EFFECT OF GINGER BY-PRODUCT MEAL SUPPLEMENTATION WITH ENZYME/PALM OIL ON PERFORMANCE, BLOOD CHEMISTRY AND HISTOPATHOLOGY OF BROILER CHICKENS

BY

DAUDU OLUREMI MARTHA
Ph.D/Agric/11095/07-08

DEPARTMENT OF ANIMAL SCIENCE
AHMADU BELLO UNIVERSITY, ZARIA NIGERIA

NOVEMBER, 2012

EFFECT OF GINGER BY-PRODUCT MEAL SUPPLEMENTATION WITH ENZYME/PALM OIL ON PERFORMANCE, BLOOD CHEMISTRY AND HISTOPATHOLOGY OF BROILER CHICKENS

BY

DAUDU OLUREMI MARTHA
B.Agric (ABU 2000), M.Sc. Animal Science (ABU 2006)
Ph.D/Agric/11095/07-08

A DISSERTATION SUBMITTED TO THE POST-GRADUATE SCHOOL, AHMADU BELLO UNIVERSITY, ZARIA IN PARTIAL FULFILLMENT OF THE AWARD OF DOCTOR OF PHILOSOPHY IN ANIMAL SCIENCE
DEPARTMENT OF ANIMAL SCIENCE
AHMADU BELLO UNIVERSITY, ZARIA NIGERIA

NOVEMBER, 2012

DECLARATION

I declare that the work in the dissertation entitled "**Effect of Ginger By-Product Meal Supplementation with Enzyme/Palm oil on Performance, Blood Chemistry and Histopathology of Broiler Chickens"** has been carried out by me in the Department of Animal Science under the supervision of Prof. (Mrs.) A.A.Sekoni, Prof. S.O. Ogundipe and Prof. (Mrs.) G.T. Iyeghe-Erakpotobor.

The information derived from the literature has been duly acknowledged in the text and a list of references provided. No part of this dissertation was previously presented for another degree or diploma at any university.

Name of student	Signature	Date

CERTIFICATION

This dissertation entitled **"Effect of Ginger By-Product Meal Supplementation with Enzyme/Palm oil on Performance, Blood Chemistry and Histopathology of Broiler Chickens"** by Daudu Oluremi Martha meets the regulations governing the award of the degree of Doctor of Philosophy of Ahmadu Bello University, Zaria and is approved for its contribution to knowledge and literary presentation.

…… Date……
Prof. (Mrs.) A. A. Sekoni
Chairperson, Supervisory Committee

…… Date……
Prof. S. O. Ogundipe
Member, Supervisory Committee

…… Date…….
Prof. (Mrs.) G.T Iyeghe-Erakpotobor
Member, Supervisory Committee

…….. Date……
Prof. G.S. Bawa
Head, Department of Animal Science
Ahmadu Bello University, Zaria.

…… Date……
Prof. Adebayo A. Joshua
Dean, School of Post Graduate Studies
Ahmadu Bello University, Zaria.

DEDICATION

This work is dedicated to the Lord God Almighty, my Glory, my shield and the lifter up of my head.

ACKNOWLEDGEMENT

I give thanks to God Almighty who made this possible. My sincere gratitude goes to my supervisors, Prof. (Mrs.) A.A. Sekoni, Prof. S.O. Ogundipe and Prof. (Mrs.) G.T. Iyeghe-Erakpotobor for their contributions toward the success of this work. A big thank you to my husband, Prof. C.K. Daudu, children (Oseeyi and Osebi), my parents, Prof. and Mrs. P.K. Oyebanji and Mrs. C. Daudu. I want to appreciate my uncle, Prof. I.A. Adeyinka for taking time to put me through the analysis of my data.. I also want to appreciate my friends, the Olugbemis, Ogunwoles, Dr. P.A. Onimisi and Dr. (Mrs.) D. Orunmuyi for their encouragement and assistance. A big thank you to Dr. B. Mohammed for taking time to interpret the histology slides. I also appreciate the staff of the farm, biochemical and meat laboratory of Department of Animal Science for their various inputs towards the success of this work. I also want to appreciate Belphins Limited Kafanchan, Kaduna State for providing the ginger by-product meal used in this research. This dissertation has been completed with support from the ABU MacArthur Foundation Projects Grant.

ABSTRACT

Three experiments were conducted to evaluate growth, haematological, histopathological and carcass characteristics of chickens fed Ginger By-product Meal (GBM) diets supplemented with enzyme/palm oil. In experiment one, GBM was supplemented with a multi enzyme preparation (Maxigrain©), using 270 broiler chicks allocated to six experimental diets (0, 15 and 30% GBM; 0 and 0.01% enzyme) in a completely randomized design for eight weeks. Birds fed 0% GBM diet performed significantly ($p<0.05$) better than others. Maxigrain© enzyme did not improve performance of the birds. Serum Alkaline Phosphatase (ALP) significantly ($p<0.05$) increased with enzyme inclusion. The diets had no negative effect on most of the organs except the intestine where there was sloughing of the micro-villi caused by GBM and enzyme. In experiment two, 306 broiler chicks were allocated to six treatments (0, 7.5 and 15% GBM; 0 and 4% palm oil) in CRD. At the starter phase, final weight and weight gain of birds fed 0 and 15% GBM diets were significantly ($p<0.05$) greater than those fed 7.5% GBM diets. Feed to gain ratio significantly ($p<0.05$) increased with increase in dietary GBM. Efficiency of feed utilization significantly ($p<0.05$) increased with addition of palm oil. At the finisher phase, efficiency of feed utilization decreased ($p <0.05$) significantly with increase in GBM. Palm oil had no significant ($p>0.05$) effect on performance. At week eight, serum AST was significantly ($p<0.05$) lower in birds fed 15% GBM diet. Tissue ALT was significantly ($p<0.05$) higher in birds fed 15% GBM diet. The abdominal fat content of birds fed 0% GBM diet was significantly ($p>0.05$) greater than others. GBM and palm oil can be included at 7.5% and 4% respectively for starter birds and 15% and 4% respectively for finisher birds. Experiment three was conducted with 405 broiler chicks allocated to 9 dietary treatments (0, 7.5 and 15% GBM; 0, 4 and 6% palm oil) in CRD. At starter phase, final weight and weight gain for birds fed 0% was similar to 7.5 and 15% GBM diets. Feed efficiency of

birds fed 0 and 7.5% GBM diets were significantly ($p<0.05$) greater than those fed 15% GBM diets. Final weight, weight gain and feed to gain ratio of birds fed 0 and 4% palm oil diets were significantly ($p<0.05$) greater than those fed 6% palm oil diet. Inclusion of GBM and palm oil at 7.5 and 4% respectively significantly improved performance. At week 4, the serum total protein (TP) of birds fed 0 and 15% GBM were significantly ($p<0.05$) greater than that of birds fed 7.5% GBM. Birds fed 15% GBM diets had significantly ($p<0.05$) lower serum ALP. Addition of 6% palm oil significantly decreased ALP. At the finisher phase, feed to gain ratio significantly ($p<0.05$) increased for birds fed 15% GBM diet. The intestinal length and abdominal fat pad of birds fed 4 and 6% palm oil diets was significantly ($p<0.05$) greater than those fed 0% palm oil diet. Haemoglobin concentration of birds fed 4% palm oil was significantly lower than those fed 6% palm oil. The TP of birds fed 7.5% GBM was significantly ($p<0.05$) greater than other birds and significantly ($p<0.05$) increased with palm oil inclusion. The diets had no negative effect on most of the organs except the kidney of birds fed 7.5 and 15% GBM diet supplemented with 4% palm oil that showed congestion. Sloughing of the intestinal micro-villi was observed in all treatments but reduced with palm oil inclusion. The birds fed the control diet performed better than those fed GBM diets with or without enzyme, enzyme did not improve the utilization of GBM. Birds fed 7.5% GBM and 4% palm oil gained more weight than other birds. GBM had no negative effect on the haematological profile of the birds and liver function enzymes hence it is not harmful. GBM decreased the cholesterol content of the plasma of birds at the starter phase. GBM reduced abdominal fat in the carcass. Inclusion of palm oil improved growth performance at the starter phase. Diets of GBM with either palm oil or enzyme induced histopathological changes in the tissues of liver, kidney and intestine associated with dysfunction of these organs.

TABLE OF CONTENTS

Cover page		i
Title page		ii
Declaration		iii
Certification		iv
Dedication		v
Acknowledgement		vi
Abstract		vii
Table of Contents		x
List of Tables		xv
List of Figures		xviii
List of Plates		xx
1.0	CHAPTER ONE: INTRODUCTION	1
2.0	CHAPTER TWO: LITERATURE REVIEW	4
2.1	The Ginger Plant	4
2.2	Ginger Production in Nigeria	7
2.3	Ginger and Animal feed	7
2.4	The Use of Enzymes in Poultry Diets	10
2.4.1	Importance of Enzymes in Poultry Diets	11
2.5	Non-Starch Polysaccharides (NSP) Found in Feedstuffs	16
2.6	Fat in Poultry Diets	17
2.7	Haematology and Serum Chemistry	21
2.8	Histopathology of Birds fed GBM/Palm Oil	25

3.0	CHAPTER THREE: MATERIALS AND METHOD	28
3.1	Processing of Ginger By-product Meal (GBM)	28
3.2	Experimental Site	28
3.3	Experiment 1: Effect of Enzyme and Non-Enzyme Supplementation On the utilization of GBM in Broiler Chicken Diets	28
3.3.1	Growth Study	28
3.3.1.1	Experimental Design (Starter Phase)	28
3.3.1.2	Experimental Design (Finisher Phase)	29
3.3.1.3	Data Collection	29
3.3.2	Haematological and Serum Chemistry Study	32
3.3.3	Carcass Study	33
3.3.4	Statistical Analysis	33
3.3.5	Histopathological Study	34
3.4	Experiment 2: Effect of Palm Oil Supplementation on the Utilization of GBM in Broiler Chicken Diets	34
3.4.1	Growth Study	34
3.4.1.1	Experimental Design (Starter Phase)	34
3.4.1.2	Experimental Design (Finisher Phase)	36
3.4.2	Statistical Analysis	36
3.5	Experiment 3: Effect of Graded Levels of Palm Oil on the Utilization GBM in Broiler Chickens	36
3.5.1	Growth Study	36
3.5.1.1	Experimental Design (Starter Phase)	36
3.5.1.2	Experimental Design (Finisher Phase)	38

3.5.2	Statistical analysis	38
4.0	CHAPTER FOUR: RESULTS	41
4.1	Proximate Composition of Ginger By-Product Meal	41
4.2	Experiment 1: Effect of Enzyme and Non-Enzyme Supplementation on Utilization of GBM in Broiler Chickens Diets	41
4.2.1	Performance Of Broiler Chickens (Starter Phase)	41
4.2.2	Effect of Dietary Levels of GBM/Enzyme on Haematological Profile of Broiler Chickens	49
4.2.3	Effect of Dietary Levels of GBM and Enzyme on Serum Chemistry of Broiler Chickens	49
4.2.4	Performance of Broiler Chickens (Finisher Phase)	49
4.2.5	Effect of Dietary Levels of GBM and Enzyme on Haematological Parameters of Broiler Chickens	58
4.2.6	Effect of Dietary Levels of GBM and Enzyme on Serum Chemistry of Broiler Chickens	58
4.2.7	Effect of Dietary Levels of GBM/Enzyme on Carcass and Organ Characteristics of Broiler Chickens	61
4.2.8.	Effect of Dietary Levels of GBM and Enzyme on Histology of Organs of Broiler Chickens	61
4.3	Experiment 2: Effect of Palm Oil Supplementation on the Utilization of GBM in Broiler Chicken Diets	70
4.3.1	Performance of Broiler Birds (Starter Phase)	70
4.3.2	Performance of Broiler Chickens (Finisher Phase)	76
4.3.3	Effect of Dietary Levels of GBM and Palm oil on Haematological Parameters of Broiler Chickens	80
4.3.4	Effect of Dietary Levels of GBM and Palm Oil on Serum Chemistry of Broiler Chickens	83

4.3.5	Effect of Dietary Levels of GBM and Palm Oil on Carcass and Organ Characteristics of Broiler Chickens	87
4.4	Experiment 3: Effect of Graded Levels of Palm Oil on the Utilization of GBM in Broiler Chicken Diets	90
4.4.1	Performance of Broiler Chickens (Starter Phase)	90
4.4.2	Effect of Dietary Levels of GBM and Palm Oil on Serum Chemistry of Broiler Chickens	95
4.4.3	Effect of Dietary Levels of GBM and Palm Oil on Haematological Indices of Broiler Chickens	99
4.4.4	Performance of Broiler Chickens (Finisher Phase)	99
4.4.5	Effect of Dietary Levels of GBM and Palm Oil on Serum Chemistry	103
4.4.6	Effect of Dietary Levels of GBM and Palm Oil on Haematological Indices of Broiler Chickens	107
4.4.7	Effect of Dietary Levels of GBM and Palm Oil on Carcass and Organ Characteristics	107
4.4.8	Effect of Dietary Levels of GBM and Palm oil on Histology of Organs of Broiler Chickens	110
5.0	CHAPTER FIVE: DISCUSSION	119
5.1	Proximate Composition of Ginger By-Product Meal	119
5.2	Experiment 1: Effect of Enzyme and Non-Enzyme Supplementation on the Utilization of GBM in Broiler Chicken Diets	119
5.2.1	Performance of Broiler Chickens (Starter Phase)	119
5.2.2	Effect of Dietary Levels of GBM and Enzyme on Haematological Profile	120
5.2.3	Effect of Dietary Levels of GBM and Enzyme on Serum Chemistry	121
5.2.4	Performance of Broiler Chickens (Finisher Phase)	121

5.2.5	Effect of Dietary Levels of GBM and Enzyme on Haematological Parameters	122
5.2.6	Effect of Dietary Levels of GBM and Enzyme on Serum Chemistry	122
5.2.7	Effect of Dietary Levels of GBM and Enzyme on Carcass and Organ characteristics	123
5.2.8	Effect of Dietary Levels of GBM and Enzyme on Histology of Organs	124
5.3	Experiment 2: Effect of Palm Oil Supplementation on the Utilization of GBM in Broiler Chicken Diets	126
5.3.1	Performance of Broiler Birds (Starter Phase)	126
5.3.2	Performance of Broiler Birds (Finisher Phase)	126
5.3.3	Effect of Dietary Levels of GBM and Palm oil on Haematological Parameters	127
5.3.4	Effect of Dietary Levels of GBM and Palm Oil on Serum Chemistry	127
5.3.5	Effect of Dietary Levels of GBM/ Palm Oil on Carcass and Organ Characteristics	128
5.4	Experiment 3: Effect of Graded Levels of Palm Oil on the Utilization Of GBM in Broiler Chicken Diets	129
5.4.1	Performance of Broiler Chickens (Starter Phase)	129
5.4.2	Effect of Dietary Levels of GBM and Palm Oil on Serum Chemistry	130
5.4.3	Effect of Dietary Levels of GBM and Palm Oil on Haematological Indices	130
5.4.4	Performance of Broiler Chickens (Finisher Phase)	130
5.4.5	Effect of Dietary Levels of GBM and Palm Oil on Serum Chemistry	131
5.4.6	Effect of Dietary Levels of GBM and Palm Oil on Haematological Indices	131
5.4.7	Effect of Dietary Levels of GBM and Palm Oil on Carcass and Organ Characteristics	131

5.4.8	Effect of Dietary Levels of GBM and Palm oil on Histology of Organs of Broiler Chickens	132
6.0	CHAPTER SIX: SUMMARY, CONCLUSIONS AND RECOMMENDATIONS.	133
6.1	Summary	133
6.2	Conclusions	135
6.3	Recommendations	136
	References	137

LIST OF TABLES

Table 2.1:	Enzymes used in Poultry feeds	13
Table 3.1:	Composition of Broiler Starter Diets in Experiment 1	30
Table 3.2:	Composition of Broiler Finisher Diets in Experiment 1	31
Table 3.3:	Composition of Broiler Starter Diets in Experiment 2	35
Table 3.4	Composition of Broiler Finisher Diets in Experiment 2	37
Table 3.5	Composition of Broiler Starter Diets in Experiment 3	39
Table 3.6	Composition of Broiler Finisher Dies in Experiment 3	40
Table 4.1	Proximate analysis of GBM	42
Table 4.2	Effect of Dietary Levels of GBM and Enzyme on Performance of Broiler Chicks during Starter Phase	43
Table 4.3	Effect of Dietary Levels of GBM and Enzyme on Production Parameters of Broiler Chicks	46
Table 4.4	Eigen values and Principal Component Loading for Broiler Starter Phase	48
Table 4.5	Effect of Dietary Levels of GBM/Enzyme on Haematological Parameters of Broiler Chickens	50
Table 4.6	Effect of Dietary Levels of GBM and Enzyme on Serum Chemistry of Broiler Chickens	51
Table 4.7	Effect of Dietary Levels of GBM/Enzyme on Performance of Broiler Chickens during Finisher Phase	53
Table 4.8	Effect of Dietary Levels of GBM and Enzyme on Production Parameters of broilers during Finisher phase	55
Table 4.9	Eigen values and Principal Component Loading for Broiler Finisher Phase	59
Table 4.10	Effect of Dietary Levels of GBM/Enzyme on Serum Chemistry of Broiler Chickens during Finisher Phase	60
Table 4.11	Effect of Dietary Levels of GBM/Enzyme on Carcass and Organ Characteristics of Broiler Chickens	62

Table 4.12	Effect of Dietary Levels of GBM and Enzyme on Carcass and Organ Characteristics of Broiler Chickens	63
Table 4.13	Summary of Effect of Dietary Levels of GBM and Enzyme on Histology of Organs of Broiler Chickens	64
Table 4.14	Effect of Dietary Levels of GBM/Palm Oil on Performance of Broiler Chickens during Starter Phase	71
Table 4.15	Effect of Dietary Levels of GBM and Palm Oil on Performance of Broiler chickens during Starter Phase	73
Table 4.16	Eigenvalues and Principal Component Loading for Broiler Starter phase	78
Table 4.17	Effect of Dietary Levels of GBM/Palm Oil on Performance of Broiler Chickens during Finisher Phase	79
Table 4.18	Effect of Dietary Levels of GBM/Palm Oil on Haematological Parameters of Broiler Chickens during the Finisher Phase	82
Table 4.19	Effect of Dietary Levels of GBM and Palm Oil on Haematological Parameters of Broiler Chickens at Week 5	84
Table 4.20	Effect of Dietary Levels of GBM/Palm Oil on Serum Chemistry of Broiler Chickens during Finisher Phase	85
Table 4.21	Effect of Dietary Levels of GBM and Palm Oil on Serum Chemistry of Broiler Chickens during Finisher Phase	86
Table 4.22	Effect of Dietary Levels of GBM/Palm Oil on Carcass and Organ Characteristics of Broiler Chickens	88
Table 4.23	Effect of Dietary Levels of GBM and Palm Oil on Carcass and Organ Characteristics of Broiler Chickens	89
Table 4.24	Effect of Dietary Levels of GBM/Palm Oil on Performance of Broiler Chickens during Starter Phase	91
Table 4.25	Effect of Dietary Levels of GBM and Palm Oil on Performance of Broiler Chickens during Starter Phase	93
Table 4.26	Eigenvalues and Principal Component loading for Broiler Starter Phase	96

Table 4.27	Effect of Dietary Levels of GBM/Palm Oil on Serum Chemistry of Broiler Chickens during Starter Phase	97
Table 4.28	Effect of Dietary Levels of GBM and Palm oil on Serum Chemistry of Broiler Chickens during Starter Phase	98
Table 4.29	Effect of Dietary Levels of GBM/Palm Oil on Haematological Indices of Broiler chickens during Starter Phase	100
Table 4.30	Effect of Dietary Levels of GBM/Palm Oil on Performance of Broiler Chickens during Finisher Phase	101
Table 4.31	Eigenvalues and Principal Component Loading for Broiler Finisher Phase	104
Table 4.32	Effect of Dietary Levels of GBM/Palm Oil on Performance of Broiler Chickens (0-7weeks)	105
Table 4.33	Effect of Dietary Levels of GBM/Palm oil on Serum Chemistry of Broiler Chickens during Finisher Phase	106
Table 4.34	Effect of Dietary Levels of GBM/Palm Oil on Haematological Indices of Broiler Chickens during Finisher Phase	108
Table 4.35	Effect of Dietary Levels of GBM/Palm Oil on Carcass and Organ Characteristics of Broiler Chickens	109
Table 4.36	Summary of Effect of Dietary Levels of GBM and Palm Oil on Histology of Organs of Broiler Chickens	111

LIST OF FIGURES

Figure 2.1	Ginger Plant (*Zingiber officinale*)	5
Figure 2.2	Ginger Rhizome	5
Figure 4.1	Trend line of final weight for broiler starter chickens fed varying levels of Ginger by-product meal	44
Figure 4.2	GBM and Enzyme interaction on Feed Intake at starter phase	47
Figure 4.3	GBM and Enzyme interaction on Feed/Gain at starter phase	47
Figure 4.4	Trend line of final weight of broiler finisher chickens fed varying levels of Ginger by-product meal	54
Figure 4.5	GBM and Enzyme interactions for final weight during finisher phase	56
Figure 4.6	GBM and Enzyme interactions for weight gain during finisher phase	56
Figure 4.7	GBM and Enzyme interaction for feed/gain during finisher phase	57
Figure 4.8	Trend line of final weight for broiler chickens fed varying levels of GBM at starter phase	72
Figure 4.9	Interaction of dietary levels of GBM and Palm oil on feed intake during starter phase	74
Figure 4.10	Interaction of dietary levels of GBM and Palm oil on final weight during starter phase	74
Figure 4.11	Interaction of dietary levels of GBM and Palm oil on weight gain during starter phase	75
Figure 4.12	Interaction of dietary levels of GBM and Palm oil on feed/gain during starter phase	77
Figure 4.13	Trend line of final weight for broiler chickens fed varying levels of GBM during finisher phase	81
Figure 4.14	Trend line of final weight for broiler chickens fed varying levels of GBM during starter phase	92

Figure 4.15	Interaction of Dietary Levels of GBM and Palm oil on Final weight during starter phase	94
Figure 4.16	Interaction of Dietary Levels of GBM and Palm oil on Weight gain during starter phase	94
Figure 4.17	Trend line of final weight for broiler chickens fed varying levels of GBM during finisher phase	102
Figure 4.18	Trend line of weight gain for broiler chickens fed varying levels of GBM during finisher phase	102

LIST OF PLATES

Plate 1a – Photomicrograph of the liver of chicken fed 0% GBM and 0% enzyme 66
Plate 1b – Photomicrograph of the liver of chicken fed 15% GBM and 0% enzyme 66
Plate 1c – Photomicrograph of the liver of chicken fed 30% GBM and 0% enzyme 66
Plate 2a – Photomicrograph of the liver of chicken fed 0% GBM and 0.01% enzyme 66
Plate 2b – Photomicrograph of the liver of chicken fed 15% GBM and 0.01% enzyme 66
Plate 2c – Photomicrograph of the liver of chicken fed 30% GBM and 0.01% enzyme 66
Plate 3a – Photomicrograph of the kidney of chicken fed 0% GBM and 0% enzyme 67
Plate 3b – Photomicrograph of the kidney of chicken fed 15% GBM and 0% enzyme 67
Plate 3c – Photomicrograph of the kidney of chicken fed 30% GBM and 0% enzyme 67
Plate 4a – Photomicrograph of the kidney of chicken fed 0% GBM and 0.01% enzyme 67
Plate 4b – Photomicrograph of the kidney of chicken fed 15% GBM and 0.01% enzyme 67
Plate 4c – Photomicrograph of the kidney of chicken fed 30% GBM and 0.01% enzyme 67
Plate 5a – Photomicrograph of the spleen of chicken fed 0% GBM and 0% enzyme 68
Plate 5b – Photomicrograph of the spleen of chicken fed 15% GBM and 0% enzyme 68
Plate 5c – Photomicrograph of the spleen of chicken fed 30% GBM and 0% enzyme 68
Plate 6a – Photomicrograph of the spleen of chicken fed 0% GBM and 0.01% enzyme 68
Plate 6b – Photomicrograph of the spleen of chicken fed 15% GBM and 0.01% enzyme 68
Plate 6c – Photomicrograph of the spleen of chicken fed 30% GBM and 0.01% enzyme 68
Plate 7a – Photomicrograph of the intestine of chicken fed 0% GBM and 0% enzyme 69
Plate 7b – Photomicrograph of the intestine of chicken fed 15% GBM and 0% enzyme 69
Plate 7c – Photomicrograph of the intestine of chicken fed 30% GBM and 0% enzyme 69
Plate 8a – Photomicrograph of the intestine of chicken fed 0% GBM and 0.01% enzyme 69

Plate 8b – Photomicrograph of the intestine of chicken fed 15% GBM and 0.01% enzyme 69

Plate 8c – Photomicrograph of the intestine of chicken fed 30% GBM and 0.01% enzyme 69

Plate 9a - Photomicrograph of the liver of chicken fed 0% GBM and 0% palm oil 113

Plate 9b - Photomicrograph of the liver of chicken fed 7.5% GBM and 0% palm oil 113

Plate 9c - Photomicrograph of the liver of chicken fed 15% GBM and 0% palm oil 113

Plate 10a - Photomicrograph of the liver of chicken fed 0% GBM and 4% palm oil 113

Plate 10b - Photomicrograph of the liver of chicken fed 7.5% GBM and 4% palm oil 113

Plate 10c - Photomicrograph of the liver of chicken fed 15% GBM and 4% palm oil 113

Plate 11a - Photomicrograph of the liver of chicken fed 0% GBM and 6% palm oil 114

Plate 11b - Photomicrograph of the liver of chicken fed 7.5% GBM and 6% palm oil 114

Plate 11c - Photomicrograph of the liver of chicken fed 15% GBM and 6% palm oil 114

Plate 12a - Photomicrograph of the kidney of chicken fed 0% GBM and 0% palm oil 114

Plate 12b - Photomicrograph of the kidney of chicken fed 7.5% GBM and 0% palm oil 114

Plate 12c - Photomicrograph of the kidney of chicken fed 15% GBM and 0% palm oil 114

Plate 13a - Photomicrograph of the kidney of chicken fed 0% GBM and 4% palm oil 115

Plate 13b - Photomicrograph of the kidney of chicken fed 7.5% GBM and 4% palm oil 115

Plate 13c - Photomicrograph of the kidney of chicken fed 15% GBM and 4% palm oil 115

Plate 14a - Photomicrograph of the kidney of chicken fed 0% GBM and 6% palm oil 115

Plate 14b - Photomicrograph of the kidney of chicken fed 7.5% GBM and 6% palm oil 115

Plate 14c - Photomicrograph of the kidney of chicken fed 15% GBM and 6% palm oil 115

Plate 15a - Photomicrograph of the spleen of chicken fed 0% GBM and 0% palm oil 116

Plate 15b - Photomicrograph of the spleen of chicken fed 7.5% GBM and 0% palm oil 116

Plate 15c - Photomicrograph of the spleen of chicken fed 15% GBM and 0%

palm oil 116

Plate 16a - Photomicrograph of the spleen of chicken fed 0% GBM and 4% palm oil 116
Plate 16b - Photomicrograph of the spleen of chicken fed 7.5% GBM and 4% palm oil 116
Plate 16c - Photomicrograph of the spleen of chicken fed 15% GBM and 4% palm oil 116
Plate 17a - Photomicrograph of the spleen of chicken fed 0% GBM and 6% palm oil 117
Plate 17b - Photomicrograph of the spleen of chicken fed 7.5% GBM and 6% palm oil 117
Plate 17c - Photomicrograph of the spleen of chicken fed 15% GBM and 6% palm oil 117
Plate 18a - Photomicrograph of the intestine of chicken fed 0% GBM and 0% palm oil 117
Plate 18b - Photomicrograph of the intestine of chicken fed 7.5% GBM and 0% palm oil 117
Plate 18c - Photomicrograph of the intestine of chicken fed 15% GBM and 0% palm oil 117
Plate 19a - Photomicrograph of the intestine of chicken fed 0% GBM and 4% palm oil 118
Plate 19b - Photomicrograph of the intestine of chicken fed 7.5% GBM and 4% palm oil 118
Plate 19c - Photomicrograph of the intestine of chicken fed 15% GBM and 4% palm oil 118
Plate 20a - Photomicrograph of the intestine of chicken fed 0% GBM and 6% palm oil 118
Plate 20b - Photomicrograph of the intestine of chicken fed 7.5% GBM and 6% palm oil 118
Plate 20c - Photomicrograph of the intestine of chicken fed 15% GBM and 6% palm oil 118

CHAPTER ONE

1.0 INTRODUCTION

The importance of animal protein in the diet of man has necessitated the need to seek for cheap and affordable alternative sources of feed ingredients in developing countries in order to provide meat at a moderate price. Poultry production, especially broiler chicken remains one of the veritable ways of achieving sustainable and rapid production of quality protein to meet the increasing national protein demand (Apata and Ojo, 2000; Akinmutimi and Okwu, 2006).

The competition between man and livestock for foods such as cereals is partially responsible for the high cost of feeds with the attendant increase in the price of animal products such as meat, eggs and milk. This challenge has led to research into the use of non-conventional feed ingredients in the feeding of domestic animals. The focus of research in recent times has been the utilization of agro-industrial by-products that are not consumed by man, readily available and cheap. This research effort has been expanded in recent times to include the evaluation of medicinal plants because of associated low cost, availability, affordability, good antimicrobial nature, reduced disease associated risks, lowered blood cholesterol level and diversified functions in improving performance, growth rate, feed conversion rate and weight gain in birds (Lewis *et al*., 2003).

A major challenge in the utilisation of some of these alternative sources of feed ingredients by monogastrics has been their high fibre content which limits their utilization as these animals poorly digest cellulose, hemicellulose and lignin which are the major components of agro-industrial by-products (Madubuike and Obidimma, 2009). The digestibility of Non-Starch Polysaccharides (NSP) is very low in poultry and a large amount is voided through faeces.

Non-Starch Polysaccharides are able to bind large amounts of water thus causing increase in the viscosity of the fluid, which may impair the digestion of fat, protein and carbohydrate. Further, high viscosity of digesta will increase the amount of sticky droppings (Bedford, 1996).

The addition of enzyme to the feed of monogastrics can reduce the problem of poor fibre digestion in NSP rich feeds (Attia *et al*., 2003). Supplementary enzymes are added to facilitate the breakdown of larger molecular structures of feed ingredients into smaller ones by their specific actions and make nutrients readily available to the digestive system for better absorption (Attia *et al*., 2008). An increased use of enzymes in feed is expected not only to increase economic gain but also decrease negative environmental impact by reducing the manure output and nutrient excretion particularly excess phosphorus, nitrogen, copper and zinc (Attia *et al*., 2008). Experimental results generally indicate that enzymes added to diets improve feed efficiency, accelerate growth and increase dressing percentage.

Ginger By-product Meal (GBM) is an agro-industrial by-product. Nigeria was rated as the number five in world ginger production with an estimated annual output of 138,000 tonnes (FAO 2008). Ginger by-product meal has high energy content (13 MJ/kg) comparable to that of maize and can therefore replace maize up to 10% (Onimisi, 2004). Other authors such as Ademola *et al*. (2009) fed 0.25-0.50 Kg/100Kg diet of dried ginger to broiler chickens and reported an impaired growth but a reduction in serum cholesterol. Saeid *et al*. (2010) added aqueous extract of ginger at concentration of 0.4 and 0.6% to the drinking water of broiler chickens. It was observed that there was no significant difference in total protein and albumin but serum cholesterol was significantly reduced in chickens administered the extract. However there is a paucity of data on feeding trials carried out to improve the utilization of

GBM, its effect on blood parameters and histopathology of broiler chickens. The inclusion of multi-enzyme preparation and palm oil are potential ways of improving the palatability, digestibility and utilization of higher levels of GBM. This research will be of great importance as it is aimed at the production of cheaper feed and more animal protein.

Research Hypothesis

H_o - The inclusion of enzyme and palm oil will not improve the utilization of GBM

H_a - The inclusion of enzyme and palm oil will improve the utilization of GBM

OBJECTIVES OF THE STUDY

This study was initiated to:

(i) determine the growth performance of broiler chickens fed graded levels of GBM rations supplemented with either enzyme or palm oil.

(ii) evaluate histopathology, haematology and serum chemistry of broiler chickens fed GBM with enzyme or palm oil supplementation.

CHAPTER 2

2.0 LITERATURE REVIEW

2.1 The Ginger Plant

Ginger (*Zingiber officinale*) is a perennial herb whose rhizome (i.e. underground stem) is used widely as a spice, for pickles, candies, preservatives and many medicinal purposes (Figs. 2.1 and 2.2). It is also called red ginger. The plant belongs to the family *Zingibeaceae* which are aromatic herbs with fleshy, tuberous or non-tuberous rhizomes and often have tuber bearing roots (Ke *et al*., 2000). Ginger is harvested between 6 and 12 months after planting and can be grown in many countries of the tropics under a moist ecology.

Ginger contains 44 constituents of nutritional importance, mostly zingebirine, beta sisquiphellandrence, terinole and various amounts of nutrients such as protein, lipids and minerals. The main components are a mixed composition of zingerone, shogaols and gingerols and paradol (Comell and McLachlan, 1972; Nidaullah *et al*., 2010). Its aromatic principles are zingiberene and bisabolene, while the arylalkane - pungent substances are known as gingerols (chief components include [6]-gingerol, [8]-gingerol, [10]- gingerol) and shogaols (chief components include [6]-shogaol, [8]- shogaol, [10]- shogaol), gingerdiols and diarylheptanoids which include among others, gingerenone A and B. Zingerone and shogaols are degradation products of gingerol. Fresh ginger contains the "gingerols" which when exposed to air and heat change into the "shogaols," which is more pungent. This chemical change is one of the most important aspects of ginger's therapeutic value.



Figure 2.1: Ginger Plant (*Zingiber officinale*)



Figure 2.2: Ginger Rhizome

The most abundant gingerol is [6]-gingerol, which is decomposed by heat if the distillation process is carried out and found at higher concentrations in the oleoresin extract (Connell and Sutherand, 1969; Chen *et al*., 1986; Weiss, 2002). The warm, spicy scent from ginger's essential oil makes up about 1.0 to 2.5% of the rhizome, depending on the country of origin (Conley, 1997).

The main components of the volatile oil are zingiberene and arcurcumene, beta-bisabolene and arcurcumene, neral and geranial, D-camphor, beta-phellandrene, geranial, neral and linalool, (E)-alpha-farnesene, important as aroma carrier zingiberol (mixture of cis- and trans-beta-eudesmol). The rhizome contains a spectra of biologically active compounds such as curcumin, 6-gingerol (5-hydroxy-1-4-hydroxy-3-methoxy phenyl), 6-shogoals, zingiberene, bisaboline and several other types of lipids that confers on ginger the characteristic medicinal properties of being pungent and a stimulant (Bliddal *et al*., 2000). These properties have been reported to be responsible for its various medical applications as analgesic, antiulcer, antipyretic, prostaglandin suppression and cardio depressant among many others (Mascolo *et al*., 1989).

Hundreds of ingredients interact to produce ginger's ultimate effect; within this category is a protein-digesting enzyme called "zingibain" acting very much like bromelain in pineapple. This enzyme is one of nature's richest proteolytic enzymes. Other constituents include capsaicin, curcumin and limonene which have an array of physical effects (Conley, 1997). African ginger is darker in colour and higher in monoterpene content, giving a more pungent aroma with camphoraceous notes; it has a high oil content and level of pungency. Therefore it is usually preferred for the production of oils and oleoresins (Surfano *et al*., 1999; Weiss,

2002). Ginger has been known to have antioxidant activity due to the presence of gingerol-related compounds and diarylheptanoids (Kikuzaki and Nakatani, 1993).

Ginger is highly valued in the international market for its aroma, pungency, high oil and oleoresin content. According to Adanlawo and Dairo (2007), ginger contains 5.28% crude protein (CP), 5.54% ether extract (EE), 5.97% ash and 66.26% total carbohydrate. The oxalate content was 4.55 mg g^{-1} and phytin 28.83 mg g^{-1}.

2.2 Ginger Production in Nigeria

Ginger *(Zingiber officinale)* is widely produced in five States of the Federation namely, Kaduna, Nasarawa, Benue, Niger and Gombe; with Kaduna State being the major producer. Nigeria's production in 2008 was estimated at 138,000 metric tonnes (FAO, 2008). Out of this, 10% is locally consumed as fresh ginger while 90% is dried primarily for export. Nigeria is the third largest exporter of ginger in the world after China and India. Commercial varieties of ginger come in either white or black. Black ginger is produced by scalding the root in boiling water before leaving it to dry. White ginger is scraped and dried without the scalding. Other varieties of ginger root include green or immature ginger and preserved ginger which is steeped in syrup.

2.3 Ginger and Animal feed

Herbs such as ginger and garlic can serve as feed additives due to their lower cost of production, reduced risk of toxicity, minimum health hazards and environmental friendliness *(*Devegowda, 1996). Moreover there is a great phobia in using antibiotics as feed additives because of public concern about antibiotic residues in animal products and the potential for evolving antibiotic resistant bacteria.

Ginger is a perennial herb whose rhizome is used widely for many purposes. Ginger as a natural feed additive may be of immense benefit and value in poultry nutrition especially for broilers due to their antibacterial, anti-inflammatory, antiseptic, anti-parasitic and immunomodulatory properties (Onu, 2010). It possesses a mixed composition of pungent substances such as zingerone, shogaols and gingerols which can adversely affect feed intake in animals. Gingerol and shogoal have also been found to suppress gastric contraction (Suekawa *et al*., 1984; Nidaullah *et al., 2010*). Ginger is one of the natural plants which can be used as phytobiotic to improve broiler performance. Its low anti-nutrient content makes it suitable for both animal and human herbal medicine (Adanlawo and Dairo, 2007). The major components of ginger are zingiberene and zingerol that can stimulate the digestive system by controlling the digestive pH and the activity of digestive enzymes and microbial activity.

Red ginger is also bacteriostatic, reducing pathogenic microorganisms in the digestive tract. Moreover, red ginger spice has two types of digestive enzymes; protease enzyme that is used to break down protein and lipase enzyme that is used to break down fat. Both improve nutrient digestion and absorption by animals. Herb spices like ginger and garlic (*Allium sativum*) have been reported to possess useful pharmacological potent chemical substances for use in poultry (Akhtar *et al*., 1984). Recent research on herbal formulations as feed additives have shown encouraging results as regards weight gain, feed efficiency, lowered mortality and increased liveability in poultry (Kumar*,* 1991*;* Mishra and Singh, 2000; Deepak *et al*., 2002; Onu *et al*., 2010).

