effects on animal health in finishing crossbred beef cattle and in buffaloes. Another study (Carvalho et al., 2006) reported that solvent-extracted Palm Kernel Meal (PKM) up to 15% in corn silage-based diets did not affect DMI of dairy cows. Chanjula *et al.,*(2010) also observed no adverse effect on feed intake of goats fed PKC based diets at varying inclusion level.

Feed conversion ratio (FCR) of 7.11-8.08 obtained in the yearling study is superior to 9.04-9.55, 13.71-22.40, 9.03-12.05,14.58%-21.81 and 10.6-13.71 reported by Madziga *et al.* (2013), Idowu (2011), Lamidi (2005), Adesote (2013)and Yusuf (2016) respectively but FCR 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) reported by Sani (2014) for fattened bulls is more superior to what was obtained in this study. This suggests that PKC based diets could potentially replace CSC as a dietary protein sources in bulls growwer and fattening diets without compromising feed utilization efficiency.

There was no significant (P>0.05) difference observed in the average weight gain of fattened bulls on 0%, 20% and 40% PKC inclusion though weight gain was highest for animal on 10% PKC but no significant (P>0.05) difference with those of 30% PKC inclusion .The average daily weight gain of 1.14-1.33Kg/day obtained in the present study was similar to Sani *et al.* (2015) 1.11-1.29Kg/day when diets containing graded levels of raw and parboiled rice offal were fed to bunaji bulls, the weight gain of animals on diets containing 0% PKC, 20% PKC and 40% PKC is similar to the AWG of 1.13 kg/d observed by Luziga (2005) in Boran crosses supplemented with molasses based concentrate. but higher than those obtained in earlier studies reported by Lamidi et al. (2007) 0.69-0.91Kg/day, Idowu (2011) 0.40.66Kg/day, Madziga *et al.*, (2013) , 0.961.01Kg/day and 0.50-0.92kg/day reported by Goska(2016) for matured bulls. Also, Feed conversion ratio (FCR) of 6.52-7.57 obtained in this study was similar to 6.26-6.93 obtained by Sani *et al* (2015) but superior to 9.04-9.55, 13.71-22.4 , 9.03-12.05 and 8.31-16.16 reported by Madziga et al. (2013), Idowu (2011), Lamidi (2005) and Goska(2016) respectively but Feed conversion ratio (FCR) 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) reported by Sani (2014) for

fattened bulls is more superior than what was obtained in this study. Higher values obtained could probably be due to differences in experimental diets and efficiency of feed utilization. This implies that PKC can be efficiently utilized to improve feed conversion to body tissue . This differences is also in agreement with the report of McDonald *et al*. (2002) which stated that the amount and quality of feeds consumed directly influence the performance of animals in terms of live weight gain. The average dry matter intake obtained in this study is similar to 8.5 kg DM intake reported by Meissner et al. (2006) for Holstein Friesian growing steers fed diets based on cereal by-product and 8.84 kg DM/d reported by Mawona (2010) for cattle fed cotton seed hulls based diets. These data support earlier studies (Hutagalung and Mahyuddin, 1985; Jelan et al., 1991) in which inclusion of PKC-based diets or supplements generally resulted in satisfactory animal performance and no negative effects on animal health in finishing crossbred beef cattle and in buffaloes. Another study (Carvalho et al., 2006) reported that solvent-extracted PKM up to 15% in corn silage-based diets did not affect DMI for dairy cows This is contrary to the observation made by Mwilawa (2012) who reported 6.1 and 5.7 kg DM per day for Boran and Tanzania Short Zebu (TZSZ), respectively, fed hay and concentrate diet based on conventional feedstuff adlibitum feeding. Chamatata (1996) reported a feed intake of 6.282 kg DM/d of steers fed cotton seed hulls (50%) and hay. The differences in intake may be caused by many factors. Emmans (1997) reported that, animals stop eating to limit metabolic or physical discomfort and energy requirement is considered to be the main intake driver. Similarly, McDonald et al. (2002) reported that intake is not only restricted by gut fill but also the animal's requirements. Fernandez-Rivera et al. (1994) reported that intake is dependent on animal body size, feed physical structure and fibre content, feed selectivity by free grazing animals and the way in which feed breaks down during digestion. Zahari and Alimon (2005) also reported

that supplementing the traditional rations of beef cattle with 30-50% PKC gave improved performance and increased Live weight (LW) gain.

5.3.3 Effect of feeding diet containing varying levels of PKC on the apparent digestibility of yearling and finishing Bunaji bulls

There was significant ($P<0.05$) difference in all the digestibility parameters obtained from feeding diets containing varying levels of PKC to yearling bulls. Animals on 40% PKC inclusions had the highest digestibility values for all the parameters measured, this might have resulted to the higher weight gain obtained at 40% inclusion of PKC when compared to other PKC inclusion levels (10%,20% and 30%) though differences was not statistically significant ($P>0.05$). The inclusion of PKC in diets did not show any adverse effect on digestibility up to 40 % inclusion level of PKC. Similar report was obtained by Chanjula *et al.*(2010) when PKC based diets where fed to goat up to 35% level of inclusion. Crude protein digestibility in this study (56.30% -69.11%) was within the range of 50.11-68.48% reported by Yousuf *et al.* (2013) for goats fed increasing concentrate supplement,49.2-72.8% reported by Wong and Wan Zahari, (1997) when growing sahiwal- friesian bulls where fed diets containing PKC and cocoa pod husk and values reported for Bunaji bulls fattened on diets containing sundried broiler litter as replacement for cottonseed (Lamidi *et al.*, 2007). Dry matter digestibility which ranged from 58.06-67.42% was in agreement with 51-66% reported for sheep supplemented with grade levels of velvet bean hay (Mupangwa et al., 2002) and 56.4-75.8% reported by Wong and Wan Zahari, (1997) when growing sahiwal- friesian bulls where fed diets containing PKC and cocoa pod husk. The NDF and ADF reported in this studies also fell within the range reported by 46.1-76% and 42.1-73.1 reported by Wong and Wan Zahari, (1997). Differences observed in digestibility value reported this study and those of previous workers could be as a result of nutrient contents of the ingredients used in diet formulations in the previous studies and the

actual values of such feedstuffs obtained after laboratory analysis in this study, liveweight and age of the animal, season the experiment was conducted and breed of animal used.

