

**MORINGA (*Moringa oleifera*) LEAF MEAL SUPPLEMENTATION
ON THE PERFORMANCE, CARCASS CHARACTERISTICS AND
BLOOD PROFILE OF BROILERS**

BY

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DEDICATION

I dedicate this work first and foremost to the Almighty God for giving me the strength to endure.

I also dedicate this thesis to my dear Parents, Mr. Samuel Amevor and Madam Aku Agamah, my lovely Supervisors (Dr. T.N.N. Nortey and Prof. A. Naazie), my lovely sisters and brothers, my friends and love ones.



DECLARATION

I, Amevor Felix Kwame author of this thesis entitled ‘**Moringa (*Moringa oleifera*) Leaf Meal supplementation on the Performance, Carcass Characteristics and Blood Profile of Broilers**’ do declare that except for the references to other people’s work, the work presented in this thesis was done entirely by me in the Department of Animal Science, University of Ghana, Legon from August, 2016 to July, 2017 under the supervision of Dr. T.N.N. Nortey and Professor A. Naazie. The information derived from the literature has been duly acknowledged in the text and a list of references provided. This work has never been submitted in whole or in part for any degree or diploma of this University or elsewhere.

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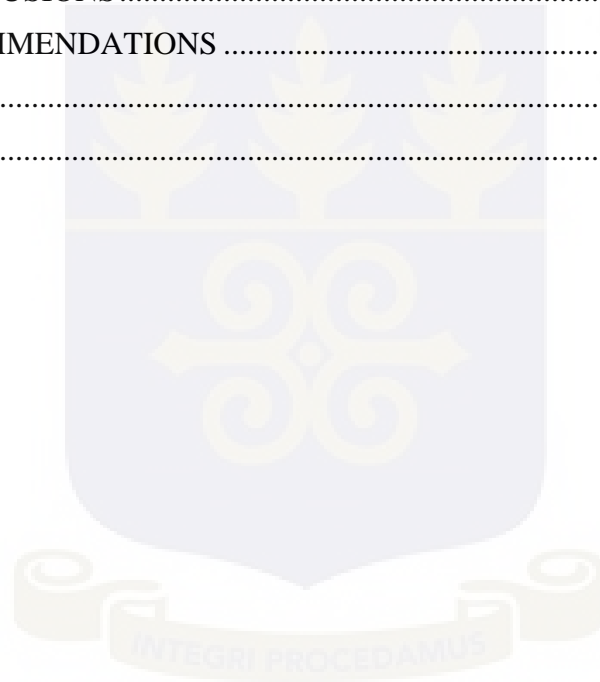
I do accept responsibility for all faults in content and style, however marginal or substantial that remains despite all the assistance received.

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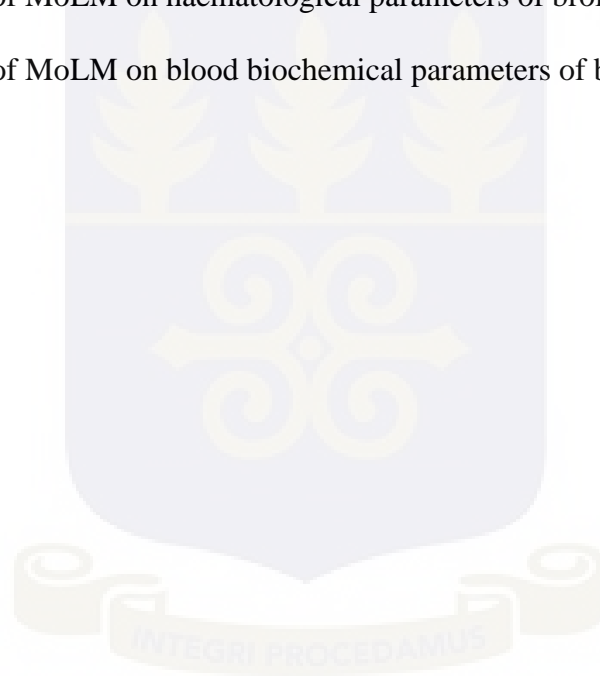
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ABSTRACT

This study was carried out to determine the effects of *Moringa oleifera* leaf meal supplementation on the performance, carcass characteristics and blood haematological and serum biochemical profile of broiler chickens. Fresh Moringa leaves (FML) were harvested and shade – dried for three to four days and milled into meal. The experiment lasted for 8 weeks.

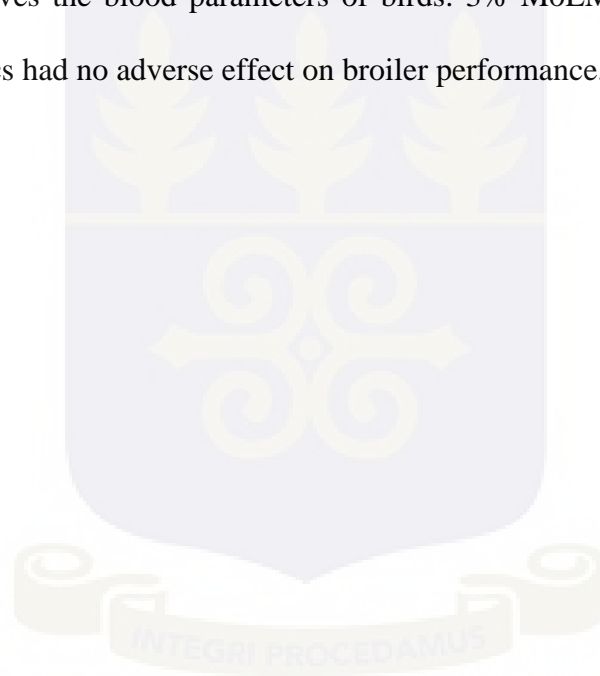
A total of 448 day old broiler chicks were used in this experiment. The experimental birds were distributed randomly into seven groups of 64 birds per treatment. The 64 birds in each treatment were further divided into four (4) replicates of 16 birds each.

Four experimental diets were formulated to be iso-nitrogenous and iso-caloric broiler starter and finisher diets: Diet 1 (0% MoLM with conventional ingredients), Diet 2 (3% MoLM with conventional ingredients), Diet 3 (6% MoLM with conventional ingredients), and Diet 4 (9% MoLM with conventional ingredients).

In total there were seven treatments, namely T1, T2, T3, T4, T5, T6 and T7. Experimental birds in T1 were given 0% MoLM without antibiotic through drinking water. Birds on T2 were given 3% MoLM without antibiotic. Birds on T3 were given 6% MoLM without antibiotics. Birds on T4 were given 9% MoLM without antibiotics. Birds on T5 were given 3% MoLM with antibiotic (Keproceryl-wsp) through drinking water. Birds on T6 were given 6% MoLM and an antibiotic (Keproceryl-wsp) was offered through water. Birds on T7 were also given 9% MoLM with antibiotics through their drinking water.