Ginger has been reported to significantly decrease the live weight of animals (Gujaral *et al*., 1978; Ademola *et al*., 2009). Onimisi (2004) reported a significant increase in feed consumption with the inclusion of solvent extracted GBM up to 30%, however a significant

decrease in final weight and weight gain from 15 to 30% inclusion of GBM was observed. Ademola *et al*. (2009) reported significant decrease in weight gain when 2% ginger was included in broiler diet; the decrease was attributed to the hypolipidemic effect of ginger on abdominal fat. Onimisi (2004) observed significant decrease in the efficiency of feed conversion beyond 10% inclusion of GBM. Omage *et al*. (2007) reported no adverse effect of GBM on the growth of rabbits, non-significant differences in weight gain and feed conversion ratio while there was a significant increase in feed intake of rabbits fed GBM diets.

The results of Dooley *et al*. (2009) showed that feed intake and live weight gain did not differ significantly for diets supplemented with 0.25% ginger, garlic or turmeric. The best feed conversion efficiency was observed in the birds fed basal diet supplemented with garlic. Results published by Onu (2010) showed non-significant difference in the feed consumption of broiler finisher birds fed 0.25% ginger. However, Denbow *et al*. (1989) reported an increase in feed intake and feed conversion ratio when ginger was fed and attributed it to zingerones' ability to stimulate catecholamine secretion from the adrenal medulla which influences the appetite control centres of the brain. On the other hand, in traditional medicine, ginger is believed to have weight-loss properties being described as a root that stimulates digestion and speeds up the body processes.

Spices such as ginger, turmeric and pepper are able to act at various levels of the digestive process from feed intake to nutrient absorption in the gut; at the level of the taste buds they activate the heat receptors, which in turn stimulate salivation (increased synthesis of amylases), secretion of digestive juices in the stomach, secretion of gastric juices and mucus by the stomach epithelium, secretion of bile and increase in the level of biliary acids in the gastric juices. At the stomach level, it brings about increased gastric motility and at the gut

level, there is increased permeability of the gut mucosa to improve nutrient absorption. Ginger has been found to enhance pancreatic lipase activity (Platel and Srinivasan, 2000), intestinal lipase, disaccharidase, sucrase, and maltase activities in rats (Platel and Srinivasan, 1996); all of these have favourable effects on gut function, which is the primary mode of action for growth-promoting feed additives (Windisch *et al*., 2008).

2.4 The Use of Enzymes in Poultry Diets

Enzymes are biological catalysts that bring about biochemical reactions without themselves undergoing any change. They are products of living organisms such as bacteria, yeast, fungi and plant tissue. Enzymes are protein in nature and composed of amino acids arranged in a sequence. Enzymes either act on the substrate randomly or at a specific site on the substrate. They accelerate chemical reactions of living cells to make certain nutrients from feedstuffs available to the organs and tissues by enhancing the digestibility of the feed nutrients 'insitu'. Enzymes are involved in all anabolic and catabolic pathways of digestion (Panda *et al*., 2011). Exogenous enzymes have been used to improve nutrient digestibility in maize-soya bean feeds and to supplement the bird's developing endogenous enzyme function (Ngxumeshe and Gous, 2009).

Mutant or genetically modified strains of microbes that produce excessive quantities of particular enzymes are grown on sugar and starch hydrolysis substrates using modern fermentation technology. The enzymes produced are extracted and separated from the microbes and sterilized before being prepared as free flowing powders or liquids for mixing into feeds. Commercial enzymes used as feed supplements do not contain a single enzyme but rather they are preparations of a variety of enzymes. Some of the preparations available in the market are **Novozyme Sp-243**© which contains beta glucanase, cellulase, pectinase and

amylase; **Selfeed**© composed of protease, amylase, cellulase, lipase and pectinase and **Maxigrain**© which contains cellulase, phytase, beta-glucanase and xylanase.

2.4.1 Importance of Enzymes in Poultry Diets

About 85-90% of poultry feed consists of plant materials that contain large amount of dietary fibres. Poultry however do not produce enzymes like cellulase, hemicellulases, xylanase and β-glucanase which are required for the digestion of cell wall component of plant materials. The nutritional strategy involving the use of commercial feed enzymes offers the potential to overcome the problem by careful selection of the appropriate enzyme from the wide range of commercially available enzymes. Ideal commercial enzymes have good shelf life in terms of storage, show specificity of action, exhibit heat stability and uniform distribution in feed during feed preparation; inexpensive and safe (Panda *et al*., 2011).

Enzymes permit utilization of high levels of agro-industrial by-products by disrupting the plant cell walls which brings about improved performance of monogastrics, enhance the absorption of nutrients by improving nutrient digestibility, destruction of anti-nutritional factors, manipulation of gut flora population, as well as through their effect on the intestinal morphology (Brenes *et al*., 1993; Bedford, 1996; Acamovic, 2001; Attia *et al*., 2003; Ngxumeshe and Gous, 2009). Indigestible non-starch polysaccharides (NSP) in poultry diets adversely affect growth but such negative effects may be ameliorated by the use of exogenous polysaccharidases e.g Maxigrain. Attia *et al*. (2008) reported that multi-enzymes containing β-glucanase, α-amylase, cellulase, pectinase, xylanase, hemicellulase with or without protease and phytase could improve feed utilization and overcome the anti-nutritional factors of feedstuffs and improve gut health and immune response. Viveros *et al.* (1993) reported that enzymes improve digestibility and might improve nutrient absorption a little but they act

mainly by changing microbial flora and improving gut health.Other advantages of enzymes include maximization of the utilization of conventional feedstuffs (Panda *et al*., 2011).

Panda *et al*. (2011) reported that the use of enzymes allows for full expression of the genetic potential of birds, as it brings about increased feed intake to achieve maximum growth and production. This will also reduce early mortality due to the problems associated with harmful moulds and aflatoxin in poultry feeds as well as allow for greater flexibility and accuracy in feed formulation thus leading to a reduction in the cost of feed. Microbial phytase supplementation of low phosphorus maize-soybean diet increased the availability of phosphorus to over 60% and decreased the amount of phosphorus in the droppings by 50% while increasing the apparent absorption of Mg, Zn, Cu and Fe up to 13%, 13%, 7% and 9% respectively. Table 2.1 shows a list of enzymes used in poultry feeds.

The type of microflora present in the gastrointestinal tract (GIT) of the bird plays an important role in the response of the host to enzyme supplementation. Enzyme inclusion in the diets of birds with healthy or beneficial microflora present in the GIT was reported to be of no beneficial effect (Ngxumeshe and Gous, 2009). The testa of sun flower meal (SFM) and cereal grains is rich in non-starch polysaccharides (NSP) which reduce their digestibility. These NSP are polymeric carbohydrates which differ in composition and structure from starch (Annison, 1992) and possess chemical cross linkages among them and therefore are not well digested by poultry (Annison, 1993). Cell wall polysaccharides mainly consist of non-starch polysaccharides (NSP) which are the recombinant anti-nutritional factors (ANF'S) in the feed. A part of these NSP is water soluble and notorious for forming a gel-like viscous consistency in the intestinal tract which is generally associated with reduced growth performance. Therefore, supplementation of wheat diets with an enzyme reduced gut content supernatant

Table 2.1 Enzymes used in Poultry feeds

Enzyme	Substrate	Effect
Cellulase	Cellulose	Degradation of cellulose
Glucanase	β -glucans	Reduction of intestinal digesta viscosity, Reduction of dirty eggs problem
Pectinase	Pectins	Reduction of intestinal digesta viscosity
Xylanase	Xylans	Reduction of intestinal digesta viscosity
Galactosidases	Galactosides	Removal of galactosides
Phytase	Phytic acid	Enhanced utilization of plant phosphorus

Source: Panda *et al*. (2011)

viscosity which was accompanied by improved performance (Pettersson, 1987, Bedford, 1996). Predominantly water soluble and viscous arabinoxylans are assumed to be the factor responsible for the low metabolizable energy (ME) in cereal grains (Choct and Annison, 1990), resulting in relatively poor chick performance (Friesen *et al.,* 1992). Pentasans are the main constituents of the endosperm cell wall of cereal grains and they greatly increase water intake by birds which leads to un-manageable litter problems caused by wet and sticky droppings (Dunn, 1996).

Wet dropping is a big problem especially in laying hens because of increase in percentage of dirty eggs. It may also increase gas production (i.e. ammonia) as well as fly and rodent population in the shed. Similarly, β-glucans also adversely affect all nutrients, especially protein and starch utilization and are known to give rise to highly viscous conditions in the small intestine of the chicks (Hesselman and Aman, 1986).

Bedford (1996), Douglas *et al*. (2000) and Dudley-Cash (2001) reported significant improvements when enzyme supplementation is made to poor quality feed ingredients, resulting in increased feed consumption. Improvement in live weight gain and feed conversion ratio, phosphorus availability and reduced sticky dropping in broilers due to inclusion of enzymes in the diet have also been reported by several workers (Marquardt *et al*., 1994; Hruby, 2003; Anonymous 2005). Panda *et al*. (2011) observed significant improvements in body weight and feed conversion ratio in low and high fibre diets with reduction in the moisture content of droppings. This result contrasts the findings of other researchers who observed that performance of birds fed enzyme-supplemented diets was similar to birds fed diets without enzyme (Abbas *et al*., 1998; Mushtaq *et al*., 2006; Nagaraj *et*

al., 2007; Aftab 2009; Ngxumeshe and Gous, 2009). The result could be due to the variability in nutrient density and the quality of the ingredients used to formulate the diets.

The difference in enzyme preparation, potency and activity might also account for differences in results. It has also been reported that enzymes may be denatured due to the acidic condition (i.e. low pH) of the stomach, resulting in minimal improvements in live performance (Nagaraj *et al*., 2007). Smiricky *et al*. (2002) inferred that there may be other anti-nutritional factors apart from oligosaccharides that potentially inhibit efficient soy protein utilization in the gut, even with enzyme supplementation. Enzyme supplementation in all-vegetable diets showed improved feed efficiency in birds compared to other treatments. This finding suggests that enzymes could help improve performance in older birds (Nagaraj *et al*., 2007).

Selle *et al*. (2010) reported that enzymes depressed intake in wheat based diets by 4.8%. This result also agrees with the findings of Naqvi (1996) who noticed non-significant difference in feed consumption among diets with or without supplementation of enzymes. In contrast to these studies, Marquardt *et al*. (1994) showed that enzyme supplementation resulted in increased feed consumption. The possible explanation for these differences may be the quality of the SFM used in the experimental diets (Raza *et al*., 2009). Youseff and Hassan (2008) also reported that the effect of enzyme mixture depends on the level of Nigella seed meal (NSM). It was observed that there was a significant increase in feed intake for an inclusion level of 66% NSM that was enzyme treated and a significant decrease in feed intake for an inclusion level of 100% NSM that was enzyme treated; a non-significant decrease in feed to gain ratio was observed for both enzyme treated and untreated NSM.

Abbas *et al*. (1998) found that enzyme supplementation had no significant influence on feed to gain ratio when broilers were fed sunflower meal but it was reported that the activity of the commercial enzymes used was not determined, the enzyme preparation might have lost its potency to degrade fibre or had very low activity. Mushtaq *et al*. (2006) and Aftab (2009) also revealed no significant effect of enzyme supplementation of sun flower meal (SFM) based diets for broilers and attributed the variation in results to differences in enzyme preparation. In contrast, Oladunjoye and Ojebiyi (2010) reported an improvement in weight gain and feed efficiency in enzyme treated rice bran diets.

2.5 Non Starch Polysaccharides (NSP) Found in Feedstuffs

The NSP found in feedstuff include arabinoxylans, pectin, β- glucanase, galactosidase and phytic acid (Panda *et al*., 2011).

Arabinoxylans in feedstuffs

These consist of xylose residues as back-bone and branched with Arabinoses. These are the predominant anti-nutritional factors (ANFs) present in cereals like wheat, rye and triticales. The addition of xylanase to rye based diet will reduce the amount of sticky droppings (Panda *et al*., 2011).

Pectin in feedstuffs

The carbohydrates of pectin are galacturonic acid and ramose which constitute the back-bone of pectin. Pectins like xylem also increase the viscosity of the digesta. The use of pectinase gives the best results in diets containing legume like soya beans and peas.

β-glucanase in feedstuffs

These are glucose polymers containing a mixture of β-3 and β-4 linkages which make their physiochemical properties totally different from cellulose which is a straight chain glucose

polymer with only β l-4 linkage. Barley and oats contain a high level of mixed linked β-glucanase (3-4%) which is responsible for its poor nutritive value in chickens. Barley also contains an appreciable amount of soluble non-starch polysaccharides other than glucanase. The negative effect of β-glucans in barley and oat can be alleviated by the use of dietary enzymes containing β-glucanase activity (Panda *et al*., 2011).

Galactosidase in feedstuffs

Addition of galactosidase will not improve the nutritional value of the feed but eliminate the anti-nutritional value of galactosidase which causes diarrhea and stomach problems.

Phytic acid in feedstuffs

Phytic acid or phytase is a naturally occurring organic complex found in plants. It is a reactive anion, which forms a wide variety of insoluble salts with divalent and trivalent cations. It is also known to form complexes with proteins and consequently reduce their availability. Poultry lack endogenous phytase, which hydrolyses phytic acid hence phytic phosphorus is biologically less available to them. Phytic acid consists of a six carbon inositol ring with six phosphate groups which can be hydrolyzed by the enzyme phytase (produced by a number of microorganisms) to release six phosphates. This molecule can bind other cations like calcium, magnesium, zinc and iron and make them unavailable to the system. Supplementation of microbial phytase not only reduces the need for mineral supplementation by increasing the availability of cations (Phosphorus, calcium, and copper) bound to phytic acid, but also has the potential to reduce environmental pollution by minimizing the excretion of phosphorus and nitrogen in manure (Panda *et al.*, 2011).

2.6 Fat in Poultry Diets

The terms fat and oil refer to triglycerides of several profiles of fatty acids. Fatty acids that are not bound to other organic components as glycerol are called free fatty acids. Fats and oils are

esters of glycerol; the former are solid, whereas the latter are liquid at room temperature. A number of different fat sources are available for poultry from animals, vegetables and the rendering industry. The primary sources are poultry fat, tallow, lard, blends and vegetable fats such as sunflower oil, soybean oil, or palm oil. When different fat sources were fed to birds as a portion of a diet, no difference was observed in performance parameters (Baiao and Lara, 2005).

Palm oil is of vegetable origin but is rich in the saturated fatty acid palmitic acid, which constitutes about 45% of the total fatty acids. The use of palm oil in broiler diets is attractive, because it is a saturated source that may be associated with a positive influence on meat firmness (Smink *et al*., 2008) and it can replace animal fat without any negative impact on carcass quality. Palm oil is relatively cheap compared to other fats and it possesses many good qualities such as a high level of saturated fatty acids as well as β carotene and vitamin E (antioxidant agents) which make it more stable.

Lipids constitute the main energy reserve of animals and it has the highest caloric value among all nutrients. The carbon atoms of fatty acids are chemically broken down more than carbon atoms found in sugar. Therefore, the oxidation of triglycerides releases more than twice the energy present in carbohydrates. The deposition of 1 g of energy from carbohydrates or protein by an animal requires higher quantities of these nutrients in comparison to the deposition of 1 g of energy from fat (Baiao and Lara, 2005).

The energetic value of oils and fats depend on the following: the length of the carbonic chain, the number of double bonds, the presence or absence of ester bonds (triglycerides or free fatty acids), the specific arrangements of the saturated and unsaturated fatty acids on the glycerol

backbone, the composition of the free fatty acid, the composition of the diet, the quantity and type of triglycerides supplemented in the diet, the intestinal flora, the sex and the age of the birds (Baiao and Lara, 2005).

Besides supplying energy, the addition of fat to animal diets improves the absorption of fat-soluble vitamins, decreases pulverulence, provides essential fatty acids, improves the palatability of rations and efficiency of utilization of consumed energy (Baiao and Lara, 2005). Furthermore, it increases digestibility, slows the rate of food passage through the gastrointestinal tract, which allows a better absorption of all nutrients present in the diet and increases egg production. Heat stress can also be reduced with the addition of palm oil in diets due to the lowering of heat increment (Bartov *et al.*, 1974; Dale and Fuller 1979).

In birds, body fat composition is similar to the composition of the fat from the diet and apparent digestibility of unsaturated fats is high in the first days of life of birds, whereas apparent digestibility of saturated fats is low (Baiao and Lara, 2005). They also reported that birds fed rations containing oil performed better than birds fed no oil when diets with the same nutritive values were compared.

Nwoche *et al*. (2006) reported significant difference in final weight, weight gain and feed to gain ratio for broilers fed 4% palm oil diets. The birds fed 4% palm oil diets performed significantly better than those fed 0, 2 and 6% palm oil diets. There was no significant difference in feed intake for birds fed 0, 2 and 4% palm oil diets but intake was significantly greater for birds fed 6% palm oil diets. Pesti *et al*. (2002) reported that increasing fat level in the diet from 3 to 6% decreased feed conversion from 1.63 to 1.66 but feed intake was the same. However, birds fed 2, 4 and 8% palm oil diets consumed non-significantly more feed

than the control with the exception of chicks on 6% palm oil. The increase in voluntary intake can be attributed to decrease in heat increment with increase in the level of palm oil in the diets. The consumption of ME was significantly higher in the treated groups compared to the control and the relationship between ME intake and dietary energy level appeared to be linear (r=0.98). Similar effects were also observed by Fuller and Mora (1973) and Lipstein and Bornstein (1975), there was no significant difference in the body weight between the control and birds fed 2, 4 and 6% palm oil diets. There was also no difference in body weight between birds fed 6 and 8% palm oil diets. Chicks fed 8% palm oil gained significantly more weight than the control mainly due to higher ME consumption in the palm oil supplemented group.

Growth rate of chicks reared under tropical conditions with fluctuating (23- 36^{o}C) ambient temperature can be improved by incorporating palm oil in the diets to increase the ME density. The increase in ME density resulted in higher ME consumption which resulted in an improvement of both average daily gain and feed conversion ratio. Broilers fed palm oil treated diets consumed more nutrients per day and required fewer days to reach a given weight which explained the differences in the results between the control and the treated group. The total carcass fat content of broilers was found to increase while protein decreased at higher levels of palm oil inclusion (Panja, 1996).

Sinurat *et al*. (2000) reported that fermented palm oil sludge (FPOS) and non-fermented palm oil sludge (NFPOS) can be included in broiler diets since the mortality, carcass yield, abdominal fat, liver and gizzard were not significantly affected. Best level of inclusion of NFPOS was 5%, although inclusion of 10-15% did not affect growth and feed conversion

significantly but feed intake was significantly depressed. The best level of inclusion of FPOS was 10%, since a higher level (15%) resulted in growth depression.

Fajimi *et al*. (1993) reported that the optimal level of inclusion of rubber seed oil (RSO) in the diets of broiler chicks was 3.0 g kg^{-1}, and that the inclusion of palm oil in broiler diets resulted in superior performance of broilers than the inclusion of RSO. Broilers fed palm oil diets consumed significantly more feed and had greater body weight gain than those fed RSO diets. Treatments had no significant effect on feed conversion ratio or haematological parameters considered. The gizzard was the only organ significantly influenced by sources or levels of oil used. It was also found that broilers metabolized the fat without visible adverse effects on the liver, kidney, spleen, gizzard and heart weight and gross carcass measurements were not significantly affected by oil type and level.

2.7 Haematology and Serum Chemistry

Haematological examinations provide valuable information on the metabolic profile, support objective assessment of the state of health, and are often helpful in the revelation of health disorders already at the preclinical stage. Serum biochemical parameters may provide valuable information for evaluation of health status of birds and reflect many metabolic alterations of organs and tissues. It has also been established that certain haematological parameters are associated with certain production traits in chickens, for example, high PCV and high Hb are indicators of high feed conversion ratio while high serum protein is an indicator of good feathering ability and tissue growth in chickens (Mitruka and Rawnsley, 1977).

Several factors that may have an influence on biochemical parameters in chickens' serum include: feed additives, drugs, environmental temperature and diseases. The blood picture

changes with the advancement of an animal's age and also varies with certain conditions as stress, bacteria or viral infections and intoxication (Sturkie and Textor, 1960; Khan and Zafar, 2005). Changes in the components of the blood when compared to normal values could be used to interpret the metabolic state of the animal as well as the quality of feed (Babatunde *et al*., 1992). These changes correspond with the growth and may be attributed to differences in bone formation or to physical role in general metabolic activity. The evaluation of the levels of total protein and its fractions supply the information required to interpret the occurrence of dehydration, infections, immune diseases, and inflammatory responses (Silva *et al*., 2007).

The determination of blood component values using laboratory examinations is an important procedure to aid the diagnosis of several diseases and dysfunctions, as they provide reliable results, and may also give inputs for research studies on nutrition, physiology, and pathology (Bounous *et al*., 2000). Appearance of abnormal amounts of certain enzymes of intercellular origin in the blood reflects damage to an organ or tissue (Hoffbrand and Pettit, 1997; Dash *et al*., 2007). The liver is rich in enzymes such as serum glutamic-oxaloacetic transaminase/aspartate aminotransferase (SGOT or AST) and serum glutamic-pyruvic transaminase/alanine aminotransferase(SGPT or ALT) and its damage often results in releasing these enzymes to the blood. The parameters include haemoglobin content (Hb), packed cell volume (PCV), total protein, AST, ALT, alkaline phosphatase (ALP), total and differential white blood cell count.

Alterations in blood parameters may be due to changes in cellular integrity, membrane permeability of cells or even due to exposure to toxic chemicals (Choudhari and Deshmukh, 2007). In living systems, the liver is considered to be highly sensitive to toxic agents. The study of different enzyme activities such as AST, ALT, ALP and total protein have been

found to be of great value in the assessment of clinical and experimental liver damage. Necrosis or membrane damage releases the enzyme into circulation; therefore, it can be measured in serum. High levels of AST indicate liver damage, such as that due to viral hepatitis, cardiac infarction and muscle injury. ALT catalyzes the conversion of alanine to pyruvate and glutamate and is released in a similar manner. Therefore, ALT is more specific to the liver and is thus a better parameter for detecting liver injury. The rise in the AST is usually accompanied by an elevation in the levels of ALT, which plays a vital role in the conversion of amino acids to keto acids (Hoffbrand and Pettit, 1997; Dash *et al*., 2007). Serum ALP level on the other hand, is related to the function of hepatic cell. Increase in serum level of ALP is due to increased synthesis of the enzyme, in presence of increasing biliary pressure (Adanlawo and Dairo, 2007).

The effect of ginger supplementation in feeds is generally variable. Haematological indices, serum biochemistry and carcass characteristics of birds were not significantly influenced by feeding ginger supplemented diets (Onu, 2010). The haemoglobin of rats that received administration of aqueous extract of ginger intraperitoneally decreased significantly, some serum enzymes activity such as aspartate aminotransaminase (AST) alanine aminotransaminase (ALT) were affected whereas the liver acid phosphatase was not (Alnaqeeb *et al*., 2003). Saeid *et al*. (2010) reported that ginger extract caused reduction in the levels of plasma cholesterol, triglycerides, LDL-Cholesterol and VLDL-Cholesterol but HDL-cholesterol level statistically increased. It can be included beneficially up to 0.4 and 0.6% in broiler drinking water for reducing blood glucose and serum cholesterol level. On the other hand, treatment with ginger extract followed by induction of diabetes caused reduction in the

plasma levels of cholesterol and LDL-cholesterol and increased the level of plasma HDL-cholesterol, but plasma triglycerides statistically did not change.

Ginger was evaluated as an antilipidemic agent to lower abdominal fat pad, LDL-cholesterol, VLDL-cholesterol, triglycerides, triacylglycerol and serum alkaline phosphatase with consequential reduced growth in animals and increase in HDL- cholesterol level. It also inhibited LDL oxidation and development of atherosclerosis (Bhandari and Grover, 1998; Fuhrman *et al*., 2000; Ademola *et al*., 2009; Saeid *et al*., 2010). It was concluded that (E)-8 beta, 17-epoxyllabed-12-ene-15, 16-dial, a compound isolated from ginger, interfered with cholesterol biosynthesis in liver homogenates of hypercholesterolaemic mice causing its reduction (Tanabe *et al*., 1993).

Zhang *et al*. (2009) reported that the concentration of total protein in serum of ginger-supplemented broilers tended to be lower at 21 days and higher at 42 days of age compared with that of broilers birds fed the control diet. Reducing particle size of ginger powder linearly reduced cholesterol (day 21) and increased glutathione peroxidase (day 21), total superoxide dismutase (day 42), and total protein (day 21 and 42). Supplementation of ginger at the level of 5 g/kg improved antioxidant status of broilers and the efficacy was enhanced as the particle size was reduced from 300 to 37 µm.

Furthermore, Neess *et al*. (1996) reported that the reduction of cellular cholesterol biosynthesis is associated with increased activity of the LDL receptor, which in turn leads to enhanced removal of LDL from plasma, resulting in reduced plasma cholesterol concentration. Bruan and Severson (1992) concluded that deficiency of lipoprotein lipase activity may contribute significantly to the elevation of triglycerides in diabetes. Furthermore, Lopes-Virella (1983) reported that treatment of diabetes with insulin served to lower plasma

triglycerides levels by returning lipoprotein lipase levels to normal. The decreasing levels of plasma triglycerides following treatment with ginger extract may be due to the stimulating effect of ginger extract on insulin (Saeid *et al*., 2010).

Adanlawo and Dairo (2007) reported that when 200 mg/ml of ginger extract was administered, the ALT activity in the liver was highest followed by the brain and lowest activity was recorded in the heart. The serum and kidney ALT was highest for the control group of rats and decreased significantly as the extract concentration increased. ALP activity was highest in the stomach. The enzyme activity as indicated in the liver showed that oral administration of ethanol ginger extract was not damaging to rats. This is contrary to the report of Kasinath *et al*. (1997) who recorded increased activity for AST and ALT when high dose of garlic (also a common spice plant) was administered even though the dosage was not specified. It was however reported that liver toxicity was implicated in the study. Oral administration indicated increased gastrointestinal motility which sets in motion spontaneous peristaltic movement. This could be responsible for the observed increase in alkaline phosphatase activity at the highest ethanol extract concentration (500 mg/ml) for improved food digestion and passage in the stomach and small intestine (Adanlawo and Dairo, 2007).

ALP level for the stomach, small intestine, brain and serum were all significantly influenced by ginger ethanol extract. While the enzyme activity was similar and highest in 400 and 500 mg mL^{-1} extract for the stomach; the small intestine recorded the highest value at 500 mg mL^{-1}, the brain tissue had its highest activity at 400 mg mL^{-1} and the serum at 100 mg mL^{-1}.

2.8 Histopathology of Birds fed GBM/Palm Oil

Alnaqeeb *et al*. (2003) reported that the administration of aqueous extract of ginger to rat orally and intraperitoneally at two different levels did not inflict any histopathological toxicity

on the rat. Ramudu *et al*. (2011) reported that the histological picture of ginger treated diabetic rats showed restoration of glomeruli, tubules and renal cells. Ginger treatment exerts a therapeutic protective effect in diabetes by decreasing oxidative stress, and hepatic and renal damage.

Sakr *et al*. (2011) reported that animals treated with ginger showed no histological alterations but Incharoen *et al*. (2010) reported that intestinal villus height, villus area, cell area and cell mitosis in all the intestinal segments were higher in animals fed dried fermented ginger (DFG) compared to the control. The cells of animals fed DFG were also protuberated and in clusters, suggesting that the intestinal villi and cells might be hypertrophied indicating that dietary DFG can be used as a natural feed additive to induce broiler growth as a result of stimulation of morphological maturation which will increase absorption.

Ajith *et al*. (2007) reported that the presence of polyphenols and flavonoids in ginger extract might be responsible for the antioxidant nephroprotective activities. Adanlawo and Dairo (2007) also reported that the ethanolic extract of ginger root (100-500 mg/ml) did not cause any damage to the vital organs of the body such as heart, brain and the kidney; therefore, its consumption may not have deleterious effect directly on these tissues.

Excessive consumption of fat combined with restricted activity is believed to overwhelm cell repair mechanisms and result in fatty liver syndrome (Chauhan and Roy, 1996; Riddell, 1997). A strong association of reticulolysis with severity of liver haemorrhage and rupture of intrahepatic portal veins associated with degenerative changes in the veins has been described in experimental birds. Focal necrosis of hepatocytes may also lead to vascular injury and haemorrhage.

Inflammation is a series of the vital changes that happen in living cells in response to injury or disruption. The second response of inflammation, are the cellular and vascular responses. The cellular response involves the migration of cells primarily from the venule after the damage has occurred. The first cells that migrate are the neutrophils that actively find the damaged cell while the vascular response is the exudation of blood from the cells and small venules and capillaries. The damage of the capillaries will stop blood flow and conduct the thrombocytes which will agglutinate the white blood cells which will block the lumen of capillaries (Banks, 1993). Some important cells which are involved in the inflammation process are neutrophils, eosinophils, basophils, lymphocytes, cell plasm and macrophages. There are two types of lymphocytes, B and T, lymphocytes B secrete cell plasm, while lymphocytes T secrete immunoblast for cellular immunity and lymphotoxin which function in localized damaged tissues (Hariono, 1993).

Infiltration of cells such as heterophils is due to the influence of chemical substances such as cadmium, zinc, lead and mercury contained in the ginger which are detected by the tissues as toxins (Donatus *et al*., 1983). Toxins may destroy some organs immediately (inter-cellular) or later (extracellular), it affects either biochemical functions or structure of organs depending on the dosage and therapy. A few hours after infection, inflammation products cause faster migration of heterophils from the bone marrow to the damaged tissues or site of inflammation (Guyton, 1991).

CHAPTER 3

3.0 MATERIALS AND METHODS

3.1 PROCESSING OF GINGER BY-PRODUCT MEAL (GBM)

The ginger by-product meal used for these experiments was obtained from Belphins Nigeria Limited, Kafanchan, Kaduna State. The company processes ginger into various products such as ginger juice, ginger tea and ginger spice. Ginger By-product Meal (GBM) is the residue after extraction of juice from ginger rhizome. The ginger was washed and crushed in a local grinding machine in order to extract the juice, after which the residue (GBM) was air dried. The proximate composition of GBM was carried out according to the methods described by AOAC (1990).

3.2 EXPERIMENTAL SITE

The feeding trial was conducted at the Poultry Unit of the Department of Animal Science, Ahmadu Bello University (ABU), Samaru Zaria, Kaduna State. It is located within the Northern Guinea Zone at latitude 11^0 12' N and longitude 7^0 33' E and altitude of 610 m above sea level. The climate is sub-humid with a mean annual rainfall of 1050 mm (Oluwasemire, 1999).

3.3 Experiment 1: EFFECT OF ENZYME AND NON-ENZYME SUPPLEMENTATION ON THE UTILIZATION OF GBM IN BROILER CHICKEN DIETS.

3.3.1 Growth Study

3.3.1.1 Experimental Design (Starter Phase)

A total of 270, three day-old broiler chicks were purchased from Nu- breed hatchery Akure, Ondo State. The chicks were randomly allocated to six (6) treatments with 3 replicates per

treatment and 15 birds per replicate. The experimental design was 3x2 factorial arrangement in a completely randomized design. The factors were GBM fed at three levels (0, 15 and 30%) and enzyme included at two levels (0 Kg/MT and 0.10 Kg/MT). This phase lasted for four weeks. At the end of the 4th week, the birds were fed a common diet for 3 days and then randomized to different treatments. The six experimental diets formulated for the starter phase are shown on Table 3.1.

3.3.1.2 Experimental Design (Finisher Phase)

A total of 252 broiler chickens aged 34 days were randomly allocated to six (6) treatments with 3 replicates per treatment; each replicate consisted of 14 birds in a 3 x 2 factorial arrangement in a completely randomized design. The six experimental diets formulated for this phase is shown on Table 3.2. This phase lasted for four weeks.

3.3.1.3 Data Collection

The broilers were weighed at the beginning of the experiment and weekly thereafter. Feed and water was provided *ad libitum* at 7.00 am daily. Values for feed consumption, weight gain, feed to gain ratio and mortality were calculated and recorded.

Table 3.1: Composition of Broiler Starter Diets in Experiment 1

	GBM Level (%)					
	0		15		30	
	Enzyme Level (%)					
Ingredient	0	0.01	0	0.01	0	0.01
Maize	40.50	40.49	23.00	22.99	6.00	5.79
Enzyme	0.00	0.01	0.00	0.01	0.00	0.01
Soya bean full fat	40.00	40.00	40.00	40.00	40.00	40.00
Groundnut cake	7.50	7.50	10.00	10.00	12.00	12.20
Maize offal	8.00	8.00	8.00	8.00	8.00	8.00
Ginger By-product Meal	0.00	0.00	15.00	15.00	30.00	30.00
Bone meal	3.00	3.00	3.00	3.00	3.00	3.00
Common salt	0.30	0.30	0.30	0.30	0.30	0.30
Methionine	0.40	0.40	0.40	0.40	0.40	0.40
*Premix	0.30	0.30	0.30	0.30	0.30	0.30
Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
Calculated Analysis						
ME (MJ/kg)	13	13	13	13	12	12
Crude Protein (%)	23.00	23.00	23.09	23.09	23.03	23.10
Crude Fibre (%)	4.59	4.59	5.89	5.89	7.13	7.15
Ether Extract (%)	4.45	4.45	4.25	4.25	4.03	4.04
Calcium (%)	1.20	1.20	1.71	1.71	2.31	2.31
Available P (%)	0.85	0.85	1.23	1.23	1.61	1.61
Lysine (%)	1.33	1.33	1.33	1.33	1.32	1.32
Methionine (%)	0.67	0.67	0.75	0.75	0.74	0.74
Met.+Cys. (%)	0.96	0.96	0.89	0.89	0.88	0.88
Cost (₦/Kg)	71.08	71.44	68.38	68.74	65.68	66.04

*Biomix premix supplied per Kg of diet: Vit. A, 10,000iu;Vit D_3, 2000iu; Vit E, 23mg; Vit. K, 2mg; Vit, B_1, 1.8mg, Vit B_2, 5.5mg; pantothenic acid, 7.5mg; Vit. B_{12}, 0.015mg; Folic acid, 0.75mg; Biotin, 0.06mg; Choline chloride, 300mg; Cobalt, 0.2mg; Copper, 3mg; Iodine, 1mg; Iron, 20mg; Manganese, 40mg; Selenium, 0.2mg; Zinc, 30mg; Antioxidant, 1.25mg.

Table 3.2: Composition of Broiler Finisher Diets in Experiment 1

	GBM Level (%)					
	0		15		30	
	Enzyme Level (%)					
Ingredients	0	0.01	0	0.01	0	0.01
Maize	48.70	48.69	32.00	31.49	14.50	14.49
Enzyme	0.00	0.01	0.00	0.01	0.00	0.01
Soya bean (full fat)	39.00	39.00	39.00	39.00	39.00	39.00
Groundnut cake	0.30	0.30	2.00	2.50	4.50	4.50
Maize offal	8.00	8.00	8.00	8.00	8.00	8.00
Ginger By-product Meal	0.00	0.00	15.00	15.00	30.00	30.00
Bone meal	3.00	3.00	3.00	3.00	3.00	3.00
Common salt	0.30	0.30	0.30	0.30	0.30	0.30
Methionine	0.40	0.40	0.40	0.40	0.40	0.40
*Premix	0.30	0.30	0.30	0.30	0.30	0.30
Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
Calculated Analysis						
ME (MJ/kg)	13	13	13	13	13	13
Crude Protein (%)	20.10	20.10	19.93	20.11	20.04	20.04
Crude Fibre (%)	3.85	3.85	5.07	5.11	6.36	6.36
Ether Extract (%)	9.26	4.19	3.96	3.98	3.76	3.76
Calcium (%)	1.09	1.09	1.69	1.69	2.30	2.30
Available P (%)	0.83	0.83	1.20	1.20	1.58	1.58
Lysine (%)	1.19	1.19	1.18	1.19	1.18	1.18
Meth. (%)	0.74	0.74	0.72	0.73	0.71	0.71
Met.+Cys.(%)	0.88	1.98	2.14	2.57	2.32	0.85
Cost (₦/Kg)	70.68	71.04	67.98	68.34	65.28	65.64

*Biomix premix supplied per Kg of diet: Vit. A, 10,000iu;Vit D3, 2000iu; Vit E, 23mg; Vit. K, 2mg; Vit, B1, 1.8mg; Vit B2, 5.5mg; pantothenic acid, 7.5mg; Vit. B12, 0.015mg; Folic acid, 0.75mg; Biotin, 0.06mg; Choline chloride, 300mg; Cobalt, 0.2mg; Copper, 3mg; Iodine, 1mg; Iron, 20mg; Manganese, 40mg; Selenium, 0.2mg; Zinc, 30mg; Antioxidant, 1.25mg.

3.3.2 Haematological and Serum Chemistry Study

At the end of the fourth and ninth week in experiment one and three, two millimetres of blood was collected from the wing vein of two fasted birds per replicate into labelled bottles, one set contained ethylene diamine tetraacetic acid (EDTA) and the others were plain bottles for serum chemistry. Blood sampling was carried out at weeks five and eight for the second experiment and weeks four and seven for the third experiment.

The blood samples (0.5 ml) in the EDTA bottles were used for haematological analyses carried out at the Clinical Pathology Laboratory, Faculty of Veterinary Medicine, A.B.U. Zaria, Kaduna State. The uncoagulated blood samples were used for determination of haemoglobin (Hb) concentration, packed cell volume (PCV) using cyanmethaemoglobin and Wintrobe microhaematocrit methods respectively (Coles, 1986) and total protein (Tp). Absolute and differential white blood cell count was determined at the Department of Haematology, Ahmadu Bello University Teaching Hospital, Zaria.

The coagulated blood samples (1.5 ml) were allowed to stand in a test tube rack and the separated serum was decanted following centrifugation at 3,000 revolutions per minute (rpm) for 10 minutes at ambient temperature of 28^{o}C, and stored at -20^{o}C in a deep freezer until required for the serum tests. A portion of weighed liver tissue was pounded in a mortar and the homogenate was centrifuged at 10,000 rpm for 15 minutes and the supernatant used in the determination of aspartate aminotransaminase, alanine aminotransaminase and alkaline phosphatise at the Department of Chemical Pathology, Ahmadu Bello University Teaching Hospital, Shika using the enzyme analytical kits technique for serum and liver (Reitman and Frankel, 1957).