The digestibility of a feedstuff is the proportion of the feed or of any single nutrient of the feed which is not recovered in feces (Ranjhan, 2001). High digestibility expresses the high amount of certain nutrient absorbed by cattle. Low digestibility indicates that the feedstuffs have less ability to supply nutrient for primary needs or production purposes (Mayulu, 2014). The ability to digest the feed is determined by several factors such as feed chemical composition and feed preparation. Measuring the digestibility of feedstuff is an effort to determine the nutrient amount contained in a feedstuff which will be degraded and digested in gastrointestinal tract (Coleman and Moore, 2003; Nurhaita et al., 2010).

There was no significant (P>0.05) difference in the dry Matter digestibility, NDF digestibility and ADF digestibilty for all the fattened Bunaji bulls fed diets containing varying levels of PKC. Animals on 20% and 30% PKC inclusions have the higher CP digestibility values than those on 10% and 30% CP digestibility while the least CP digestibility value was obtained for Bulls on control diet. The DM digestibility obtained in these studies was similar to the range of 61.68-76.33% reported by Goska (2016) but higher than the range of 50.11-68.48% reported by Yousuf et al., (2013) for goats fed increasing concentrate supplement and values reported for Bunaji bulls fattened on diets containing sundried broiler litter as replacement for cottonseed (Lamidi et al., 2007). PKC levels did not have an effect on both voluntary feed intake and nutrient digestibility. A similar report was obtained byChanjula *et al*. (2011) fed rubber seed kernel and palm kernel cake to goat.Dry matter digestibility which ranged from 78.43%-83.30% but higher than the range of 66.49-69.11% reported by Goska *et al.*(2016) and 51-66% reported for sheep supplemented with grade levels of velvet bean hay (Mupangwa et al., 2002).

The digestibility coefficients of various nutrients from the same feedstuffs is affected by species of the animal, age of the animals, level of feeding, feed composition and ration composition (Ranjhan, 1999). Digestibility of a feed is influenced not only by its composition, but also by the composition of others feeds consumed with it. For the ruminant to express their full genetic potential for growth, the apparent digestibility should exceed 70% on dry weight basis. When apparent digestibility is 60%, performance will be intermediate and the minimum range of apparent digestibility to assure body maintenance needs is 42-45%, whereas at lower digestibility of feeds animals lose weight (McDowell, 1988).

5.3.4 Effect of feeding diet containing varying levels of PKC on the Nitrogen balance of yearling and finishing Bunaji bulls

The result shows a decrease in Urinary nitrogen loss, the faecal nitrogen loss and total nitrogen output as the level of PKC increased in the diets of yearling bunaji bulls. Nitrogen retained and nitrogen retained (% N intake) was highest for animals on 40% PKC diets. Nitrogen retained ranged from 70.06-93.78g/day obtained in this study is different from 72.01-79.48 g/day reported Yusuf (2016) while Nitrogen retained as a percentage of intake ranged from 54.73-68.08 obtained in this study was within the normal range of 52.8-64.6% reported by Prakash *et al.*(2003). Differences observed in value reported in this study and those of previous workers could be as a result of feed composition of diets fed and efficiency of feed utilization.

All the yearling and fattening bulls had positive nitrogen balance irrespective of the level of PKC in their diet. This is an indication that the nitrogen was well metabolized and utilized by the bulls. This is also an indication that there was no detrimental effect on feeding PKC up to 40% inclusion level. Hence PKC can be utilized for growing and fattening bulls without any adverse effect. This is inline with the report of Chanjula *et al.*(2010) who observed no any adverse effect on nitrogen utilization of goat feed PKC. who observed Nitrogen retention is a

major indicator used to assess the protein nutrition status of ruminant livestock (Abdu *et al.*, 2012).This is in agreement with the report of Sarwar *et al.* (2003) who stated that nitrogen depends on good digestibility of nutrients and or utilization. In some cases this effect is sufficient to maintain an adequate N balance (Woodward and Reed, 1997).

The Urinary nitrogen reported for fattened bunaji bulls was similar across treatment while the control has the highest faecal nitrogen loss and Total nitrogen output .This is similar to the findings of chanjula *et al.,* 2010 who observed that there was no differences in urinary output of goat at different levels of inclusion of PKC. Nitrogen retained and nitrogen retained (% N intake) is highest for animals on 20% PKC diets but similar to those on diets containing 30% PKC inclusion and lowest for animals on control diets without PKC inclusions. Nitrogen retained ranged from 82.31-171.16 g/day obtained in this study is higher than 72.01-79.48 g/day reported by Yusuf (2016) when he fed graded levels of BDG to yearling Bunaji bulls. Nitrogen intake depend on nitrogen contents of feed and dry matter intake (mohammed *et al.*, 2001).