Productive performance, carcass characteristics and blood parameters were measured. The results showed that, treatment effect on average final body weight, average daily

gain, total feed intake, feed conversion ratio were not significant ($p>0.05$). However Birds fed on MoLM gained higher average final body weight and superior feed conversion ratio than birds fed the control diet. However, birds fed on 3% MoLM diet with or without antibiotics showed heaviest final body weight. Inclusion of MoLM up to 3% (with or without antibiotics) in broiler diets significantly ($p<0.05$) improved live weight, Carcass weight, intestine weight, liver weight, heart, neck shank, head, breast, thigh and abdominal fat weights of the birds. 3% MoLM with or without the use of antibiotics improves the blood parameters of birds. 3% MoLM inclusion level with or without antibiotics had no adverse effect on broiler performance.



LIST OF ABBREVIATIONS

ADFI	Average Daily Feed Intake
ADG	Average Daily Gain
ALT	Alanine Aminotransferase
ANOVA	Analysis of Variance
AOAC	Association of Official Analytical Chemist
AST	Aspartate Aminotransferase
CF	Crude Fibre
CP	Crude Protein
DM	Dry Matter
EDTA	Ethylene Diamine Tetra Acetic Acid
EE	Ether Extract
FAO	Food and Agriculture Organization
FBW	Final Body Weight
FCE	Feed Conversion Efficiency
FCR	Feed Conversion Ratio
fl	Femtoliters
g	Gram
g/dL	Gram per deciliter
GIT	Gastro Intestinal Tract
HDL	High Density Lipoprotein
HGB	Haemoglobin
Kg	Kilogram
LDL	Low Density Lipoprotein
LIPREC	Livestock and Poultry Research Centre
MCH	Mean Cell Haemoglobin
MCHC	Mean Cell Haemoglobin Concentration

MCV	Mean Cell Volume
ME	Metabolizable Energy
MoLM	Moringa Leaf Meal
NRC	National Research Council
PCV	Packed Cell Volume
pg	Picogram
RBC	Red Blood Cell
SBM	Soya Bean Meal
WBC	White Blood Cell
WHO	World Health Organisation



CHAPTER ONE

INTRODUCTION

1.1 Background of the study

A well formulated diet adequate in all nutrients including protein is essential for normal growth and physiological function of poultry (Onu, 2011). This is done by carefully balancing the nutrients involved and taking into account the physiological state of the bird (Onu, 2011).

Soyabean meal and fish meal have been widely and successfully used as conventional protein sources for livestock production (Aniebo, 2013). However, the prices of these protein sources have been escalating continuously in recent times, whilst availability is often erratic. The problem has been worsened by the increasing competition between humans (demands for soybean) and livestock for these protein ingredients (Aniebo, 2013).

According to Odunsi, 2007, the rapid increases of human and livestock populations are creating increased needs for food in the less developed countries.

In low-income and countries facing food-shortages, surplus of cereals and legumes are usually not available; therefore, it is not prudent to practice a wholly grain-based system of feeding. This demands that substitute feed ingredient must be recognized and used (Odunsi, 2007).

The recommended policy is to identify and use locally available feed resources to formulate diets that are as balanced as possible (Kakengi *et al.*, 2007). There is the need, therefore, to explore the use of non-conventional feed sources that have the capacity to yield the same output as conventional feeds, and perhaps at cheaper cost. Hence, any similar high protein ingredient which could partially or completely be used as a substitute for soyabean meal or fishmeal is desirable (Gadzirayi, 2012).

The economization of feed cost using cheaper and unconventional feed resources is an important aspect of commercial poultry production (Muriu *et al.*, 2002). This strategy could help to reduce the cost of production, and ensure cheaper meat production thereby freeing up the major crops for human consumption (Olugbemi, 2010).

One possible source of cheap protein is the leaf meals of some tropical legume browse plants. Leaf meals do not only provide protein, but also some essential vitamins such as vitamins A and C, minerals, etc. (Gadzirayo, 2012).

The consumption of moringa (*Moringa oleifera*) as a protein source for poultry farming has been recently of high interest (Akangbe, 2014; Ologhobo, 2014). Moringa leaves have quality attributes that makes it a potential replacement for soyabean meal or fish meal in non-ruminant diets (Kakengi, 2003).

Moringa oleifera is one of the elevated nourishing browse plants with all parts been of food importance (Gadzirayi, 2012) and medicinal properties (Patel, 2011) which could help cut down on antibiotic use in poultry keeping.

Poultry diets normally contain antibiotics designed to promote production or prevent diseases (Ologhobo *et al.*, 2014).

Antibiotics are non-nutritive feed ingredients that are added to feed at high therapeutic levels (disease treatment) or low sub therapeutic levels (growth promotion) or antibiotics are man-made or semi-artificial composite with antimicrobial action which can be orally given and are used in veterinary and human medicine to avoid and/or treat diseases and also for additional reasons comprising performance or growth improvement in meat livestock (Phillips *et al.*, 2004). These non-nutritive feed ingredients (antibiotics) have repercussions on human health.

Medication of water using antibiotics helps birds to recover from certain diseases of bacterial origin. However, there may be problems associated with the use of antibiotics such as drugs toxicity, residual effects and microbial resistance (Puvaca *et al.*, 2013).

The negative impact on consumers of meat or poultry products due to residual effects has also raised some concern. This has led to the ban on the use of antibiotics as growth promoters since 2006 by the European Union (Puvaca *et al.*, 2013).

According to the World Health Organisation (WHO, 2009) feeding certain antibiotics for production purposes (i.e growth promotion or increased feed efficiency) is a public health problem.

The surfacing of pathogens becoming resistant to antibiotics has demanded the search for cheaply variable substitutes to standard antibiotics. These alternatives include prebiotics, phytogetic additives, organic acids and their salts and probiotics. The phytogetic additives in animal nutrition have attracted attention for their potential role as alternatives to antibiotic growth promoters. They have been shown to activate digestion, strengthen the immune system and have bactericidal properties (Puvaca *et al.*, 2013).

The use of modern antibiotics as growth promoters, as well as for disease prevention and treatment is becoming unaffordable in developing countries. The use of affordable alternative plant materials that possess medicinal properties which can replace the expensive modern antibiotics in developing countries then becomes a necessity. The nutritional and medicinal property of *Moringa oleifera* leaves suggest it as a good option for the replacement. There is little information available on MoLM use as substitute replacement for antibiotics in poultry feed (Ologhobo *et al.*, 2014).

1.2 HYPOTHESIS

- Feeding Moringa Leaf Meal (MoLM) to broilers will not affect performance or cost.
- Feeding MoLM to broilers will not negatively affect the blood profile (blood haematological and biochemical indices).
- The health of birds fed on added antibiotics will not be better than those fed on MoLM.

1.3 OBJECTIVES OF THE STUDY

The objectives of the study are to:

- Assess the value of MoLM as
 - part replacement for soyabean meal and
 - total replacement for antibiotics in broiler diets.
- Assess the performance of broilers fed on diets containing varying levels of MoLM.
- Determine the carcass and blood haematological and biochemical indices of the broilers fed varying levels of the MoLM.
- To determine the efficacy of moringa and standard antibiotics in reducing mortality in birds.