3.3.3 Carcass Study

At the end of each broiler experiment, 9 birds of average weight were randomly selected from each treatment and used for the study. The birds were slaughtered and divided into standard cuts and weighed. The length and weight of the GIT and the weight of the organs were expressed as percent of the live weight of the corresponding broiler, resulting in a relative length and weight measurement.

3.3.4 Statistical Analysis

All data obtained from the trial were subjected to analysis of variance test using the SAS (2002) general linear model procedure and treatment means were compared for significance using Tukey's studentized range test.

Model $Y_{ijk} = \mu + A_i + B_j + (AB)_{ij} + E_{ijk}$

Y_{ijk} = observation K in level i of factor A and level j of factor B

μ - overall means

A_i = effect of level i of factor A (level of GBM)

B_j = effect of level j of factor B (level of enzyme)

$(AB)_{ij}$ - effect of the interaction of level i of factor A with level j of factor B

E_{ijk} – random error with mean o and variance $\square^2$

In order to compensate for variance heterogeneity, measured values for cholesterol, triglyceride, AST, ALP, spleen, kidney, intestinal length were logarithm transformed and those of ALT, PCV, Hb and Tp were log (10+x) transformed prior to data analysis; where 'x' is the value of the parameter to be analyzed. The principal component analysis (PCA) was carried out on performance parameters using SPSS (PASW Statistics 18). It allows identification of clusters of parameters that are interrelated by identifying latent principal

components. The eigenvalues of the principal component were used to explain the extent of multiple correlations of the analyzed parameters (Burstyn, 2004).

3.3.5 Histopathological Study

Tissues samples (intestine, liver, spleen and kidney) were collected from two sacrificed birds per treatment at the end of the experiments and trimmed to about 0.5 – 1 cm thick and about 1 -2 cm long, and fixed in buffered neutral 10% formalin for at least 48 hours. The fixed tissues were dehydrated in graded concentrations of alcohol (70%, 80%, 90%, 95% and 100%) at intervals of one hour. The tissues were cleared with xylene for about two hours, infiltrated with molten paraffin wax at 50^{o}C to 60 ^{o}C for about two hours, embedded in the molten paraffin and labelled appropriately. Sections 5μ thick were cut from the embedded tissues using a microtome knife attached to a microtome. The sectioned tissues were mounted on grease free, clean glass slides dried at room temperature and stained with Haematoxylin and Eosin (H and E) stain. The slides were studied using light microscope x 400 magnifications. Photomicrographs of the slides were taken using a digital camera, transferred to a computer and appropriately labelled.

3.4 EXPERIMENT 2: EFFECT OF PALM OIL SUPPLEMENTATION ON THE UTILIZATION OF GBM IN BROILER CHICKEN DIETS

3.4.1 Growth Study

3.4.1.1 Experimental Design (Starter Phase)

A total of 306 broiler chicks were used in this phase. The chicks were randomly allocated to six treatments with 3 replicates per treatment; each replicate consisted of 17 chicks arranged in a completely randomized design (3 x 2 factorial). Ginger By-product Meal was fed at three levels (0, 7.5 and 15%) and palm oil included at two levels (0 and 4%) for each level of GBM as shown on Table 3.3.

Table 3.3: Composition of Broiler Starter Diets in Experiment 2

	GBM Level (%)					
	0		7.5		15	
	Palm Oil Level (%)					
	0	4	0	4	0	4
Ingredients						
Maize	56.15	50.15	47.65	41.65	38.15	33.15
Soya bean cake	15.00	15.00	15.00	15.00	15.00	15.00
Groundnut cake	25.00	27.00	26.00	28.00	28.00	29.00
palm oil	0.00	4.00	0.00	4.00	0.00	4.00
Ginger By-product Meal	0.00	0.00	7.50	7.50	15.00	15.00
Bone meal	2.80	2.80	2.80	2.80	2.80	2.80
Common salt	0.30	0.30	0.30	0.30	0.30	0.30
Methionine	0.25	0.25	0.25	0.25	0.25	0.25
Lysine	0.20	0.20	0.20	0.20	0.20	0.20
*Premix	0.30	0.30	0.30	0.30	0.30	0.30
Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
Calculated analysis						
ME MJ/kg	12	13	12	13	12	13
Crude Protein (%)	23.05	23.11	23.02	23.08	23.05	23.05
Crude fibre (%)	5.15	5.27	5.78	5.89	6.50	6.51
Ether Extract (%)	4.32	8.19	4.21	8.08	4.13	7.97
Calcium (%)	1.08	1.32	1.38	1.62	1.68	1.92
Available P (%)	0.55	0.55	0.61	0.61	0.68	0.67
Lysine (%)	1.23	1.25	1.22	1.24	1.23	1.24
Methionine (%)	0.58	0.58	0.57	0.57	0.57	0.56
Meth.+cyst. (%)	0.94	0.95	0.93	0.93	0.92	0.92
Cost (₦/Kg)	61.23	70.03	59.88	68.68	58.53	67.33

**Biomix premix supplied per Kg of diet: Vit. A, 10,000iu;Vit D3, 2000iu; Vit E, 23mg; Vit. K, 2mg; Vit, B1, 1.8mg; Vit B2, 5.5mg; pantothenic acid, 7.5mg; Vit. B12, 0.015mg; Folic acid, 0.75mg; Biotin, 0.06mg; Choline chloride, 300mg; Cobalt, 0.2mg; Copper, 3mg; Iodine, 1mg; Iron, 20mg; Manganese, 40mg; Selenium, 0.2mg; Zinc, 30mg; Antioxidant, 1.25mg.*

3.4.1.2 Experimental Design (Finisher Phase)

A total of 270 broiler chickens were used in this phase. The birds were randomly allocated to six treatments with 3 replicates per treatment; each replicate consisted of 15 chicks arranged in a completely randomized design (3 x 2 factorial). Ginger By-product Meal was fed at three levels (0, 7.5 and 15%) and palm oil included at two levels (0 and 4%/kg feed) for each level of GBM as shown on Table 3.4.

3.4.2 Statistical Analysis

The procedure used is same as in experiment one but in order to compensate for variance in heterogeneity, measured values for cholesterol, triglyceride, ALT, TP and WBC (week 5) were log (10+x) transformed prior to data analysis; where 'x' is the value of the parameter. Cholesterol, triglyceride, PCV, Hb, TP, neutrophil, lymphocyte, liver, intestinal weight and length, kidney, breast, wing, back, thigh, gizzard and fat (week 8) were logarithm transformed. Mortality data were also transformed.

The result obtained in experiment two showed no significant ($p>0.05$) difference in feed intake between birds fed 0 and 4% palm oil at starter phase and most of the growth indices at finisher phase; hence experiment three was designed to include a higher level of palm oil (6%).

3.5 Experiment 3: EFFECT OF GRADED LEVELS OF PALM OIL ON THE UTILIZATION OF GBM IN BROILER CHICKEN DIETS

3.5.1 Growth Study

3.5.1.1 Experimental Design (Starter Phase)

This experiment was carried out with 405 broiler chicks randomly allocated to nine treatments with 3 replicates each consisting of 15 chicks arranged in a completely randomized design (3x3factorial).

Table 3.4: Composition of Broiler Finisher Diets in Experiment 2

	GBM Levels (%)					
	0		7.5		15	
	Palm oil Levels (%)					
	0	4	0	4	0	4
Ingredients						
Maize	60.95	55.45	52.45	46.95	43.45	38.45
Soya bean Cake	13.00	13.00	13.00	13.00	13.00	13.00
Groundnut Cake	22.00	23.50	23.00	24.50	24.50	25.50
Palm oil	0.00	4.00	0.00	4.00	0.00	4.00
Ginger By-product Meal	0.00	0.00	7.50	7.50	15.00	15.00
Bone meal	3.00	3.00	3.00	3.00	3.00	3.00
Common salt	0.30	0.30	0.30	0.30	0.30	0.30
Methionine	0.25	0.25	0.25	0.25	0.25	0.25
Lysine	0.20	0.20	0.20	0.20	0.20	0.20
*Premix	0.30	0.30	0.30	0.30	0.30	0.30
Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
Calculated Analysis						
ME MJ/kg	12	13	12	13	12	13
Crude Protein (%)	21.24	21.16	21.20	21.12	21.09	21.09
Crude fibre (%)	4.76	4.83	5.39	5.45	6.06	6.08
Ether Extract (%)	4.23	8.09	4.12	7.98	4.03	7.87
Calcium (%)	1.14	1.38	1.44	1.68	1.74	1.98
Available P (%)	0.57	0.57	0.64	0.64	0.70	0.70
Lysine (%)	1.13	1.14	1.12	1.14	1.13	1.13
Methionine (%)	0.55	0.55	0.55	0.55	0.54	0.54
Cysteine (%)	0.34	0.34	0.33	0.33	0.33	0.33
Met.+cys. (%)	0.89	0.89	0.88	0.88	0.87	0.86
Cost (₦/Kg)	60.42	69.22	59.07	67.87	57.72	66.52

*Biomix premix supplied per Kg of diet: Vit. A, 10,000iu;Vit D3, 2000iu; Vit E, 23mg; Vit. K, 2mg; Vit, B1, 1.8mg; Vit B2, 5.5mg; pantothenic acid, 7.5mg; Vit. B12, 0.015mg; Folic acid, 0.75mg; Biotin, 0.06mg;Choline chloride, 300mg; Cobalt, 0.2mg; Copper, 3mg; Iodine, 1mg; Iron, 20mg; Manganese, 40mg; Selenium, 0.2mg; Zinc, 30mg; Antioxidant, 1.25mg.

The birds were not randomized at the end of the starter phase in order to avoid carry over effect and to get the true picture of blood chemistry. Ginger By-product Meal was fed at three levels (0, 7.5 and 15%) and the palm oil included at three levels (0, 4 and 6%) for each level of GBM as shown on Table 3.5.

3.5.1.2 Experimental Design (Finisher Phase)

This experiment was carried out with 387 broiler chickens randomly allocated to nine treatments with 3 replicates each arranged in a completely randomized design (3x3 factorial). The experimental diets are shown on Table 3.6.

3.5.2 Statistical Analysis

The statistical analysis is as described for experiment one but in order to compensate for variance heterogeneity, measured values for cholesterol, triglyceride, AST, ALT, ALP, PCV and Hb (week 4); PCV, Hb, TP, neutrophil and lymphocyte (week 8) were logarithm transformed and gizzard, fat, TP (week 4); AST, ALT, ALP, cholesterol, triglyceride, spleen, liver, intestinal weight and length, kidney, back, heart, breast, wing, thigh, gizzard and fat (week 8) were log (10+x) transformed prior to data analysis; where 'x' is the value obtained for each parameter. The initial weights for the finisher phase were used as a covariate. Mortality data were also transformed.

Table 3.5: Composition of Broiler Starter Diets in Experiment 3

	GBM Level (%)								
	0	7.5	15	0	7.5	15	0	7.5	15
	Palm Oil Level (%)								
Ingredients	0	0	0	4	4	4	6	6	6
Maize	55.86	47.06	37.86	49.86	41.36	32.86	47.36	38.86	30.36
Soya bean cake	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00
Groundnut cake	25.00	26.30	28.00	27.00	28.00	29.00	27.50	28.50	29.50
Palm oil	0.00	0.00	0.00	4.00	4.00	4.00	6.00	6.00	6.00
Ginger By-product Meal	0.00	7.50	15.00	0.00	7.50	15.00	0.00	7.50	15.00
Bone meal	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Common salt	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Methionine	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24
Lysine	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Premix	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
Calculated Analysis									
ME MJ/kg	12	11	11	12	12	12	13	12	12
Crude Protein (%)	23.03	23.10	23.02	23.09	23.05	23.02	23.09	23.05	23.02
Crude Fibre (%)	5.15	5.80	6.49	5.26	5.89	6.51	5.27	5.89	6.52
Ether Extract (%)	4.31	4.21	4.12	8.18	8.07	7.96	10.10	9.99	9.88
Calcium (%)	1.15	1.45	1.75	1.15	1.45	1.75	1.15	1.45	1.75
Available Phosphorus (%)	0.58	0.64	0.71	0.58	0.64	0.70	0.58	0.64	0.70
Lysine (%)	1.32	1.33	1.33	1.35	1.34	1.34	1.35	1.35	1.34
Methionine (%)	0.57	0.56	0.56	0.57	0.56	0.55	0.57	0.56	0.55
Cysteine (%)	0.36	0.36	0.36	0.37	0.36	0.35	0.37	0.36	0.35
Met.+cys. (%)	0.93	0.92	0.91	0.94	0.92	0.91	0.93	0.92	0.91
Cost (₦/Kg)	61.81	60.46	59.11	70.61	69.26	67.91	75.01	73.66	72.31

*Biomix premix supplied per Kg of diet: Vit. A, 10,000iu;Vit D_3, 2000iu; Vit E, 23mg; Vit. K, 2mg; Vit, B_1, 1.8mg, Vit B_2, 5.5mg; pantothenic acid, 7.5mg; Vit. B_{12}, 0.015mg; Folic acid, 0.75mg; Biotin, 0.06mg; Choline chloride, 300mg; Cobalt, 0.2mg; Copper, 3mg; Iodine, 1mg; Iron, 20mg; Manganese, 40mg; Selenium, 0.2mg; Zinc, 30mg; Antioxidant, 1.25mg.

Table 3.6: Composition of Broiler Finisher Diets in Experiment 3

	GBM Level (%)								
	0	7.5	15	0	7.5	15	0	7.5	15
	Palm Oil Level (%)								
Ingredients	0	0	0	4	4	4	6	6	6
Maize	60.96	52.46	43.46	55.46	46.96	38.46	53.46	44.66	35.96
Soya bean cake	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
Groundnut cake	22.00	23.00	24.50	23.50	24.50	25.50	23.50	25.00	26.00
palm oil	0.00	0.00	0.00	4.00	4.00	4.00	6.00	6.00	6.00
Ginger By-product Meal	0.00	7.50	15.00	0.00	7.50	15.00	0.00	7.50	15.00
Bone meal	3.00	3.00	3.00	3.00	3.00	3.00	3.00	2.80	3.00
Common salt	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Methionine	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21
Lysine	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23
*Premix	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
Calculated Analysis									
MJ/Kg	12	12	11	12	12	12	13	13	13
Crude Protein (%)	21.24	21.2	21.09	21.16	21.12	21.09	20.98	21.14	21.09
Crude fibre (%)	4.77	5.39	6.06	4.83	5.45	6.08	4.79	5.46	6.08
Ether Extract (%)	4.23	4.12	4.03	8.09	7.98	7.87	9.99	9.91	9.79
Calcium (%)	1.14	1.44	1.74	1.14	1.44	1.74	1.14	1.37	1.74
Available Phosphorus (%)	0.57	0.64	0.70	0.57	0.64	0.70	0.57	0.60	0.70
Lysine (%)	1.16	1.15	1.16	1.17	1.17	1.16	1.16	1.17	1.16
Methionine (%)	0.51	0.51	0.5	0.51	0.51	0.5	0.51	0.5	0.5
Cysteine (%)	0.34	0.33	0.33	0.34	0.33	0.33	0.34	0.33	0.33
Met.+cys. (%)	0.85	0.84	0.83	0.85	0.84	0.82	0.85	0.84	0.82
Cost (₦/Kg)	60.02	58.67	57.32	68.82	67.47	66.12	73.22	71.88	70.52

*premix supplied per Kg of diet: Vit. A, 10,000iu;Vit D_3, 2000iu; Vit E, 23mg; Vit. K, 2mg; Vit, B_1, 1.8mg, Vit B_2, 5.5mg; pantothenic acid, 7.5mg; Vit. B_{12}, 0.015mg; Folic a
Biotin, 0.06mg; Choline chloride, 300mg; Cobalt, 0.2mg; Copper, 3mg; Iodine, 1mg; Iron, 20mg; Manganese, 40mg; Selenium, 0.2mg; Zinc, 30mg; Antioxidant, 1.25mg.

CHAPTER FOUR

4.0 RESULTS

4.1 PROXIMATE COMPOSITION OF GINGER BY- PRODUCT MEAL

Table 4.1 shows the proximate composition of GBM used in the experiments.

4.2 EXPERIMENT 1

EFFECT OF ENZYME AND NON-ENZYME SUPPLEMENTATION ON THE UTILIZATION OF GBM DIETS IN BROILER CHICKEN DIETS.

4.2.1 Performance of Broiler Chickens (Starter Phase)

Table 4.2 shows the performance of birds fed varying levels of GBM with or without enzyme supplementation. There was a significant decrease ($p<0.05$) in feed intake, final weight, weight gain and significant ($p<0.05$) increase in feed to gain ratio with increase in dietary levels of GBM. Birds fed 0% GBM diet had significantly ($p<0.05$) better performance than birds fed 15 and 30% GBM diets. The performance of birds fed 15% and 30% GBM were statistically ($p>0.05$) similar for final weight, weight gain and feed to gain ratio. Inclusion of 15 and 30% GBM respectively resulted in 13 and 22% reductions in feed intake, 42 and 45% decrease in final weight and 46 and 50% reduction in weight gain relative to the 0% GBM diet. The efficiency of feed utilization decreased by 62 and 55% at 15 and 30% GBM inclusion respectively when compared with the 0% GBM diet. Final weight of the broilers showed a polynomial trend, there was a decrease in weight with increase in GBM inclusion (Figure 4.1). Feed cost/Kg gain was lowest in the 0% GBM and highest in the 15% GBM group. There was no significant ($p>0.05$) difference in mortality across the treatments.

With the inclusion of enzyme, a non-significant difference ($p>0.05$) in feed intake was observed, but there were significant ($p<0.05$) decreases in final weight, weight gain and

Table 4.1: Proximate analysis of GBM

Parameters	% Composition
Crude protein	3.75
Crude fibre	9.09
Ether extract	1.86
Ash	3.85
NFE	81.45

Table 4.2: Effect of Dietary Levels of GBM and Enzyme on Performance of Broiler Chicks during Starter Phase

	Level of GBM (%)					Enzyme Supplementation (%)			
	0	15	30	SEM	P	0	0.01	SEM	P
Initial weight (g)	59	59	59	0.00	0.72	60	59	0.00	0.27
Feed Intake (g)	1417[a]	1239[b]	1108[c]	20.00	0.0001	1272	1237	15.0	0.13
Final weight (g)	679[a]	393[b]	371[b]	10.00	0.0001	517[a]	445[b]	9.00	0.0001
Weight gain (g)	620[a]	334[b]	312[b]	10.00	0.0001	458[a]	386[b]	9.00	0.0001
Feed/Gain	2.29[a]	3.71[b]	3.55[b]	0.04	0.0001	2.78[a]	3.20[b]	0.03	0.0001
Feed cost/Kg gain	116.49[a]	161.31[c]	146.12[b]	2.43	0.0001	129.93[a]	152.68[b]	1.98	0.0001
Mortality (%)	3.30	1.11	0.00	1.11	0.14	1.48	1.48	0.91	0.63
Feed Intake (g/b/d)	48.92[a]	71.27[b]	67.21[c]	1.22	0.0001	57.28[b]	67.66[a]	33.33	0.0001
Weight Gain (g/b/d)	18.79[a]	10.11[b]	9.45[b]	0.33	0.0001	13.87[a]	11.70[b]	1.33	0.0001

[ab] Means within rows with different superscript are significantly different ($p<0.05$)

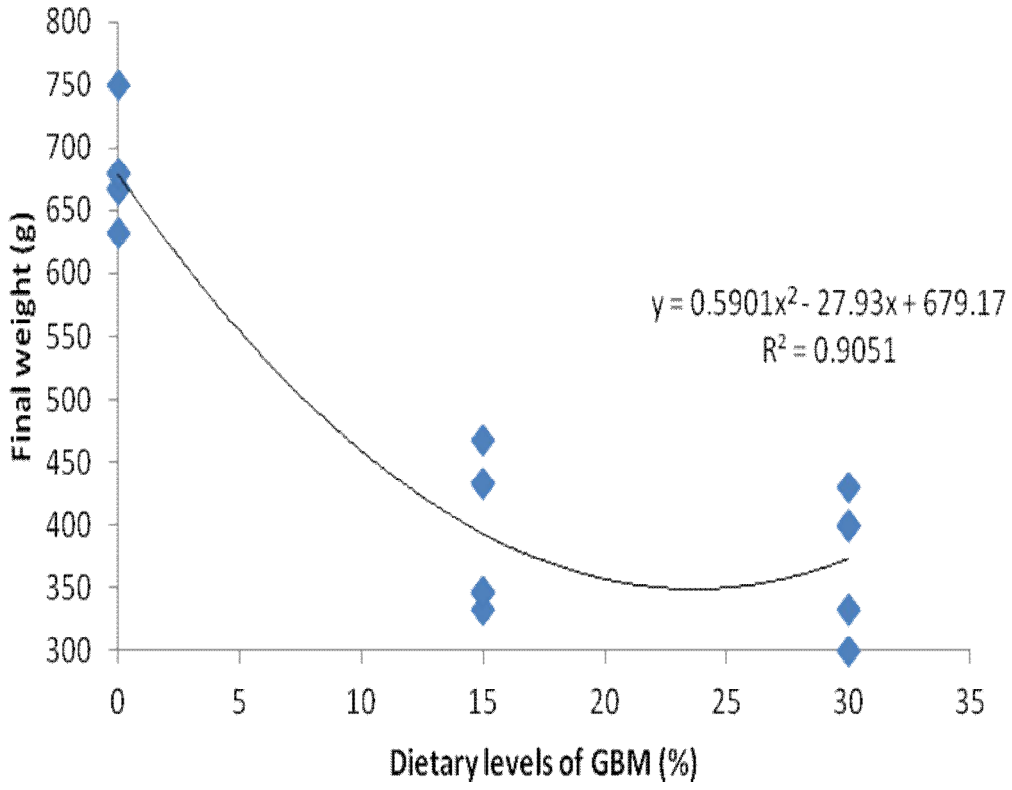


Figure 4.1: Trend line of final weight for broiler starter chickens fed varying levels of Ginger by- product meal

efficiency of feed utilization with the inclusion of enzyme. The performance of birds fed non-enzyme supplemented diets was significantly ($p<0.05$) better than that of birds fed enzyme supplemented diets. The final weight and weight gain decreased by 14 and 16% for non-enzyme and enzyme supplemented GBM diets respectively. Efficiency of feed utilization decreased ($p<0.05$) significantly by 15% for the enzyme supplemented GBM diet. Feed cost/kg gain increased with supplementation of the diet with enzyme. There was no significant ($P>0.05$) difference in mortality for all the dietary treatments.

Table 4.3 shows interaction between GBM and palm oil. There was interaction between GBM and the enzyme for feed intake and feed to gain ratio (Figures 4.2 and 4.3) but there was no interaction ($p>0.05$) for final weight and weight gain. At 0 and 15% GBM, there was a negative interaction between GBM and enzyme, which brought about a decrease in consumption but no interaction was observed at 30%. A negative interaction was also observed between GBM and enzyme for feed to gain ratio at 15 and 30% GBM diets; the inclusion of enzyme increased the quantity of feed consumed to gain a kilogramme of weight.

The PCA was aimed at identifying clusters of performance parameters that would explain significant proportion of total variation. There were two PCs with significant loadings that collectively explained 91.46% of the total variance (Table 4.4). The PC 1 values increased with feed intake, final weight, weight gain and gain per day explaining 70.19%. The negative value of feed to gain ratio means that feed to gain ratio is lacking in a latent variable associated with PC 1. Only one parameter, initial weight clustered in PC 2 which accounted for 21.27 % of the total variance. Final weight and weight gain had the highest loading. Therefore, final weight and weight gain seem to be the principal controlling factor in the trial. These buttresses the existing logic that any management practice that increases final weight

Table 4.3: Effect of Dietary Levels of GBM and Enzyme on Production Parameters of Broiler Chicks

	GBM Levels (%)							
	0		15		30			
	Enzyme Supplementation (%)							
	0	0.01	0	0.01	0	0.01	SEM	P
Broiler starter								
Initial weight (g)	60.00	60.00	60.00	60.00	60.00	60.00	0.00	0.14
Feed Intake (g)	1492.00^{a}	1342.00^{b}	1248.00^{c}	1229.00^{c}	1075.00^{d}	1140.00^{d}	30.00	0.005
Final weight (g)	698.00	660.00	444.00	342.00	410.00	333.00	20.00	0.17
Weight gain (g)	638.00	602.00	384.00	283.00	351.00	273.00	20.00	0.15
Feed/Gain	1.66^{a}	1.57.00^{a}	2.03^{b}	2.67^{d}	1.97^{b}	2.46^{c}	0.05	0.0001
Feed cost/Kg gain	121.06^{ab}	111.93^{a}	139.12^{c}	183.54^{e}	129.63^{bc}	162.62^{d}	3.44	0.0001
Mortality (%)	2.00	4.00	2.00	0	0	0	1.57	0.78
Feed Intake (g/b/d)	52.28^{a}	47.93^{b}	44.57^{c}	43.89^{c}	38.39^{d}	40.71^{d}	1.73	0.005
Weight gain (g/b/d)	22.79	21.50	13.71	10.11	12.54	9.75	4.62	0.15

^{abcd} Means within rows with different superscripts are significantly different ($p<0.05$)

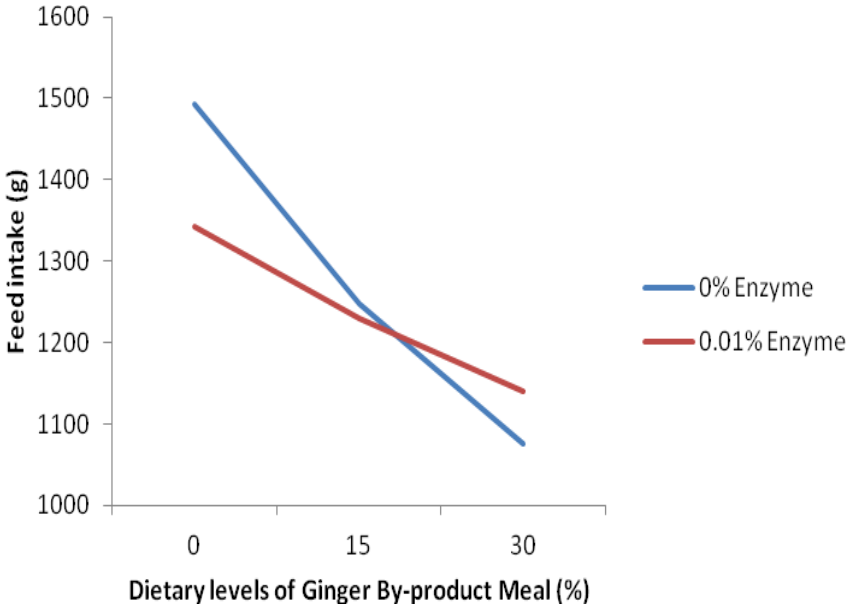


Figure 4.2: GBM and Enzyme Interaction on Feed Intake at Starter Phase

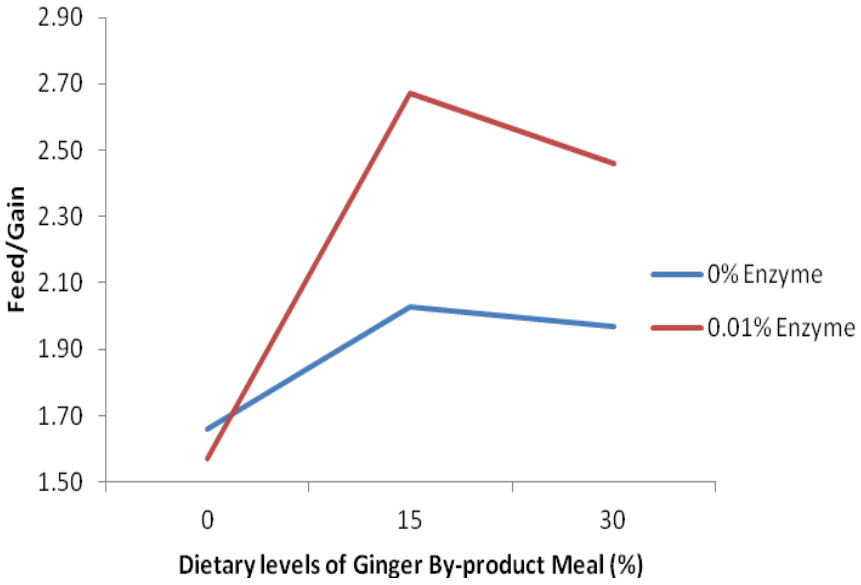


Figure 4.3: GBM and Enzyme Interaction on Feed/Gain at Starter Phase

Table 4.4: Eigenvalues and Principal Component Loading for Broiler Starter Phase

	Principal Components	
Parameters	PC 1	PC 2
Eigenvalue	3.51	1.06
Variance (%)	70.19	21.27
Cumulative Variance (%)	70.19	91.46
Initial Weight	-0.113	***0.972***
Feed Intake	***0.841***	0.307
Final Weight	***0.998***	-0.001
Weight Gain	***0.998***	-0.010
Feed/Gain	-0.893	0.155

PC 1- principal component 1; PC2- principal component 2

and weight gain of chickens will definitely influence other parameters.

4.2.2 Effect of Dietary Levels of GBM/Enzyme on Haematological Profile of Broiler Chickens

Table 4.5 shows no significant ($p>0.05$) differences in the haematological profile of broilers fed GBM diets suggesting that the diets had no negative effect on blood levels of PCV, Hb and Tp. There were also non-significant ($p>0.05$) differences in the haematological profile of the birds fed both the enzyme and non-enzyme supplemented GBM.

4.2.3 Effect of Dietary Levels of GBM and Enzyme on Serum Chemistry of Broiler Chickens

Table 4.6 shows that at week 4, there was a non-significant ($p>0.05$) decrease in cholesterol and increase in triglyceride with increase in the level of GBM. Enzyme and non-enzyme treated GBM diets had the same cholesterol values and a non-significant ($p>0.05$) decrease was observed in the triglyceride values.

4.2.4 Performance of Broiler Chickens (Finisher Phase)

There was no significant ($p>0.05$) difference in feed intake with increase in inclusion level of GBM but inclusion of GBM in broiler diets led to a significant decrease ($p<0.05$) in final weight and weight gain (Table 4.7). Birds fed 0% GBM performed significantly ($p<0.05$) better than birds fed 15 and 30% GBM diets. Feed to gain ratio also significantly ($p<0.05$) increased at 15 and 30% level of GBM. Final weight reduced by 35 and 34%; weight gain decreased by 58% and 55% and efficiency of feed utilization decreased at a rate of 138% and 142% in 15% and 30% GBM diets respectively when compared to birds fed 0% GBM diets. The trend line of the final weight of the broilers at the finisher phase is shown in Fig 4.4. The trend was polynomial, final weight decreased with increase in GBM level.

Table 4.5: Effect of Dietary Levels of GBM/Enzyme on Haematological Parameters of Broiler chickens

	GBM Level (%)					Enzyme Level (%)			
	0	15	30	SEM	P	0	0.01	SEM	P
WEEK 4									
Packed Cell Volume (%)	34.50	33.00	32.25	1.78	0.77	33.17	33.33	1.46	0.95
Haemoglobin (g/dl)	11.45	10.95	10.73	0.59	0.78	11.00	11.08	0.55	0.92
Total protein (g/dl)	2.75	2.33	2.90	0.26	0.47	2.60	2.72	0.24	0.77

GBM- Ginger By-product Meal

Table 4.6: Effect of Dietary Levels of GBM and Enzyme on Serum Chemistry of Broiler Chickens

	GBM Level (%)					Enzyme Level (%)			
	0	15	30	SEM	P	0	0.01	SEM	P
WEEK 4									
Cholesterol (mmol/L)	5.90	4.99	3.14	0.04	0.51	4.68	4.68	0.03	0.25
Triglyceride (mmol/L)	0.96	1.07	1.47	0.09	0.63	1.24	1.07	0.08	0.32

GBM- Ginger By-product Meal

Feed cost per kg gain was lowest at 0% GBM diet and highest at 15% GBM diet. No significant difference was observed in mortality.

There was a non-significant ($p>0.05$) difference in feed intake and rate of mortality, while final weight, weight gain and efficiency of feed utilization decreased significantly ($p<0.05$) with inclusion of enzyme (Table 4.7). The growth of the birds fed the non-enzyme supplemented diets was significantly ($p<0.05$) better than the birds fed the enzyme supplemented diets. Final weight and weight gain decreased by 14 and 27% for non-enzyme and enzyme supplemented GBM diets respectively. Efficiency of feed utilization decreased ($p<0.05$) significantly by 37% for the enzyme supplemented GBM diet. There was a significant ($p<0.05$) difference in feed cost per kg gain. Non-enzyme supplemented diets had a lower value, an indication that less feed was eaten to gain a kilogram of weight.

GBM and enzyme interactions are shown on Table 4.8. Interactions were observed at 0% for final weight, weight gain and feed to gain ratio. The interactions are shown in Figures 4.5, 4.6 and 4.7. Final weight and weight gain decreased significantly ($p<0.05$) with enzyme inclusions at 15 and 30% GBM levels. The efficiency of feed utilization also decreased with enzyme inclusions at both levels of GBM. Feed to gain ratios were similar at 0% GBM with or without enzyme inclusion. Feed cost/Kg gain increased with increase in GBM in the non-enzyme and enzyme supplemented diets, hence it is not economical to include GBM at 15 and 30%.