5.3.5 Effect of palm kernel cake on the rumen metabolite of yearling and finishing Bunaji bulls

The pH of rumen fluid obtained in the yearling study showed significant difference at different sampling time. At 0hr, the pH of the rumen fluid was slightly above 7 but within the range of 6.2-7.2 reported by Van Soest (1994.) The ruminal pH fluctuation is in agreement with Bargo *et al.* (2002) who reported that ruminal pH is the highest pre-concentrate feeding and lowest post-concentrate feeding. At 3hrs, 6hrs and 9hrs after feeding, the pH of the rumen fluid fall within the normal range of 6-7 (Mould and Orskov, 1984), while at 3hrs and 9hrs after feeding, the pH of the rumen fluid fall within the normal range of 6.2 – 6.9 (Reddy and Reddy,1999) and6.55 to 6.77 (Geiger *et al.*, 2014) in Holstein calves. So the pH is adequate for normal rumen function. Rumen digesta pH is variable in the assessment of fermentation in the rumen. The growth of

fiber digesting bacteria is favoured when the rumen digesta content pH is within 6.00-6.80. This result implies that the values of pH obtained in the present study favour the fiber digesting bacteria. Likewise the rumen digesta pH of the bulls in this study was above 5.60 -5.80 reported to cause diet- induced acidiosis in ruminants.

The pH of rumen fluid obtained in the fattening study showed significant difference at different sampling time. At 0hr and 9hrs, the pH of the rumen fluid was slightly above 7 but within the range of 6.2-7.2 reported by Van Soest (1994). 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, microbial activiy, it is known that salivation (buffer) increases pH, absorption via rumen wall also increases pH while build up of VFA reduces pH . At 3hrs and 6hrs after feeding, the pH of the rumen fluid fall within the normal range of 6-7 (Mould and Orskov, 1984), 6.2 – 6.9 (Reddy and Reddy,1999) and 6.18-6.31(Chanjula *et al.,* 2010). However, all treatment means were within the normal range and the values were quite stable at 6.22-6.53, which was in optimal level for microbial digestion of fiber (Hoover, 1986; Van Soest, 1994) and also digestion of protein (6.0-7.0).

There was no significant difference in pH of rumen fluid of all the Bulls in the yearlingand fattening study irrespective of the level of inclusion of PKC. the pH values (6.89-6.92 and 7.03-7.15) for yearling and fattened bull respectively, were 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 5.8-6.4 (Nagaraja and Titgemeyer, 2007). This finding is also in agreement with the report of Lamidi (2005). Chanjula *et al,* (2010) reported a pH value of 6.18-6.31 when goats where fed diets containing varying levels of PKC.

The pH of rumen fluid obtained in the yearlingand fattening study showed significant difference at varying levels of PKC inclusion and at different sampling time. At 0hr, the pH of the rumen fluid was slightly above 7 across treatment except for animal on diets containing 30% PKC levels. This was similar to the values obtained by Yusuf (2016) at ohrsbefore feeding diets containing brewers grain to young bulls. This result 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 3hrs post feeding across treatment, the pH value fall within the normal range of 6-7 (Mould and Orskov, 1984) and 6.2 – 6.9 (Reddy and Reddy,1999) and this signifies that the pH is adequate for normal rumen function., at 6hrs post feeding, the pH value is within the range of 6.98 – 7.13 (Finangwai *et al.,* 2013). This is in line with the report of Aschenbach *et al.*(2014) who observed that pH can vary due the nature of the diet, but typically found between 5.5 and 7.0 when ruminants are fed with predominantly on forage diet.

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 the yearling study were 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. Rumen ammonia nitrogen is a measure of the extent of rumen microbial protein degradation. The rumen NH_3-N values in this study were also higher than the value of 2-8 mg/100ml reported for high producing ruminant livestock (Drewnoski and Poore, 2012) but lower than the value of 11.42 -14.43mg/100ml reported by Jonas and Vilma (2007) and 19-25mg/100ml (Mehrez *et al.,* 1976). The differences observed in the present study and other workers may be due to differences in the protein contents of the diets fed and the animals involved. This is also in line with the report of Gadzama (2017).

The RAN values obtained in the fattening 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. It is also within the range of to the mean ruminal NH3-N concentration of 18.3 mg/dL (range: 8.7 to 32.2 mg/dL) compiled by Bargo et al. (2002) from grazing studies. The rumen NH_3-N values in this study were also higher than the value of 2-8 mg/100ml reported for high producing ruminant livestock (Drewnoski and Poore, 2012) and the value of 11.42 -14.43mg/100ml reported by Jonas and Vilma (2007) but lower than 19-25mg/100ml (Mehrez *et al.,* 1976). The differences observed in the present study and other workers may be due to differences in the protein contents of the diets fed in this studies and those of previous workers and the nutrient retention ability of the animals involved.

Rumen Ammonia Nitrogen of 8.41-10.15 reported for yearling bulls falls within the normal range of 5-20mg/100ml (Leng and Nolan, 1984) but lower than the value of 14.14-16.71mg/dl reported by Chanjula *et al*, (2010) when goats where fed diets containing varying levels of PKC. It was also lower than the value of (12.31-33.95mg/100ml) based on rice offal type, inclusion level (10.98-33.95mg/100ml) and interaction between rice offal type and inclusion level (10.93-33.95mg/100ml) reported by Sani (2014). RAN of 13.51-15.30 obtained in the fattening trials falls within the normal range of 5-20mg/100ml (Leng and Nolan, 1984) for optimum rumen ammonia nitrogen (RAN) level required for maximum rumen function and the values obtained for fattened bunaji bulls by Sani (2014).

The RAN value reported in the yearling and fattening study were within the range of between 3.6 – 17 mg/100 ml NH3 – N reported by Powel *et al.,* (1981) which is the concentration microbial protein production is promoted. Ammonia-Nitrogen is an important factor in determining the utilization of nitrogen in the rumen (Jokthan, 2006). Irrespective of the level of

inclusion of PKC and sampling time, the RAN values obtained at 0hr, 3hr, 6hrs and 9hrs respectively all falls within the normal range of 5-20mg/100ml (Leng and Nolan, 1984) for optimum Rumen Ammonia Nitrogen (RAN) level required for maximum rumen function.