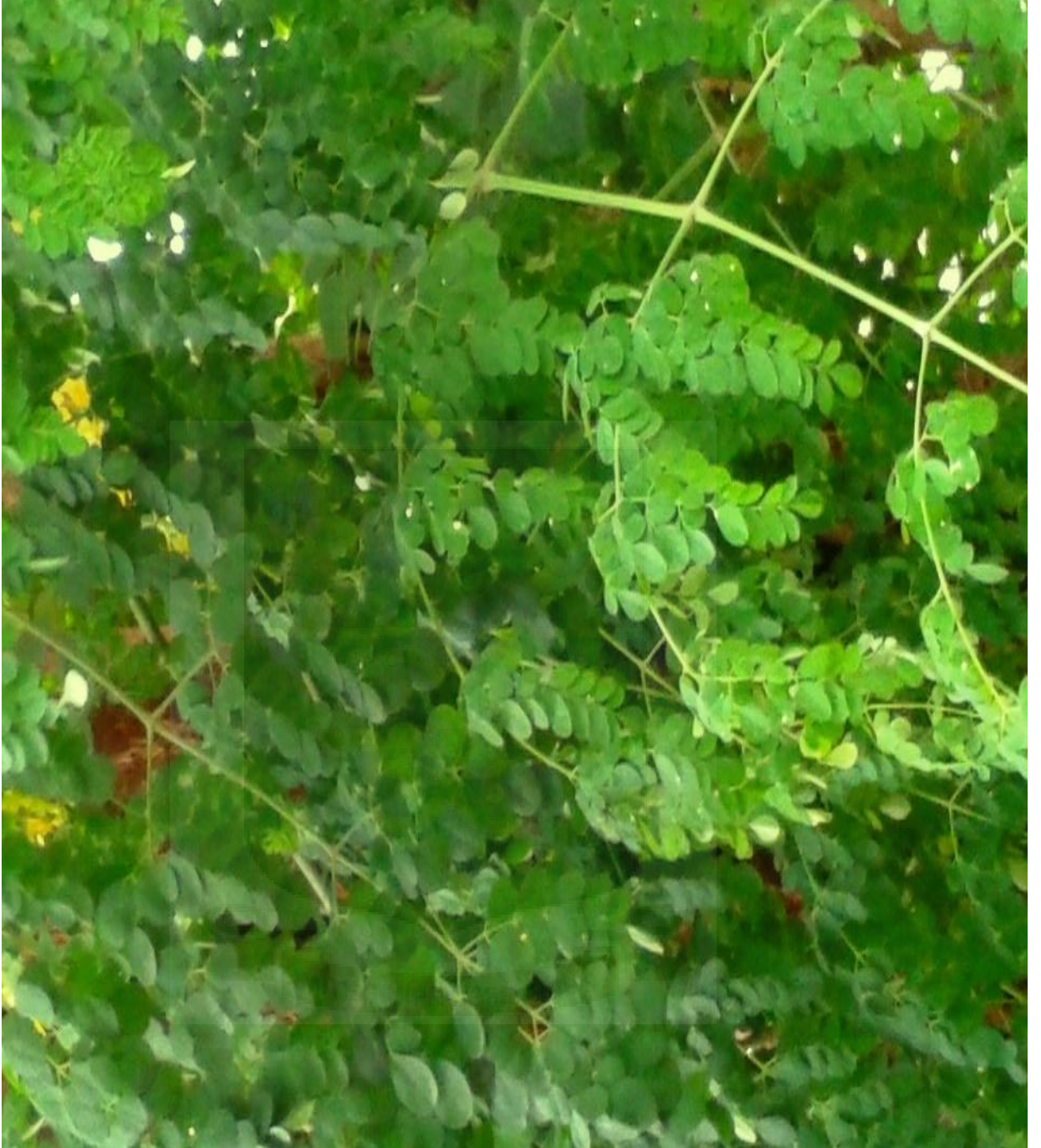


Plate 1: *Moringa oleifera* plant

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Importance of poultry production

The group name specified to a collection of domesticated birds raised or kept for valuable purposes (for meat, eggs, feather production, entertainment and cultural purposes) is termed poultry (Aja, 2007). Poultry production is undertaken in a multitude of ways, utilizing different sets of resources, in a wide spectrum of socio-cultural and economic conditions. Major poultry species kept include chicken, ducks, guinea fowls, turkeys, pigeons, quails, and ostrich of which chicken dominate the industry (Chukwu, 2010).

The poultry industry plays important roles in supplementing protein requirement needed by man. Poultry is the fastest source of meat and its production process is least hazardous and arduous in relation to other livestock enterprises. Hence, increasing poultry production is one of the surest and quickest ways of bridging the animal protein intake gap between developing and developed countries of the world (FAO, 2009).

Although the task of bridging this protein intake gap appears formidable in view of the present economic and technological constraints besetting our livestock industry, emphasis is on broiler production which is the key to bridging the protein intake gap (El Boushy and Vanderpoel, 2000).

Poultry keeping in Ghana happened to be one of the major sources of providing protein derived from animal to the ever-growing Ghanaian populace, making important input to economic improvement and human nutrition.

Producing poultry in Ghana plays extremely vital roles for humanity through, income and employment generation, food provision, providing raw materials to some industries, facilitating research works etc. (Chukwu, 2010).

2.2 Challenges facing the poultry industry

Despite the benefits obtained in poultry production, Ghana's poultry industry is facing a lot of challenges. These challenges tend to affect the production of poultry meat. Some of the challenges include: lack of capital, disease outbreaks (eg. Avian influenza), inadequate skilled labour, marketing problems, challenges in importation of poultry products, access to flexible loans and high feed cost due to competition with humans (Tagoe *et al.*, 2012).

2.2.1 Addressing the Problem of High Feed Cost in poultry production

Cost of feed however, forms about 70 to 80 percent of the production costs of intensively reared livestock. This problem is further worsened by the competition between man and animals over cereals and grains, resulting in the high costs of these ingredients (Ashitey, 2008; Aviagen, 2009).

Feed producers are faced with the task of finding alternative feedstuffs without compromising quality. There is every indication that when properly processed, and diets well formulated and balanced, moringa leaf meal (MoLM) can effectively replace part of those conventional feed ingredients (such as maize, soybean meal) used in rations for broiler birds (Chauynarong *et al.*, 2009).

According to Esonu (2001), the bulk of the feed cost arises from protein concentrates such as groundnut cake, fishmeal and soybean meal. The costs of these conventional protein ingredients have been increasing endlessly in recent times, whilst availability is often inconsistent (Aniebo, 2013).

Poultry farming must progress together with resourceful methods of integrating less costly and easily accessible by-products. The use of agricultural by-products in poultry nutrition represents a valuable means of the indirect production of food from waste (El Boushy and Vanderpoel, 2000).

Soybean meal and fishmeal are conventional feed resource, which have been used as the sources of animal protein in diets of poultry in many countries including Ghana due to unavailability of cheaper alternative protein sources. With the present trend of rising prices of feedstuffs, considerable attention has been placed on the search for non-conventional feedstuffs, such as leaf meals (Esmail, 2002). With the elevated protein content of the MoLM (Moringa Leaf Meal) of 25.56% (Zanu *et al.*, 2012), 29.71% (Kakengi *et al.*, 2003), provides the basis to partially substitute soyabean meal or fishmeal in poultry diets (Fuglie, 2000).