The PCA was aimed at identifying clusters of performance parameters that would explain significant proportion of total variation. Here there are two PCs with significant

Table 4.7: Effect of Dietary Levels of GBM/Enzyme on Performance of Broiler Chickens during Finisher Phase

	Level of GBM (%)					Enzyme Level (%)			
	0	15	30	SEM	P	0	0.01	SEM	P
Initial weight (g)	810	812	810	11.00	0.99	810	812	9.00	0.93
Feed Intake (g)	3884	3858	4208	107.00	0.07	3984	3983	87.00	0.99
Final weight (g)	2083[a]	1344[b]	1380[b]	40.00	0.0001	1727[a]	1478[b]	33.00	0.0002
Weight gain (g)	1272[a]	532[b]	571[b]	36.00	0.0001	917[a]	667[b]	29.00	0.0001
Feed/Gain	3.05[a]	7.25[b]	7.37[b]	0.44	0.0001	4.35[a]	5.97[b]	0.36	0.0001
Feed cost/Kg gain	213.80[a]	537.03[b]	512.86[b]	0.02	0.0001	302.00[a]	512.86[b]	0.02	0.0001
Mortality (%)	16.22	14.13	17.38	0.03	0.22	15.49	16.22	0.03	0.63
Feed Intake (g/b/d)	155.37	154.32	168.32	4.08	0.07	159.35	159.32	3.33	0.99
Weight gain (g/b/d)	50.90[a]	21.29[b]	22.81[b]	1.60	0.0001	36.67[a]	26.67[b]	0.30	0.0001

[ab] Means within rows with different superscripts are significantly different ($p<0.05$)

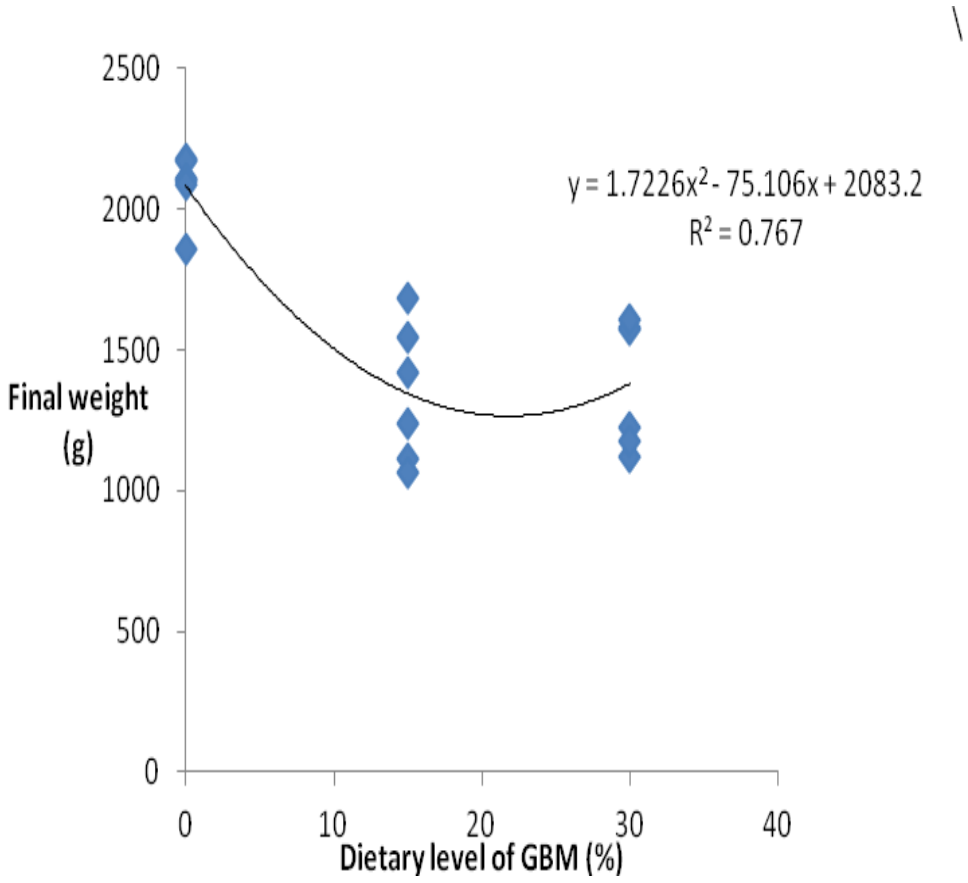


Figure 4.4: Trend line of Final Weight of Broiler Finisher Chickens fed varying Levels of Ginger By-Product Meal

Table 4.8: Effect of Dietary Levels of GBM and Enzyme on Production Parameters of Broilers during Finisher Phase

	GBM Level (%)							
	0		15		30			
	Enzyme Supplementation (%)							
	0	0.01	0	0.01	0	0.01	SEM	P
Initial weight (g)	810.00	812.00	811.00	813.00	811.00	810.00	20.00	0.99
Feed Intake (g)	3861.00	3907.00	3790.00	3926.00	4300.00	4116.00	150.00	0.57
Final weight (g)	2045.00[a]	2121.00[a]	1550.00[b]	1138.00[c]	1586.00[b]	1175.00[c]	60.00	0.001
Weight gain (g)	1236.00[a]	1309.00[a]	739.00[b]	325.00[c]	775.00[b]	365.00[c]	50.00	0.001
Feed/Gain	3.18[a]	2.99[a]	5.24[b]	12.31[c]	5.57[b]	11.31[c]	0.63	0.0002
Feed cost /Kg gain	218.78[a]	213.80[a]	354.81[b]	831.76[c]	363.08[b]	741.31[c]	0.03	0.0001
Mortality (%)	16.22	16.22	14.13	14.13	16.22	18.62	0.05	0.78
Feed Intake (g/b/d)	154.44	156.30	151.62	157.03	172.00	164.63	5.78	0.57
Weight Gain (g/b/d)	49.43[a]	52.37[a]	29.57[b]	13.01[c]	31.00[b]	14.62[c]	2.31	0.001

[ab] Means within rows with different superscripts are significantly different ($p<0.05$)

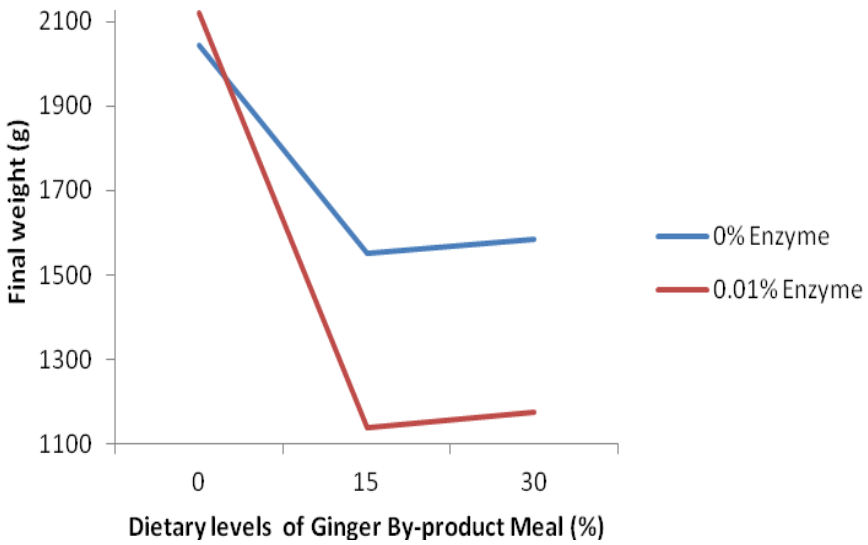


Figure 4.5: GBM and Enzyme interactions for final weight during finisher phase

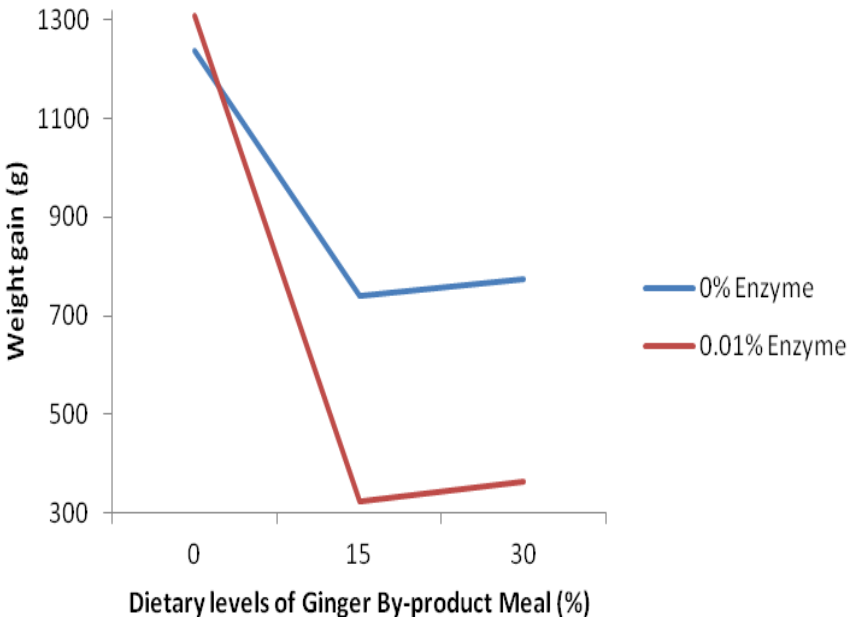


Figure 4.6: GBM and Enzyme Interactions for Weight Gain during Finisher Phase

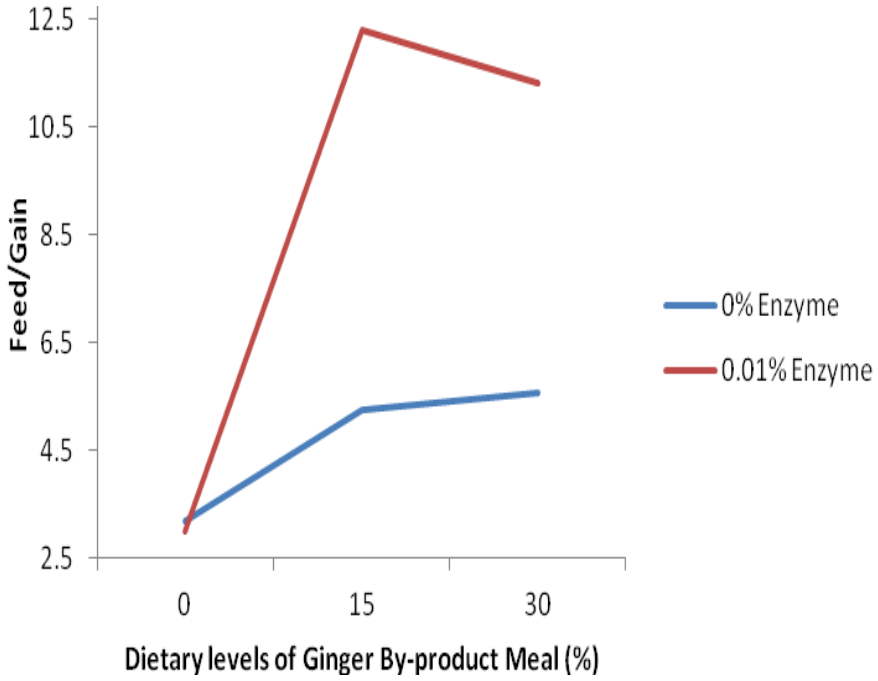


Figure 4.7: GBM and Enzyme interaction for feed/gain during finisher phase

loadings that collectively explained 82.71% of the total variance (Table 4.9). The PC 1 values increased with final weight and weight gain explaining 58.62%. The negative loading of feed to gain ratio means that feed to gain ratio is lacking in a latent variable associated with PC 1 (Burstyn, 2004). Final weight and weight gain had the highest loading and seem to be the principal controlling factors in the trial. Initial weight and feed intake clustered in PC 2 which accounted for 24.09 % of the total variance.

4.2.5 Effect of Dietary Levels of GBM and Enzyme on Haematological Parameters of Broiler Chickens

The haematological profile of the broilers fed GBM diets at the finisher phase (week 8) did not vary statistically ($p>0.05$), values ranged from 30.92 to 32.75 for PCV, 10.27 to 10.89 for hb and 4.33- 4.98 for Tp. There was also no significant ($p>0.05$) difference in the haematological profile of the birds fed both the enzyme and non-enzyme supplemented GBM ($p>0.05$), values ranged from 31.06 -32.94 for PCV, 10.31-10.96 for hb and 4.62 to 4.83 for TP .

4.2.6 Effect of Dietary Levels of GBM and Enzyme on Serum Chemistry of Broiler Chickens

The serum chemistry profile of broilers fed GBM diets at the finisher phase (Table 4.10) did not vary statistically ($p>0.05$) for most of the parameters but for non-enzyme supplemented diets, there was a slight increase in the level of cholesterol at 15 and 30% GBM levels. A significant ($p<0.05$) increase in ALP was also observed due to enzyme supplementation.

Table 4.9: Eigenvalues and Principal Component Loading for Broiler Finisher Phase

	Principal Components	
Parameters	PC 1	PC 2
Eigenvalue	2.93	1.20
Variance (%)	58.62	24.09
Cumulative Variance (%)	58.62	82.71
Initial Weight	0.086	***0.792***
Feed Intake	-0.193	***0.757***
Final Weight	***0.988***	0.065
Weight Gain	***0.987***	0.021
Feed/Gain	***-0.967***	0.006

PC 1- principal component 1; PC2- principal component 2

Table 4.10: Effect of Dietary Levels of GBM/Enzyme on Serum Chemistry of Broiler Chickens during Finisher Phase

	GBM Level (%)					Enzyme Level (%)			
	0	15	30	SEM	P	0	0.01	SEM	P
Cholesterol (mmol/L)	2.29	2.68	2.39	0.07	0.62	2.34	2.51	0.06	0.61
Triglyceride (mmol/L)	0.85	0.80	0.71	0.04	0.16	0.81	0.74	0.03	0.20
AST (U/L)	190.55	213.80	223.87	0.04	0.16	218.78	199.53	0.03	0.18
ALT (U/L)	34.67	25.48	19.51	0.09	0.19	21.62	30.74	0.08	0.16
ALP (U/L)	75.86	63.10	66.07	0.20	0.69	51.29[b]	91.20[a]	0.08	0.004

[ab] Means within rows with different superscript are significantly different ($p<0.05$); AST- Aspartate aminotransferase; ALT- Alanine aminotransferase; ALP- Alkaline phosphatase

4.2.7 Effect of Dietary Levels of GBM/Enzyme on Carcass and Organ Characteristics of Broiler Chickens

Table 4.11 shows that the inclusion of GBM had a significant effect ($p<0.05$) on the weight of intestine, gizzard, intestinal length and abdominal fat. The weight of the gizzard increased while the abdominal fat decreased. There was also an increase in the length and weight of the intestine. Enzyme supplementation brought about a significant ($p<0.05$) decrease in the weight of the breast but a significant ($p<0.05$) increase in the weight and length of the intestine.

Table 4.12 shows that there was no interaction between GBM and enzyme for most of the parameters measured except for the weight of the breast and intestinal length. There was a negative interaction between GBM and enzyme for breast weight at 30%, causing a decrease in weight. There was also a negative interaction between GBM and enzyme for the length of the intestine at 15 and 30%, an increase was observed for the intestinal length with the inclusion of enzyme.

4.2.8 Effect of Dietary Levels of GBM and Enzyme on Histology of Organs of Broiler Chickens

The summary of the result is presented on Table 4.13. Light microscopic examination showed normal liver structure for chickens fed 15 and 30% GBM with no enzyme supplementation (Plates 1b and 1c). Birds fed 15 and 30% GBM with enzyme supplementation (Plates 2b and 2c) also had normal liver structures. The feeding of 0% GBM only and 0% GBM and 0.01% enzyme diet (Plates 1a and 2a) caused widening of the liver sinusoidal spaces of birds. Light microscopic examination showed normal kidney structures for chickens fed 0, 15 and 30% GBM diets with and without enzyme supplementation (Plates 3 and 4). The histology of the spleen of chickens fed 0 and 15%

Table 4.11: Effect of Dietary Levels of GBM/Enzyme on Carcass and Organ Characteristics of Broiler Chickens

	GBM Levels (%)					Enzyme Levels (%)			
	0	15	30	SEM	P	0	0.01	SEM	P
Dressing percent	76.26	77.83	77.41	3.25	0.88	78.87	75.46	2.66	0.22
Shank (%)	5.34	5.97	5.87	0.48	0.39	5.63	5.82	0.38	0.63
Wing (%)	10.71	10.61	10.85	0.53	0.90	10.65	10.8	0.43	0.74
Back (%)	15.94	14.46	15.12	0.77	0.18	15.51	14.83	0.63	0.29
Breast (%)	20.10	18.63	19.29	0.96	0.32	20.30^{a}	18.38^{b}	0.78	0.02
Thigh (%)	24.14	22.23	23.02	1.09	0.23	23.84	22.41	0.89	0.12
Spleen (%)	0.16	0.17	0.18	0.03	0.58	0.18	0.16	0.02	0.32
Liver (%)	2.35	2.67	2.63	0.18	0.16	2.51	2.59	0.14	0.59
Intestinal weight (%)	4.70^{b}	6.03^{a}	6.06^{a}	0.29	0.0001	5.27^{b}	5.92^{a}	0.24	0.01
Gizzard (%)	3.13^{b}	3.48^{b}	4.53^{a}	0.36	0.002	3.43	4.01	0.29	0.059
Kidney (%)	0.91	0.75	1.02	0.18	0.17	0.91	0.88	0.15	0.42
Heart (%)	0.57	0.58	0.58	0.04	0.98	3.37	3.71	0.03	0.61
Intestinal length (%)	14.48^{b}	18.76^{a}	21.05^{a}	1.42	0.0003	16.1^{b}	20.09^{a}	1.16	0.002
Abdominal fat (%)	2.64^{a}	1.16^{b}	1.41^{ab}	0.62	0.05	2.02	1.46	0.50	0.27

[ab] Means within rows with different superscripts are significantly different ($p<0.05$); GBM- Ginger By-product Meal

Table 4.12: Effect of Dietary Levels of GBM and Enzyme on Carcass and Organ Characteristics of Broiler Chickens

	GBM Level (%)							
	0		15		30			
	Enzyme Supplementation (%)							
	0	0.01	0	0.01	0	0.01	SEM	P
Dressing percent	75.95	76.57	83.45	72.21	77.22	77.60	4.69	0.14
Shank (%)	5.65	5.03	5.39	6.55	5.86	5.89	0.69	0.20
Wing (%)	10.76	10.67	10.13	11.08	11.07	10.64	0.76	0.41
Back (%)	15.97	15.90	14.69	14.23	15.87	14.38	1.11	0.64
Breast (%)	19.70[a]	20.50[a]	19.41[ab]	17.86[ab]	21.80[a]	16.79[b]	1.38	0.02
Thigh (%)	24.92	23.36	22.46	22.00	24.14	21.89	1.57	0.71
Spleen (%)	0.16	0.15	0.17	0.17	0.21	0.16	0.04	0.57
Liver (%)	2.36	2.34	2.59	2.75	2.58	2.67	0.25	0.87
Gizzard (%)	3.02	3.24	3.50	3.47	3.77	5.30	0.52	0.08
Kidney (%)	1.02	0.80	0.82	0.68	0.89	1.16	0.26	0.11
Heart (%)	0.55	0.60	0.61	0.55	0.60	0.56	0.59	0.37
Intestine length (%)	15.35[c]	13.61[c]	14.17[c]	23.35[a]	18.80[b]	23.31[a]	2.05	0.002
Abdominal fat (%)	2.57	2.70	1.72	0.59	1.76	1.07	0.89	0.59

[ab] Means within rows with different superscripts are significantly different ($p<0.05$); GBM- Ginger By-product Meal

Table 4.13: Summary of Effect of Dietary Levels of GBM and Enzyme on Histology of Organs of Broiler Chickens

	GBM Levels (%)					
	0		15		30	
	Enzyme Supplementation (%)					
	0	0.01	0	0.01	0	0.01
Liver	WSS	WSS	Normal	Normal	Normal	Normal
Kidney	Normal	Normal	Normal	Normal	Normal	Normal
Spleen	Normal	Hemosiderosis	Normal	Hemosiderosis	Hemosiderosis	Hemosiderosis
Intestinal villi	MS	SS	SS	SS	SS	SS

WSS- wider sinusoidal spaces; MS- mild sloughing; SS-severe sloughing

GBM diets without enzyme supplementation were normal (Plates 5a and 5b). Microscopic investigation showed the presence of hemosiderin particles in the spleen of birds fed 30% GBM diet without enzyme supplementation (Plate 5c). Birds fed 0, 15 and 30% GBM diets with enzyme supplementation also had hemosiderin particles in their spleen (Plates 6a, 6b and 6c).

Changes were observed in the intestinal structure of birds fed 0, 15 and 30% GBM diet with or without enzyme supplementation. This was indicated by sloughing of the villi which increased at higher inclusion level of GBM and with the inclusion of enzyme (Plates 7 and 8).

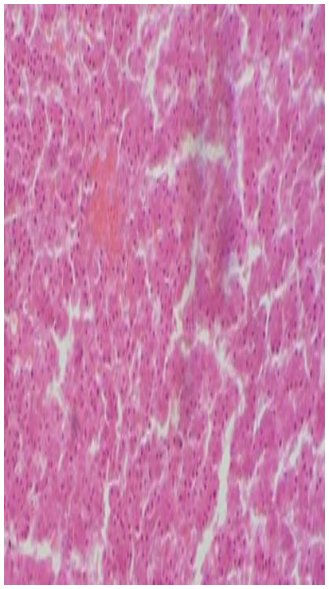


Plate 1a. Photomicrograph of a section of the liver of a broiler chicken fed 0% GBM and 0% enzyme showing wider sinusoidal spaces (H and E stained, x400)

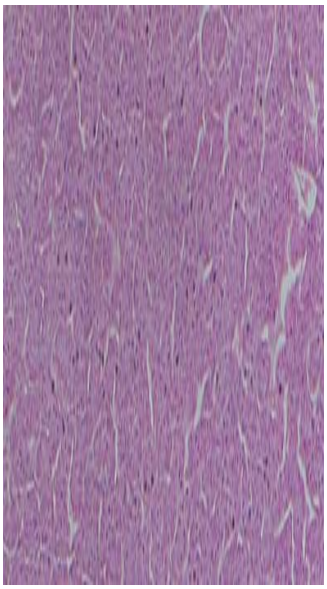


Plate 1b. Photomicrograph of a section of normal liver of a broiler chicken fed 15% GBM and 0% enzyme (H and E stained, x400)

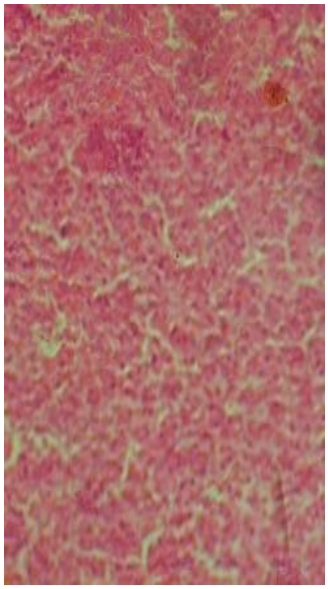


Plate 1c. Photomicrograph of a section of normal liver of a broiler chicken fed 30% GBM and 0% enzyme (H and E stained, x400)

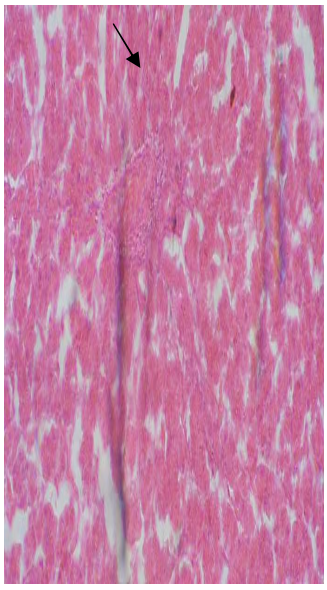


Plate 2a. Photomicrograph of a section of the liver of a broiler chicken fed 0% GBM and 0.01% enzyme showing wider sinusoidal spaces (H and E stained, x400)

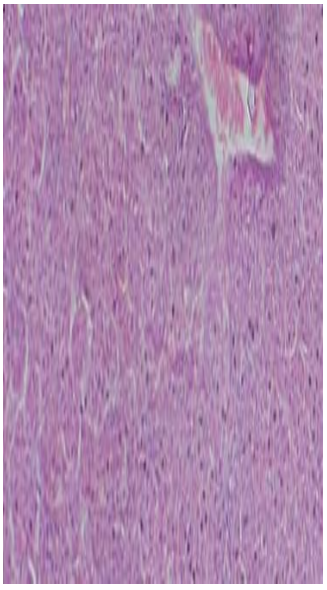


Plate 2b. Photomicrograph of a section of normal liver of a broiler chicken fed 15% GBM and 0.01% enzyme (H and E stained, x400)

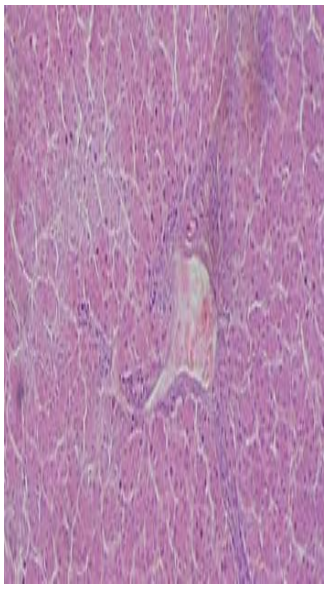


Plate 2c. Photomicrograph of a section of normal liver of a broiler chicken fed 30% GBM and 0.01% enzyme (H and E stained, x400)

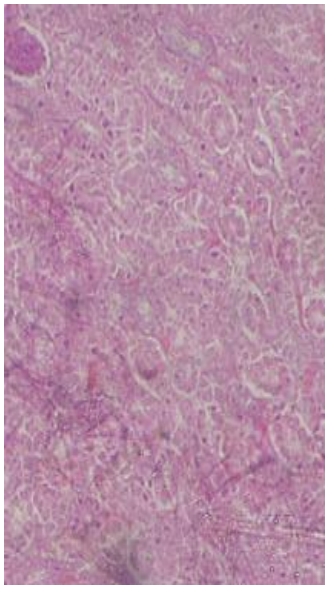


Plate 3a. Photomicrograph of a section of normal kidney of a broiler chicken fed 0% GBM and 0% enzyme (H and E stained, x400)

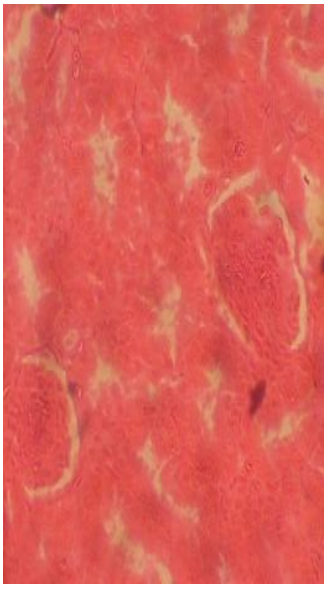


Plate 3b. Photomicrograph of a section of normal kidney of a broiler chicken fed 15% GBM and 0% enzyme (H and E stained, x400)



Plate 3c. Photomicrograph of a section of normal kidney of a broiler chicken fed 30% GBM and 0% enzyme (H and E stained, x400)

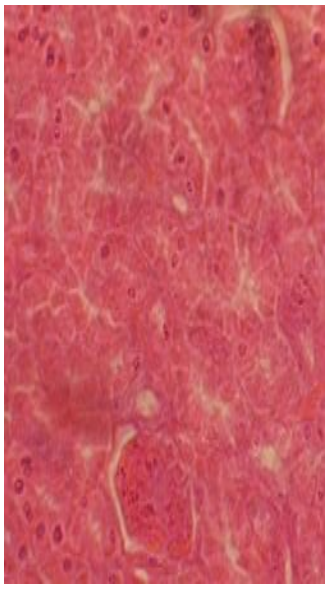


Plate 4a. Photomicrograph of a section of normal kidney of a broiler chicken fed 0% GBM and 0.01% enzyme (H and E stained, x400)



Plate 4b. Photomicrograph of a section of normal kidney of a broiler chicken fed 15% GBM and 0.01% enzyme (H and E stained, x400)

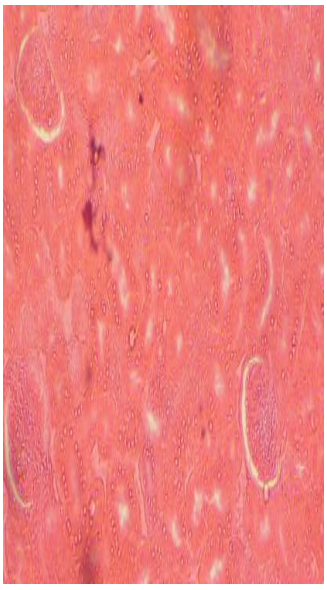


Plate 4c. Photomicrograph of a section of normal kidney of a broiler chicken fed 30% GBM and 0.01% enzyme (H and E stained, x400)

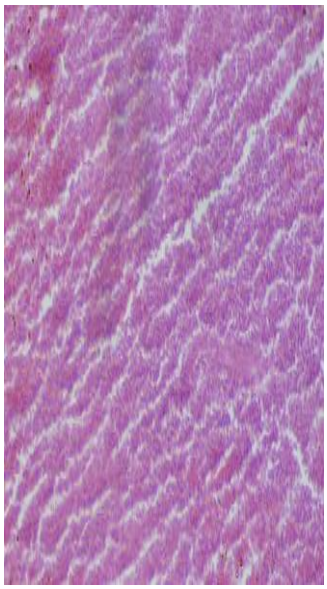


Plate 5a. Photomicrograph of a section of the normal spleen of a broiler chicken fed 0% GBM and 0% enzyme (H and E stained, x400)

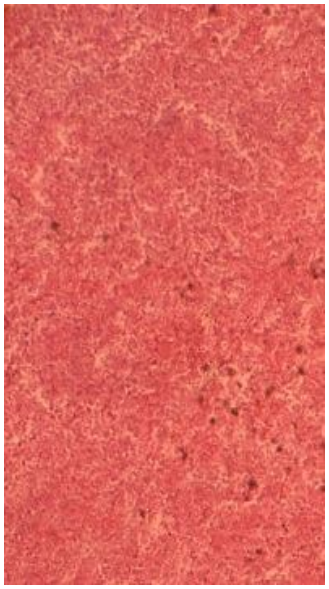


Plate 5b. Photomicrograph of a section of the normal spleen of a broiler chicken fed 15% GBM and 0% enzyme (H and E stained, x400)

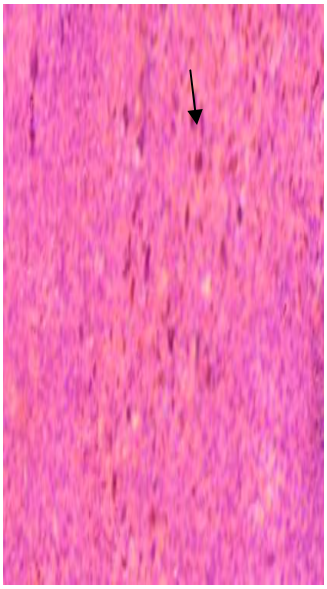


Plate 5c. Photomicrograph of a section of the spleen of a broiler chicken fed 30% GBM and 0% enzyme showing hemosiderosis (H and E stained, x400)

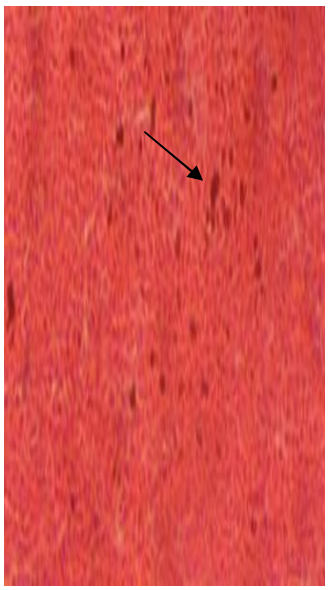


Plate 6a. Photomicrograph of a section of the spleen of a broiler chicken fed 0% GBM and 0.01% enzyme showing hemosiderosis (H and E stained, x400)

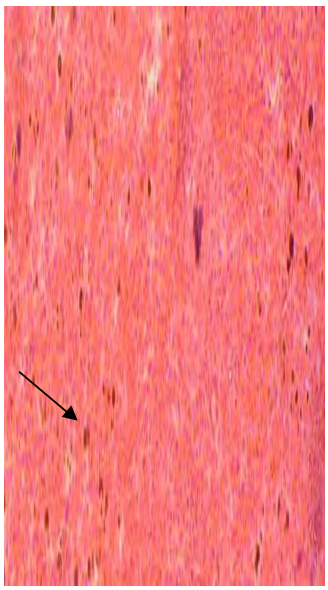


Plate 6b. Photomicrograph of a section of the spleen of a broiler chicken fed 15% GBM and 0.01% enzyme showing hemosiderosis (H and E stained, x400)

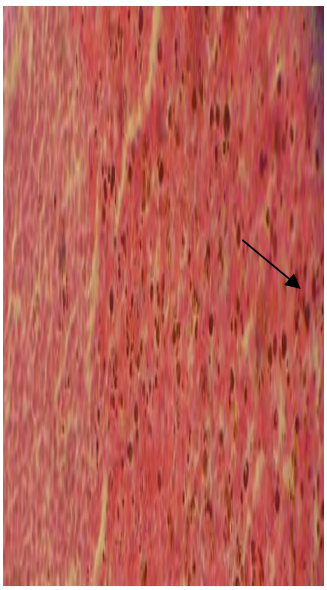


Plate 6c. Photomicrograph of a section of the spleen of a broiler chicken fed 30% GBM and 0.01% enzyme showing hemosiderosis (H and E stained, x400)

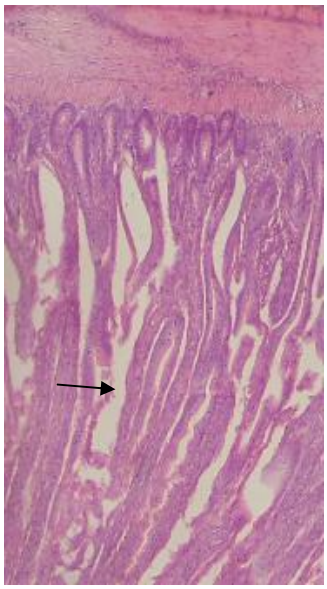


Plate 7a. Photomicrograph of a section of the intestine of a broiler chicken fed 0% GBM and 0% enzyme showing mild sloughing (H and E stained, x400)

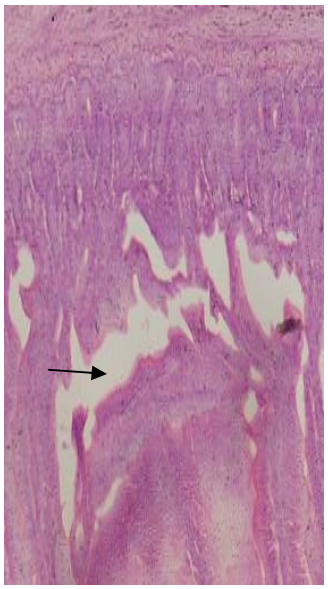


Plate 7b. Photomicrograph of a section of the intestine of a broiler chicken fed 15% GBM and 0% enzyme showing severe sloughing (H and E stained, x400)

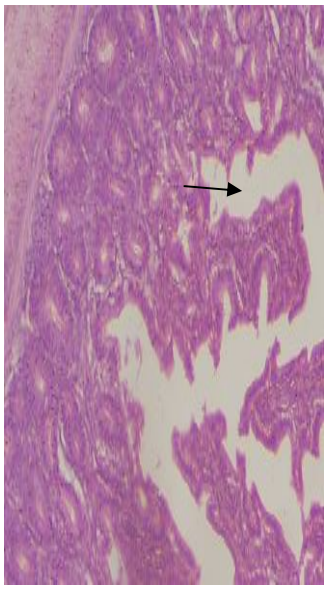


Plate 7c. Photomicrograph of a section of the intestine of a broiler chicken fed 30% GBM and 0% enzyme showing severe sloughing (H and E stained, x400)

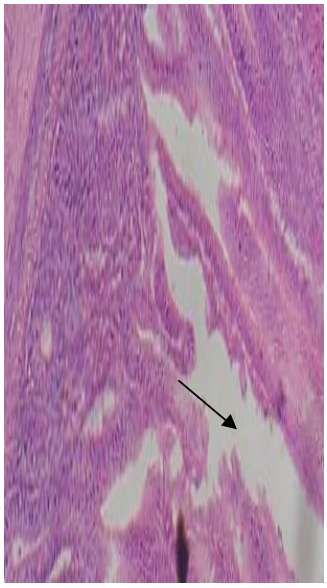


Plate 8a. Photomicrograph of a section of the intestine of a broiler chicken fed 0% GBM and 0.01% enzyme showing severe sloughing (H and E stained, x400)

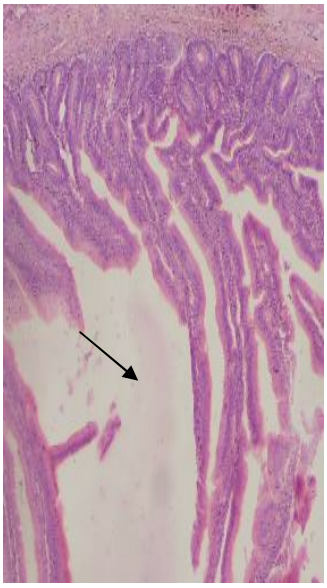


Plate 8b. Photomicrograph of a section of the intestine of a broiler chicken fed 15% GBM and 0.01% enzyme showing severe sloughing (H and E stained, x400)

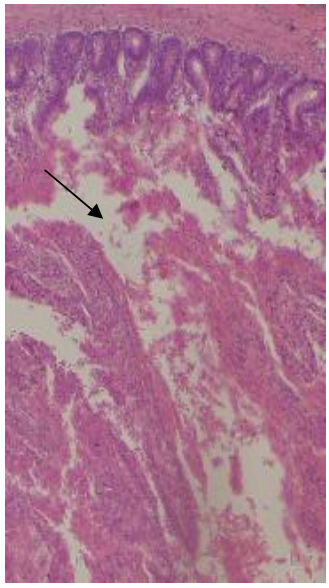


Plate 8c. Photomicrograph of a section of the intestine of a broiler chicken fed 30% GBM and 0.01% enzyme showing severe sloughing (H and E stained, x400)

4.3 EXPERIMENT 2: EFFECT OF PALM OIL SUPPLEMENTATION ON THE UTILIZATION OF GBM IN BROILER CHICKEN DIETS

4.3.1 Performance of Broiler Birds (Starter Phase)

The results showed that feed intake was statistically ($p>0.05$) similar for birds fed 0 and 7.5% GBM diets and significantly lower than the intake of birds fed 15% GBM diet (Table 4.14). The final weight, weight gain and feed cost per kilogram weight gain of birds fed 0 and 15% GBM diets were similar ($p>0.05$) and significantly ($p<0.05$) greater than that of birds fed 7.5% GBM diet. There was no significant ($P>0.05$) difference in mortality.

The inclusion of palm oil in the diet had no significant ($p>0.05$) effect on the feed intake of the birds but there was a significant ($p<0.05$) increase in final weight and weight gain. Efficiency of feed utilization also improved. Feed cost per kilogram weight gain and mortality rate of birds decreased ($p<0.05$) significantly with the inclusion of palm oil.