The TVFA value obtained in the yearling and fattenening study were higher than the values (10.5- 12.8mm/l) reported by Kandil *et al.* (1996). There was an increase in volatile fatty acids at 6 hours post feeding, this could be associated with the digestibility of the feed material (Orskov and Ryle, 1990; Khampa and Wanapat, 2007), since the volatile fatty acids are products of degradation of feed in the rumen. The slight decline in TVFA values at 9 hours post feeding across inclusion levels agrees with the work of Orskov (1982), who reported that the concentration of rumen volatile fatty acids decline with time, since volatile fatty acids are the major source of energy and are always absorbed through the walls of the rumen. Similar trend was also observed by Gadzama (2017). The ability of cattle to digest solid feed material in the rumen is a function of the age of the animal, development of the rumen and quality of feed that is provided from liquid and solid feed (Baldwin *et al.*, 2004). This gave a positive indication of the energy value of the experimental diets and signifies better utilization by the animals. 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).

TVFA concentrations gave an indication of the energy value. All the values obtained in the yearling and fattening study for animals on different levels of inclusion was lower than 96.1 - 111.9Mmol/L reported by Jonas and Vilma (2007) but within the value reported by Sani (2014) based on rice offal type (11.19-92.87Mmol/L), inclusion level (10.38-94.36Mmol/L) and interaction between rice offal type and inclusion level (10.33-107.45Mmol/L).The non-

significant difference (P>0.05) on the level of Total volatile fatty acid (TVFA) in the rumen fluid irrespective of the levels of inclusion of PKC in the fattening diets is in line with the report of Orskov (1982). Who 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.

According to Pourazad *et al.* (2015), highly fermentable diets are rapidly converted to volatile fatty acid (VFA) in the rumen. All the values obtained in the yearling and fattening study for animals on different levels of PKC inclusion and sampling time were within the range reported by Sani (2014) based on rice offal type (11.19-92.87Mmol/L), inclusion level (10.38-94.36Mmol/L) and interaction between rice offal type and inclusion level (10.33-107.45Mmol/L) but lower than 60.05 – 87.80 Mmol/L (Finangwai *et al* 2013) and 96.1 - 111.9Mmol/L reported by Jonas and Vilma (2007) .

5.3.6 Effect of palm kernel cake on Packed Cell Volume and some biochemical parameter of yearling and finishing Bunaji bulls

Packed cell volume (PCV) is the volume of erythrocytes expressed as a percentage of the volume of whole blood in a sample. It is the most accurate means of determining red blood cell volume and can be used to deduce total blood volume and haemoglobin levels. When the effect of levels of inclusion on PCV and some biochemical parameter of yearling and finishing Bunaji bulls fed diets containing palm kernel cake was considered, the packed cell volume of (28.08%-30.42% and 31.48-33.10) reported across treatment for yearling and finishing bulls respectively, were higher than 27.40 to 28.00% (Finangwai *et al.*, 2013) but fell within normal range (24-46 %) reported for healthy cattle (Coppock *et al.*, 1985) and the range of 22-38% was also reported by Jain (1993) though moderately lower than the range of 39.79 to 41.42% reported by Moloney et al. (1994).Chineke*et al.* (2006) and Etim *et al.* (2014a) reported that high PCV values

indicated either an increase in number of red blood cells or reduction in circulating plasma volume.Bello and Tsado (2013) stated that PCV within the normal range suggests that there wasno toxic factor (such as haemaglutinin) in the feed of the animal which may adverselyaffectblood formation.

The Packed Cell Volume of experimental animals reported at the Beginning, middle and end of the yearling and weaners study all fell within normal range (24-46 %) reported for healthy Zebu cattle by blood and Radostists (2007) and Biyazen *et al.* (2014.) The normal PCV obtained for animals across treatment show that CP intake was adequate across treatment, This result is in agreement with the finding of Coppock *et al.* (1985) and oyedipe *et al.* (1984) that reduction in crude protein intake resulted in depressed PCV in Zebu cattle. Olalokun and Oyenuga (1975) reported PCV values of 29.5 – 32.8% for white Fulani in Nigeria. Whereas Smith (1959) and Fiennes (1953) reported values of 32.88 – 38.00% for Xebu breed in East Africa. This shows that all of the diets can be fed to the animal without any known adverse effect. This result is in agreement with the finding of Lamidi (2005).

The PCV value for yearling and finishing bulls at the begining, middle and end of the experiment were significantly different ($P<0.05$) at varying levels of PKC inclusion. The PCV value was similar to the values observed in Friesian x Bunaji heifers fed diets with varying levels of cottonseed cake (Barje, 2006). It also falls within the normal range of (24-46 %) reported for healthy cattle by Sani *et al* (2014), Lamidi (2005) and Coles (1986). Olalokun and Oyenuga (1975) also reported PCV values of 29.5 – 32.8% for white Fulani in Nigeria. There was no any known adverse effect exhibited by the animals hence all of the diet can be fed to the animals. Chanjula *et al,*.(2010) also reported that the inclusion of PKC-based diets fed to goat had no effect on BUN, blood glucose and PCV concentrations.A normal PCV value reported in

this study implies the diets was adequate nutritionally as no malnutrition and suppression of the bone marrow or enlarged spleen associated with low PCV nor dehydration and abnormal increase in red blood production associated with high PCV.

The blood glucose values for all the yearling bulls at various levels of inclusion of PKC in this experiment fall within the normal range of 3.0-8.3Mmol/L (Woodsman and Evans, 1974) but higher than 3.45- 3.59 reported by Chanjula *et al* (2010) when goats where fed diets containining PKCand the value of 2.11- 2.90 reported by Jonas and Vilma (2007).In growing animals, glucose requirement is determined by growth rate, which is set by metabolizable energy intake (Reynolds *et al.*, 2003) whereas in mature animals only maintenance energy is required. The physiological status of an animal also affects the glucose concentration (Otto *et al.*, 2000).The blood glucose values for the fattened bulls at 0% and 10% levels of inclusion of PKC fall within the normal range of 3.0-8.3Mmol/L (Woodsman and Evans, 1974) while those animals on diet containing 20%.30% and 40% PKC inclusion falls within the range of 2.11-2.90 reported by Jonas and Vilma (2007).