2.3 Origin of Moringa

According to Kristin (2000), the common moringa species in the moringaceae family are thirteen in number and that *Moringa oleifera* happened to be the most widely cultivated species. These varieties include; *Moringa oleifera*, *Moringa borziana*, *Moringa concanensis*, *Moringa drouhardii*, *Moringa hildebrandtii*, *Moringa longituba*, *Moringa*

ovalifolia, *Moringa pygmaea*, *Moringa arborea*, *Moringa rivae*, *Moringa ruspoliana*, *Moringa stenopetala*, *Moringa peregrina* Kristin (2000).

Moringa oleifera originated from India in the North-West province, south of the Himalayan Mountains. It is currently extensively planted and has become established in the tropics (Fahey *et al.*, 2001).

Moringa oleifera is indigenous to Northern India and Pakistan and was introduced throughout the tropics and sub-tropics becoming naturalized in many African countries (Bosch, 2004).

2.3.1 Uses of *Moringa oleifera*

Several components of moringa are fit for human consumption, with local utilization varying widely. Juvenile seed pods, foliage, flowers, mature seeds are all edible (Peter, 2008).

The leaves are the most nutritious part of the plant, being a significant source of vitamin B, vitamin C, provitamin A as beta-carotene, vitamin K, manganese, and proteins, among other essential nutrients (Olsen and Hammack, 2001; Peter, 2008) are all edible.

The leaves of *Moringa oleifera* are widely utilized traditionally for its antimicrobial capabilities (Suarez *et al.*, 2005) and its pharmacological characteristics (Mehta *et al.*, 2003).

Also, moringa (*Moringa oleifera*) leaves had been used as a natural antioxidant for its antioxidant activity (Yang *et al.*, 2006). It contains high amounts of polyphenols (Sreelatha and Padma, 2009).

The seeds and leaves of moringa were analyzed by researchers and they found out that these parts of moringa helps in promoting the immune response and physiological and productive performance of birds (Abbas and Ahmed, 2012).

Moringa has the potential to boost food security, foster rural development, improve nutrition, and maintain sustainable land care in developing countries (National Research Council, 2006).

Moringa oleifera leaf powder was as effective as soap for hand washing when wetted in advance to enable anti-septic and detergent properties from phytochemicals in the leaves (Ndabigengesere and Narasiah, 1995).

Moringa seed cake, obtained as a by-product of pressing seeds to obtain oil, is used to filter water using flocculation to produce potable water for animal or human consumption (Ndabigengesere and Narasiah, 1995). Moringa seeds contain dimeric cationic proteins which absorb and neutralize colloidal charges in turbid water, causing the colloidal particles to clump together, making the suspended particles easier to remove as sludge by either settling or filtration. Moringa seed cake removes most impurities from water. This aspect is of particular interest for being non-toxic and sustainable compared to other materials in moringa-growing regions where drinking water is affected by pollutants (Hellsing *et al.*, 2013).

2.3.2 Nutritive value of *Moringa oleifera*

Moringa is known to contain at least 12 MJ/Kg of metabolizable energy, 23% crude protein, and have 79.7% digestibility (Becker, 1995). It also contains adequate amount of cystine, carotene, ascorbic acid, iron and methionine (Makkar and Becker, 1996).

Moringa oleifera leaves are packed with nutrients important both for humans and animals. A crude protein percentage of 25- 27% suggest that the leaves are good source of protein for livestock. The high proportion of this protein is available in the intestines (Makkar and Becker, 1997).

The low levels of anti-nutrients and the sufficient levels of important amino acids present in moringa indicate their nutritional value. The low acid detergent insoluble protein (1-2%) and high pepsin soluble nitrogen (82-90%) values for the leaf meal of moringa implies that majority of the protein content in the MoLM is accessible to most farm animals (Makkar and Becker, 1997).

Makkar and Becker, (1997), also concluded that the amino acid profile of *Moringa oleifera* leaves is comparable to that of soya bean meal.

In 2003, Kakengi and friends reported the proximate composition of MoLM as shown in the Table 1. Whiles in 2008, Oduro *et al.* also analyzed the content of moringa leaf meal and their findings are presented in Table 1.

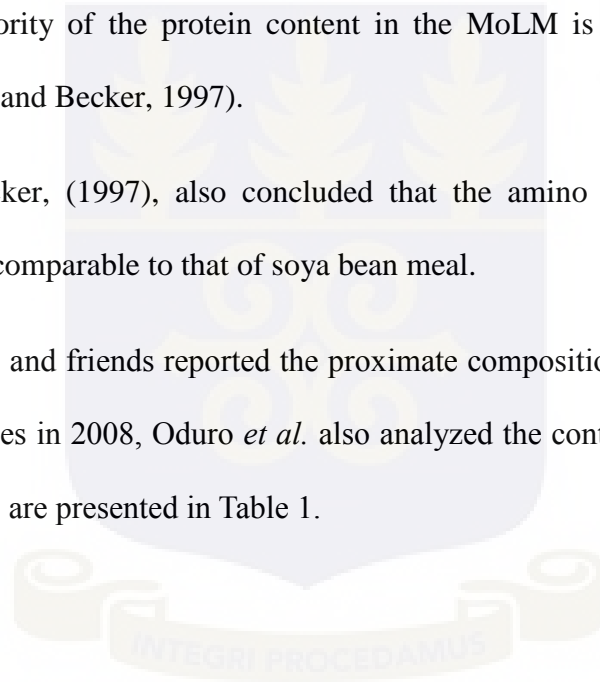


Table 1: Proximate composition of *Moringa oleifera*

Parameter	%	Reference
Dry matter (DM)	86	
Crude protein (CP)	29.71	
Crude fibre (CF)	22.5	Kakengi <i>et al.</i> (2003)
Ether Extract (EE)	4.38	
Calcium	27.9	
Phosphorus	0.26	
Dry matter (DM)	76.53	
Crude protein (CP)	27.51	
Crude fibre (CF)	19.25	Oduro <i>et al.</i> (2008)
Ether Extract (EE)	2.23	
Ash	7.13	

According to Kakengi *et al.* (2003), *Moringa oleifera* leaf meal do not only serve as protein sources but also provide some necessary vitamins, minerals and also oxycarotenoids which causes yellow colour of broiler skin, shank and egg yolk.

Table 2 and 3 shows the nutritional value of the various parts of *Moringa oleifera* plant:

Table 2: Nutritional value per 100 g of *Moringa oleifera* leaf (Nutritional value per 100g)

CONTENT	VALUE
Energy	64 kcal (270 kJ)
Carbohydrates	8.28g
Dietary fiber	2.0g
Fat	1.40g
Protein	9.40g
Vitamins	
Vitamin A equiv.	378µg
Thiamine (B)	0.257mg
Riboflavin (B)	0.660mg
Niacin (B)	2.220mg
Pantothenic acid (B)	0.125mg
Vitamin B	1.200mg
Folate (B)	40µg
Vitamin C	51.7mg
Minerals	
Calcium	185mg
Iron	4.00mg
Magnesium	147mg
Manganese	0.36mg
Phosphorus	112mg
Potassium	337mg
Sodium	9mg
Zinc	0.6mg
Other constituents	
Water	78.66 g

Source: USDA Nutrient Database (Units µg = micrograms • mg = milligrams IU = International units)

Table 3: Nutritional value per 100 g of *Moringa oleifera* pod.