Figure 4.8 shows polynomial trend of final weight for starter phase of broiler chickens fed GBM diets. A decrease was observed at 7.5% GBM level and an increase was observed at 15% GBM level. Table 4.15 shows interaction between GBM and palm oil for feed intake, final weight, weight gain and feed to gain ratio. With the inclusion of palm oil, feed intake decreased for birds fed 0 and 15% GBM diet but increased for birds fed 7.5% GBM diet (Fig. 4.9). The addition of palm oil improved final weights for 0 and 7.5% GBM but not for 15% GBM diet (Fig. 4.10). There was an increase in weight gain for birds fed 0 and 7.5% GBM diets with the inclusion of palm oil but a non significant decrease was observed at 15% GBM diet with palm oil (Fig. 4.11). Efficiency of feed utilization was significantly improved for birds fed 0 and 15% GBM

Table 4.14: Effect of Dietary Levels of GBM/Palm Oil on Performance of Broiler Chickens during Starter Phase

	GBM Level (%)					Palm oil Level (%)			
	0	7.5	15	SEM	P	0	4	SEM	P
Initial Weight (g)	70.00	70.00	70.00	0.00	0.61	70.00	70.00	0.00	0.88
Feed Intake (g)	710.00^{b}	660.00^{b}	830.00^{a}	18.00	0.0001	720.00	750.00	14.00	0.12
Final Weight (g)	460.00^{a}	400.00^{b}	480.00^{a}	13.00	0.0018	410.00^{b}	480.00^{a}	10.00	0.0002
Weight Gain (g)	390.00^{a}	330.00^{b}	400.00^{a}	12.00	0.0018	330.00^{b}	410.00^{a}	10.00	0.0002
Feed to Gain ratio	1.84^{a}	2.12^{b}	2.06^{b}	0.05	0.004	2.19^{b}	1.83^{a}	0.04	0.0001
Feed cost/Kg gain (₦)	120.22^{a}	135.19^{b}	129.39^{a}	3.02	0.01	131.08^{b}	125.45^{a}	2.47	0.13
Mortality (%)	1.22	1.22	1..22	0.01	0.72	1.48^{b}	0.96^{a}	0.01	0.04
Feed Intake (g/b/d)	25.31^{b}	23.59^{b}	29.69^{a}	0.61	0.0001	25.58	26.81	0.50	0.12
Weight Gain (g/b/d)	13.85^{a}	11.61^{b}	14.44^{a}	0.45	0.002	11.90^{b}	14.70^{a}	0.37	0.0002

^{ab} Means within rows with different superscripts are significantly different ($p<0.05$); GBM- Ginger By-product Meal

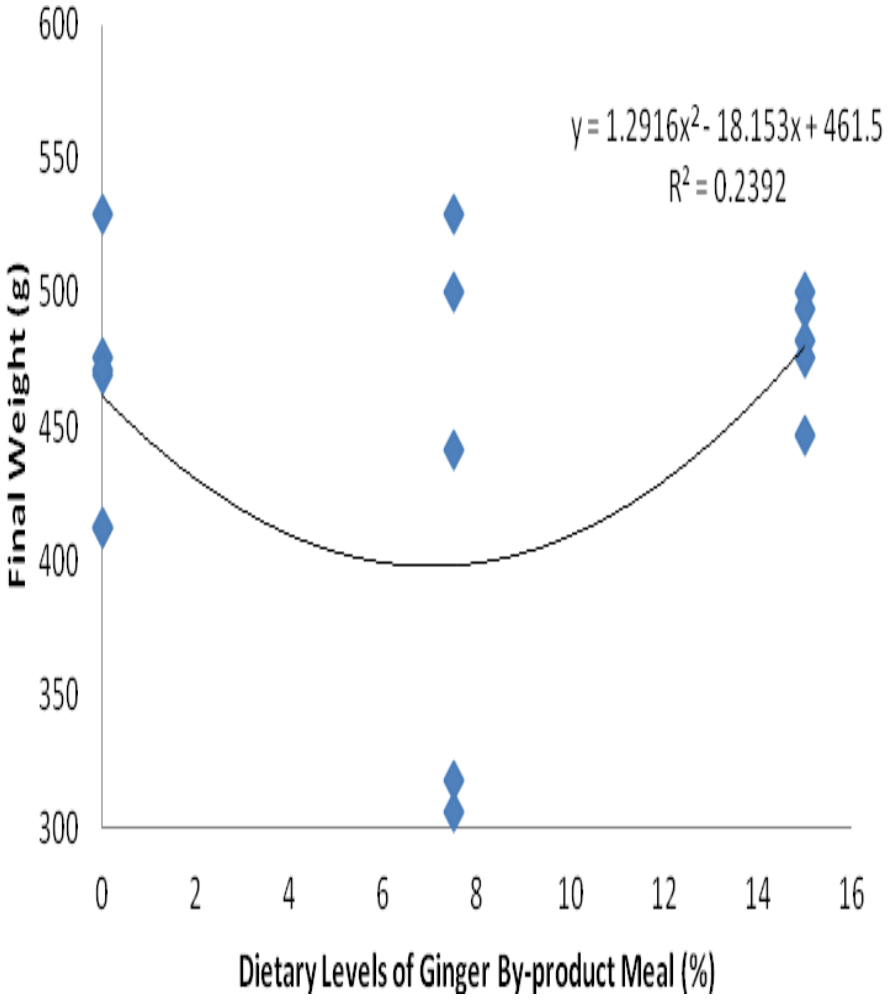


Figure 4.8: Trend line of final weight for broiler chickens fed varying levels of GBM at starter phase

Table 4.15: Effect of Dietary Levels of GBM and Palm Oil on Performance of Broiler chickens during Starter Phase

	GBM Level (%)							
	0		7.5		15			
	Palm Oil Level (%)							
	0	4	0	4	0	4	SEM	P
Initial Weight (g)	70.00	70.00	70.00	70.00	70.00	70.00	0.00	0.26
Feed Intake (g)	720.00 ^{b}	700.00 ^{b}	570.00 ^{c}	750.00 ^{b}	860.00 ^{a}	800.00 ^{a}	30.00	0.001
Final Weight (g)	430.00^{b}	490.00^{a}	310.00^{c}	490.00^{a}	480.00^{ab}	470.00^{ab}	20.00	0.001
Weight Gain (g)	360.00 ^{b}	420.00 ^{a}	230.00 ^{c}	420.00 ^{a}	410.00 ^{ab}	400.00 ^{ab}	20.00	0.001
Feed/ Gain	2.01 ^{bc}	1.68 ^{a}	2.44^{d}	1.81 ^{ab}	2.12 ^{c}	2.00 ^{bc}	0.07	0.011
Feed cost/Kg gain (~~N~~)	122.80^{ab}	117.64^{a}	146.09^{c}	124.28^{ab}	124.35^{ab}	134.43^{bc}	4.28	0.01
Mortality	1.22	0.96	1.75	0.96	1.72	0.96	0.01	0.72
Feed Intake (g/b/d)	25.70^{b}	24.91^{b}	20.31^{c}	26.87^{b}	30.74^{a}	28.64^{a}	0.87	0.001
Weight Gain (g/b/d)	12.85^{b}	14.86^{a}	8.33^{c}	14.89^{a}	14.53^{ab}	14.35^{ab}	0.64	0.001

^{ab} Means within rows with different superscripts are significantly different at ($p<0.05$); GBM- Ginger By-product Meal

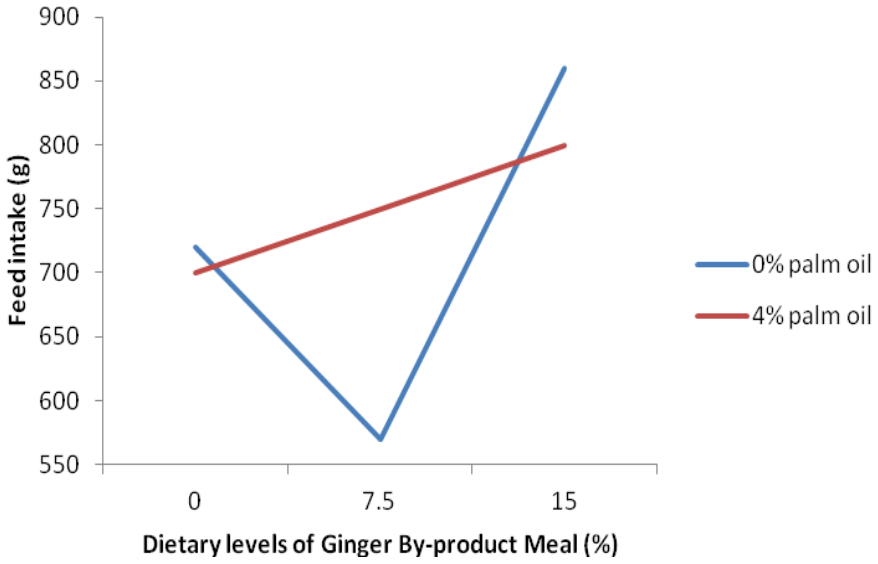


Figure 4.9: Interaction of dietary levels of GBM and Palm oil on feed intake during starter phase

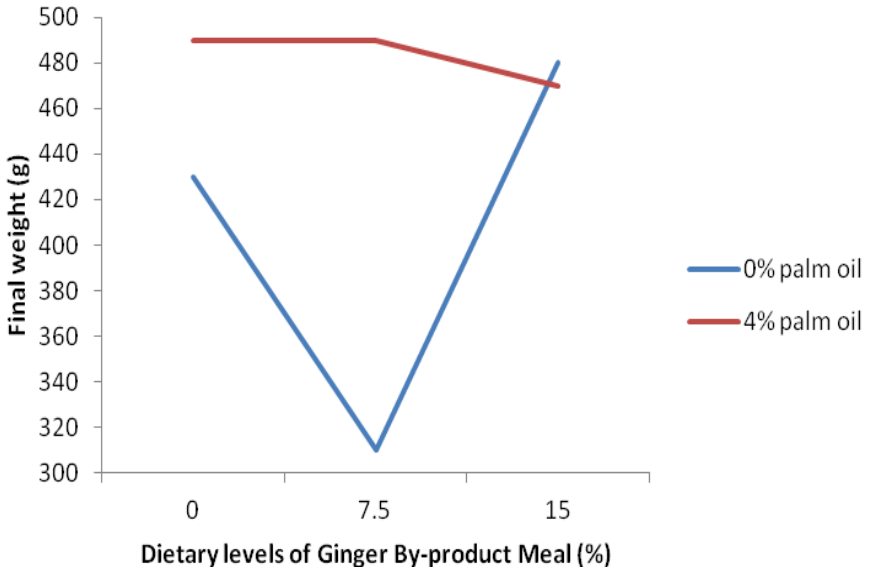


Figure 4.10: Interaction of Dietary Levels of GBM and Palm oil on final weight during starter phase

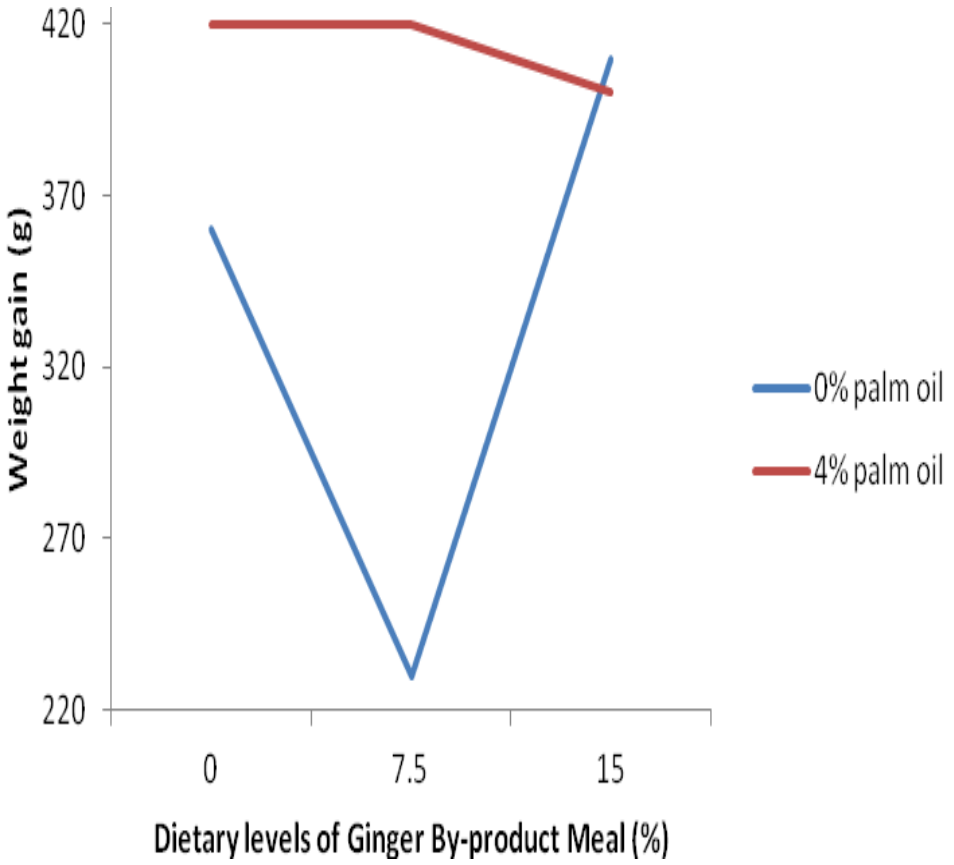


Figure 4.11: Interaction of dietary levels of GBM and Palm oil on weight gain during starter phase

diets with the inclusion of palm oil but there was no significant improvement for birds fed 15% GBM diet and palm oil (Fig. 4.12).

Feed cost per kg gain was similar for 0% GBM diet with and without the inclusion of palm oil. A decrease was observed in feed cost per kg gain for 7.5% GBM diet with the inclusion of palm oil and an increase observed for 15% GBM diet with the inclusion of palm oil.

The PCA presented on Table 4.16 was aimed at identifying clusters of performance parameters that would explain significant proportion of the total variation. Only one PC had significant loading that explained 69.85% of the total variance. The PC 1 values increased with initial weight, feed intake, final weight and weight gain explaining 69.85%, final weight and weight gain had the highest loading and seem to be the principal controlling factor in the trial. The negative value of feed to gain ratio means that feed to gain ratio is lacking in a latent variable associated with PC 1.

4.3.2 Performance of Broiler Chickens (Finisher Phase)

Feed intake, final weight and weight gain of birds fed 0, 7.5 and 15% GBM diets (Table 4.17) were statistically similar ($p>0.05$). The efficiency of feed utilization decreased significantly ($p <0.05$) with increase in the level of GBM in the diet. It was significantly ($p<0.05$) better for birds fed 0% GBM diet compared to birds fed 7.5 and 15% GBM diets which were both statistically similar ($p>0.05$). The feed cost per kilogram gain for birds fed 0% GBM diet was significantly ($p<0.05$) better than that of birds fed 7.5 and 15% GBM diets. There was no significant ($P>0.05$) difference in rate of mortality for all levels of GBM.

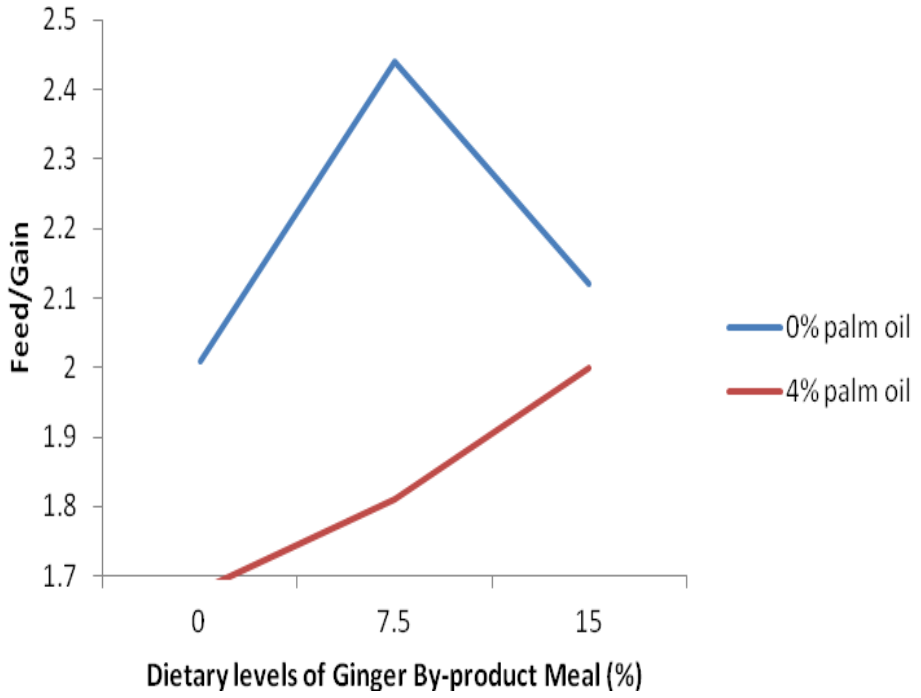


Figure 4.12: Interaction of dietary levels of GBM and Palm oil on feed/gain during starter phase

Table 4.16: Eigenvalues and Principal Component Loading for Broiler starter phase

	Principal Component
Parameters	PC1
Eigenvalue	3.49
Variance (%)	69.85
Cumulative Variance (%)	69.85
Initial Weight	***0.503***
Feed Intake	***0.77***
Final Weight	***0.99***
Weight Gain	***0.99***
Feed/Gain	***-0.83***

PC 1- principal component 1; PC2- principal component 2

Table 4.17: Effect of Dietary Levels of GBM/Palm Oil on Performance of Broiler Chickens during Finisher Phase

	GBM Level (%)					Palm Oil Level (%)			
	0	7.5	15	SEM	P	0	4	SEM	P
Initial Weight (g)	1000.00	1000.00	1000.00	0.00	-	1000.00	1000.00	0.00	-
Feed Intake (g)	2840.00	3060.00	3160.00	90.00	0.07	2970.00	3070.00	70.00	0.38
Final Weight (g)	2150.00	2030.00	2030.00	40.00	0.06	2030.00	2110.00	30.00	0.10
Weight Gain (g)	1150.00	1000.00	1000.00	40.00	0.06	1030.00	1110.00	30.00	0.10
Feed to Gain ratio	2.47[a]	3.01[b]	3.09[b]	0.14	0.02	2.91	2.80	0.01	0.48
Feed cost/Kg gain (₦)	147.29[a]	172.98[b]	174.88[b]	9.98	0.03	156.45[a]	173.65[b]	5.76	0.056
Mortality (%)	4.13	3.80	4.13	0.13	0.41	3.80[a]	4.45[b]	0.16	0.03
Feed Intake (g/b/d)	105.08	113.30	117.16	3.26	0.07	110.10	113.59	2.66	0.38
Weight Gain (g/b/d)	46.21	41.79	41.84	0.41	0.06	41.91	44.65	1.00	0.10

[ab] Means within rows with different superscripts are significantly different ($p<0.05$); GBM- Ginger By-product Meal

The inclusion of palm oil had no significant ($p>0.05$) effect on feed intake, final weight, weight gain and feed to gain ratio of the birds. Feed cost per kilogram gain and mortality significantly ($p<0.5$) increased with the inclusion of palm oil. Figure 4.13 shows polynomial trend for final weight of chickens fed GBM diets, a decrease was observed with the inclusion of GBM.

4.3.3 Effect of Dietary Levels of GBM and Palm oil on Haematological Parameters of Broiler Chickens

Table 4.18 shows the effect of GBM and palm oil at early finisher phase (week five) on haematological parameters. The PCV, haemoglobin, total protein, neutrophil, monocyte, eosinophil and basophil values of the birds were not significantly ($p>0.05$) different for all levels of GBM but the WBC of the birds fed 7.5% GBM was significantly ($p<0.05$) higher than that of birds fed 0% and 15% GBM diet. There was no significant ($p>0.05$) effect of palm oil addition on PCV, Hb, TP, WBC, neutrophils, lymphocytes, monocytes, eosinophils and basophils levels.

At the end of the finisher phase (week eight), the PCV, Hb, WBC, basophil, eosinophil and monocyte values were not significantly ($p>0.05$) affected by GBM dietary levels but there were significant ($p<0.05$) differences in TP, neutrophil and lymphocyte levels. The TP of the birds fed 0 and 15% GBM were significantly ($p<0.05$) greater than 7.5% GBM while the neutrophil levels were significantly ($p<0.05$) greater at 7.5% GBM. Neutrophil levels for 0 and 15% GBM diets were statistically similar. The level of lymphocytes in birds fed 0 and 15% GBM were significantly ($p<0.05$) greater than for those fed 7.5% GBM diet. The inclusion of palm oil had no significant effect on most of the haematological parameters except WBC that significantly ($p<0.05$) decreased with the inclusion of palm oil.

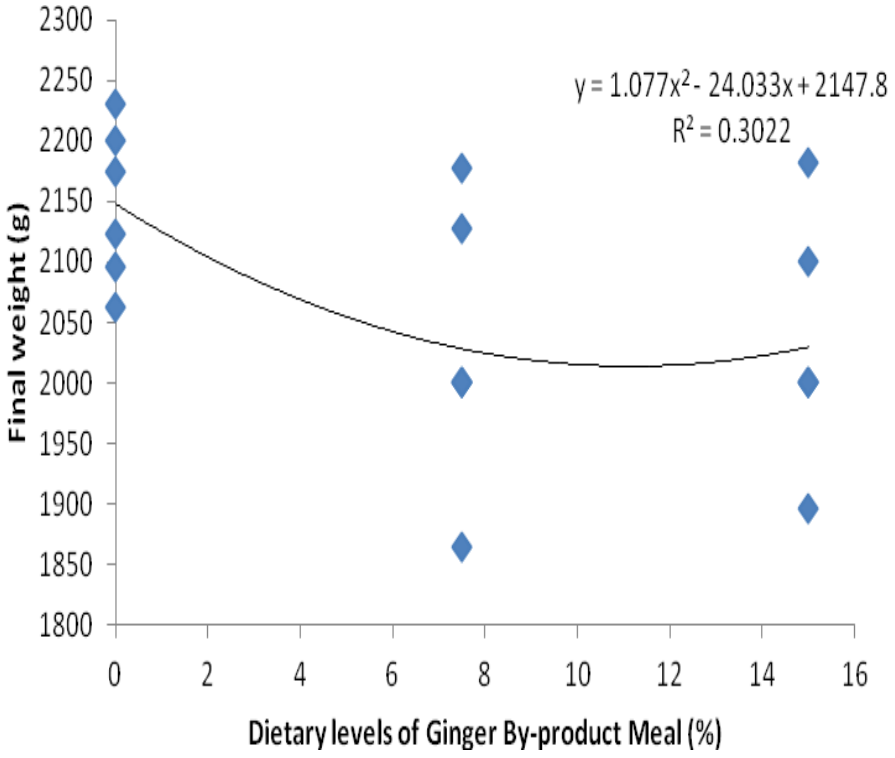


Figure 4.13: Trend line of final weight for broiler chickens fed varying levels of GBM during finisher phase

Table 4.18: Effect of Dietary Levels of GBM/Palm Oil on Haematological Parameters of Broiler Chickens during the Finisher Phase

	GBM Level (%)					Palm Oil Level (%)			
	0	7.5	15	SEM	P	0	4	SEM	P
Week 5									
Packed Cell Volume (%)	36.50	34.67	41.83	2.12	0.08	38.11	37.22	1.73	0.72
Haemoglobin (g/dl)	12.00	12.30	13.87	0.73	0.19	12.67	12.76	0.60	0.92
Total protein (g/dl)	5.14	4.13	4.79	0.01	0.10	5.14	4.13	0.01	0.06
White Blood Cell(10^9/L)	4.45[b]	11.88[a]	6.98[b]	0.03	0.002	7.78	7.38	0.02	0.90
Neutrophil (%)	48.98	38.90	46.77	0.05	0.17	45.71	42.66	0.04	0.70
Lymphocyte (%)	45.71	53.70	44.67	0.05	0.06	45.71	50.12	0.04	0.92
Monocyte (%)	1.33	2.5	1.67	0.40	0.14	1.89	1.78	0.32	0.81
Eosinophil (%)	1.17	1.5	1.5	0.40	0.79	1.22	1.56	0.32	0.48
Basophil (%)	0.83	0.50	0.67	0.25	0.66	0.67	0.67	0.21	1.00
Week 8									
Packed Cell Volume (%)	33.11	34.67	33.11	0.04	0.83	33.11	33.88	0.03	0.61
Haemoglobin (g/dl)	10.96	11.48	10.96	0.04	0.85	10.96	11.22	0.03	0.63
Total protein (g/dl)	5.75[a]	4.07[b]	5.62[a]	0.04	0.001	4.79	5.37	0.03	0.17
White Blood Cell (10^9/L)	7.21	8.58	6.68	1.76	0.74	8.99[a]	5.98[b]	1.44	0.07
Neutrophil (%)	43.65[b]	57.54[a]	43.65[b]	0.05	0.03	46.77	48.98	0.04	0.56
Lymphocyte (%)	47.86[a]	36.31[b]	50.12[a]	0.05	0.01	42.66	45.71	0.04	0.45
Basophil (%)	0.50	0.75	0.50	0.24	0.51	0.44	0.72	0.20	0.18
Eosinophil (%)	1.83	2.00	1.66	0.39	0.70	1.67	2.00	0.32	0.30
Monocyte (%)	1.08	1.67	1.42	0.36	0.29	1.17	1.61	0.30	0.15

[ab] Means within rows with different superscripts are significantly different at ($p<0.05$)

Table 4.19 shows an interaction between GBM and palm oil for PCV and WBC at finisher phase (week five). The inclusion of palm oil significantly ($p<0.05$) increased PCV in birds fed 0% GBM diet. The inclusion of palm oil decreased WBC of birds fed 7.5% GBM diet but an increase was observed for the 15% GBM diet. No interaction was observed between GBM and palm oil for the other haematological parameters.

4.3.4 Effect of Dietary Levels of GBM and Palm Oil on Serum Chemistry of Broiler Chickens

Table 4.20 shows that at finisher phase (week five), there were no significant ($p>0.05$) differences in the total cholesterol and ALT levels with the inclusion of GBM but there was a significant decrease ($p<0.05$) in the level of triglyceride with increase in the level of GBM. With the inclusion of palm oil, there were significant ($p<0.05$) increases in the cholesterol and triglyceride levels and a non significant difference ($p>0.05$) in the serum ALT. At week eight, GBM had no significant ($p>0.05$) effect on the cholesterol and serum ALT of the birds. There was a significant ($p<0.05$) decrease in serum AST in birds fed 15% GBM diet but a significant ($p<0.05$) increase in the tissue ALT of the birds.

Table 4.21 shows a positive interaction between GBM and palm oil at week 5. The addition of palm oil significantly ($p<0.05$) increased serum cholesterol level for 0 and 7.5% GBM diets but it decreased for the 15% GBM diet. Serum triglyceride levels were also significantly ($p<0.05$) increased by the addition of palm oil to 0 and 7.5% GBM diets. At week 8, there was no interaction between GBM and palm oil for cholesterol, serum AST and ALT but there was an interaction for tissue ALT at 0 and 15% GBM with the inclusion of palm oil. A decrease was observed in tissue ALT with the inclusion of palm oil in 0% GBM diet but an increase

Table 4.19: Effect of Dietary Levels of GBM and Palm Oil on Haematological Parameters of Broiler Chickens at Week 5

	GBM Level (%)							
	0		7.5		15			
	Palm Oil Level (%)							
	0	4	0	4	0	4	SEM	P
Packed Cell Volume (%)	32.00^{c}	41.00^{ab}	37.33^{bc}	32.00^{c}	45.00^{ab}	38.67^{bc}	3.05	0.04
Haemoglobin (g/dl)	10.63	13.30	12.40	12.20	15.00	12.77	1.06	0.10
Total Protein (g/dl)	6.22	4.13	4.13	3.80	4.80	4.79	0.01	0.20
White Blood Cell (10^9/L)	4.45^{b}	4.45^{b}	15.70^{a}	8.62^{b}	4.79^{b}	9.95^{a}	0.04	0.01
Neutrophil (%)	50.12	47.86	38.02	38.90	51.29	42.66	0.08	0.87
Lymphocyte (%)	44.67	46.77	54.95	52.48	38.90	51.29	0.08	0.57
Monocyte (%)	0.67	2.00	3.00	2.00	2.00	1.33	0.57	0.12
Eosinophil (%)	1.00	1.33	1.33	1.67	1.33	1.67	0.57	1.00
Basophil (%)	0.67	1.00	0.33	0.67	1.00	0.33	0.36	0.31

[abc] Means within rows with different superscripts are significantly different at ($p<0.05$)

Table 4.20: Effect of Dietary Levels of GBM/Palm Oil on Serum Chemistry of Broiler Chickens during Finisher Phase

	GBM Level (%)					Palm oil Level (%)			
	0	7.5	15	SEM	P	0	4	SEM	P
Week 5									
Cholesterol (mmol/L)	1.32	1.31	1.40	1.93	0.39	0.95[b]	1.73[a]	1.58	0.0001
Triglyceride (mmol/L)	1.00[a]	0.96[a]	0.11[b]	1.89	0.0001	0.09[b]	1.30[a]	1.54	0.0001
Serum ALT (U/L)	4.45	4.13	4.13	0.01	0.40	4.13	4.45	0.01	0.34
Week 8									
Cholesterol (mmol/L)	1.88	1.67	1.34	13.13	0.37	1.13[b]	2.15[a]	10.72	0.0003
Serum AST (U/L)	57.54[a]	60.26[a]	42.66[b]	0.06	0.04	48.98	57.54	0.05	0.16
Tissue ALT (U/L)	16.98[b]	17.78[b]	20.42[a]	0.03	0.04	18.20	18.62	0.03	0.69
Serum ALT (U/L)	33.11	40.74	40.74	0.04	0.07	38.90	38.02	0.04	0.80

[ab]Means within rows with different superscripts are significantly different ($p<0.05$); GBM- Ginger By-product Meal; AST- Aspartate aminotransferase; ALT- Alanine aminotransferase

Table 4.21: Effect of Dietary Levels of GBM and Palm Oil on Serum Chemistry of Broiler Chickens during Finisher Phase

	GBM Level (%)							
	0		7.5		15			
	Palm Oil Level (%)							
	0	4	0	4	0	4	SEM	P
Week 5								
Cholesterol (mmol/L)	0.57^{d}	2.07^{a}	0.57^{d}	2.04^{a}	1.71^{b}	1.09^{c}	2.79	0.0001
Triglyceride (mmol/L)	0.07^{c}	1.93^{a}	0.09^{c}	1.83^{b}	0.10^{c}	0.13^{c}	2.72	0.0001
Serum ALT (U/L)	4.13	5.14	4.13	4.13	4.13	4.13	0.02	0.40
Week 8								
Cholesterol(mmol/L)	1.40	1.78	1.12	2.37	0.63	1.98	1.01	0.16
Serum AST(U/L)	53.70	63.10	57.54	63.10	38.02	47.86	0.09	0.86
Tissue ALT(U/L)	23.99^{a}	12.02^{c}	17.38^{b}	18.20^{b}	14.13^{bc}	28.84^{a}	0.05	0.0001
Serum ALT(U/L)	30.90	35.48	38.90	43.65	47.86	35.48	0.06	0.09

[ab] Means within rows with different superscripts are significantly different ($p<0.05$); GBM- Ginger By-product Meal; AST- Aspartate aminotransferase; ALT- Alanine aminotransferase; ALP- Alkaline phosphatase

was observed in 15% GBM diet. Haemoglobin, TP, neutrophil, lymphocyte, monocyte, eosinophil and basophil levels for all treatments were statistically similar.

4.3.5 Effect of Dietary Levels of GBM and Palm Oil on Carcass and Organ Characteristics of Broiler Chickens

Table 4.22 shows that the carcass and organ characteristics of the birds were statistically ($P>0.05$) similar but the abdominal fat content of birds fed 0% GBM diet was significantly ($p<0.05$) greater than that of birds fed 7.5 and 15% GBM diets. The abdominal fat content decreased at a rate of 32% between 0 and 7.5% inclusion of GBM and decreased at a rate of 3% between 7.5 and 15% GBM inclusion. The inclusion of palm oil decreased the intestinal length and increased the abdominal fat content significantly ($p<0.05$).

Table 4.23 shows that there was no interaction between GBM and palm oil for most of the carcass and organ characteristics except for the weight of the liver that decreased due to the addition of palm oil at 0% GBM level. There was an interaction for abdominal fat weight at 7.5% GBM with the inclusion of palm oil, an increase was observed in abdominal fat weight. At 0% GBM, inclusion of palm oil had no significant effect on abdominal fat while at 15% GBM level, there was a non-significant decrease in abdominal fat weight

.

Table 4.22: Effect of Dietary Levels of GBM/Palm Oil on Carcass and Organ Characteristics of Broiler Chickens

	GBM Level (%)					Palm oil Level (%)			
	0	7.5	15	SEM	P	0	4	SEM	P
Dressing percent	80.43	77.18	79.52	4.11	0.72	77.76	80.32	3.36	0.45
Shank (%)	8.41	8.05	8.19	0.40	0.67	8.35	8.08	0.33	0.40
Neck (%)	4.51	4.17	4.17	0.22	0.22	4.23	4.33	0.18	0.57
Wing (%)	7.62	7.25	7.46	0.39	0.65	7.47	7.41	0.32	0.87
Breast (%)	14.13	13.18	15.14	0.03	0.12	14.45	13.80	0.02	0.39
Spleen (%)	0.13	0.12	0.13	0.05	0.74	0.12	0.13	0.05	0.41
Liver (%)	1.74	1.48	1.74	0.004	0.38	1.74	1.48	0.003	0.13
Intestine weight (%)	3.26	3.47	3.61	0.19	0.20	3.42	3.48	0.16	0.74
Gizzard (%)	2.02	2.02	2.02	0.004	0.74	2.02	2.02	0.003	0.14
Kidney (%)	0.16	0.16	0.17	0.05	0.79	0.15	0.17	0.04	0.09
Heart (%)	0.58	0.56	0.52	0.03	0.46	0.52	0.58	0.02	0.17
Intestine length (%)	9.33	9.33	9.77	0.02	0.53	10.00^{a}	9.12^{b}	0.02	0.05
Abdominal fat (%)	1.55^{a}	1.05^{b}	1.02^{b}	0.07	0.03	1.02^{b}	1.41^{a}	0.16	0.01

[ab] Means within rows with different superscripts are significantly different at ($p<0.05$); GBM- Ginger By-product Meal

Table 4.23: Effect of Dietary Levels of GBM and Palm Oil on Carcass and Organ Characteristics of Broiler Chickens

	GBM Level (%)							
	0		7.5		15			
	Palm Oil Level (%)							
	0	4	0	4	0	4	SEM	P
Dressing percent	80.56	80.31	74.12	80.24	78.60	80.43	5.92	0.73
Shank (%)	8.90	7.92	8.14	7.96	8.02	8.35	0.58	0.27
Neck (%)	4.63	4.38	3.96	4.37	4.09	4.25	0.32	0.34
Wing (%)	7.68	7.56	7.55	6.94	7.17	7.74	0.57	0.34
Breast (%)	16.22	12.88	12.88	13.49	15.49	15.14	0.04	0.19
Spleen (%)	0.14	0.12	0.11	0.13	0.11	0.14	0.08	0.35
Liver (%)	2.02^{a}	1.48^{b}	1.48^{b}	1.48^{b}	1.75^{ab}	1.75^{ab}	0.01	0.04
Intestine weight (%)	3.24	3.28	3.44	3.50	3.58	3.64	0.28	0.10
Gizzard (%)	2.02	2.02	2.02	1.74	2.02	2.02	0.01	0.23
Kidney (%)	0.14	0.17	0.14	0.18	0.16	0.18	0.08	0.78
Heart (%)	0.58	0.56	0.54	0.58	0.48	0.58	0.04	0.28
Intestine length (%)	9.77	8.91	10.23	8.71	10.23	9.55	0.03	0.99
Abdominal fat (%)	1.35^{ab}	1.74^{a}	0.63^{c}	1.74^{a}	1.15^{bc}	0.93^{bc}	0.11	0.002

^{ab} Means within rows with different superscripts are significantly different at ($p<0.05$); GBM- Ginger By-product Meal

4.4 Experiment 3: Effect of Graded Levels of Palm Oil on the Utilization of GBM in Broiler Chicken Diets.

4.4.1 Performance of Broiler Chickens (Starter Phase)

There was no significant ($p>0.05$) difference in the feed intake of birds for all the GBM diets (Table 4.24). The final weight and weight gain of birds fed 7.5% GBM diets were significantly ($p<0.05$) greater than that of birds fed 15% GBM diets but similar to those fed 0% GBM diet. There were also no significant ($p<0.05$) differences in final weight and weight gain between birds fed 0 and 15% GBM diet. The efficiency of feed utilization of birds fed 0 and 7.5% GBM diets were significantly ($p<0.05$) greater than that of birds fed 15% GBM diets. Feed cost per kg gain was significantly ($p<0.05$) better for birds fed 0 and 7.5% GBM diets than 15% GBM diet. Mortality rate was statistically ($p>0.05$) for all levels of GBM.

The final weights, weight gains, feed to gain ratios and feed cost per kg gain of birds fed 0 and 4% palm oil diets were statistically similar ($p>0.05$) and significantly ($p<0.05$) better than that of birds fed 6% palm oil diet. Final weight of the broilers at starter phase, had polynomial trend, with a decrease observed beyond the inclusion of 7.5% GBM (Figure 4.14). Mortality rate was significantly ($p<0.05$) greater for birds fed 6% palm oil diet compared to birds fed 0 and 4% palm oil diets.