The blood glucose values at the middle and end of the yearlingand fatteningexperiments fell within the normal range of 3.0-8.3Mmol/L (Woodsman and Evans, 1974). However, values obtained at the beginning of the trial were below this range but within the value of 2.11- 2.90 reported by Jonas and Vilma (2007). Similar trend was observed by Sani *et al* (2014).Glucose, as a source of energy, is necessary for production and reproduction performance. Blood glucose and BUN level may serve as indicators for a ruminant energy status. In the present experiments, these data indicate that bulls consuming the diets with palm kernel cake were in a normal energy status. Similar trend was observed by Sani *et al.* (2014) when rice offal was fed to bulls and chanjula *et al*, (2010) when diets containing PKC was fed to goats. However, the variation in

blood glucose could be affected by physiological status (Firat and Ozpinar, 1996) or disease conditions

There was significant difference ($P<0.05$) in glucose value for experimental animals at the beginning, middle and end of the experiment at varying levels of PKC inclusion. The glucose value obtained in the yearling trial falls within the range of 3.0-8.3Mmol/L reported by Woodsman and Evans (1974) while those reported in the fattening trials at the middle and end of the experiments across all the treatment falls within the range obtained by Sani *et al.* (2014), those on 0% and 10% PKC inclusion diets at the beginning of the experiment falls within the range of 2.11- 2.90 reported by Jonas and Vilma (2007).

The Blood Urea level for healthy animals has been reported by Mehrez *et al.* (1976) to range between 2.5-6.5 mmol/L. The value of 3.60 - 4-43 and 4.31 - 5.04 reported in the yearling and fattening trials respectively fell within the normal range. Measurement of blood urea nitrogen (BUN) may be useful as a tool for making real-time adjustments in protein supplementation for grazing or wintering beef cattle (Hammond, 2006).

The urea value reported in yearling and fattening trials fell within the normal range of Blood Urea for healthy animals reported by Woodsman and Evans (1974) which range between 2.5-6.5 mmol/L. Chanjula *et al.* (2010)reported urea value of 15.58-17.58 mg/dL (5.56-6.28 mmol/L) when goats where fed diets containining PKC. It also falls within the range reported by Sani *et al* (2014) when rice offal baseed diets was fed to Bunaji bulls.

The urea value obtained for yearling and fattening bunaji bulls fed diets containing varying levels of PKC inclusion at different sampling intervals were within the normal range of 2.5-6.5 Mmol/L (Moloney *et al.*, 1994). Similar report was obtained by Finangwai (2013) who fed Friesian x Bunaji heifers with concentrate diets containing varying levels of groundnut

haulms.When rumen ammonia is absorbed into the systemic blood, it is converted to urea by the liver, thus, the moderate levels of serum urea with inclusion of PKC in the diet could be a pointer to better urea nitrogen utilization. Values obtained from fattening bulls across treatment at the middle of the experiment was slightly lower. When rumen ammonia is absorbed into the systemic blood, it is converted to urea by the liver; thus, the moderate levels of serum urea with inclusion of PKC in the diet could be a pointer to better urea nitrogen utilization. Monitoring of blood urea levels can be used for measuring protein status in cattle from different feeding regimes and seasons (Hammond, 2006).

The total protein of the experimental animals reported across treatment for the yearling and fattened bulls (70.83-78.92g/L and 76.17g/L) respectively fells within normal range of 60-82 g/L reported by Gleghorn *et al* (2004). This is in line with the reports of Hagawane *et al*. (2009) who indicated that TP concentrations are usually used as an appraisal of nutritive status of animals reflecting improved feed intake and metabolism.Total protein levels are lower in young animals and higher in mature animals whilst albumin levels are lower at birth and then increases (Otto et al., 2000).

The Total Protein of the experimental animals reported at the start, middle and end of the yearling and fattened trials all fell within normal range of 60-82 g/L reported by Gleghorn *et al* (2004). This could however mean that the animals received adequate levels of protein from the diets and this translated into adequate production of microbial proteins by the microbes to the animal. This result is in agreement with the finding of Sani *et al.*(2014).

The Total Protein value reported for yearling bulls fed diets containing varying levels of PKC inclusion at different sampling intervals in this study falls within normal range of 60-82 g/L

reported by Gleghorn *et al* (2004), Finangwai (2013) and Sani *et al* (2014). This could however mean that the animals received adequate levels of protein from the diets and this translated into adequate production of microbial proteins by the microbes to the animal except at the end of the yearling experiment at 0% (90.75g/L) and 30%(93.50) PKC level of inclusion which was slightly above the normal range.

The Total Protein value reported for animals fed diets containing varying levels of PKC inclusion at different sampling intervals in this study falls within normal range of 60-82 g/L reported by Gleghorn *et al.*,(2004), Finangwai (2013) and Sani *et al.*,(2014). Total serum protein concentration reflects all of the different proteins in plasma with the exception of those that are consumed in clot formation, such as fibrinogen and the clotting factors. The normal range of TP obtained implies that the animals received adequate levels of protein from the formulated diets which was well utilized for adequate production of microbial proteins by the microbes to the animal except at the end of the fattening trial at 0% (83.00g/L) and 30% (84.50g/L) PKC level of inclusion which was slightly above the normal range.