Content	Value
Energy	37kcal
Carbohydrates	8.53g
Dietary fiber	3.2g
Fat	0.20g
Protein	2.10g
Vitamins	
Vitamin A equiv.	4 μ g
Thiamine (B)	0.0530mg
Riboflavin (B)	0.074mg
Niacin (B)	0.620mg
Pantothenic acid (B)	0.794mg
Vitamin B	0.120mg
Folate (B)	44 μ g
Vitamin C	141.0mg
Minerals	
Calcium	30mg
Iron	0.36mg
Magnesium	45mg
Manganese	0.259mg
Phosphorus	50mg
Potassium	461mg
Sodium	42mg
Zinc	0.45mg
Other constituents	
Water	88.20g

Source: USDA Nutrient Database (Units μ g = micrograms • mg = milligrams IU = International units)

2.3.3 Chemical composition of *Moringa oleifera*

Anti-nutritional elements are compounds primarily organic, which may inhibit normal feed consumption or hinder the physiological functioning of farm animals when present in their diet (Nityanand, 1997).

Nityanand, (1997), stated that anti-nutritional factors may occur as natural contents of plant and animal feeds or as artificial factors but come about during processing or as contaminants of the environment.

Chronic intoxication and interference with digestion and consumption of dietary protein and carbohydrate will occur when feed containing anti-nutritional factors is ingested, this will eventually interfere with the accessibility of some major minerals, hence hindering growth rate and feed conversion efficiency (Nityanand, 1997).

Mabalaha *et al.* (2007), reported that phytochemicals such as vanillin, omega fatty acids, and carotenoids, ascorbates, tocopherols, beta-sitosterol, moringine, kaempferol, and quercetin have been found in the flowers, roots, fruits, and seeds of moringa. The leaves, in particular, have been found to contain phenols and flavonoids (Gupta *et al.*, 1989; Mabalaha *et al.*, 2007) and some anti-nutritional elements such as oxalate, saponins, phytate and tannins. (Gupta *et al.*, 1989).

In 1997, Makkar and Becker indicated that Moringa leaves have negligible tannin; saponin content is similar to that present in soya bean meal, trypsin inhibitors and lectins were not detected.

In another study carried out by Gupta and Ramni, (2003), the authors suggested that, the total content of phenol in moringa is 2.7% and therefore at this level, this negligible amount of phenols do not initiate any harmful consequence when consumed by birds.

These compounds have various biological activities, including antioxidant, anticarcinogenic, immunomodulatory, anti-atherogenic, anti-diabetic and heat to protect the functions and the regulation of thyroid condition (Mehta, 2003).

Moreover, moringa leaves contain trace elements that are important to the wellbeing of human. For instance, magnesium, selenium, zinc and iron play a vital function in metabolism, and concern in these elements is rising together with reports connecting trace element status and oxidative diseases (Morton, 1991). Therefore, identifying the mineral make-up of *Moringa oleifera* foliage that is broadly utilized by animals and humans is necessary.

The phytochemicals content of the species of moringa gives the outlook to determine a variety of quite distinctive compounds (Fahey *et al.*, 2001). Interestingly, plants in the moringaceae family are rich in compounds containing the simple sugar, rhamnose and it is rich in a fairly unique group of compounds called glucosinolates and isothiocyanates (Fahey *et al.*, 2001; Bennett *et al.*, 2003).

Foidl and Paull (2001), reported that the pigments of flavonoid such as kaempferitrin, rhamnetin, quercetin, isoquercitrin and kaempferol were contained in the flowers of moringa.

In an experiment conducted by Siddhuraju and Becker (2003), reported that the flavonoids such as quercetin and kaempferol were identified as the most potent

antioxidants in moringa leaves. Their antioxidant activity was higher than the conventional antioxidants such as ascorbic acid, which is also present in large amounts in moringa leaves.

Research by Igwilo (2013), concluded that there is the presence of oxalates and phytates in *Moringa oleifera* roots by using the method of Munro and Bassir, (1996) and Griffiths and Thomas, (2001), respectively while tannins, saponins and cyanogenic glucosides were also determined in guiding principles of the methods of Association of Official Analytical Chemist (AOAC, 1984).

Makkar and Becker, (1988), also reported that tannins that are hydrolysable are possibly poisonous and could cause poisoning if enormous quantities of tannins from plant substances are consumed. They also stated that tannins can hinder the actions of valuable microbes in the rumen of non-monogastrics.

Saponins content in some plants have harmful effect on the development of animals but those present in moringa foliage manifested to be harmless and humans consumed them without any sign of damage. However, Cyanogenic glucosides and glucosinolates were not discovered in moringa foliage (Makkar and Becker, 1997).

2.3.4 *Moringa oleifera* as a natural antibiotic

Years ago, plants have been utilized as important resources of natural products for sustaining human and animal health. Nascimento *et al.* (2000), also reported that plants

contain large multiplicity of chemical materials that possess vital curative and defensive therapies.

The use of modern antibiotics as growth promoters, as well as for disease prevention and treatment is becoming unacceptable because of antibiotic resistance and unaffordable in developing countries (Ogbe, 2012).

Interest in plants with antimicrobial properties has received increased attention because of antimicrobial resistance. This resistance could be attributed to indiscriminate use of commercial drugs or not taking an antibiotic prescription according to the instruction, for example not taking all the prescription in the treatment of infectious diseases (Aliero and Afolayan, 2006).

Moreover, certain antibiotics present detrimental side effects such as depression of bone marrow, nausea, thrombocytopenic purpura and agranulocytosis (Marchese and Shito, 2001; Poole, 2001). This has given scientists the momentum to investigate for newer and substitute for anti-microbial compounds from therapeutic plants (Aliero and Afolayan, 2006).

The use of affordable alternative plant materials that possess medicinal properties which can be used to replace the expensive modern antibiotics in developing countries then becomes a necessity. Plant extracts and phytochemicals with antimicrobial properties are of great significance in therapeutic treatments. Their antimicrobial properties are due to compounds synthesized in the secondary metabolism of the plant. The screening of plant extracts and plant products for antimicrobial activity has shown that plants represent a potential source of novel antibiotic prototypes (Afolayan, 2003).

According to Ogbe, 2012, the dietary and medicinal characteristics of *Moringa oleifera* foliage and seeds suggest it as a good option for the replacement of antibiotics and soybean meal. Furthermore, the moringa plant has been discovered to contain some antimicrobial features such as pterygospermin (Lockett *et al.*, 2000; Anwar *et al.*, 2007).

The moringa seeds were found to contain a natural antibiotic that can be used to control or treat contaminations or infections. Pterygospermin for instance can be used to counteract the effects of a number of bacteria accountable for causing infections and also offers an anti-fungal effect (Anwar *et al.*, 2007). Though pterygospermin occurs naturally in moringa seeds, it typically does not carry the same high risk of allergic response as more highly processed antibiotics (Anwar *et al.*, 2007).

Additionally, a study conducted in 2007 by Chuang and Jones, identified that moringa seeds contain benzyl isothiocyanate. This compound is also a highly effective antibiotic and can be employed to treat bacterial infection, therefore, making moringa a valuable medicinal supplement in situations where bacteria may pose a danger to human and animal health (Chuang and Jones, 2007).