Table 4.25 shows an interaction between GBM and palm oil for final weight and weight gain at 7.5 and 15%. The inclusion of 4% palm oil brought about an increase in final weight (Figure 4.15) and weight gain (Figure 4.16) for birds fed 7.5% GBM diet but the

Table 4.24: Effect of Dietary Levels of GBM/Palm Oil on Performance of Broiler Chickens during Starter Phase

	GBM Level (%)					Palm Oil Level (%)				
	0	7.5	15	SEM	P	0	4	6	SEM	P
Initial Weight (g)	60.00	60.00	60.00	0.00	0.68	60.00	60.00	60.00	0.00	0.84
Feed Intake (g)	880.00	940.00	940.00	20.00	0.08	940.00	930.00	880.00	20.00	0.13
Final Weight (g)	570.00^{ab}	610.00^{a}	530.00^{b}	10.00	0.003	580.00^{a}	600.00^{a}	520.00^{b}	10.00	0.001
Weight Gain (g)	510.00^{ab}	550.00^{a}	470.00^{b}	10.00	0.003	530.00^{a}	540.00^{a}	460.00^{b}	10.00	0.001
Feed to Gain ratio	1.73^{a}	1.73^{a}	2.02^{b}	0.05	0.0003	1.79^{ab}	1.74^{a}	1.95^{b}	0.05	0.012
Feed cost/Kg gain	120.00^{a}	117.60^{a}	134.35^{b}	3.09	0.002	108.22^{a}	120.57^{a}	143.16^{b}	3.09	0.0001
Mortality	0.75	0.75	0.48	0.02	0.58	0.48^{a}	0.20^{a}	1.02^{b}	0.02	0.02
Feed Intake (g/b/d)	31.43	33.57	33.57	0.67	0.08	33.57	33.21	31.43	0.67	0.13
Weight gain (g/b/d)	20.36^{ab}	21.79^{a}	16.79^{b}	0.33	0.003	18.93	19.29	16.43	0.33	0.001

^{ab} Means within rows with different superscripts are significantly different ($p<0.05$); GBM- Ginger By-product Meal

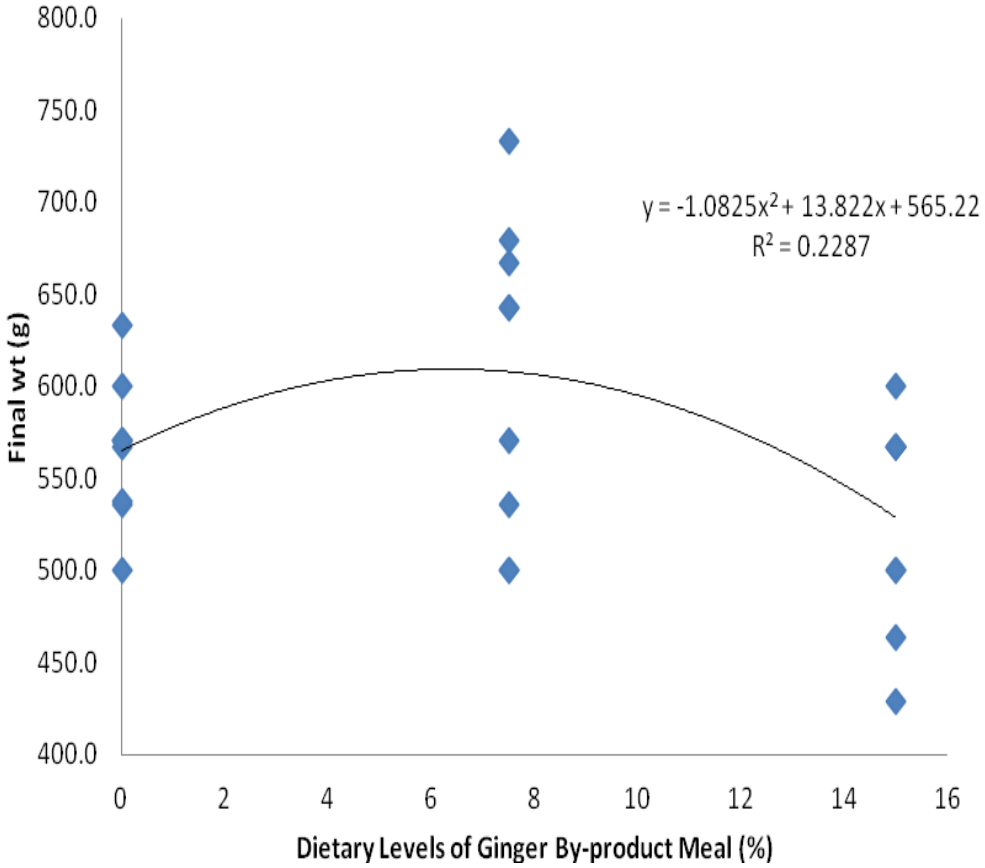


Figure 4.14: Trend line of final weight for broiler chickens fed varying levels of GBM during starter phase

Table 4.25: Effect of Dietary Levels of GBM and Palm Oil on Performance of Broiler Chickens during Starter Phase

	GBM Level (%)										
	0			7.5			15				
	Palm Oil Level (%)										
	0	4	6	0	4	6	0	4	6	SEM	P
Initial Weight (g)	58.00	59.00	59.00	58.00	58.00	58.00	58.00	58.00	58.00	0.00	0.99
Feed Intake (g)	890.00	870.00	870.00	920.00	1010.00	890.00	1010.00	930.00	890.00	37.00	0.21
Final Weight (g)	580.00^{b}	560.00^{b}	560.00^{b}	610.00^{b}	690.00^{a}	520.00^{cd}	570.00^{bc}	560.00^{bc}	460.00^{d}	25.00	0.024
Weight Gain (g)	520.00^{b}	500.00^{b}	500.00^{b}	550.00^{b}	630.00^{a}	470.00^{cd}	510.00^{bc}	500.00^{bc}	410.00^{d}	25.00	0.023
Feed to Gain ratio	1.71	1.76	1.73	1.68	1.59	1.92	1.98	1.88	2.19	0.08	0.19
Feed cost/kg gain	105.59	124.41	130.00	101.79	109.92	141.09	117.29	127.37	158.40	5.35	0.14
Feed Intake (g/b/d)	31.79	31.07	31.07	32.86	36.07	31.79	36.07	33.21	31.79	0.67	0.21
Weight Gain (g/b/d)	18.57^{b}	17.86^{b}	17.86^{b}	21.79^{b}	22.50^{a}	16.79^{cd}	18.21^{bc}	17.86^{bc}	14.64^{d}	0.33	0.023

[ab] Means within rows with different superscripts are significantly different ($p<0.05$); GBM- Ginger By-product Meal

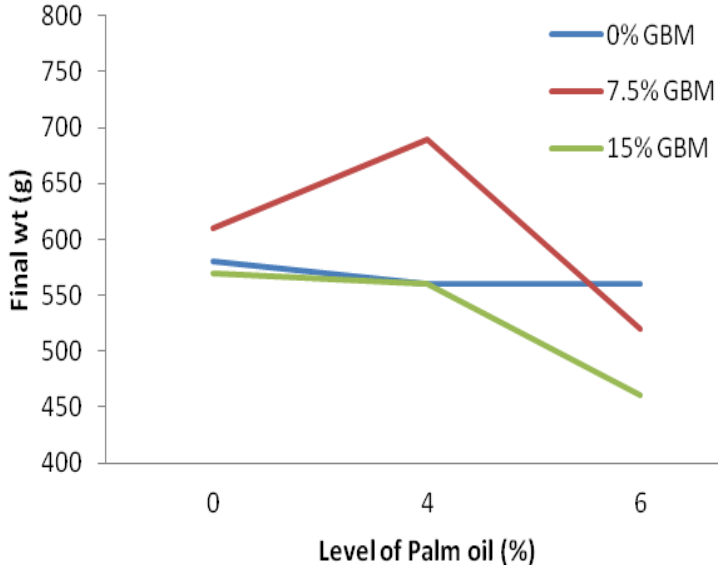


Figure 4.15: Interaction of dietary levels of GBM and Palm oil on final weight during starter phase

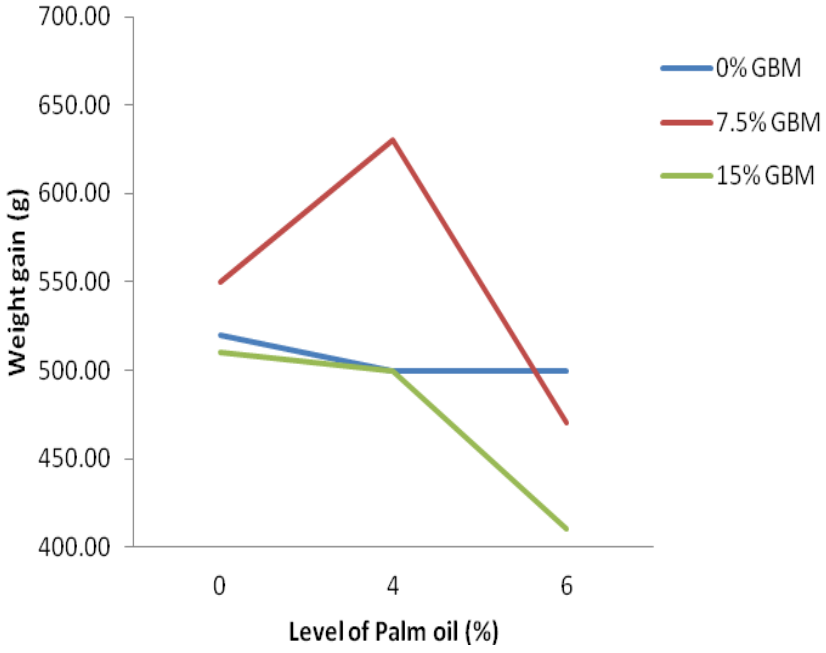


Figure 4.16: Interaction of dietary levels of Ginger By-product Meal and Palm oil on weight gain during starter phase

inclusion of 6% palm oil resulted in a decrease in final weight and weight gain for birds fed 7.5 and 15% GBM diet.

The PCA presented on Table 4.26 showed two PCs with significant loadings at the starter phase that collectively explained 86.4% of the total variance. The PC 1 values increased with feed intake, final weight and weight gain explaining 62.5%. The negative value of feed to gain ratio means that feed to gain ratio is lacking in a latent variable associated with PC 1. Only two parameters, feed intake and feed to gain ratio clustered in PC 2 which accounted for 23.9 % of the total variance. Final weight and weight gain had the highest loading and Pearson Correlation statistics revealed that it correlated with all the other parameters. Therefore, final weight and weight gain seem to be the principal controlling factor in the trial. This buttresses the existing logic that any management practice that increases final weight of chickens will definitely influence other parameters.

4.4.2 Effect of Dietary Levels of GBM and Palm Oil on Serum Chemistry of Broiler Chickens

The GBM levels had no significant effect ($p>0.05$) on cholesterol, triglyceride, AST and ALT at the starter phase (week 4) but it had a significant effect ($p<0.05$) on ALP levels of the birds (Table 4.27). A decrease of ALP levels was observed with increase in dietary GBM levels. Palm oil had no significant effect ($p>0.05$) on cholesterol, triglyceride, AST and ALT. However, ALP significantly ($p<0.05$) decreased for birds fed 6% palm oil diets.

At the starter phase (week 4), there were interactions between GBM and palm oil for cholesterol and ALT for but no interaction for triglyceride, AST and ALP (Table 4.28).

Table 4.26: Eigenvalues and Principal Component loading for Broiler Starter Phase

	Principal Components	
Parameters	PC1	PC2
Eigenvalue	4.37	1.68
Variance (%)	62.48	23.94
Cumulative Variance (%)	62.48	86.43
Initial Weight	0.176	-0.305
Feed Intake	**0.694**	**0.714**
Final Weight	**0.986**	-0.155
Weight Gain	**0.985**	-0.153
Feed/Gain	**-0.683**	**0.704**

PC 1- principal component 1; PC2- principal component 2

Table 4.27: Effect of Dietary Levels of GBM/Palm Oil on Serum Chemistry of Broiler Chickens during Starter Phase

	GBM Level (%)					Palm oil Level (%)				
	0	7.5	15	SEM	P	0	4	6	SEM	P
Cholesterol (mmol/L)	3.49	3.18	3.80	0.01	0.25	3.80	3.49	3.49	0.01	0.72
Triglyceride (mmol/L)	1.22	1.48	1.22	0.01	0.52	0.96	1.75	1.22	0.01	0.07
AST (U/L)	25.48	27.15	25.48	0.02	0.86	27.15	26.31	25.48	0.02	0.55
ALT (U/L)	2.88	1.75	2.02	0.02	0.08	2.30	2.30	2.02	0.02	0.82
ALP (U/L)	56.54[a]	43.67[b]	39.74[b]	0.01	0.003	49.12[a]	50.29[a]	39.74[b]	0.01	0.04

[ab] Means within rows with different superscripts are significantly different ($p<0.05$); GBM- Ginger By-product Meal; AST- Aspartate aminotransferase; ALT- Alanine aminotransferase; ALP- Alkaline phosphatase

Table 4.28: Effect of Dietary Levels of GBM and Palm oil on Serum Chemistry of Broiler Chickens during Starter Phase

	GBM Level (%)										
	0			7.5			15				
	Palm Oil Level (%)										
	0	4	6	0	4	6	0	4	6	SEM	P
Cholesterol (mmol/L)	3.18^{bc}	4.13^{ab}	2.88^{bc}	4.45^{ab}	2.02^{c}	3.18^{bc}	3.49^{bc}	4.45^{ab}	3.80^{b}	0.01	0.02
Triglyceride (mmol/L)	0.71	1.22	1.75	1.48	2.02	0.96	1.22	1.75	1.22	0.01	0.11
AST (U/L)	28.02	23.11	26.31	28.02	28.02	23.88	25.48	26.31	25.48	0.02	0.45
ALT (U/L)	3.18^{ab}	3.80^{ab}	2.30^{bc}	1.22^{c}	1.22^{c}	3.18^{ab}	2.59^{bc}	2.30^{bc}	0.96^{c}	0.02	0.03
ALP (U/L)	51.48	57.88	59.26	50.29	44.71	37.02	44.71	49.12	27.84	00.01	0.07

[ab] Means within rows with different superscripts are significantly different ($p<0.05$); GBM- Ginger By-product Meal

Palm oil addition to 7.5% GBM diet brought about a decrease in cholesterol levels of the birds but a slight increase was observed with inclusion of 6% palm oil. The inclusion of 6% palm oil to 7.5% GBM diet increased serum ALT but when it was added to 0 and 15% GBM diet, ALT levels decreased.

4.4.3 Effect of Dietary Levels of GBM and Palm Oil on Haematological Indices of Broiler Chickens

There was no significant ($p>0.05$) difference in packed cell volume and haemoglobin concentration in starter broiler chickens fed varying levels of GBM and palm oil (Table 4.29). The total protein of birds fed 0 and 15% GBM diets was significantly ($p<0.05$) lower than that of birds fed 7.5% GBM diet.

4.4.4 Performance of Broiler Chickens (Finisher Phase)

There were significant ($p<0.05$) differences in initial weight because the birds were not randomized at the end of the starter phase (Table 4.30). There were no significant ($p>0.05$) differences in feed intake, final weight, weight gain and mortality for all levels of GBM. There was also no significant ($p>0.05$) difference in feed to gain ratio between the birds fed 0 and 7.5% GBM diet but birds fed 15% GBM diet had a significantly ($p<0.05$) lower feed to gain ratio. Feed cost per kilogram weight gain was lower for 0 and 7.5% GBM diets than 15% GBM diet.

The addition of palm oil had no significant ($p<0.05$) effect on feed intake, final weight, weight gain, feed to gain ratio, feed intake per bird, weight gain per bird and mortality. Feed cost per kilogram weight gain was lower for 0 and 4% palm oil diets than 6% palm oil diet.

Figures 4.17 and 4.18 show that final weight and weight gain had a polynomial trend. Final weight increased from 0 to 7.5% GBM diet and then decreased while a decrease was observed at all levels for weight gain. Mortality rates were similar for all levels of palm oil.

Table 4.29: Effect of Dietary Levels of GBM/Palm Oil on Haematological Indices of Broiler chickens during Starter Phase

	GBM Level (%)					Palm oil Level (%)				
	0	7.5	15	SEM	P	0	4	6	SEM	P
Packed cell volume (%)	30.17	31.98	29.17	1.3	0.10	30.94	29.67	30.70	1.3	0.51
Haemoglobin (g/dl)	10.03	10.62	9.69	0.43	0.11	10.29	9.84	10.21	0.43	0.50
Total protein (g/dl)	1.75[a]	1.48[b]	1.75[a]	0.01	0.01	1.75	1.75	1.75	0.01	0.87

[ab] Means within rows with different superscripts are significantly different ($p<0.05$); GBM- Ginger By-product Meal

Table 4.30: Effect of Dietary Levels of GBM/Palm Oil on Performance of Broiler Chickens during Finisher Phase

	GBM Level (%)					Palm Oil Level (%)				
	0	7.5	15	SEM	P	0	4	6	SEM	P
Initial Weight (g)	570.00[ab]	610.00[a]	530.00[b]	10.00	-	580.00[a]	600.00[a]	520.00[b]	10.00	-
Feed Intake (g)	3180.00	3100.00	3250.00	80.00	0.60	3300.00	3270.00	2960.00	80.00	0.07
Final Weight (g)	1737.00	1672.98	1607.40	50.00	0.15	1702.81	1753.83	1561.00	50.00	0.10
Weight Gain (g)	1167.00	1062.98	1077.40	40.00	0.15	1122.81	1153.83	1041.00	40.00	0.10
Feed to Gain ratio	2.72[a]	2.92[a]	3.02[b]	0.08	0.008	2.94	2.83	2.84	0.08	0.26
Feed cost/Kg gain	327.50[a]	336.85[a]	418.39[b]	8.90	0.0001	319.69[a]	339.33[a]	423.73[b]	8.90	0.0001
Mortality	1.30	1.02	1.02	0.03	0.48	1.02	0.70	1.59	0.03	0.10
Feed Intake (g/b/d)	151.43	147.62	154.76	2.67	0.60	157.14	155.71	140.95	2.67	0.07
Weight gain (g/b/d)	55.71	52.86	49.52	43.33	0.15	54.76	57.62	45.71	1.33	0.10

[ab] Means within rows with different superscripts are significantly different ($p<0.05$); GBM- Ginger By-product Meal

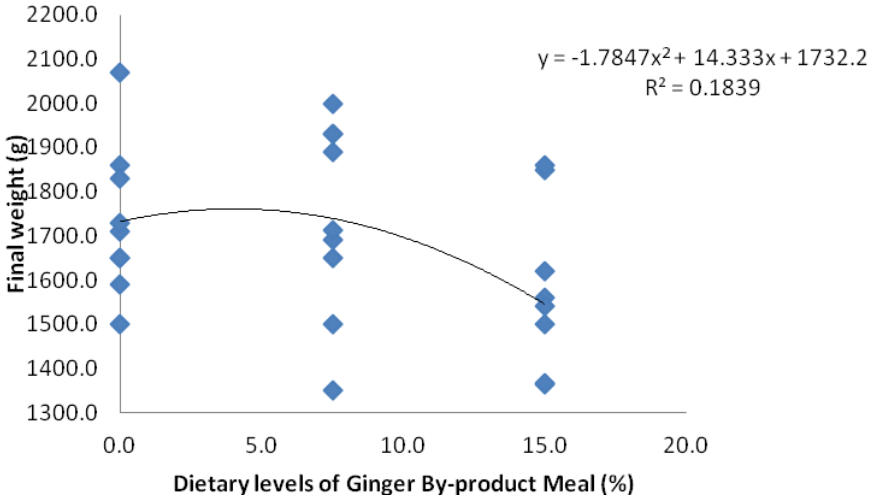


Figure 4.17: Trend line of final weight for broiler chickens fed varying levels of GBM during finisher phase

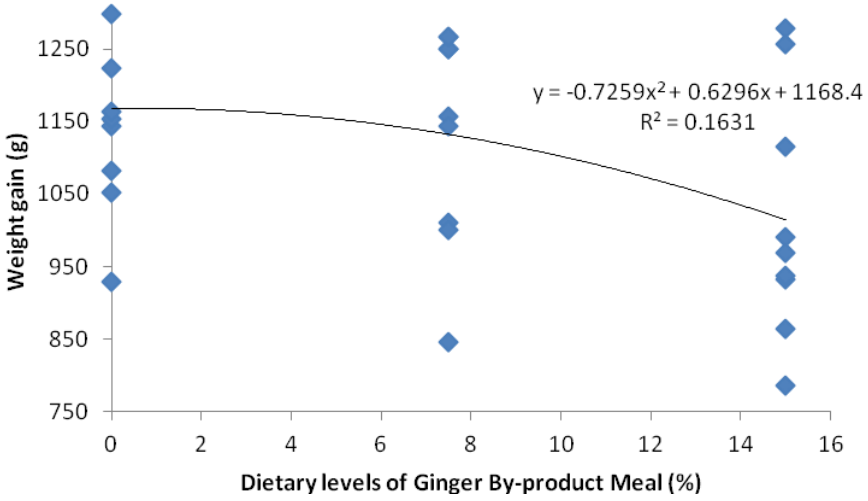


Figure 4.18: Trend line of weight gain for broiler chickens fed varying levels of GBM during finisher phase

The principal component analysis (Table 4.31) showed two PCs with significant loadings at the finisher phase that collectively explained 92.58% of the total variance. The PC 1 values increased with initial weight, feed intake, final weight and weight gain explaining 75.54%. The negative value of feed to gain ratio means that feed to gain ratio is lacking in a latent variable associated with PC 1. Only one parameter, feed to gain ratio clustered in PC 2 which accounted for 17% of the total variance. Final weight had the highest loading and Pearson Correlation statistics revealed that it correlated with all the other parameters. Therefore, final weight seems to be the principal controlling factor in the trial. This buttresses the existing logic that any management practice that increases weight gain of chickens will definitely influence other parameters.

From week 0 to 7, final weight, weight gain and efficiency of feed utilization of birds fed 0 and 7.5% GBM based diet were significantly ($p<0.05$) greater than that of birds fed 15% GBM (Table 4.32). Mortality rates were similar for all GBM levels. Feed intake, final weight and weight gain of birds fed 0 and 4% palm oil diets were significantly ($p<0.05$) greater than those of birds fed 6% palm oil diets. The efficiency of feed utilization of birds fed 4% palm oil diet was also significantly ($p<0.05$) better than those fed 6% palm oil diets. The efficiency of feed utilization of birds fed 0% palm oil diet gave statistically ($p>0.05$) similar results to those fed 4 and 6% palm oil diets. Mortality rate was significantly higher among birds fed 6% palm oil diet compared to birds fed 0 and 6% palm oil diets.

4.4.5 Effect of Dietary Levels of GBM and Palm Oil on Serum Chemistry

Ginger By-product Meal and palm oil levels had no significant ($p>0.05$) effect on the serum chemistry of finisher broiler birds (Table 4.33).

Table 4.31: Eigenvalues and Principal Component Loading for Broiler Finisher Phase

	Principal Components	
Parameters	PC1	PC2
Eigenvalue	5.29	1.19
Variance (%)	75.54	17.04
Cumulative Variance (%)	75.54	92.58
Initial Weight	***0.735***	0.267
Feed Intake	***0.885***	0.418
Final Weight	***0.991***	-0.074
Weight Gain	***0.971***	-0.205
Feed/Gain	***-0.56***	***0.826***

PC 1- principal component 1; PC2- principal component 2

Table 4.32: Effect of Dietary Levels of GBM/Palm Oil on Performance of Broiler Chickens (0-7weeks)

	GBM Level (%)					Palm Oil Level (%)				
	0	7.5	15	SEM	P	0	4	6	SEM	P
Initial Weight (g)	60.00	60.00	60.00	0.00	0.68	60.00	60.00	60.00	0.00	0.84
Feed Intake (g)	4050.00	4150.00	4090.00	95.00	0.73	4290.00[a]	4300.00[a]	3700.00[b]	95.00	0.0003
Final Weight (g)	1730.00[a]	1740.00[a]	1540.00[b]	47.00	0.01	1730.00[a]	1810.00[a]	1480.00[b]	47.00	0.0002
Weight Gain (g)	1670.00[a]	1680.00[a]	1480.00[b]	47.00	0.01	1670.00[a]	1750.00[a]	1420.00[b]	47.00	0.0002
Feed to Gain ratio	2.42[a]	2.48[a]	2.76[b]	0.05	0.0002	2.58	2.47	2.62	0.05	0.09
Feed cost/Kg gain	447.50[a]	454.45[a]	552.74[b]	9.67	0.0001	427.91[a]	459.90[a]	566.89[b]	9.67	0.0001
Mortality	3.13	2.80	2.49	0.02	0.60	2.49[a]	3.45[a]	3.79[b]	0.02	0.02
Feed Intake (g/b/d)	82.65	84.69	83.47	3.00	0.73	87.55[a]	87.76[a]	75.51[b]	3.00	0.0003
Weight Gain (g/b/d)	34.08[a]	34.29[a]	30.20[b]	1.00	0.01	34.08[a]	35.71[a]	28.98[b]	1.00	0.0002

[ab] Means within rows with different superscripts are significantly different at ($p<0.05$); GBM- Ginger By-product Meal

Table 4.33: Effect of Dietary Levels of GBM/Palm oil on Serum Chemistry of Broiler Chickens during Finisher Phase

	GBM Level (%)					Palm oil Level (%)				
	0	7.5	15	SEM	P	0	4	6	SEM	P
Cholesterol (mmol/L)	3.49	2.88	3.18	0.01	0.45	3.18	3.18	3.18	0.01	0.90
Triglyceride (mmol/L)	0.96	0.72	0.96	0.01	0.25	0.72	0.72	0.96	0.01	0.48
AST (U/L)	28.90	28.90	27.15	0.04	0.84	30.74	28.02	26.31	0.04	0.52
ALT (U/L)	9.95	8.62	11.88	0.03	0.05	8.62	10.89	11.38	0.03	0.09
ALP (U/L)	17.54	12.91	22.36	0.08	0.20	13.99	20.21	18.18	0.08	0.58

[ab] Means within rows with different superscripts are significantly different ($p<0.05$); GBM- Ginger By-product Meal

4.4.6 Effect of Dietary Levels of GBM and Palm Oil on Haematological Indices of Broiler Chickens

At finisher phase (week 8), the packed cell volume, haemoglobin concentration and white blood cell count of birds were statistically similar for all levels of GBM (Table 4.34). The haemoglobin concentration of birds fed 0% palm oil diet was statistically ($p>0.05$) similar to that of birds fed 4 and 6% palm oil diet. Haemoglobin concentration of birds fed 6% palm oil diet was significantly ($p<0.05$) greater than that of birds fed 4% palm oil diet. The total protein of the birds fed 7.5% GBM was significantly ($p<0.05$) greater than that of birds fed 7.5 and 15% GBM diets. There was also significant ($p<0.05$) increase in total protein with increase in the level of palm oil in the diet. The inclusion of GBM and palm oil had no significant ($p>0.05$) effect on the white blood cell count.

4.4.7 Effect of Dietary Levels of GBM and Palm Oil on Carcass and Organ Characteristics

The result showed that GBM had no significant ($p>0.05$) effect on the weight of the wing, back, thigh, liver, kidney, intestine, gizzard and spleen of the birds (Table 4.35). The dressing percent of birds fed 0% GBM diet was significantly ($p<0.05$) greater than that of birds fed 7.5 and 15% GBM diets. The weights of the breast of birds fed 7.5% GBM were statistically ($p>0.05$) similar to those fed 15% GBM diet but significantly ($p<0.05$) greater than that of birds fed 0% GBM diet. There was no significant difference in the weight of the breast of birds fed 0 and 15% GBM diets. The intestinal length of birds fed 15% GBM was significantly ($p<0.05$) greater than that of birds fed 0 and 7.5% GBM diets. The abdominal fat pad of birds decreased ($p<0.05$) significantly with inclusion of GBM but was statistically ($p>0.05$) similar for birds fed 7.5 and 15% GBM diets.

Table 4.34: Effect of Dietary Levels of GBM/Palm Oil on Haematological Indices of Broiler Chickens during Finisher Phase

	GBM Level (%)					Palm oil Level (%)				
	0	7.5	15	SEM	P	0	4	6	SEM	P
Packed cell volume (%)	34.67	33.94	34.00	1.35	0.84	33.22^{b}	33.06^{b}	36.33^{a}	1.35	0.03
Haemoglobin (g/dl)	11.54	11.28	11.30	0.46	0.82	11.02^{ab}	10.98^{b}	12.12^{a}	0.46	0.03
Total protein (g/dl)	3.46^{b}	4.83^{a}	3.68^{b}	0.28	0.0001	2.38^{c}	4.22^{b}	5.37^{a}	0.28	0.0001
White blood cell (10^{9}/L)	4.28	4.49	5.02	0.43	0.22	4.76	4.63	4.40	0.43	0.71

^{ab} Means within rows with different superscripts are significantly different ($p<0.05$); GBM- Ginger By-product Meal

Table 4.35: Effect of Dietary Levels of GBM/Palm Oil on Carcass and Organ Characteristics of Broiler Chickens

	GBM Level (%)					Palm Oil Level (%)				
	0	7.5	15	SEM	P	0	4	6	SEM	P
Dressing percent	78.92[a]	77.10[b]	75.11[b]	0.01	0.01	79.13	79.13	73.18	0.01	0.13
Wings (%)	12.39	13.44	12.91	0.01	0.16	13.44	12.39	13.44	0.01	0.29
Breast (%)	19.51[b]	23.11[a]	21.62[ab]	0.02	0.01	23.88[a]	21.38[b]	18.62[c]	0.02	0.01
Back (%)	18.18	20.90	19.50	0.02	0.09	20.90	19.51	18.84	0.02	0.058
Thigh (%)	31.62	32.36	33.11	0.02	0.68	32.66	31.69	33.65	0.02	0.50
Intestinal length (%)	14.12[b]	15.25[b]	17.11[a]	0.01	0.006	14.12[b]	15.49[a]	16.22[a]	0.02	0.009
Liver (%)	2.88	2.88	2.59	0.004	0.09	2.88	2.88	3.18	0.004	0.11
Kidney (%)	0.72	0.72	0.72	0.002	0.17	0.72	0.72	0.72	0.002	0.42
Intestinal Weight (%)	4.45	4.45	4.79	0.01	0.31	4.45	4.79	4.79	0.01	0.36
Gizzard (%)	2.59	2.30	2.59	0.01	0.30	2.30	2.59	2.59	0.01	0.33
Spleen (%)	0.23	0.23	0.23	0.0001	0.15	0.23	0.23	0.23	0.0001	0.42
Abdominal Fat (%)	2.88[a]	2.02[b]	1.75[b]	0.01	0.02	1.48[b]	2.30[a]	2.59[a]	0.01	0.003

[ab] Means within rows with different superscripts are significantly different ($p<0.05$); GBM- Ginger By-product Meal

The dressing percent of all the birds were similar for all levels of palm oil inclusion. The weight of the wings, back, thigh, liver, kidney, intestinal weight, gizzard and spleen were statistically ($p>0.05$) similar for all levels of palm oil. The weight of the breast of birds fed 0% palm oil diet was significantly ($p<0.05$) greater than that of birds fed 4 and 6% palm oil diets. The intestinal length of birds fed 4 and 6% palm oil were statistically ($p>0.05$) similar but significantly ($p<0.05$) greater than birds fed 0% palm oil diet. Abdominal fat pad of birds fed 4 and 6% palm oil were similar and significantly ($p<0.05$) greater than that of birds fed 0% palm oil diet.

4.4.8 Effect of Dietary Levels of GBM and Palm oil on Histology of Organs of Broiler Chickens

The summary of the histopathology result is presented on Table 4.36. Microscopic investigation showed that birds fed 0, 7.5 and 15% GBM diets with or without palm oil supplementation (Plates 9, 10, 11a and b) had normal liver structures. There was cellular infiltration in the liver of birds fed 15% GBM diet supplemented with 6% palm oil. The kidney of birds fed 0, 7.5 and 15% GBM diets without palm oil supplementation; 0% GBM diet with 4% palm oil supplementation and 0, 7.5 and 15% GBM diets with 6% palm oil supplementation (Plates 12, 13a and 14) were normal. The intercellular space of the kidneys of birds fed 15 and 30% GBM diets supplemented with 4% palm oil (Plates 13b and 13c) were congested. The spleen of birds fed 0 and 15% GBM diets without palm oil supplementation; 7.5 and 15% GBM diet with 4% palm oil supplementation and 7.5% GBM diet with 6% palm oil supplementation (Plates 15a, c, 16b,c and 17b) were normal. Birds fed 7.5% GBM diet without palm oil; 0% GBM diet with 4% palm oil supplementation and 7.5 and 15% GBM diets with 6% palm oil supplementation (Plates 15b, 16a, 17b and 17c) had accumulation of hemosiderin

.

Table 4.36: Summary of Effect of Dietary Levels of GBM and Palm Oil on Histology of Organs of Broiler Chickens

	GBM Level (%)								
	0			7.5			15		
	Palm Oil Level (%)								
	0	4	6	0	4	6	0	4	6
Week 4									
Liver	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	CI
Kidney	Normal	Normal	Normal	Normal	Congested	Normal	Normal	Congested	Normal
Spleen	Normal	Hemosiderin	Normal	Hemosiderin	Normal	Hemosiderin	Normal	Normal	Hemosiderin
Intestinal villi	MS	MS	SS	SS	MS	SS	SS	MS	MS

MS- mild sloughing; SS- severe sloughing; CI- cellular infiltration

Plate 18 shows the photomicrograph of intestinal villi of broiler chickens with varying degree of sloughing which reduced with the inclusion of palm oil (Plates 19 and 20). The intestines of the birds fed 0% GBM diet were relatively intact but the intestines of birds fed 7.5 and 15% GBM diets were sloughed. With the addition of 4% palm oil, the intestines of the birds fed GBM diets were sloughed but the sloughing was less than that observed in birds fed 0% palm oil diet. With the addition of 6% palm oil, sloughing of the intestine was minimal.

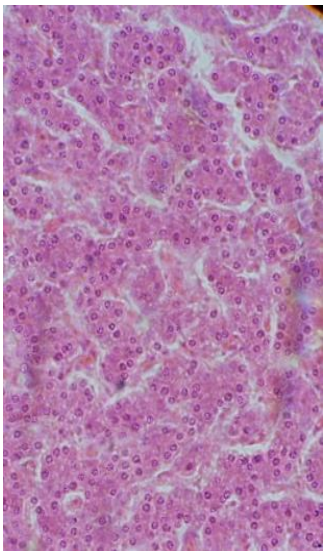


Plate 9a. Photomicrograph of a normal section of liver of a broiler chicken fed 0% GBM and 0% palm oil (H and E stained, x400)

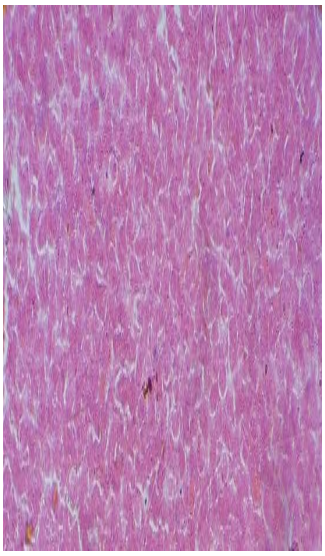


Plate 9b. Photomicrograph of a normal section of liver of a broiler chicken fed 7.5% GBM and 0% palm oil (H and E stained, x400)

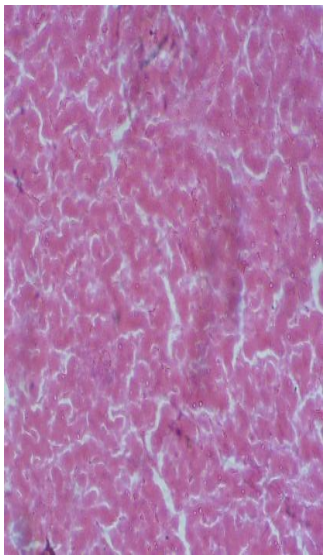


Plate 9c. Photomicrograph of a normal section of liver of a broiler chicken fed 15% GBM and 0% palm oil (H and E stained, x400)

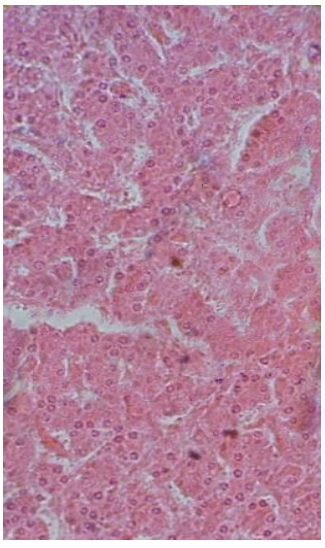


Plate 10a. Photomicrograph of a normal section of liver of a broiler chicken fed 0% GBM and 4% palm oil (H and E stained, x400)

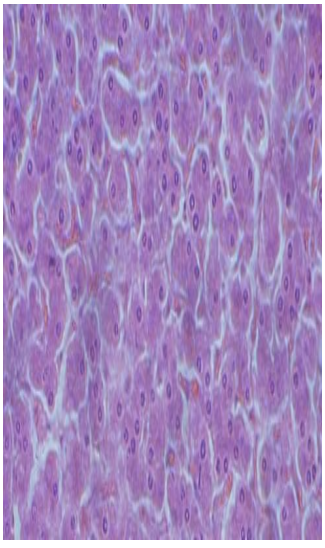


Plate 10b. Photomicrograph of a normal section of liver of a broiler chicken fed 7.5% GBM and 4% palm oil (H and E stained, x400)

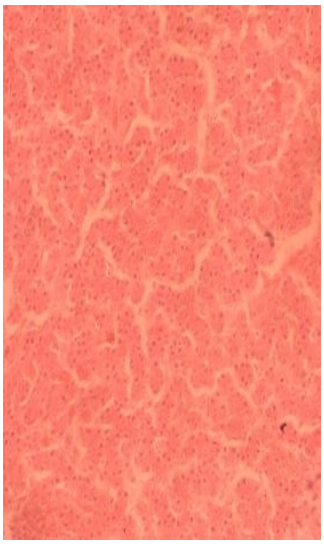


Plate 10c. Photomicrograph of a normal section of liver of a broiler chicken fed 15% GBM and 4% palm oil (H and E stained, x400)

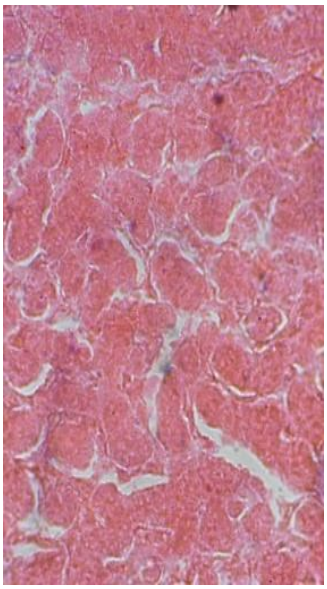


Plate 11a. Photomicrograph of a section of liver of a broiler chicken fed 0% GBM and 6% palm oil (H and E stained, x400)

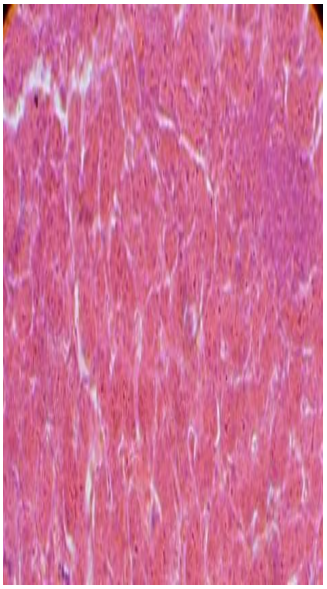


Plate 11b. Photomicrograph of a normal section of liver of a broiler chicken fed 7.5% GBM and 6% palm oil (H and E stained, x400)

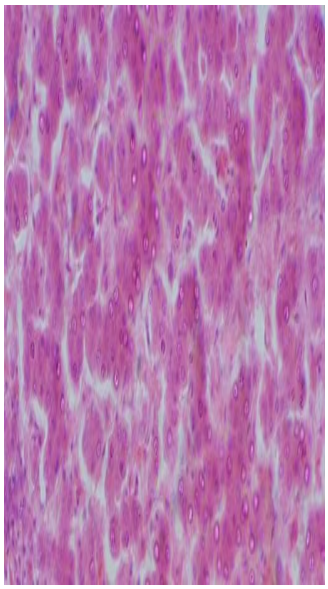


Plate 11c. Photomicrograph of a normal section of liver of a broiler chicken fed 15% GBM and 6% palm oil showing cellular infiltration (H and E stained, x400)

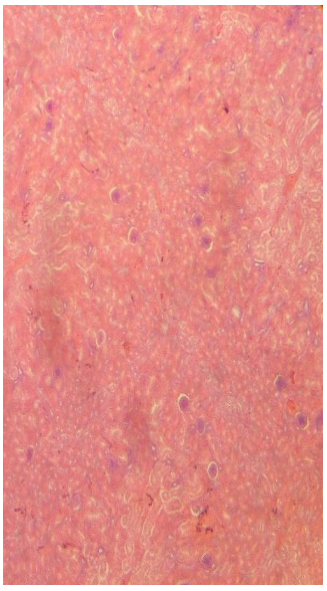


Plate 12a. Photomicrograph of a section of normal kidney of a broiler chicken fed 0% GBM and 0% palm oil (H and E stained, x400)

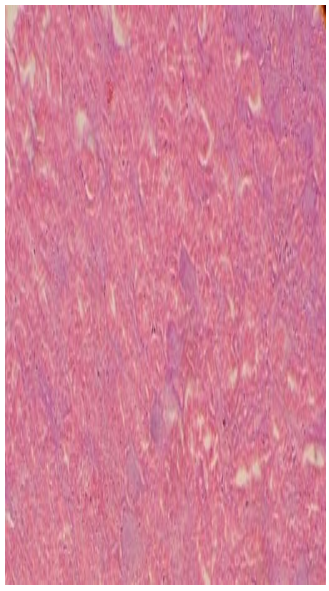


Plate 12b. Photomicrograph of a section of normal kidney of a broiler chicken fed 7.5% GBM and 0% palm oil (H and E stained, x400)

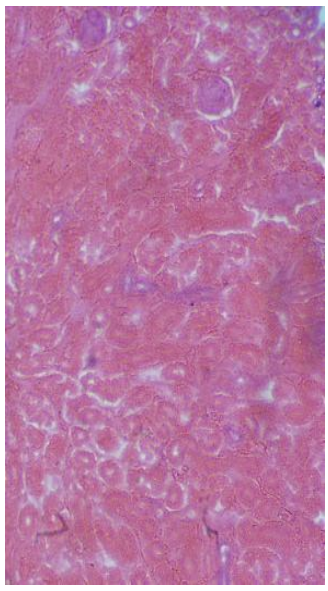


Plate 12c. Photomicrograph of a section of normal kidney of a broiler chicken fed 15% GBM and 0% palm oil (H and E stained, x400)