5.3.7 Partial budget analyses of yearling and finishing Bunaji bulls fed diet containing varying levels of PKC

Feed cost was the major cost monitored during the study. The economic returns were base-d on this. The calculations of other cost such as capital required for pens, depreciation and purchase of stock and labour were not considered. The feed cost (concentrate) in Naira per kg declined with increase in PKC levels in the yearling diets from ₦38.07kg to ₦20.51/kg. This is in agreement with the report of Chanjula *et al.* (2010) who observed similar trend of reduced cost of feed as the quantity of PKC increases in the diet.The feed cost to gain ratio was higher at 10% inclusion level (₦ 299.75/ Kg live weight gain) and lowest at 40% PKC inclusion level (₦ 249.70/Kg live weight gain) which implies that the 40% inclusion was economically better than

the control. The net benefits were ₦21052.00, ₦19039.00, ₦18585.00, ₦20835.00 and ₦22341.00 for feeding Bunaji yearling Bulls on 0, 10, 20, 30 and 40% PKC diets respectively. Net benefit was higher in the diets with 40% inclusion levels of PKC though statistically similar at 0% and 30%PKC inclusion.

The feed cost (concentrate) in Naira per kg declined with increase in PKC levels from ₦37.75/kg to ₦20.19/kg for the fattened bulls.The reason for the lower cost of feed with increase in the level of PKC in the diets might have resulted from the low cost of the feed material used in formulation and also because there is low competition for use of PKC wit monogastric animal due to its high fiber content. The feed cost to gain ratio was higher at 0% inclusion level (₦ 315.84/ Kg liveweight gain) and lowest at 40% PKC inclusion level (₦230.33/Kg live weight gain) which implies that the 40% inclusion was economically better than the control though value of gain is higher for animals on 10 and 30%PKC inclusion. Bulls on diets containing varying level of PKC had their initial weights improved by 102.25Kg, 119.75Kg, 104.00Kg, 117.50Kg and 106.00Kg for 0%, 10%, 20%, 30% and 40% PKC inclusion respectively The net benefits were ₦29755.00, ₦40495.00, ₦34571.00, ₦43522.00 and ₦39226.00 for feeding fattened Bunaji bulls on 0, 10, 20, 30 and 40% PKC diets respectively. Net benefit was higher for animals on the diets with 30% inclusion levels of PKC though statistically not significant for those on 10%PKC inclusion.The income over feed cost (net benefit) which is the most important economic factor for the farmers and rate of return to feed investment observed at the levels of inclusion were all positive. The net benefit reported in this study when graded levels of PKC was fed to yearling and finishing bunaji bulls were higher than the value reported when Yusuf (2016) and Sani (2014) who fed graded level of brewer dried grains and raw and parboiled rice offal to yearling and fattened bunaji bulls respectively. This

differences might have occurred because of differences in test ingredient used in this study and that used by Yusuf (2016) and Sani (2014).

5.2.8 Effect of feeding diet containing varying levels of Palm Kernel Cake on carcass yield of fattened Bunaji bulls.

There was significant ($P<0.05$) differences on most of the carcass traits with varying levels of the Palm Kernel Cake fed to the animal. The dressing percentage obtained in this study (53.05%-55.27%) is within the range of 53.69-60.88 reported by Sani (2014) when interaction between rice offal type and inclusion level is considered for fattened Bunaji bulls but lower than the value of 57.21-60.88% based on rice offal type and 55.12-60.88 based on inclusion level of rice offal for fattened Bunaji bulls. Thevalues reported for animals on diets containing 0,10 and 20%PKC inclusion is within range 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. It was also within the range of 51 to 53 % reported for Nguni steers (Muchenje *et al.*, 2008; Mapiye *et al.*, 2009), but were higher than the DP of 49 to 50.5% reported for Zebu cattle (Michael *et al.*, 2001; Nalaila, 2005). This was probably due to different diets and feeding systems used, which contributed to differences in GIT contents. 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 earlier could be due to diet effect since high quality concentrate (maize grain and soybean cake) were fed in those studies. Differences in dressing percentage could also be as a result of breed and season effect as stated by the beef site (2006).

The weight of legs obtained in this study (7.38-8.03) is within the range reported by Sani (2014) 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) but 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 (19.38-22.60) was similar to 19.10 -22.00 reported by Sani (2014). Hide weight of Animals on diets containing 10% and 40% PKC is within the range of 21.8 – 24.60Kg (Olayiwole and Fulani, 1980) and 21.30 – 22.15Kg (Lamidi, 2005). The value reported for head (18.08-20.15) is higher than that reported by Sani (2014) 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) for matured Bulls, 13.8-15.50Kg (Olayiwole and Fulani, 1980), 16.53-18.87Kg as reported by Lamidi (2005). However, the meat to bone ratio obtained in this study is higher than 2.4-2.6% reported by Madziga (2013) and Sani (2014). The weight of the empty stomach reported in this study was similar to the value reported by Sani (2014) when interaction between rice offal type and inclusion level (7.05-8.92 Kg) where considered for fattened bulls.

CHAPTER SIX

6.0 SUMMARY, CONCLUSION AND RECOMMENDATIONS

6.1 Summary

The study comprises of three experiments with 30 weaner (15 Bulls and 15 heifers) calves, 20 yearling and matured Bulls for the weaning, growth and fattening trials respectively. Proximate compositions of the feed ingredients are generally similar to those reported by previous workers. The Animals were penned individually and fed concentrate diets containing Palm Kernel Cake (PKC) at 0, 10, 20, 30 and 40% PKC inclusion and hay (*digitaria smutsii*) at 2% of their body weight each for a period of 90 days. The first experiment comprised a feeding trial with3 weaner heifer and bull calves each allotted to five (5) dietary treatments in a 2x5 factorial arrangement laid in Completely Randomized Design (CRD). The second and third experiments were growth and fattening trials involving twenty (20) yearlings and finishing bulls alloted to 5 dietary treatments in a CRD with 4 bulls per treatment. Blood samples were collected from all the animals at the beginning, middle and end of each experiments for biochemical and PCVanalyses. Water intake was measured and evaporative loss was accounted for. At the end of the growth and fattening trial, rumen fluid was collected from the yearling and finishing Bulls at intervals of 0hr before feeding, 3hrs, 6hrs and 9 hrs after feeding. Digestibility trial was conducted after feeding trial with 3 bull and heifer calves each for the first experiment while 3 bulls per treatment were randomly selected for the second and third trial that lasted for 21 days (14 days adjustment period to the metabolic crate and 7 days total faecal and urine collection) . Economic analyses were carried out to determine the profitability of feeding animals with PKC for growth and fattening perfomance. Carcass analyses was carried out at the end of the fattening trial with ten (10) bulls, 2 bullsrandomly picked per treatment were slaughtered.