Work by Moyo *et al.* (2012), established that the acetone extract content of *Moringa oleifera* foliage shows antimicrobial effect against both Gram-negative and Gram-positive bacteria. The acetone extract of *Moringa oleifera*, however, demonstrated superior anti-bacterial action against Gram-negative bacteria than Gram-positive bacterial strains.

Acetone possess a better solvent-like feature than water that makes it possible to extract the active constituents from the foliage of *Moringa oleifera* (Eloff, 1998). *Moringa oleifera* also contains polyphenol and tannins which are soluble in acetone and have been reported to possess antibacterial actions (Makkar and Singh, 1992; Khosravi and Behzadi, 2006).

2.3.5 Effect of *Moringa oleifera* on performance of broilers

Zanu *et al.* (2012), reported that the mean body weight gain, final body weight (FBW), feed conversion efficiency significantly declined ($P < 0.05$) with the inclusion levels of 5%, 10%, 15% and 20% MoLM (Table 4). Olugbemi, (2010) also reported a decrease in weight gain and final weight with increasing the levels of MoLM in cassava based diets.

In the study conducted by Atuahene *et al.* (2008), FCE was highest for birds fed diets containing 750g/100kg moringa leaf meal and declined as the proportion of it in the diet decreased.

Naazie and Akoto (2011), reported that dietary supplementation of *Moringa oleifera* at 2.5%, 5% (with or without antibiotics inclusion) levels respectively has increase immune ability of broilers and hence the wellbeing of the birds recorded throughout their period of experimentation was influenced by the inclusion of MoLM in the diets.

Table 4: Effect of *Moringa oleifera* on performance of broilers

Value	Level of Dietary MoLM			
	0%	5%	10%	15%
Mean Initial body weight (g)	40±0.00 ^a	40±0.00 ^a	40±0.00 ^a	40±0.00 ^a
Mean Final Body Weight (g)	2173±23.76 ^a	1860± 1.00 ^a	1880± 43.00 ^a	1460± 90.00 ^b
Mean Total Body Weight Gain (g)	1913±37.12 ^a	1600±1.00 ^a	1620±50.33 ^a	1200±94.52 ^b
Mean Daily Weight Gain	46.33±0.67 ^a	39.33±2.67 ^b	39.66±1.33 ^b	29.27±2.27 ^c
Mean Feed Intake (g)	125.43±0.97 ^a	137.53±7.72 ^a	124.50±0.76 ^a	125.70±4.43 ^a
FCR (Feed/Gain)	2.67±0.07 ^a	3.53±0.12 ^b	3.17±0.07 ^b	4.33±0.18 ^c
Mortality (%)	0.00±0.00 ^a	2.22±2.22 ^a	0.00±0.00 ^a	2.22±2.23 ^a

Source: (Zanu *et al.*, 2012).

Table 5 summarizes the results obtained from a research conducted by Safa and Tazi, (2012).

Table 5: Performance of broiler chicks fed on different levels of *Moringa oleifera* leaf meal (MoLM).

Parameter	0% MoLM)	3% MoLM	5% MoLM	7% MoLM	SEM
Initial live weight (g/chick)	45.10 ^a	45.50 ^a	45.39 ^a	45.21 ^a	-
Final live weight (g/chick)	1742.0 ^c	1940.00 ^{ab}	1976.50 ^a	1873.00 ^b	46.50
Body weight gain (g/chick)	1696.90	1894.50 ^{ab}	1931.11 ^a	1827.79 ^b	43.20
Total feed intake (g/chick)	3480.00	3617.54 ^b	3669.10	3491.07 ^c	41.20
Feed conversion ratio	2.05 ^b	1.91 ^a	1.90 ^a	1.91 ^a	0.50
Mortality%	1.00 ^a	1.00 ^a	1.00 ^a	1.00 ^a	0.001 ^{NS}

Source: Safa and Tazi, (2012)

According to Kakengi *et al.* (2003), the inclusion of MOLM in diet of broilers significantly ($P < 0.05$) enhanced the weight gain as compared to control group. The improved weight gain of birds fed on MOLM based diets could be attributed to higher protein content of the diets which were efficiently metabolized for growth.

According to Safa and Tazi (2012), the birds fed diet that contained 5% MoLM obtained significantly ($P < 0.05$) higher weight gain compared to those fed on the diet that contained

7% MoLM. This may be credited to the high crude fibre content in the 7% MoLM diet which may hinder nutrient digestion and absorption.

Again Safa and Tazi (2012), observed in their study that the lower weight gain of birds fed on 7% MOLM diet despite its higher crude protein content might also be due to the negative effect of the anti-nutritional factors present in MoLM on the birds.

Every one kilogram of *Moringa oleifera* leaves contain 1-23g of tannin (Kakengi *et al.*, 2003). It has been stated that the biological consumption of protein can be interfered by the content of tannin in moringa leaves and to some extent interferes with the availability of lipids and carbohydrate (Safa and Tazi, 2012).

Safa and Tazi (2012), reported that the lower crude protein content of the control diet which has been inadequate to promote growth resulted in the decline weight gain of those birds on the control diet.

In the work of Safa and Tazi, (2012), the authors observed that the feed intake of the chickens among the treatments was significantly different and that intake significantly increased with the increasing level of moringa leaf meal. But there was a noticeable decline in the utilization of feed by the broilers given 7% moringa leaf meal diet (Safa and Tazi, 2012). Due to this Safa and Tazi (2012), explained that the declined trend observed could be that the palatability of the diet was not enough.

In the work of Safa and Tazi (2012), they stated that the significant development in the feed conversion ratio of the birds given diets containing moringa leaf meal compared to those birds on the control diet may be because the birds fed diets containing moringa leaf meal sufficiently used the nutrients they consumed.

2.3.6 Effect of *Moringa oleifera* leaf meal on blood haematological and blood biochemical parameters of broilers

Table 6 summarizes the work by Aderinola *et al.* (2013), they observed different serum and haematological characteristics of birds fed diets containing MoLM (0%, 0.5% MoLM, 1% MoLM, 1.5% MoLM and 2% MoLM). Their findings show that the mean PCV values were significantly different ($P < 0.05$) from each other and were in agreement with the results of Iheukwumere *et al.* (2008), who reported significant differences ($P < 0.05$) in the different inclusion levels.

The PCV values obtained in the studies of Aderinola *et al.* (2013) falls in the normal reference range of 24.9- 40.7% illustrated by Animashahun *et al.* (2006). This indicates that even though some amount of toxic factor is present in moringa leaf meal; it shows that all the treatment groups had nutritional adequacy (Church *et al.*, 2004).

PCV is an index of toxicity level of the blood or suggest the presence of a toxic factor which has adverse effect on blood formation or cause reduction in the percentage of red blood cells compared to the liquid component of blood (Oyawoye and Ogunkunle, 2008).

Olugbemi (2010), reported that Red Blood Cells (RBCs) are responsible for the transportation of oxygen and carbon dioxide in the blood as well as manufacture of haemoglobin hence higher values that are within the normal reference range indicate a greater potential for this function and a better state of health.