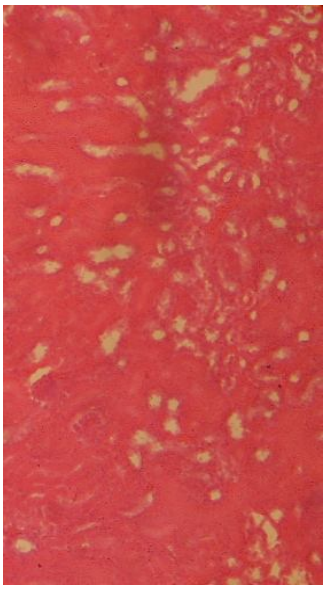


Plate 13a. Photomicrograph of a normal section of the kidney of a broiler chicken fed 0% GBM and 4% palm oil diet (H and E stained, x400)

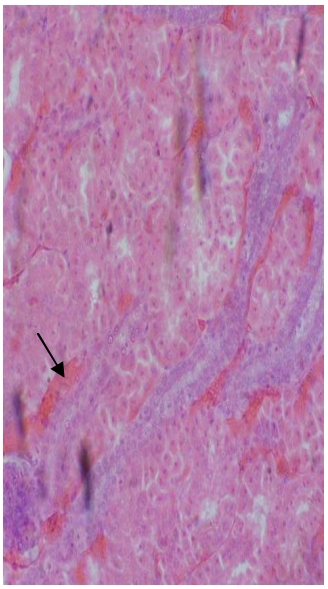


Plate 13b. Photomicrograph of a section of the kidney of a broiler chicken fed 7.5% GBM and 4% palm oil diet showing congestion (H and E stained, x400)

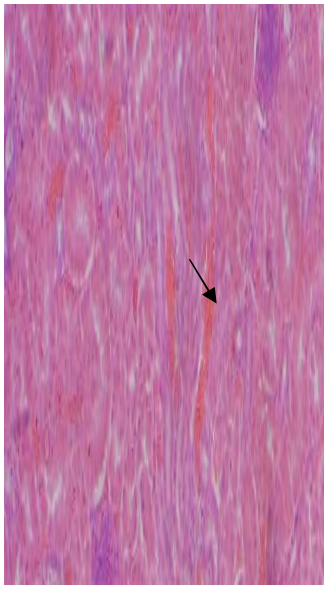


Plate 13c. Photomicrograph of a section of the kidney of a broiler chicken fed 15% GBM and 4% palm oil diet showing congestion (H and E stained, x400)

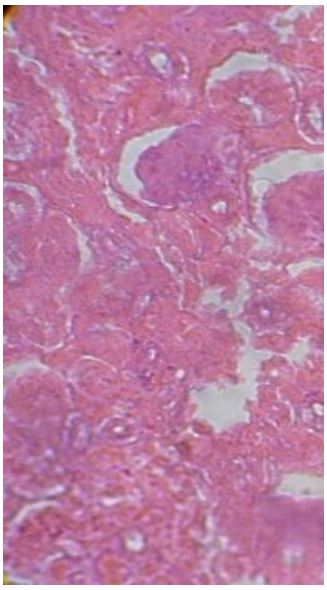


Plate 14a. Photomicrograph of a section of normal kidney of a broiler chicken fed 0% GBM and 6% palm oil diet (H and E stained, x400)

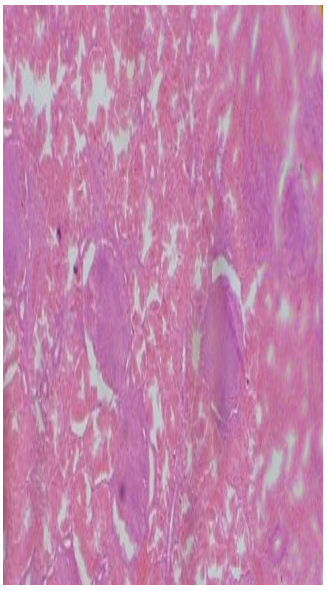


Plate 14b. Photomicrograph of a section of normal kidney of a broiler chicken fed 7.5% GBM and 6% palm oil diet (H and E stained, x400)

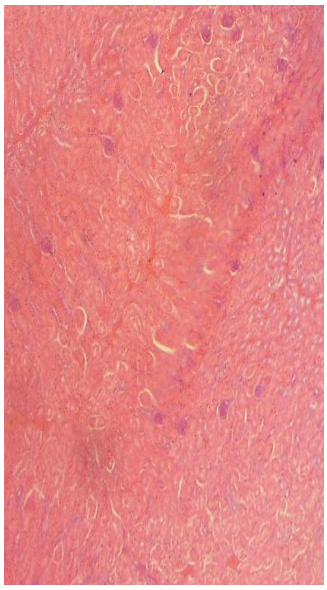


Plate 14c. Photomicrograph of a section of normal kidney of a broiler chicken fed 15% GBM and 6% palm oil diet (H and E stained, x400)



Plate 15a. Photomicrograph of a section of normal spleen of a broiler chicken fed 0% GBM and 0% palm oil diet (H and E, x400)

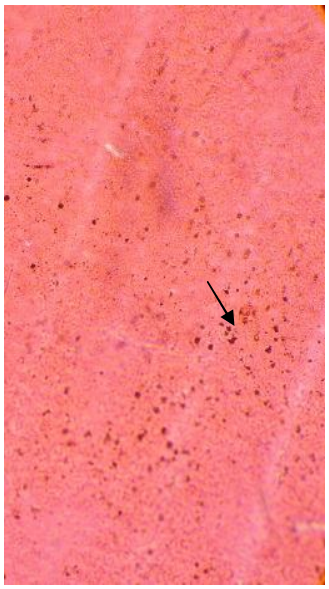


Plate 15b. Photomicrograph of a section of spleen of a broiler chicken fed 7.5% GBM and 0% palm oil diet showing haemo-siderosis (H and E stained, x400)

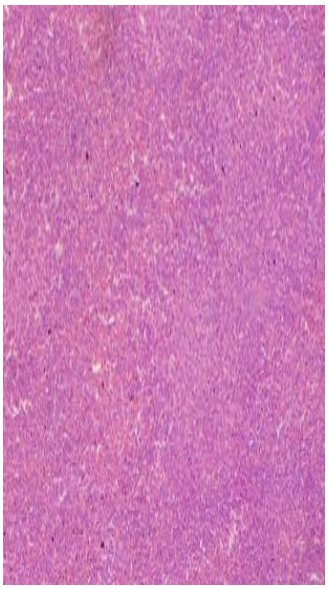


Plate 15c. Photomicrograph of a section of normal spleen of a broiler chicken fed 15% GBM and 0% palm oil diet (H and E stained, x400)

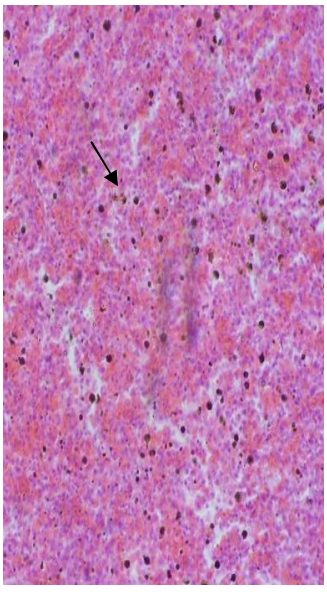


Plate 16a. Photomicrograph of a section of spleen of a broiler chicken fed 0% GBM and 4% palm oil showing haemo-siderosis (H and E stained, x400)

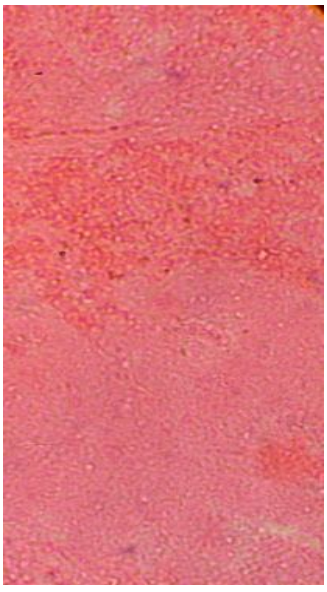


Plate 16b. Photomicrograph of a section of normal spleen of a broiler chicken fed 7.5% GBM and 4% palm oil (H and E stained, x400)

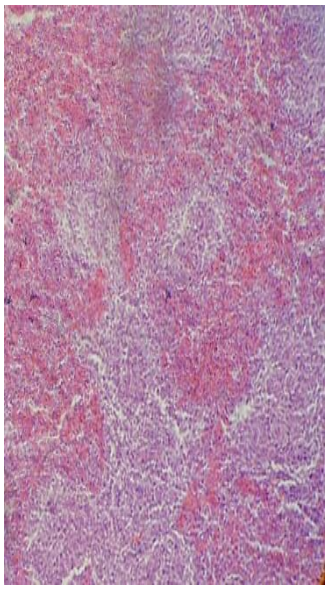


Plate 16c. Photomicrograph of a section of normal spleen of a broiler chicken fed 15% GBM and 4% palm oil (H and E stained, x400)



Plate 17a. Photomicrograph of a section of normal spleen of a broiler chicken fed 0% GBM and 6% palm oil (H and E stained, x400)

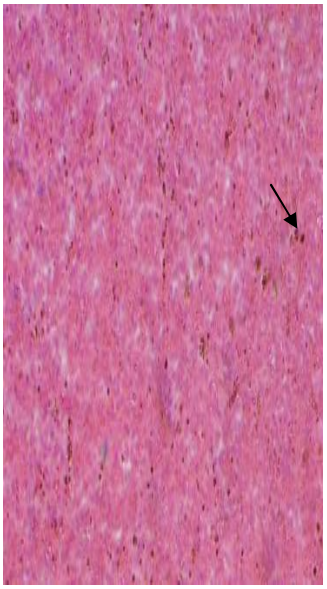


Plate 17b. Photomicrograph of a section of spleen of a broiler chicken fed 7.5% GBM and 6% palm oil showing hemosiderosis (H and E stained, x400)

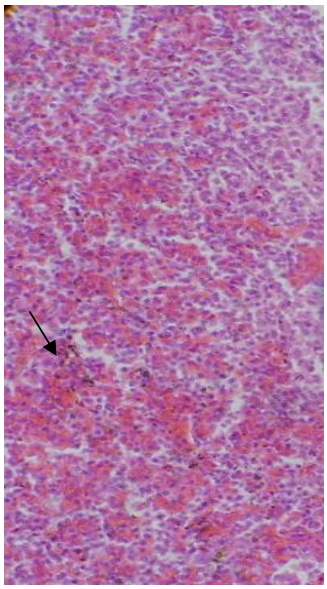


Plate 17c. Photomicrograph of a section of spleen of a broiler chicken fed 15% GBM and 6% palm oil showing hemosiderosis (H and E stained, x400)

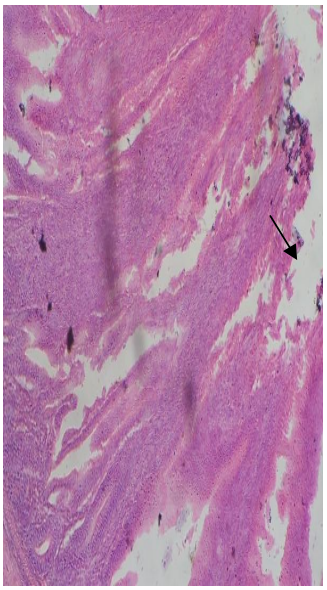


Plate l8a. Photomicrograph of a section of the intestine of a broiler chicken fed 0% GBM and 0% palm oil showing mild sloughing (H and E stained, x400)

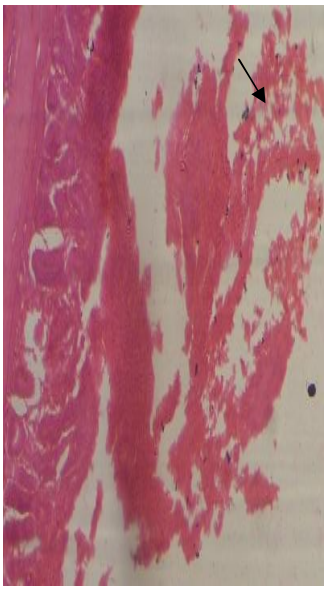


Plate l8b. Photomicrograph of a section of the intestine of a broiler chicken fed 7.5% GBM and 0% palm oil showing sloughing of the intestine (H and E stained, x400)

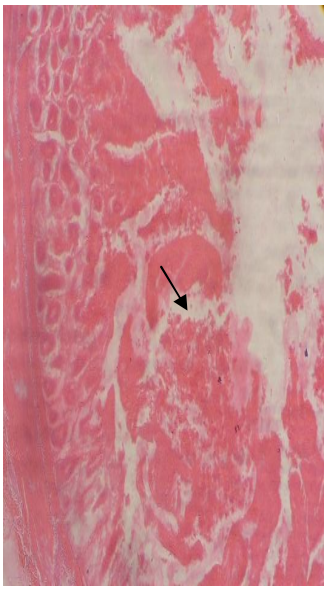


Plate I8c. Photomicrograph of a section of the intestine of a broiler chicken fed 15% GBM and 0% palm oil showing sloughing (H and E stained, x400)

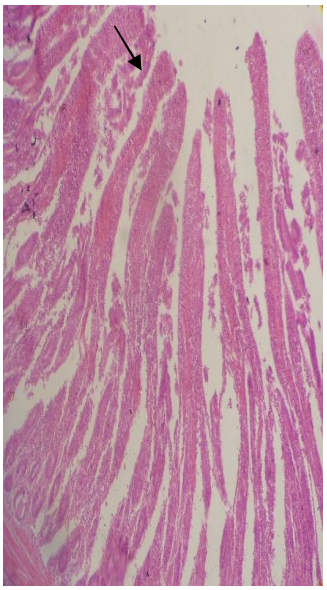


Plate 19a. Photomicrograph of a section of the intestine of a broiler chicken fed 0% GBM and 4% palm oil showing little sloughing of the intestine (H and E stained, x400)

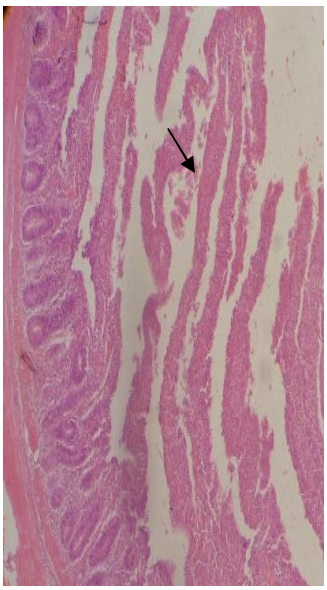


Plate 19b. Photomicrograph of a section of the intestine of a broiler chicken fed 7.5% GBM and 4% palm oil showing little sloughing of the intestine (H and E stained, x400)

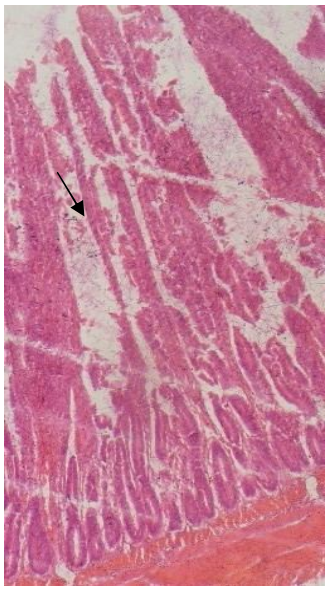


Plate 19c. Photomicrograph of a section of the intestine of a broiler chicken fed 15% GBM and 4% palm oil showing little sloughing of the intestine (H and E stained, x400)

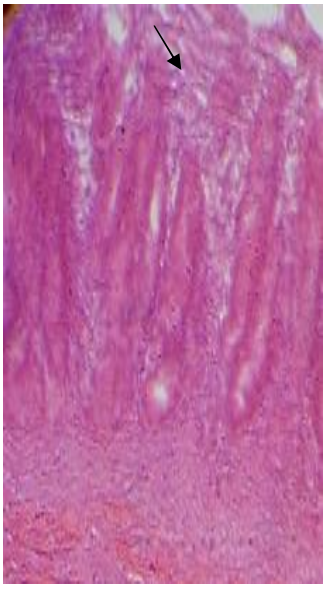


Plate 20a. Photomicrograph of a section of the intestine of a broiler chicken fed 0% GBM and 6% palm oil showing sloughing of the intestine (H and E stained, x400)

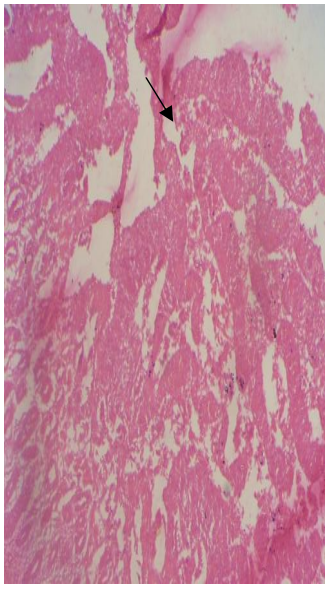


Plate 20b. Photomicrograph of a section of the intestine of a broiler chicken fed 7.5% GBM and 6% palm oil showing sloughing of the intestine (H and E stained, x400)

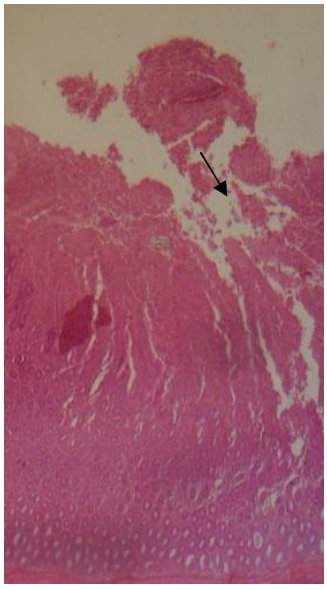


Plate 20c. Photomicrograph of a section of the intestine of a broiler chicken fed 15% GBM and 6% palm oil showing sloughing of the intestine (H and E stained, x400)

CHAPTER FIVE

5.0 DISCUSSION

5.1 PROXIMATE COMPOSITION OF GINGER BY-PRODUCT MEAL

The proximate composition indicated low crude protein content (3.75%) although higher than the value (1.99) reported by (Onimisi 2004), this could be due to differences in crop and soil management practices. The nitrogen free extract (81.45%) was high and similar to the report by (Onimisi 2004).

5.2 Experiment 1: EFFECT OF ENZYME AND NON-ENZYME SUPPLEMENTATION ON THE UTILIZATION OF GBM IN BROILER CHICKEN DIETS

5.2.1 Performance of Broiler Chickens

The significant ($p<0.05$) decrease in feed consumption of the GBM based diets could probably be due to the bulky nature of the diet. Bulkiness in feed can be a major limitation to feed intake thereby impairing intake of sufficient digestible nutrients by birds (Stanley and Ishizaki, 1982). Furthermore, the mixed composition of zingerone, shogaols and gingerols which dictates pungency in ginger could adversely affect feed intake (Nidaullah *et al*., 2010), as smell and taste are critical traits in food selection by animals (Onu, 2010). The significant ($p<0.05$) decrease observed in weight gain and final weight with increase in the level of GBM for all dietary treatments is contrary to the report of Onimisi (2004) who observed non-significant increase in these parameters with increase in inclusion level of GBM from 0 to 20% but agrees with his finding for inclusion of GBM at 30% where there was a significant decrease in weight gain and final weight. Post mortem result showed that the mortality reported was not due to the experimental diets.

The decrease in final weight and weight gain of birds fed enzyme supplemented diets at starter phase agrees with the report of Selle *et al*. (2010) who observed a depression in weight due to reduction in feed intake by 4.8% when enzyme supplemented wheat based diets were

fed. The observed decrease in performance could be due to the non-specificity of Maxigrain© enzyme for GBM. Other enzyme based experiments revealed no significant effect of enzyme supplementation on sun flower meal (SFM) based diets for broilers (Mushtaq *et al*., 2006 and Aftab, 2009). It was reported that the variation in result might be due to differences in enzyme preparation and the feed ingredients used in the studies.

Studies carried out by Abbas *et al*. (1998) and Naqvi (1996) observed no significant difference in feed consumption and feed to gain ratio among diets with or without supplementation of enzymes. Abbas *et al*. (1998) used a commercial enzyme with undetermined activity. The enzyme preparation could have lost its potency to degrade fibre or had very low activity. In contrast, Marquardt *et al*. (1994) showed that enzyme supplementation resulted in increased feed consumption. One possible explanation for these differences may be the quality of the SFM used in the experimental diets (Raza *et al*., 2009). The result also varies from the findings of Oladunjoye and Ojebiyi (2010) that reported an improvement in weight gain and feed efficiency with the inclusion of enzyme.

5.2.2 Effect of Dietary Levels of GBM and Enzyme on Haematological Profile

The values obtained for PCV (32.25-34.50) and hb (10.73-11.45) were statistically similar and agree with values obtained by Patra *et al*. (2010) for packed cell volume (22-35%) and haemoglobin (7-13 g/dl), which is within the normal range for chickens; an indication that the diets did not have any detrimental effect on the birds. The total protein values (2.33- 2.75g/dl) are lower than the normal range (4.02 – 8.36 g/dl) reported by (Mitruka and Rawnsley, 1977). Al-Homidan (2005) also observed a reduction in plasma total protein of broiler chicks fed a diet supplemented with 60 g/kg ginger and reported that the reduction might have been due to the toxicity of ginger. The decrease in total protein observed in this study might be attributed

to difference in feed ingredients and not toxicity since the weights and histology of the liver were normal.

5.2.3 Effect of Dietary Levels of GBM and Enzyme on Serum Chemistry

The cholesterol level (5.90 mmol/L) of birds fed 0% GBM diet was higher than the normal range (3.23- 5.17 mmol/L) reported by Patra *et al*. (2010) but the values (3.14 – 4.99 mmol/L) in birds' fed 15 and 30% GBM diets were within the normal range. The lowered plasma cholesterol level obtained in this work agrees with the report of Omage *et al*. (2007) who reported that GBM caused reduction in the level of plasma cholesterol. Saeid *et al.* (2010) also reported that ginger extract caused reduction in plasma levels of cholesterol and triglyceride in broilers. Srinivasan and Sambaiah (1991) reported that feeding rats with ginger significantly elevated the activity of hepatic cholesterol 7-alpha-hydroxylase, a rate limiting enzyme in the biosynthesis of bile acids and stimulated the conversion of cholesterol to bile acids leading to the excretion of cholesterol from the body. The decrease in the level of cholesterol as explained by Tanabe *et al*. (1993) may also be due to interference in biosynthesis of cholesterol in liver homogenates by (E)-8 beta, 17-epoxyllabed-12-ene-15, 16-dial isolated from ginger.

5.2.4 Performance of Broiler Chickens (Finisher Phase)

The reduction in final weight, weight gain and efficiency of feed utilization with increase in the level of GBM, agrees with a similar study by Ademola *et al*. (2009) who reported significant decrease in weight gain when 2% ginger was included in broiler diet and attributed the weight loss to the hypolipidemic effect of ginger on abdominal fat. Onimisi (2004) also reported significant decrease in efficiency of feed utilization beyond 10% inclusion of GBM.

Birds fed 0% GBM diets had significantly ($p<0.05$) better performance than those fed 15 and 30% GBM diets in terms of final weight, weight gain and efficiency of feed utilization. There

was no significant difference ($p>0.05$) in feed intake across treatments. The birds' fed 15% and 30% GBM had similar performance. Feed cost/kg gain increased with increase in the GBM level in the diets. Considering the economy of production, chickens fed 0% GBM with or without enzyme supplementation had significantly higher financial return. Post mortem result showed that the mortality reported was not due to the experimental diets.

5.2.5 Effect of Dietary Levels of GBM and Enzyme on Haematological Parameters

The packed cell volume and haemoglobin values were within the normal range for chickens (22-35%) and (7-13g/dl) respectively reported by (Patra *et al*. 2010). The observed decrease in haemoglobin values supports the findings of Azeez *et al*. (2011) who observed a decrease in haemoglobin and white blood cell values with ageing in turkeys. The total protein values increased at finisher phase but are lower than values reported by Dempsey (1999). The higher total protein values observed at week 8 agrees with reports that the blood picture changes with the advancement of age in animals (Sturkie and Textor, 1960; Khan and Zafar, 2005). On the contrary, Mmereole (2009) reported an increase in packed cell volume, haemoglobin and white blood cells as broiler chickens got older and concluded that in order to utilize blood profile as a base reference for diagnosis, selection, overall production management purposes, age and breeds must be taken into consideration.

5.2.6 Effect of Dietary Levels of GBM and Enzyme on Serum Chemistry

The significant ($p<0.05$) increase in the level of ALP with the inclusion of enzyme did not cause damage to the hepatocytes of the liver the values were within the normal range (Clinical Diagnostic Division, 1990). This is indicated by the similar size of the liver and the normal histology but the enzyme might have affected the integrity of the membrane. Ajith *et al*. (2007) reported that the presence of polyphenols and flavonoids in ginger extract might be responsible for the antioxidant nephroprotective activities. This result disagrees with Salli *et*

al. (1991) who reported that a rise in bile duct ALP indicates damage of the liver and death of hepatocytes.

5.2.7 Effect of Dietary Levels of GBM and Enzyme on Carcass and Organ Characteristics

The weights of the liver and kidney were similar for all the birds suggesting that GBM and enzyme had no toxic effect on the birds and the microscopic investigation of the organs showed normal histology for most birds. Bone (1979) reported that abnormalities in the weights of the internal organs such as liver and kidney arise because of increased metabolic rate of the organs in an attempt to reduce toxic elements or anti-nutritional factors to non-toxic metabolites. Birds fed 0% GBM diets with and without enzyme supplementation had widened liver sinusoidal spaces but there is no clear cut explanation as this observation was peculiar to this group of birds. The increase in the weight of the gizzard could be attributed to increased activity of the gizzard with increase in the level of fibre which agrees with the report of Olorede and Longe (2000) who observed significant ($p<0.05$) increase in the size of the gizzard with increase in dietary fibre.

The increase in length and weight of the intestine was due to increase in dietary fibre with increase in the level of inclusion of GBM. This result agrees with the finding of Pond *et al*. (1981) who reported that the relative weight (percentage of body weight) of the intestine increased with high level of fibre in the diet. Savoury and Gentle (1976) also reported that changes in the gut size could be due to additional bulk and greater volume of digesta staying in the gastrointestinal tract during enzymatic digestion. Stagniogias and Pearce (1985) reported that the increase in the length of the gastrointestinal tract (GIT) is an indication of the hypertrophic response of the GIT to high fibre diet. There was also a decrease in the

abdominal fat with the inclusion of GBM; an indication that GBM reduced the fat content of the carcass.

The effect of enzyme on the breast and intestine may be attributed to the enzyme not improving the digestion of the fibre in GBM. The observed increase in intestinal length agrees with the report of Zarghi and Golian (2009) who observed an increase in the length of the large intestine with the inclusion of enzyme. This finding disagrees with Khan *et al*. (2006) who observed a decrease in the length of the GIT with the inclusion of enzyme, suggesting that the enzyme did not break down much of the fibre in the GBM in this study. This could be attributed to the non specificity of the enzyme for the GBM.

5.2.8 Effect of Dietary Levels of GBM and Enzyme on Histology of Organs

The liver of chickens fed 0, 15 and 30% GBM without enzyme supplementation and birds fed 15 and 30% GBM with enzyme supplementation were normal in structure and size, an indication that the feed had no toxic effect on the organs. Ginger has been reported to have nephroprotective antioxidant effect. The widening of the liver sinusoidal spaces observed in birds fed 0% GBM diet with supplementation of 0.01% enzyme could be due to chance since this was not observed in other birds. The histology and weights of the kidneys were normal, suggesting that the feed did not affect the functioning of the kidney. It has been reported that essential oils originating from plants have antimicrobial activity which have toxic effects in poultry when administered at very high doses (Lee *et al*., 2004). Toxins may destroy some organs immediately (intra- cellular) or later (extracellular) affecting either biochemical functions or structure of organs depending on the dosage and therapy. The normalcy of the organs indicates that the levels fed were not too high. Microscopic investigation shows that the spleen of chickens fed 0 and 15% GBM diets without enzyme supplementation and 0%

GBM diet with enzyme supplementation were normal. Hemosiderin particles was observed in the spleen of some birds. Sheppard and Dierenfeld (2002) reported that the deposition of iron, in the form of hemosiderin, is normal in the liver, spleen, marrow and reticulocytes and iron load never reaches levels that cause health problems. The similarity in the weights of the spleen also suggests that the presence of hemosiderin particles did not cause health problems.

The sloughing of the intestinal villi of the broiler chickens in Plates seven and eight is an indication of reduced absorptive surface and limited utilization of digested feed (Ganong, 2005). Bennett (2002) reported that emptying of the gut stops blood flow to the intestinal lining since feed is not being absorbed and the villi start sloughing off, therefore the withdrawal of feed for about 14 hours before slaughtering could possibly account partially for the sloughing observed. Kanduri *et al*. (2009) reported that feeding of ginger and garlic increases height of villus of small intestine and activates the absorption process but the result of this study showed intestinal sloughing. This could be attributed to the high level of GBM utilized in the study. Duru (2010) reported erosion of the intestinal villi when 10 g of enzyme was added to the control diet. The sloughing was attributed to low concentration of fibre in the diet but this does not corroborate the finding of this research since sloughing was observed in all the diets. The sloughing could be attributed to the enzyme acting negatively on the intestinal villi.

5.3 EXPERIMENT TWO: EFFECT OF PALM OIL SUPPLEMENTATION ON THE UTILIZATION OF GBM IN BROILER CHICKEN DIETS

5.3.1 Performance of Broiler Birds (Starter Phase)

Feed intake decreased at a rate of 7% from 0 to 7.5% GBM but increased at a rate of 26 % from 7.5 to 15 % GBM. This agrees with the report of Onimisi (2004) who reported significant ($p<0.05$) increase in feed intake with the inclusion of GBM up to 30%. Stanley and Ishizaki (1982) reported bulkiness in feed as a limitation to feed intake by birds thus imposing a limitation on the intake of digestible nutrients. The observed decrease in feed intake for birds fed 7.5% GBM diet was due to disease outbreak. Post mortem result showed that the mortality reported was not due to the experimental diets.

The inclusion of palm oil in the diet improved final weight, weight gain and efficiency of feed utilization of the birds. The observed result confirms the report of Nwoche *et al*. (2006) who reported a significant increase in final weight, weight gain and feed to gain ratio when 4% palm oil was included in broiler starter ration. There was non-significant difference in feed intake for birds fed 0, 2 and 4% palm oil diets. Panja (1996) also reported improvement in daily weight gain and efficiency of feed utilization with the addition of palm oil in feed. Post mortem result showed that the mortality reported was not due to the experimental diets.

5.3.2 Performance of Broiler Chickens (Finisher Phase)

Feed to gain ratio significantly ($p<0.05$) increased with the inclusion of GBM, an indication that the 0% GBM diet was better utilized by the birds and thus gained more weight. Feed cost per kilogram weight gain also significantly ($p<0.05$) increased with the inclusion of GBM because of the poor efficiency in feed utilization. Feed cost per kilogram weight gain also

significantly ($p<0.05$) increased with the inclusion of palm oil because of the additional cost of purchasing palm oil.

5.3.3 Effect of Dietary Levels of GBM and Palm oil on Haematological Parameters

The non-significant differences observed in haematological parameters except WBC at early finisher phase (week five) agrees with the findings of Onu (2010) who reported that the supplementation of diets with ginger had no significant effect on haematology of broilers. The WBC of birds fed 7.5% GBM diet was high probably because the birds suffered from Gumboro and the WBC count increased in a bid to fight the infection. Guyton (1991) reported that a few hours after infection, inflammation products cause faster migration of heterophils from the bone marrow to the damaged tissues or site of inflammation.

The decrease in WBC with the inclusion of palm oil could be attributed to improved absorption of fat soluble vitamins and other nutrients (Baiao and Lara 2005) which probably increased the resistance of the birds against diseases. Rama Rao *et al*. (2011) also reported that high concentrations of dietary α-tocopherol (50 or 100 mg/kg) reduced lipid peroxidation activity, enhanced activities of anti-oxidative enzymes and also improved the cell-mediated immune responses in commercial broilers. Ochang *et al*. (2007) also observed a decrease in blood parameters with increase in level of palm oil inclusion.

5.3.4 Effect of Dietary Levels of GBM and Palm Oil on Serum Chemistry

The decrease in plasma triglyceride level with increase in GBM agrees with the findings of Saeid *et al*. (2010) who observed significant ($p<0.05$) decrease in triglyceride when aqueous extract of ginger was administered to broilers. This decrease in the level of plasma triglyceride after treatment with ginger extract may be due to ginger extract acting on insulin which returns lipoprotein lipase levels to normal bringing about a reduction in triglyceride

levels in plasma (Saeid *et al*., 2010). The significant difference in ALT and AST observed in this study disagrees with the findings of Onu (2010) who reported that the supplementation of diets with ginger had no significant effect on serum chemistry of broilers but agrees with the report of Alnaqeeb *et al*. (2003) who reported that the aqueous extract of ginger significantly decreased AST and significantly increased ALT for rats fed 500 mg/ Kg ginger compared to the group fed 50 mg/ Kg.

5.3.5 Effect of Dietary Levels of GBM/ Palm Oil on Carcass and Organ Characteristics

The observed decrease in fat content agrees with the findings of Ademola *et al*. (2009) who reported that ginger had a hypolipidemic effect on abdominal fat of broilers. The observed increase in abdominal fat with the inclusion of 4% palm oil agrees with the report of Panja (1996) who reported an increase in carcass fat with the inclusion of palm oil which is as a result of absorption, de novo synthesis and β-oxidation of fatty acids (Smink *et al*., 2010). The inclusion of palm oil in 15% GBM diet resulted in a decrease in abdominal fat, suggesting that this level of GBM had hypolipidemic effect despite the inclusion of palm oil, GBM probably interfered with the absorption, synthesis and β-oxidation of fatty acids.

5.4 EXPERIMENT THREE: EFFECT OF GRADED LEVELS OF PALM OIL ON THE UTILIZATION OF GBM IN BROILER CHICKEN DIETS

5.4.1 Performance of Broiler Chickens (Starter Phase)

The observed decrease in final weight, weight gain and efficiency of feed utilization with inclusion of 15% GBM in the diet could be attributed to increase in fibre content of the feed which reduces nutrient concentration per unit volume of feed (Fadugba, 1989). Post mortem result showed that the mortality reported was not due to the experimental diets.

The non-significant ($p>0.05$) difference in feed intake observed with the inclusion of palm oil agrees with the report of Nwoche *et al*. (2003) who observed non-significant ($p>0.05$) difference in feed intake for birds fed 0 and 4% palm oil diets. The non-significant decrease in feed intake when birds were fed 6% palm oil diet can be attributed to increase in the calorie density of the feed since birds eat to satisfy their energy requirement. The non-significant ($p>0.05$) increase in final weight, weight gain and feed to gain ratio with the inclusion of 4% palm oil agrees with the report of Nwoche *et al*. (2006) who reported a significant increase in these parameters when 4% palm oil was included in broiler starter ration; the observed significant ($p<0.05$) decrease in performance of birds fed 6% palm oil diets in this study is also in line with his result. The observed decrease in weight gain for birds fed 6% palm oil diets also agrees with the report of Moran (1986) that excessive inclusion of palm oil in poultry diet may cause depression in growth due to reduced intake of feed with increase in its energy content. The significant ($p<0.05$) increase in mortality for birds fed 6% palm oil diet can be attributed to the depression in growth which probably lowered the immunity of the birds.

5.4.2 Effect of Dietary Levels of GBM and Palm Oil on Serum Chemistry

The reduction in serum ALP levels with the inclusion of GBM in the diet agrees with Gujaral *et al*. (1978) who reported that ginger caused a reduction in ALP in rats. This result showed that ginger was scavenging for free radicals by its potent antioxidant property (Sakr, 2007). The normal histology of the liver also corroborates ginger's antioxidant properties and hence its hepatoprotective activity. Palm oil also contains vitamin E which is an antioxidant agent (Baiao and Lara, 2005) and possibly reduced the number of free radicals.

5.4.3 Effect of Dietary Levels of GBM and Palm Oil on Haematological Indices

The lower total protein observed in the birds fed 7.5% GBM diet could be due to high protein requirement for growth (Silva *et al*., 2007). It could also be due to individual differences since there was no difference in all the other haematological parameters.

5.4.4 Performance of Broiler Chickens (Finisher Phase)

The non significant difference in feed intake, final weight and weight gain of the birds could be attributed to improved utilization of the feed due to the birds tolerating the pungent principles in the feed better with increase in age (Simitzis *et al*., 2005). The numerical improvement observed in final weight, weight gain and efficiency of feed utilization of the birds with inclusion of 4% palm oil agrees with the findings of Fuller (1981) and Panja (1996) that the addition of palm oil improves both average daily weight gain and feed conversion ratio. The observed significant ($p<0.05$) decrease in weight gain for birds fed 6% palm oil diet agrees with the report of Moran (1986) that inclusion of very high levels of palm oil may retard growth of poultry due to reduced intake of feed with increase in its energy content.

5.4.5 Effect of Dietary Levels of GBM and Palm Oil on Serum Chemistry

The cholesterol value (2.88 mmol/L) of birds fed 7.55 GBM diet fell below the normal range, while others (3.18 – 4.45 mmol/L) fell within the range (3.23- 5.17 mmol/L) reported by Patra *et al*. (2010). There is no clear-cut explanation for this.

5.4.6 Effect of Dietary Levels of GBM and Palm Oil on Haematological Indices

Reddy and Salunkhe (1982) observed decreases in total protein and attributed it to inhibition of protein utilization in broilers; hence the observed increase in total protein with the inclusion of 7.5% GBM is a likely indication of protein utilization. Palm oil supplemented diets fed to fish had a protein sparing effect which resulted in higher protein retention (Lim *et al*., 2001). The TP values increased ($p<0.05$) significantly with the inclusion of palm oil at the end of the finisher phase (week eight) and agrees with reports that the blood picture changes with the advancement of age in animals (Sturkie and Textor, 1960; Khan and Zafar, 2005).