In the first experiment (weaners),Most of the parameters measured were higher in bull calves thanheifer though FCR was more superior in heifer calves than bull calves. The result of the feeding trial showed significant ($P<0.05$) difference in most of the parameter measured with level of inclusion except the initial weight which was statistically similar across treatment, Animals on diets containing 30% PKC (0.58Kg) inclusion have the highest weight gain.when sex and level of iclusion was considered, highest weight gain was obtained for bull at 30%PKC (0.65Kg) while the lowest weight gain was obtained for heifer at 0%PKC (0.38Kg). There were significant differences ($P<0.05$)in all the digestible parameters measured with level of inclusion of PKC and when effect of sex and level of inclusion of PKC were considered. There was positive nitrogen balance in all the nitrogen balance parameters measured.ThePCV and biochemical parameters analysed when effect of sex, effect of PKC inclusion and combined effect of sex and PKC inclusion where considered all fell within the normal range. The economic analyses result showed that cost per Kg gain was highest at 0% PKC inclusion and lowest at 40% PKC. Weight gain and Value of Gain (VWG) was highest at 30%PKC inclusion and lowest at 0%PKC inclusion and there was positive net benefit and Return to Investment on Feed (RIF). when sex , level of PKC inclusion and combine effect of sex and level of inclusion was considered hence,it was concluded from the result of the performance, digestibility trial ,blood analyses and economic analyses that PKC can be fed to weaner calves either bull or heiferat 30% PKC inclusionslevel for optimum performance without any known adverse effect

In the second experiment (yearlings), AWG was highest for animal on 0% PKC while those on 10, 20, 30 and 40% PKC inclusion where not significant($P>0.05$). All the bulls attained an average weight gain of between 0.66-0.75Kg. Rumen parameters were significantly ($P<0.05$) affected by sampling time,. Cost per Kg gain was similar at 0 and 20%PKC inclusion and lowest at 40% PKC. VWG were not significant ($P>0.05$) for bulls on 10, 20, 30 and 40% PKC

inclusion. There was positive net benefit and return to investment on feed across treatments. The inclusion of PKC led to reduction in feed cost from ₦ 19598 to a range of ₦ 18761.00- ₦ 15609.00 (about 4.27%-20% reduction in feed cost) therefore, it was concluded that PKC can be included in yearling diets at 40%for optimum economic benefit.

In the third experiment (matured Bulls), The result showed that Rumen pH at 0hr before feeding (7.34) and 9hr post feeding (7.24) were similar (P>0.05) but differed at 3hr (6.84) and 6hrs after feeding(6.92). Blood glucose was highest for animals on diets containing 10%PKC inclusion (3.50) and lowest for those on 30%PKC (2.88).The result of the carcass evaluation showed significant (P<0.05) difference in most of the measured parameter except for value obtained for longissimus muscle which was similar across treatment. Beef % of carcass was highest for bulls fed diets containing 0%PKC inclusion, followed by those on 10,20 and 40%PKC but differ for bulls on 30%PKC inclusion. Dressing % was highest for bulls fed 40%PKC inclusion which was similar to those on 30%PKC, the least value was obtained for animals on 20%PKC which was similar to those on 0% and 10%PKC inclusion.AWG of the bulls was lowest for the control diet (1.14Kg) which was similar (P>0.05) with those on 20% (1.16Kg) and 40% (1.18Kg) while the highest weight gain was recorded for Bulls fed diet containing 10% PKC inclusion (1.33Kg) which was not significant (P>0.05) to those on 30% PKC inclusion (1.31Kg). Bulls on 30%PKC has a more superior FCR(6.52)which was similar to those on 10%PKC (6.67) while animals on 0%PKC has the least FCR (7.57), Cost per Kg gain was highest at 0% PKC inclusion and lowest at 40% PKC. NB and VWG were similar (P>0.05) for Bulls on 10 and 30%PKC inclusion. There was positive NB and RIF across treatment. The inclusion of PKC led to reduction in feed cost from ₦ 29389 to a range of ₦ 28857- ₦ 22099 (about 1.8%-24% reduction in feed cost) therefore , it was concluded that PKC can included in fattening diets up to 40% though optimum performance was obtained at 30%PKC inclusion.

6.2 Conclusion

The following conclusions were made from these studies:

1. PKC can be incorporated in the diets of weaner calves of both sexes at 30%, yearling Bunaji bulls at 40% and fattened Bunaji bulls at 30%inclusion levels without any adverse effect on the optimum performance (feed intake, nutrient digestibilty, nitrogen balance), blood parameters, and rumen metabolite of the Animals.

2. Farmers can fatten their Bulls with PKC inclusion at 30% of the diets and still attain an average weight gain 1.31Kg per day and also produced beef with low inguinal fat, abdominal fat, depth of chest fat and lean meat.

3. There were economic advantages in feeding PKC toweaner calves of both sexes at 30%, yearling Bunaji bulls at 40% and fattened Bunaji bulls at 30% inclusion levels. Therefore, PKC can be fed to the three developmental stages of Bunaji cattle and get an increased positive Net Benefit, return to investment on feed, superiority of feed conversion ratio and average weight gain.