The values obtained for PCV in their study were within the normal range of (24.9-40.7%) described by Animashahun *et al.* (2006). Indicating that though there is presence of a toxic factor, but still all the treatment groups had nutritional adequacy, since values did not indicate mal-or under nutrition (Church *et al.*, 2004). This confirms that the inclusion of MOLM on broiler diet had little effect on the relative quantity of blood cells as compared with the total volume of blood (Health and Olusanya, 2005). The value of RBC and Hb begins to decline from T3. Reduction in the haemoglobin may be accompanied by a fall in the red cell count (RBC) and packed cell volume (haematocrit). The major function of the red blood cells is to transport haemoglobin, which in turn carries oxygen from the lungs to the tissues. The RBC values falls within the normal range of $(1.58-3.82 \times 10^6/\mu\text{L})$ described by Animashahun *et al.*, (2006). Reduced RBC is an indication that the oxygen carrying capacity of the animals' blood would be reduced. Hackbath *et al.* (1983) reported that increased RBC values were associated with high quality dietary protein and with disease free animals. The lower RBC could be as a result of the diminishing crude protein content in the broiler diets with inclusion MOLM content. Red Blood Cells (RBC) are responsible for the transportation of oxygen and carbon dioxide in the blood as well as manufacture of haemoglobin hence higher values indicate a greater potential for this function and a better state of health (Olugbemi, 2010). The study observed a significant ($P < 0.05$) difference in the WBC parameters among treatments with T5 (20% MOLM) having the highest value for WBC. This observation shows that the principal function of phagocytes, which is to defend against invading microorganisms by ingesting and destroying them, thus contributing to cellular inflammatory processes, was enhanced (Adedapo *et al.*, 2012) which may account for its

antibacterial activity (Fahey *et al.*, 2001). Thus enhancing the health condition of the experimental birds which was in line with Du *et al.* (2007) who reported that dietary supplementation of *Moringa oleifera* may increase immune ability of broilers. This was confirmed as no mortality was recorded in treatments that were fed with MoLM based diets. Serum biochemical indices, was significantly ($P < 0.05$) different with T5 having the highest values except total cholesterol and triglyceride. Triglycerides, total cholesterol and Urea in blood serum of broilers were significantly different ($P < 0.05$) among the groups. However, SGPT and SGOT values were not found in their study to be significantly ($P < 0.05$) different. The triglycerides value of the groups fed with 0% MoLM was the highest in their study. The cholesterol value of the group fed without MoLM diet were the highest. The low cholesterol and triglyceride content observed in the birds with MoLM would have been as a result of the hypocholesterolemic properties (Olugbemi, 2010) of MoLM included in the diets. It was observed that the cholesterol and triglyceride content decreased with increased MoLM inclusion, this may also be responsible for the low fat content observed in the meat. In other studies, animals fed diets rich in cholesterol or saturated fat had elevated carcass cholesterol and blood cholesterol levels (Blanch and Grashorn, 1995).

Table 6: Haematological and serum indices of Broiler Chicks fed *Moringa oleifera* leaf meal based diet.

Parameters	0%	0.5%	1.0%	1.5%	2.0%	SEM
Haematology						
PCV (%)	37.20 ^a	36.20 ^b	34.20 ^c	31.80 ^d	31.10 ^e	0.26
RBC ($\times 10^3/\mu\text{L}$)	2.75 ^{ab}	2.93 ^b	2.63 ^b	2.38 ^c	2.37 ^c	0.38
HB (g/dL)	14.10 ^a	14.20 ^b	13.20 ^c	12.60 ^c	11.80 ^e	0.11
WBC ($\times 10^6/\mu\text{L}$)	169.60 ^a	175.80 ^d	179.70 ^c	184.10 ^b	185.00 ^a	5.40
MCH	30.00 ^a	48.40 ^d	50.10	52.90 ^a	49.70	0.20
MCHC (mmol/L)	39.20 ^b	39.20 ^b	38.50 ^c	39.60 ^a	37.90 ^d	0.07
Serum						
Ttl Protein (g/L)	37.00	39.00	41.00	45.00	49.00	0.98
Albumin (g/L)	20.00	17.00	19.00	25.00	28.00	0.93
Globulin (g/L)	17.00	22.00	27.00	20.00	21.00	0.89
Ttl CHLT (mmol/L)	3.00 ^a	2.90 ^b	2.30 ^c	2.20 ^d	1.70 ^e	0.11
Triglyceride (mg/dL)	1.65 ^a	1.12 ^b	0.13 ^d	0.31 ^c	0.07 ^e	0.14
Urea (mmol/L)	5.00 ^e	7.00 ^d	7.10 ^c	7.20 ^b	9.70 ^a	0.34
SGPT (iU/L)	134.00	141.00	164.00	86.00	194.00	8.19
SGOT (iU/L)	92.00	115.00	127.00	72.00	164.00	7.16

(Aderinola *et al.*, 2013) Means of different superscript in the same row are significantly (P<0.05) different

AbouSekken, (2015) conducted a research on the Effect of feeding different levels of *Moringa oleifera* leaves meal (MLM) and its extract on blood plasma biochemical parameters are presented in Table 7. Data showed that *Moringa oleifera* extract groups (T5 and T6) were significantly ($p < 0.05$) higher in antioxidant capacity (0.86 mmol/l) meanwhile, birds of positive control (T1) was the worst one recorded in their work. Also, *Moringa oleifera* extract groups (T5 and T6) achieved significantly ($P > 0.05$) the best values of total lipids (442.2 and 410.99 mg/dl); total cholesterol (167.95 and 159.87 mg/dl); HDL cholesterol (111.9 and 125.58 mg/dl) and LDL cholesterol (86.13 and 73.4 mg/dl) compared with control or powder groups (T1;T2;T3;T4) (Table 7). Similarly, T6 birds group achieved significantly ($p < 0.05$) the best values of alkaline phosphatase (164.62 mg/dl) and blood plasma glucose (312.93 mg/dl) compared with control or powder groups (T1; T2; T3 and T4) (Table 7). In this connection, Johnson (2004) detected that exogenous antioxidants from natural sources can improve the function of the endogenous antioxidant system which is responsible for preventing free radicals in the body. Also, Charoensin and Wongpoomchai (2012) reported that the aqueous extract of *Moringa oleifera* leaves contained polyphenols. Furthermore, there are some reports which claim that *Moringa oleifera* leaves are rich in polyphenols and flavonoids and have antioxidant activity (Luqman *et al.*, 2012).

Recently Charoensin (2014) reported that *Moringa oleifera* leaves extracted with methanol and dichloromethane also showed antioxidant activity. Olugbemi, (2010) investigated the potential of MoLM as a hypocholesterolemic agent that facilitate reductions of egg cholesterol content.

Blood plasma biochemical parameters of broilers fed MoLM or extract (Table 7) showed that birds on moringa extract groups (T₅ and T₆) were significantly higher ($p < 0.05$) in antioxidant capacity (0.86mmol/l) and they also observed that birds of positive control (T₁) was the least (AbouSekken, 2015). Olugbemi, (2010) also examined the prospective of MoLM as a hypocholesterolemic agent that promote reduction of cholesterol content of egg.