5.4.7 Effect of Dietary Levels of GBM and Palm Oil on Carcass and Organ Characteristics

The observed increase in intestinal length can be attributed to increase in bulkiness of the feed with increase in the level of GBM in order for the birds to accommodate the greater volume of feed (Onimisi, 2004). The decrease in abdominal fat pad with increase in the level of GBM supports the findings of Bhandari and Grover (1998), Fuhrman *et al*. (2000), Ademola *et al*. (2009) and Saeid *et al*. (2010) that ginger is an antilipidemic agent which lowers the abdominal fat pad, hence GBM can be included in broiler rations to decrease the fat content of meat. The observed increase in abdominal fat pad for birds fed 4 and 6% palm oil diets agrees with the report of Moran (1986) that excessive inclusion of palm oil in poultry diet may cause accumulation of excess fat and obesity in birds due to intake of ME in excess of the body requirement. High fat is not a desirable characteristic in meat hence high levels of palm oil should not be included in broiler rations

5.4.8 Effect of Dietary Levels of GBM and Palm oil on Histology of Organs of Broiler Chickens

The liver of birds fed 15% GBM diet supplemented with 6% palm oil showed cellular infiltration which may have been caused by excessive lipid peroxidation of unsaturated fatty acids in the liver which resulted in tissue damage (Riddell, 1997) and migration of cells to the tissue. The similarity in the weights of the kidneys fed the different levels of GBM suggests that the chemical substances in ginger were not present in toxic levels. Congestion, infiltration and inflammation was observed in the kidney tubuli of birds fed 15 and 30% GBM diets supplemented with 4% palm oil (Plates 13b and c). Reddy *et al*. (1995) reported that congestion in the kidney may be attributed to feeding of high energy diets such as fat. Donatus *et al*. (1983) also reported that congestion of the kidney may be due to the influence of chemical substances such as Cadmium, Zinc, Lead and Mercury contained in the ginger which is detected by the tissue as toxins. Birds fed 7.5% GBM diet without palm oil; 0% GBM diet with 4% palm oil supplementation and 7.5 and 15% GBM diet with 6% palm oil supplementation (Plates 15b, 16a, 17b and 17c) had accumulation of hemosiderin which is non toxic to the birds. The average weight of the spleen of these birds suggests that the hemosiderin was non toxic (Sheppard and Dierenfeld, 2002). The sloughing of the intestinal villi (Plates 18,19 and 20) resulted in reduced absorptive surface of the intestine thus limiting the utilization of digested feed (Ganong, 2005) but the inclusion of palm oil reduced the degree of sloughing (Plates 19 and 20). The withdrawal of feed about 14 hours before slaughtering could partially account for the sloughing (Bennett, 2002). The fibre content of the GBM may also have had an abrasive effect on the intestinal villi.

CHAPTER 6

6.0 SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

6.1 SUMMARY

Three experiments were conducted to evaluate the growth performance, haematology, serum chemistry, histopathology and carcass characteristics of chickens fed GBM diets supplemented with enzyme or palm oil.

In the first experiment, birds fed 0% GBM diet performed significantly ($p<0.05$) better than others and the inclusion of Maxigrain© enzyme did not improve performance of the birds. GBM and enzyme had no significant effect on most of the serum chemistry parameters except alkaline phosphatase (ALP) that significantly ($p<0.05$) increased with enzyme inclusion. GBM and enzyme also had no significant effect on the haematological profile of the birds. The inclusion of GBM in the diets significantly ($p<0.05$) reduced the abdominal fat content of the carcass. The diets had no negative effect on most of the organs except the intestine where there was sloughing of the micro-villi.

In experiment two, at the starter phase, final weight and weight gain of birds fed 0 and 15% GBM diets were significantly greater than those fed 7.5% GBM diets. Feed conversion significantly decreased with increase in dietary GBM. Palm oil had no significant ($p>0.05$) effect on feed intake but final weight, weight gain and efficiency of feed utilization significantly increased. At the finisher phase, feed intake, final weight and weight gain of birds were similar but efficiency of feed utilization decreased significantly with increase in GBM. Palm oil had no significant effect on performance. Triglyceride value was significantly greater in birds fed 0% GBM compared to other treatments. Serum AST was significantly ($p<0.05$) lower in birds fed 15% GBM diet. Tissue ALT was significantly ($p<0.05$) higher in

birds fed 15% GBM diet. The inclusion of GBM in the diets significantly ($p<0.05$) reduced the abdominal fat content of the carcass.

In experiment three, at the starter phase, final weight and weight gain for birds fed 0% was similar to 7.5 and 15% GBM diets. Feed efficiency of birds fed 0 and 7.5% GBM diets were significantly greater than those fed 15% GBM diets. Final weight, weight gain and feed to gain ratio of birds fed 0 and 4% palm oil diets were significantly greater than those fed 6% palm oil diet. Inclusion of GBM and palm oil at 7.5 and 4% respectively significantly improved performance. At week 4, the packed cell volume (PCV) and haemoglobin (hb) concentration of birds were similar but the total protein (TP) of birds fed 0 and 15% GBM were significantly greater than that of birds fed 7.5% GBM. Palm oil had no significant effect on most serum chemistry parameters but ALP significantly decreased in birds fed 15% GBM diets. At the finisher phase, there was no significant difference in feed intake, final weight, weight gain, feed to gain ratio and feed cost per kilogram gain of all the birds. Most carcass and organ characteristics were similar for all inclusion levels of GBM except the weight of the breast and intestine length that increased with GBM inclusion. The abdominal fat also significantly reduced with the inclusion of GBM.

Palm oil addition significantly increased the intestinal length and abdominal fat pad of birds fed 4 and 6% palm oil diets compared to those fed 0% palm oil diet. Palm oil inclusion had no significant effect on serum chemistry. Haemoglobin concentration of birds fed 4% palm oil was significantly lower than those fed 6% palm oil. The TP of birds fed 7.5% GBM was significantly greater than that of birds fed 0 and 15% GBM diets. Total protein levels also significantly increased with palm oil inclusion. The diets had no negative effect on most of the organs except the kidney of birds fed 7.5 and 15% GBM diet supplemented with 4% palm

oil that showed congestion. There was also sloughing of the intestinal micro villi in all treatments but the inclusion of palm oil reduced the degree of sloughing.

6.2 CONCLUSIONS

- The birds fed the control diet performed better than those fed GBM diets with or without enzyme supplementation.
- The inclusion of enzyme did not improve the utilization of GBM
- Birds fed 7.5% GBM and 4% palm oil gained more weight than other birds
- Ginger by-product meal had no negative effect on the haematological profile of the birds, hence it is not harmful
- Ginger by-product meal decreased the cholesterol content of the plasma of birds at the starter phase
- Ginger by-product meal had no negative effect on the liver function enzymes of the birds, hence it is not harmful
- Ginger by-product meal reduced abdominal fat in the carcass
- Inclusion of palm oil improved performance at the starter phase
- Diets of GBM with either palm oil or enzyme induced histopathological changes in the tissues of liver, kidney and intestine associated with dysfunction of these organs.

6.2 RECOMMENDATIONS

- The optimum level of inclusion of GBM and palm oil at the starter phase are 7.5% and 4% respectively
- Ginger by-product meal can be included in broiler chicken rations to reduce the fat content of the carcass
- Further research is required to explore appropriate enzyme combinations that targets the indigestible components and other antinutritional factors present in GBM
- Other methods of improving utilization of GBM in broiler diets should be tested.
- Further investigation is recommended to confirm the histopathological results as well as confirm the exact mechanism of action of GBM supplemented diets.

REFERENCES

Abbas, W., Khan, S. H. and Sarwar, M. (1998). Sunflower oil meal as a substitute for soyabean meal in broiler rations with or without multienzyme (Kemzyme). *Pakistan Veterinary Journal*, 18(3): 124-129.

Acamovic, T. (2001). Commercial application of enzymes technology for poultry production. *World's Poultry Science Journal*, 57: 225-235.

Adanlawo I. G. and Dairo, F. A. S. (2007). Nutrient and Anti-nutrient Constituents of Ginger (*Zingiber officinale*, Roscoe) and the Influence of its Ethanolic Extract on Some Serum Enzymes in Albino Rats. *International Journal of Biological Chemistry*, 1: 38-46.

Ademola, S. G. Farinu, G. O. and Babatunde, G. M. (2009). Serum Lipid, Growth and Haematological Parameters of Broilers Fed Garlic, Ginger and Their Mixture. *World Journal of Agricultural Sciences*, 5 (1): 99-104.

Aftab, U. (2009). Utilization of alternative protein meals with or without multiple-enzyme supplementation in broilers fed low-energy diets. *Journal of Applied Poultry Research*, 18: 292-296.

Ajith, T. A., Nivitha, V. and Usha, S. (2007). *Zingiber officinale* Roscoe alone and in combination with alpha-tocopherol protect the kidney against cisplatin induced acute renal failure. *Food Chemical Toxicology*, 45: 921-927.

Akhtar, M. S., Afzal, H. and Chaudry, F. (1984) Preliminary *in vitro* antibacterial screening of Bakain, and Zarisk against Salmonella. Medicose, 9: 6-7.

Akinmutimi, A. H. and Okwu, N. D. (2006). Effect of quantitative substitution of cooked *Mucuna utilis* seed meal for soybean meal in broiler finisher diet. *International Journal of Poultry Science*, 5 (5): 477-481.

AL-Homidan, A. A. (2005). Efficacy of using different sources and levels of Allium sativum and Zingiber officinale on broiler chicks performance. *Saudi Journal of Biological Sciences*, 12: 96-102.

Alnaqeeb, M. A., Thomson, M., Al-qattan, K. K., Kamel, A. F., Mustafa, T. and Ali, M. (2003). Biochemical and histopathological toxicity of an aqueous extract of ginger in female rats. *Kuwait Journal of Science Engineering*, 30: 35-48.

Annison, G. (1992). Commercial enzyme supplementation of wheat-based diets raises ileal glycanase activities and improves apparent metabolizable energy, starch and pentosan digestibility in broiler chicks. *Animal Feed Science Technology*, 38: 105-121.

Annison, G. (1993). The role of wheat non-polysaccharides in broiler nutrition. *Australian Journal of Agricultural Research*, 44: 405-422.

Anonymous (2005). Opinion of the scientific panel on additives and products or substances used in animal feed on the safety of enzymatic product Avizyme® 1500 for use as feed additive for laying hens. *The European Food Safety Authority Journal*, 171: 1-5.

Apata, D. F. and Ojo, Y. (2000). Efficacy of the Trichoderma viride enzyme complex in broiler starter fed cowpea testa based diets. In: *International Journal of Poultry Science*, 5 (5): 477-481.

Association of Analytical Chemists (1990). Official Methods of Analysis (A.O.A.C.) 15th Ed. Washington D.C.

Attia, Y. A., Qota, E. M. A., Aggoor, F.A.M., and Kies, A.K. (2003). Value of rice bran, its maximal utilization and upgrading by phytase and other enzymes and diet formulation based on available amino acid for broiler chicks. *Archiv fur Geflugelkunde*, 67: 157-166.

Attia,Y. A., Tag El-Din, A. E., Zeweil, H.S., Hussein, A.S., Qota, E.M., and Arafat, M.A. (2008). The effect of supplementation of enzyme on laying and reproductive performance in Japanese quail hens fed Nigella seed meal. *The Journal of Poultry Science*, 45:110-115.

Azeez, O.I., Olayemi, F.O. and Olanrewaju, J.R. (2011). Age and Sex Influences on th haematology and Erythrocyte Osmotic Fragility of the Nigerian Turkey. *Research Journal of Veterinary Sciences*, 4: 43-49.

Babatunde, G.M., Fajimi, A.O. and Oyejide, A.O. (1992). Rubber seed oil versus palm oil in broiler chickens diet. Effect of performance, nutrient digestibility, haematology and carcass characteristics. *Animal Feed Science Technology*, 35: 133-146.

Baião, N .C. and Lara L.J.C. (2005). Oil and fat in broiler nutrition. *Brazilian Journal of Poultry Science*, 7 (3): 129 – 141.

Banks, W.J. (1993). Applied Veterinary Histology. Williams and Wilkins, Baltimore, pp: 327-335

Bartov, L., Bornstein, S. and Lipstein, B. (1974). Effect of Calorie to Protein Ratio on the Degree of Fatness in Broilers Fed on Practical Diets. *British Poultry Science*, 15: 107-ll7.

Bedford, M. (1996). The effect of enzyme on digestion. *Journal of Applied Poultry Research*, 5: 370-377.

Bennett, C. (2002). Feed withdrawal for broiler chickens. https:// www.gov.mb.ca/agriculture/livestock/poultry/.../bba 01s 28.pdf

Bhandari, U. and Grover, J.K. (1998). Effect of ethanolic extract of ginger on hyperglycemic rats. *International Journal of Diabetes*, 6: 95-96.

Bliddal, H., Rosetzsky, A., Schlichting, P., Weidner, M.S. and Andersen, L.A. (2000). A randomized, placebo-controlled, cross over study of ginger extracts and ibuprofen in osteoarthritis. *Osteoarthritis Cartilage*, 8(1): 9-12.

Bone F. J. (1979). Evaluation of two herbal spices as feed Additives for finisher broilers. In: *Biotechnology in Animal Husbandry*, 26 (5-6): 383-392.

Bounous, I.D., Wyatt, R.D., Gibbs, P.S., Kilburn, J.V. and Quist, C.F. (2000). Hematologic and serum biochemical reference intervals for juvenile wild turkeys. *Journal of Wildlife Diseases*, 36(2): 393-396.

Brenes, A., Smith, M., Guenter, W. and Marquardt, R. R. (1993). Effects of Enzyme Supplementation on Performance, Nutrient Digestibility, Gastrointestinal Morphology, and Volatile Fatty Acid Profiles in the Hindgut of Broilers Fed Wheat-based Diets. *Poultry Science*, 84: 875–881.

Bruan, J.E.A. and Severson, D.L.(1992). Lipoprotein lipase released from myocytes is increased by decavandate but not insulin. *American Journal of Physiology*, 262: 663-670.

Burstyn, I. (2004). Principal Component analysis is a powerful instrument in Occupational hygiene inquiries. *Annals of Occupational Hygiene*, 48(2): 655-661.

Chen, C.C., Kuo, M.C., Wu, C.M., and Ho, C.T. (1986). Pungent compounds of ginger (*Zingiber officinale Roscoe*) extracted by liquid carbon dioxide. *Journal of Agriculture and Food Chemistry*, 34:447-480.

Chauhan, H.V.S. and Roy, S. 1996. Poultry Diseases, Diagnosis and Treatment. 2nd Ed., New Age International Pvt. Ltd., New Delhi, India, p. 186.

Choct, M. and Annison, G. (1990). Anti-nutritive activity of wheat pentosans in broiler diets. *British Poultry Science*, 31:811-821.

Choudhari, C.V. and Deshmukh, P.B. (2007). Acute and subchronic toxicity study of Semecarpus anacardium on haemoblobin percent and RBC count of male albino rat. In: *International Journal of Biological Chemistry*, *1: 38-46.*

Coles, E.H. (1986). Veterinary Clinical Pathology. 4th edn. (Ed. E.H. Coles). W.B. Saunders Company, Philadelphia, U.S.A. p.486.

Conley, M. (1997). Ginger- Part 1. Retrieved from http: //accessnewage.com/articles/health/ginger1.htm.

Connell, D.W. and Sutherand, M.D. (1969). A re-examination of gingerol, shogaol and zingerone, the pungent principles of ginger (*Zingiber officinale Roscoe*). *Australian Journal of Chemistry*, 22: 1033-1043.

Comell, D.W. and McLachlan, R. (1972). Natural pungent compounds: Examination of gingerols, shoagaols, paradols and related compounds by thin-layer and gas chromatography. *Journal of Chromatography*, 67: 29-35.

Dale, H.M. and Fuller, FI.L. (1979). Effect of Diet Composition on Feed Intake and Growth of Chicks under Heat Stress. Dietary Fat Levels. *Poultry Science*, 58: 1529-1534.

Dash, D.K., Yeligar, V.C., Nayak, S.S., Gosh, T. and Rajalingam, D. (2007). Evaluation of hepatoprotective and antioxidant activity of *Ichnocarpus frutescens* (Linn.) on paracetamol-induced hepatotoxicity in rats. In: *International journal of pharmacology*, 4: 352-360.

Deepak G., Jogi S., Kumar A. Bais R. and Vikas K. S. (2002). Effect of herbal liver stimulants on efficacy of feed utilization in commercial broiler chicken. *Indian Journal of Animal Research*, 36 (1): 43-45.

Dempsey, S. (1999). Avian Hematology Avian Venipuncture Special Considerations Prior to Handling and Venipuncture web page/M. Kennedy/7/99.

Denbow, D.M., Duke, G.E. and Chaplin, S.B. (1989). Food intake, gastric secretion and motility as affected by avian pancreatic polypeptide administered intracerebrally in chickens. *International journal of pharmacology*, 4: 352-360.

Devegowda G. (1996). Herbal medicines, an untapped treasure in poultry production In: *Biotechnology in Animal Husbandry* 26 (5-6), Pp. 383-392.

Dooley, S., Gupta, J.J and Reddy, P.B. (2009). Effect of supplementation of ginger, garlic and turmeric in broiler chicken. *Indian Veterinary Journal*, 86 (6): 644-645.

Donatus, I.A., Gunawan, D., Wahyono, D., Taroeno and Mulyono, (1983). The effect of feeding red ginger as phytobiotic on body weight gain. Proceeding of the third Symposium on Medicinal Plants Research (Risalah Simposium Penelitian Tumbuhan Obat III). Fakultas Farmasi Universitas Gadjah Mada, Yogyakarta.

Douglas, M.W., Parsons, C.M. and Bedford, M.R. (2000). Effect of various soybean meal sources and Avizyme on chick growth performance and ileal digestible energy. In: *South African Journal of Animal Science*, 39 (Supplement 1): 312-315.

Dudley-Cash, W.A. (2001). Soybean meal source, added enzyme affect nutritional value for chicks. In: *South African Journal of Animal Science*, 39 (Supplement 1): 312-315.

Dunn, N. (1996). Combating the pentosans in cereals. *World Poultry Journal*, 12:24-25.

Duru, S. (2010). Evaluation of three types of rice offal in broiler diets. Unpublished Ph.D thesis submitted to the Department of Animal Science, Ahmadu Bello University, Zaria.

Fadugba, A.A. (1989). Evaluation of nutritive value of maize offal in poultry diet. Unpublished M.Sc. thesis submitted to the Department of Animal Science, Ahmadu Bello University, Zaria.

Fajimi, A.O. Babatunde, G. M. Ogunlana, F. F. and Oyejide, A. (1993). Comparative utilization of rubber seed oil and palm oil by broilers in a humid tropical environment. *Animal Feed Science and Technology*, 43(3-4): 177-188.

Food and Agriculture Organization of the United Nations (FAO), (2008). Economic and Social Department: The Statistical Division. Top ten Ginger Producers.

. Friesen, O. D. Guenter, W. Marquardt, R. R. and Rotter, B. A. (1992). The effect of enzyme supplementation on the apparent metabolizable energy and nutrient digestibilities of wheat, barley, oats and rye for the young broiler chicks. In: *International Journal of Poultry Science*, 9 (10): 944-947

Fuhrman, B., Roseblate, M., Hayek, T., Coleman, R. and Aviram, M. (2000). Ginger extract consumption reduces plasma cholesterol, inhibits LDL oxidation and attenuates development of atherosclerosis in atherosclerotic, apolipoprotein E-Deficient mice. *Journal of Nutrition*, 130: 1124-1131.

Fuller, H.L. and Mora, G. (1973). Effect of Heat Increment of the Diet on Feed Intake and Growth of Chicks under Heat Stress. In Proceedings Maryland Nutrition Conference Feed Manufacturers. Washington D C.

Fuller, H.I. (1981). Formulating broiler feeds for hot weather uses. Poultry Digest. Pp.321-323.

Ganong, W.F. (2005). Review of Medical Physiology. 22nd Edition. The McGraw-Hill Companies, Inc.

Gujaral, S., Bhumra, H. and Swaroop, M. (1978). Effect of ginger (*Zingiber officinale* Roscoe) Oleoresin on serum and hepatic cholesterol levels in cholesterol fed rats. *Nutrition Reports International*, 17(2): 183-189.

Guyton, A.C. (1991). Textbook of Medical Physiology. 8th Edn., W.B. Saunders Company, Philadelphia, pp: 356-372.

Hariono, B. (1993). Hematologi (Hemathology) Laboratory Clinic Pathology. Gadjah Mada University, Yogyakarta, pp: 54-81.

Hesselman, K. and Aman, P. (1986). The effect of β- glucanase on the utilization of starch and nitrogen by the broiler chickens fed on barley of low and high viscosity. *Animal Feed Science Technology*, 15: 83-93.

Hoffbrand, A.V. and Pettit, J.E. (1997). Essentials of haematology. In: *International journal of pharmacology*, 4: 352-360.

Hruby, M. (2003). Enzymes reduce food poisoning bacteria. Feed Mix, 11.

Incharoen, T., Yamauchi, K., Thongwittaya, N. (2010). Intestinal villus histological alterations in broilers fed dietary DFG. *Journal of Animal physiology and Animal Nutrition*. s*cholar.qsensei.com/content/1pdw86*

Kandra, P.A., Sell, J.C. and Guenter, N.(1974). Response of meat and egg type chicken to high fibre diet. *Canadian Journal of Animal Science*, 54: 651-658.

Kasinath, R.T., Joseph, P.K., Hebron, K., Zhang, X.H., Connock, M.J. and Maslin, D.J. (1997). The effects of garlic oil upon serum indicators of liver function. *Biochemical Society Transactions*, 25: 533S-533S.

Ke, J., Delin, W. and Larsen, K. (2000). Zingiberaceae. Flora of China 24: 322-377. (http://hua.huh.harvard.edu/china/mss/volume24/ZINGIBERACEAE.published.pdf)

Khan, S.H., Sardar, R. and Siddique, B. (2006). Influence of enzymes on performance of broilers fed sunflower-corn based diets. *Pakistan Veterinary Journal*, 26(3): 109-114.

Khan, T.A. and Zafar, F. (2005). Haematological study in response to varying doses of estrogen in broiler chicken. *International Journal of Poultry Science*, 4(10): 748-751.

Kanduri, A. B., Pawar, A.A., Kokane, S.S. and Deshmukh, G.B. (2009). Effect of Ginger and Garlic Feeding in Organic Broiler Production. Poultry line 9(7):5

Kikuzaki, H., and Nakatani, N. (1993). Antioxidant effects of some ginger constituents. *Journal of Food Science,* 58: 1407-1410.

Kumar, O.M. (1991). Effect of Liv-52® syrup on broiler performance in North Eastern region. Indian Poultry Review, Pp. 37-38.

Lee, K.W., Everts, H and Beynen, A.C. (2004). Essential Oils in Broiler Nutrition. *International Journal of Poultry Science*, 3 (12): 738-752.

Lewis, M.R.., Rose, S.P., Mac kenzie, A.M. and Tucker, L.A. (2003). Effect of dietary inclusion of plant extract on the growth performance of male broiler chicken. *Journal of British Poultry Science*, 20: 78-82.

Lim, P K., Boey, P. L. and Ng, W. K. (2001). Dietary palm oil level affects growth Performance, protein retention and tissue vitamin E concentration of African catfish, *Clarias gariepinus*. *Aquaculture,* 202: 101-112.

Lipstein, B. and Bornstein, S. (l975). Extra- Caloric' Properties of Acidulated Soybean Oil Soap stock for Broilers during Hot Weather. *Poultry Science*, 54:396-404.

Lopes-Virella, M.F. (1983). Comparison of phosphotungstate and dextran sulphate- Mg^{2+} precipitation procedures for determination of high density lipoprotein cholesterol. *Clinical Chemistry*, 23: 166-169.

Madubuike, F.N. and Obidimma, V.N. (2009). Brewer's Dried Grain as energy source on external and internal egg qualities of laying hens.`In: proceedings 34th Annual Conference of Nigerian Society of Animal Production, Uyo State, Nigeria. Editors: Umoh, B.I., Udedibie, A.B.I., Solomon, I.P., Obasi, O.L., Okon, B.I. and Udoh, E.J. Pp. 362-365.

Marquardt, R.R., Bores, P., Guenter, W. and Corw, G. (1994). The nutritive value of barley, rye, wheat and corn for young chicks as affected by use of *Trichoderma reesei* enzyme preparation. *Animal Feed Science and Technology*, 45: 363-378.

Mascolo, N., Jain, R., Jain, S.C. and Capasso, F. (1989). Ethnopharmacologic investigation of ginger (*Zingiber officinale*). *Journal of Ethnopharmacology*, 27: 129-140.

Mishra S.J. and Singh D. S. (2000). Effect of feeding root powder of *Withania somnifera* (L.) Dunal (aswagandha) on growth, feed consumption, efficiency of feed conversion and mortality rate in broiler chicks. Bioved (annual), 11: 79-83.

Mitruka, B.M. and Rawnsley, H.M. (1977). Chemical, Biochemical and Haematological reference value in normal experimental animals, Masson Publishing Dubling U.S.A. Inc. New York Pp. 88-90.

Mmereole, F.U.C. (2009). Effects of age and breeds on the haematological parameters of broilers. *Natural and Applied Sciences Journal,* 10(1): 90-95.

Moran, E.T. (1986). Variation in body conformation of poultry. Proceedings of the Nutritional Society, 45:101-109.

Mushtaq, T., Sarwar, M. Ahmad, G. Nisa, M.U. and Jamil, A. (2006). The influence of exogenous multienzyme preparation and graded levels of digestible lysine in sunflower meal-based diets on the performance of young broiler chicks two weeks posthatching. *Poultry Science*, 85: 2180-2185.

Nagaraj, M J., Hess, B. and Bilgili, S. F. (2007). Evaluation of a Feed-Grade Enzyme in Broiler diets to Reduce Pododermatitis. *Applied Poultry Research*, 16: 52-61.

National Research Council (1994). Nutrient Requirements of Poultry. ISBN: 0-309-59632-7, 176 pages

Naqvi, L. (1996). Bioavailability of metabolizable energy from rations as influenced by enzyme supplemented in broiler. M.Sc. Thesis, Department of Animal Nutrition, University of Agriculture, Faisalabad.

Neess, G.C., Zhao, Z. and Lopez, D. (1996). Inhibitor of cholesterol biosynthesis increase hepatic low density lipoprotein degradation. *Archives of Biochemical Biophysics*, 325: 242-248.

Ngxumeshe, A.M. and Gous, R.M. (2009). Effects of varying levels of thermostable xylanase, amylase and protease (TXAP) composite enzyme supplement on body growth of broiler chickens. *South African Journal of Animal Science*, 39 (Supplement 1). Pp. 312-315.

Nidaullah, H., Durrani, F. R., Ahmad, S., Jani. U. and Gul, S. (2010). Aqueous extract from different medicinal plants As anticoccidial, growth promotive and immunostimulant in broilers. *Journal of Agricultural and Biological Science*, 5(1): 53-59.

Nwoche, G.N., Ndubuisi, E.C. and Iheukwumere, F.C. (2003). Effects of dietary palm oil on the performance of broiler chicks. *International Journal of Agriculture and Rural Development*, 4: 81- 86.

Nwoche, G.N., Ndubuisi, E.C. and Iheukwumere, F.C. (2006). Performance of finisher broilers and cost implication of feeding palm oil as energy supplement. *Niger Agricultural Journal*, 37: 44-45.

Ochang, S.N., Fagbenro, O.A. and Adebayo, O.T. (2007). Growth performance, body composition, haematology and product quality of the African Catfish (*Clarias gariepinus*) fed diets with palm oil. *Pakistan Journal of Nutrition*, 6 (5): 452-459.

Oladunjoye, I.O. and Ojebiyi, O.O. (2010). Performance characteristics of broiler chicken (*Gallus gallus*) fed rice (*Oyza sativa*) bran with or without Roxazyme G2G. *International Journal of Animal and Veterinary Advances*, 2(4): 135-140.

Olorede, B.R. and Longe, O.G. (2000). Effect of replacing PKC with shea butter cake in egg quality characteristics. *Nigerian Journal of Animal Production*, 27: 9-23.

Oluwasemire, K.O. (1999). Some aspects of rainfall trends and their implications on soil and crop management practices in north western Nigeria. In: Management of the soil resources of Nigeria for sustainable agricultural production in the 21st Century. Proceedings of the 25th Annual Conference of Soil Science Society of Nigeria, pp. 244-254.

Omage, J.J., Onimisi, P.A., Adegbite, E.K. and Agunbiade, M.O. (2007). The Effect of Ginger (*Zingiber Officinale Roscoe*) Waste Meal on Growth Performance, Carcass characteristics, serum lipid and serum cholesterol profiles of rabbit. *Pakistan Journal of Nutrition*, 6(4): 359-362.

Onimisi, P.A. (2004). Evaluation of Ginger Waste Meal as energy source in the diets of broiler chicken. Unpublished M.Sc Thesis submitted to Animal Science Department, Ahmadu Bello University, Zaria.

Onu, P.N (2010). Evaluation of two herbal spices as feed Additives for finisher broilers. *Biotechnology in Animal Husbandry*, 26 (5-6): 383-392.

Panda, A.K., Rao, R., Raju, S.V., Reddy, M.R. and Praharaj, N.K. (2011). The Role of Feed Enzymes in Poultry Nutrition Project Directorate on Poultry, Hyderabad . Poulvet.com accessed 30/07/2011

Panja, P. (1996). Effects of Supplementation of Palm Oil in Isonitrogenous diets on Broilers. *Thammasat International journal of science and Technology*, 1(1): 47-54.

Patra, G., Ali, M.A., Chanu, K.V., Jonathan, L., Joy, L.K., Prava, M., Ravindran, R, Das, G. and Devi, L.I. (2010). PCR based Diagnosis of Eimeria tenella Infection in Broiler Chicken. *International Journal of Poultry Science*, 9(8): 813-818.

Pesti, G.M., Bakalli, R.I., Qiao, M. and Sterling, K.G. (2002). A comparison of eight grades of fat as broiler feed ingredients. *Poultry Science*, 81(3): 382-390.

Pettersson, D. (1987). Substitution of maize with different levels of wheat, triticale or rye in diets for broiler chicks. *Swedish Journal of Agricultural Research*, 17(1): 57-62.

Platel, K. and Srinivasan, K. (1996). Influence of dietary spices or their active principles on digestive enzymes of small intestinal mucosa in rats. *International Journal of Food Science Nutrition*, 47:55–59.

Platel, K. and Srinivasan, K. (2000). Influence of dietary spices and their active principles on pancreatic digestive enzymes in albino rats. *Nahrung*, 44:42–46.

Pond, W.G., Yen, J.T., Lind-Wall, R.N. and Itill, D. (1981). Dietary alfalfa meal for genetically obese and lean pigs. Effect on body weight gain, carcass and gastro-intestinal tract measurements and blood metabolite. *Journal of Animal Science*, 51: 367-373.

Rama Rao, S.V., Raju, M.V., Panda, A.K., Poonam, N.S. and Shyam Sunder, G. (2011). Effect of dietary α -tocopherol concentration on performance and some immune responses in broiler chickens fed on diets containing oils from different sources. *British Poultry Science*, 52(1): 97-105.

Ramudu, S.K., Korivi, M., Kesireddy, N., Chia, K.H. and Kesireddy, R.S. (2011). Protective effect of dietary ginger on antioxidant enzymes and oxidative damage in experimental diabetic rat tissues. *Food Chemistry*, 124(4): 1436-1442.

Raza, S., Ashraf, M., Pasha, T.N. and Latif, F. (2009). Effect of enzyme supplementation of broiler diets containing varying level of sunflower meal and crude fiber. P*akistan Journal of Botany*, 41(5): 2543-2550.

Reddy, N.R., and Salunkhe, D.K. (1982). Phytates in legumes and cereals – reviews *Advanced Food Research*, 28: 1-8.

Reddy,K.P., Sivaramakrishna, B. and Radhakrishniah, K. (1995). Incidence of fatty liver haemorrhagic syndrome in broiler chicken. Animal Health Cen. *Indian Poultry Advances*, 28(4): 21-23.

Reitman, S. and Frankel S, (1957). A colourimetric method for the determination of serum GOT and GPT. *American Journal of Clinical Pathology*, 28: 56 – 63.

Riddell, C., 1997. Developmental, metabolic and other non-infectious disorders In: Disease of Poultry 10th Ed. Iowa State University Press, Ames, Iowa, USA, pp: 935-936.

Saeid, M. J., Arkan, B. M. and Maad A. A. (2010). Effect of Aqueous Extract of Ginger (*Zingiber officinale*) on Blood Biochemistry Parameters of Broiler. *International Journal of Poultry Science*, 9 (10): 944-947.

Sakr, S.A. (2007). Ameliorative Effect of Ginger (*Zingiber officinale*) on Mancozeb Fungicide Induced Liver Injury in Albino Rats. *Australian Journal of Basic and Applied Sciences*, 1(4): 650-656.

Sakr, S.A., Mahran, H.A. and Lamfon, H.A. (2011). Protective effect of ginger (*Zingiber officinale*) on adriamycin - induced hepatotoxicity in albino rats. *Journal of Medicinal Plants Research*, 5(1): 133-140.

Salli, K., Tredger, J.M. and William, R. (1991). Drugs and the liver. *Biopharmaceutical Drug Dispose*, 12: 251-259.

Savoury, C.J. and Gentle, M.J. (1976). Effects of dietary dilution with fibre on the food intake and gut dimensiom of Japanese quail. *British Poultry Science*, 17:561-570.

Selle, P.H., Cadogan D.J., Ru Y.J. and Partridge G.G. (2010). Impact of Exogenous Enzymes in Sorghum- or Wheat-Based Broiler Diets on Nutrient Utilization and Growth Performance. *International Journal of Poultry Science*, 9 (1): 53-58.

Sheppard, C. and Dierenfeld, E.(2002). Iron Storage Disease in Birds: Speculation on Etiology, Implications for Captive Husbandry. www.nashvillezoo.org/piciformes/pdf/iron storage in birds.pdf

Silva, P.R.L., Freitas Neto, O.C., Laurentiz, A.C., Junqueira, O.M., and Fagliari, J.J. (2007). Blood Serum Components and Serum Protein Test of Hybro-PG Broilers of Different Ages. *Brazilian Journal of Poultry Science*, 9(4): 229 – 232.

Simitzis, P.E., Deligeorgis, S.G., Bizelis, J.A., Theodosiou, D.I. and Feggeros, K. (2005). Effect of dietary oregano oil supplementation on lamb meat characteristics. *Meat Science*, 79: 217-223.

Sinurat, A. P., Purwadaria, T., Ketaren, P. P., Zainuddin, D. and Kompiang, I. P. (2000). Utilization of palm oil sludge in poultry diet. 1. Dried palm oil sludge and its fermented product in broiler's diet. *Jurnal Ilmu Ternak dan Veteriner*, 5(2): 107-112.

Smink, W., Gerrits, W.J.J., Hovenier, R., Geelen, M.J.H., Lobee, H.W.J., Verstegen, M.W.A. and Beynen, A.C. (2008). Fatty Acid Digestion and Deposition in Broiler Chickens Fed Diets Containing either Native or Randomized Palm Oil. *Poultry Science*, 87: 506-513.

Smink, W., Gerrits, W.J.J., Hovenier, R., Geelen, M.J.H., Verstegen, M.W.A. and Beynen, A.C. (2010). Effect of dietary fat sources on fatty acid deposition and lipid metabolism in broiler chickens. *Poultry Science*, 89(11):2432-2440.

Smiricky, M. R., Grieshop, C. M., Albin, D. M., Wubben, J. E., Gabert, V. M. and Fahey, G. C. (2002). The influence of soy oligosaccharides on apparent and true digestibilities and fecal consistency in growing pigs. *Journal of Animal Science*, 80: 2433-2441.

Srinivasan, K. and Sambaiah, K. (1991). The effect of spices on cholesterol 7-alpha hydroxylase activity and on serum and hepatic cholesterol levels in the rat. *International Journal of Vitamins and Nutrition Research*, 61(4): 364-369

Stagniogias, G. and Pearce, G.R. (1985). The digestion of fibre by pigs. The effect of amount and type of fibre on apparent digestibility, nitrogen balance and rate of passage. *British Journal of Nutrition*, 53: 513-530

Stanley, R.W. and Ishizaki, S.M. (1982). Local by- products as feeds for diary cattle. Research report 223. Hawaii Agricultural Experiment Station. College of Tropical Agriculture. University of Hawaii.

Statistical Analysis System (SAS) (2002). Users guide statistics, Version 9 Edition, SAS institute Inc. Cary. North Carolina, U.S.A.

Sturkie, P.D. and Textor, K. (1960). Further studies on sedimentation rate of erythrocytes in chicken. *Poultry Science*, 39: 444.

Suekawa, M., Ishige, A., Yuasa, K., Sudo, K., Aburada, M. and Hosoya, E. (1984). Pharmacological studies on ginger. Pharmacological actions of pungent constitutents, (6)-gingerol and (6)-shogaol. *Journal of Pharmacobiodynamics* 7: 836-848.

Surfano, H., Hadad, E.A. and Brink, M. (1999). *(Zingiber officinale Roscoe).* Plant resources of South-East Asia No 13. Spices. de Guzman**,** *C.C* and Siemonsma, J.S. (Editors). Backhuys, Publishers, Leiden, The Netherlands. Pp. 239-244.

Tanabe, M., Chen, Y.D., Saito, K. and Kano, Y. (1993). Cholesterol biosynthesis inhibitory component from *Zingiber officinale* Roscoe. Chemical Pharmaceutical Bulletin (Tokyo) 41: 710-713.

Viveros, A., Brenes, A., Pizarro, M. and Castano, M. (1993). Effect of enzyme supplementation of a diet based on barley and autoclave treatment on apparent digestibility, growth performance and gut morphology of broilers. *Animal Feed Science Technology*, 48(3/4): 237-251.

Weiss, E.A. (2002). Spice Crops. 20 pp. CAB International publishing, Oxon, UK.

Windisch, W. M., Schedle, K., Plitzner, C. and Kroismayr, A. (2008). Use of phytogenic products as feed additives for swine and poultry. *Journal of Animal Science*, 86:140–148.

Youseff, A.A. and Hassan, S. Z. (2008). The Effect of Supplementation of Enzyme on Laying and Reproductive Performance in Japanese Quail Hens Fed Nigella Seed Meal. *The Journal of Poultry Science*, 45: 110-115.

Zarghi, H. And Golian, A. (2009). Effect of Triticale Replacement and Enzyme Supplementation on Performance and Blood Chemistry of Broiler Chickens. *Journal of Animal and Veterinary Advances,* 8 (7): 1316-1321

Zhang, G.F., Yang, Z.B., Wang, Y., Yang, W.R., Jiang, S.Z. and Gai, G.S. (2009). Effects of ginger root (*Zingiber officinale*) processed to different particle sizes on growth performance, antioxidant status, and serum metabolites of broiler chickens. *Poultry Science*, 88: 2159-2166.