6.3 Recommendation

From the results obtained from these studies, the following recommendations were made:

1. Small holder Farmers and large scale Farmers in Nigeria could include Palm Kernel Cake at 30, 40 and 30% in the diets of weaner calves, yearling Bulls and fattening Bulls respectively for improved performance.

2. Palm Kernel Cake can be included at 30, 40 and 30% in the diets of weaner calves, yearling Bulls and fattening Bulls respectively for improved economic gain.

3. The incorporation of PKC into the fattening diet of Bunaji bulls up to 40% for production of lean meat.

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APPENDIXES



Appendix XVI: Palm Kernel Cake used as test ingredients for the formulation of experimental diets for weaner calves, yearling Bulls and finishing Bulls



Appendix XVII : Digitaria *smutsii* hay used as basal diet for the weaner calves, yearling Bulls and finishing Bulls



Appendix XVIII: Mineral block offered to the weaner calves, yearling Bulls and finishing Bulls



Appendix XIX : Weaner Bunaji calves in individual pens



Appendix XX : Yearling Bunaji bulls in individual pens



Appendix VI : Fattened Bunaji bulls in individual pens



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



Appendix XXIII: Fattened Bunaji bulls in metabolic crate during digestibility trial



Appendix IX: Weighing of experimental diets during digestibility trial.



Appendix XXIII : (a) Feacal and (b) urine samples collected during digestibility trial.



Appendix XXIVI : Fattened Bunaji bulls waiting at the lairage prior to slaughter



Appendix XXVI : Blood collection after slaughtering



Appendix XXVII : Measurement of slaughter weight from carcass of fattened Bunaji bulls



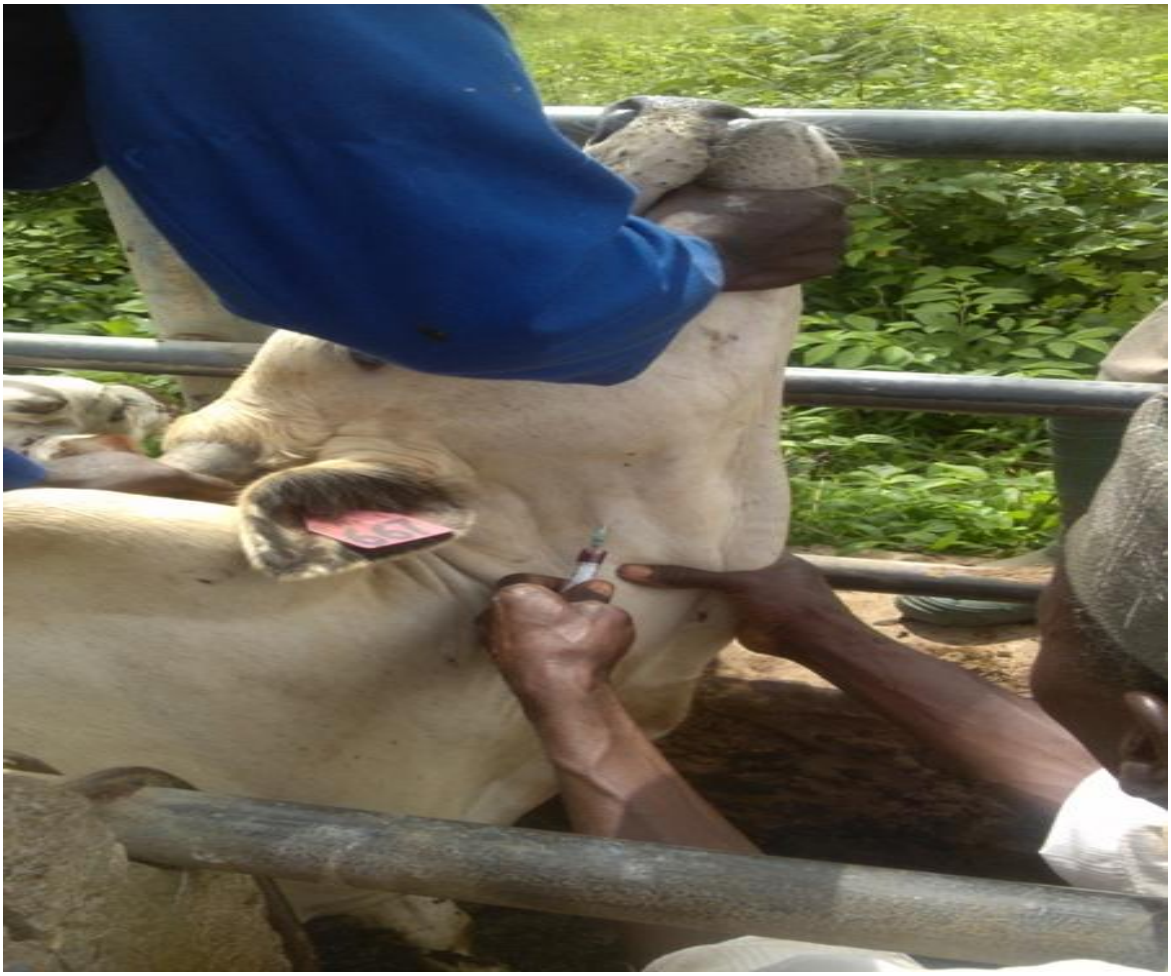
Appendix XIV: Hot carcass measurement with a weighing scale



Appendix XV: Preparation of dissectible beef for weighing



Appendix XXVIII : Prepararion of offals for weighing



Appendix XXVIIIII: Animal being bled in a crush.



Appendix XXIXII: Rumen fluid samples collection using stomach tube



Appendix XXXX : Measurement of Rumen pH using pH meter