Table 7: The effects of feeding different levels of *Moringa oleifera* leaves meal (MoLM) and its extract on blood Plasma biochemical Parameters

Item	T ₁	T ₂	T ₃	T ₄	T ₅	T ₆
Antioxidant capacity (mmol/l)	0.48±0.01	0.72 ^b ±0.01	0.74±0.010 ^b	0.73 ^b ±0.01	0.86 ^a ±0.01	0.86 ^a ±0.01
Total lipids (mg/dl)	600.47 ±40.27	576.78 ^a ±40.27	479.40 ^{ab} ±40.27	546.82 ^{ab} ±40.27	442.20 ^c ±40.27	410.99 ^c ±40.27
Total Cholesterol (mg/dl)	205.55 ^a ±3.66 ^a	192.21 ^b ±3.66	189.81 ^b ±3.66	190.60 ^b ±3.66	167.95 ±3.66	159.87 ^c ±3.66
HDL cholesterol (mg/dl)	87.83 ^c ±3.37	106.00 ^b ±3.37	95.38 ^c ±3.37	89.22 ±3.37	111.9 ^b ±3.37	125.58 ^a ±3.37
LDL cholesterol (mg/dl)	103.63 ^a ±5.95	102.07 ^a ±5.95	88.74 ^{ab} ±5.95	98.22 ^a ±5.95	86.13 ^{ab} ±5.95	73.40 ^b ±5.95
ALK. P (mg/dl)	161.19 ^{ab} ±1.29	155.36 ^d ±1.29	160.02 ^{bc} ±1.29	156.30 ^{cd} ±1.29	162.68 ^{ab} ±1.29	164.62 ^a ±1.29
Glucose (mg/dl)	285.56 ^{ab} ±9.14	258.05 ^{bc} ±9.14	177.69 ^d ±9.14	254.91 ^c ±9.14	281.75 ^{bc} ±9.14	312.93 ^a ±9.14
AST (μ/l)	90.67 ^{ab} ±8.75	70.67 ^{ab} ±8.75	81.00 ^{ab} ±8.75	83.67 ^{ab} ±8.75	67.00 ^b ±8.75	97.67 ^a ±8.75
ALT (μ/l)	25.0±1.87	25.00±1.87	19.00±1.87	24.67±1.87	22.67±1.87	19.00±1.87

(AbouSekken, 2015). Means of different superscript in the same row are significantly (P<0.05) different

Hassan and El-Moniary, (2015), conducted a research on the influence of varying levels of MoLM (0.1, 0.2 and 0.3%) on Carcass Characteristics, productive performance and blood indices (Plasma total protein, albumin and globulin) of birds kept under high temperature conditions shown in Table 9. It was observed in their study that the plasma total protein level was significantly increased as MoLM increased in the diet. The highest level was recorded for T4 and T3 (4.44 g/dL and 4.42, respectively) with no significant differences between them, followed by T2 (4.11), while the lowest level was recorded for the control group T1 (3.91) (Hassan and El-Moniary, 2015).

Levels of the plasma albumin were insignificantly ($P>0.05$) increased with the increased levels of moringa leaf meal in the experimental diet. However, plasma globulin level was also higher which may specify improved immune response of chickens.

It is hypothesized that plasma protein outline of a given bird is an indication of the metabolic actions associated to protein production and/or degradation. Since stress situations could arouse the adrenal gland cortex for corticosterone secretion, which caused a substantial increase in protein catabolism due to its gluconeogenic action (Hassan and El-Moniary, 2015).

Findings in the experiment conducted by Hassan and El-Moniary, (2015), show that increasing the inclusion levels of moringa leaf meal in the diet considerably increase the plasma total protein which is in line with the findings of Teye, (2003).

Melesse *et al.* (2013), suggested that increase in total proteins in birds fed the moringa leaf meal diet might reflect a more intensive metabolism of the proteins in the birds's organ.

Sherwin *et al.* (2003), reported that liver contain enzymes like ALT and AST; it releases these enzymes in the blood when damaged. Elevation of serum AST and ALT can occur with states of altered hepatocellular membrane permeability either due to circulatory hypoxia, exposure to toxins and toxemia, inflammation, metabolic disorders or proliferation of the hepatocyte (Rani *et al.*, 2011).

An increase in the activities of AST and ALT of the birds could be linked to intestinal and liver damage (Rani *et al.*, 2011).

The level of aspartate aminotransferase enzyme reported by Hassan and El-Moniary (2015), was decreased significantly in the plasma with the addition of MoLM in the bird's diet. However, the level of alanine aminotransferase enzyme (ALT) was not significantly affected by moringa leaf meal inclusion. Hence, this shows the normal liver and intestinal functions of the birds given varying levels of MoLM in the diets during heat stress circumstance (Hassan and El-Moniary, 2015).

Melesse *et al.* (2013) and Olugbemi (2010), explained that *Moringa oleifera* leaves enhanced the immune responses and improved intestinal health of broilers and this could reflect a protective influence of MoLM supplementation on liver tissues.

Triiodothyronine is an active metabolic thyroid hormone, which perform a vital function in metabolic rate and energy metabolism. Any prominent modification in thyroid role (hypothyroidism or hyperthyroidism) is discovered in modification of metabolic rate. Geraert *et al.* (1996), explained that the importance of the thyroid hormone in the physiological adaptation to heat stress is related to their role in regulation of metabolic

processes in birds, correspondingly the thyroid hormone output is depressed as the ambient temperature increased.

The increased Triiodothyronine level of birds on moringa leaf meal could be due to the high antioxidant content especially vitamin C which is able to lessen the harmful outcome of heat stress and also to improve the physiological responses of the birds to triumph over heat stress (Hayashi, 1993). Vitamin C Supplementation to the diets of birds under high temperature condition consequently increases serum content (Hayashi, 1993; Hemid *et al.*, 2013).

Growth and protein turnover are influenced by thyroid hormones. Therefore, a decrease in Triiodothyronine production leads to growth retardation and a decrease in protein turnover (Hayashi, 1993).

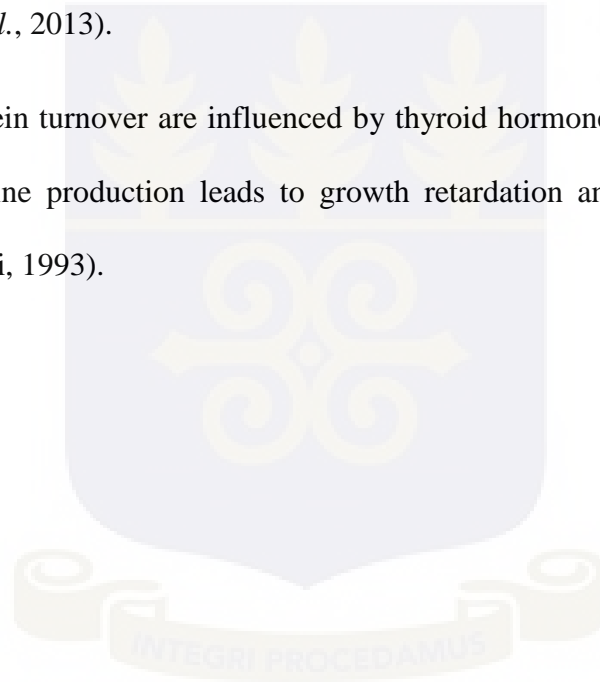


Table 8: Normal Reference Values for Blood Haematological and Biochemical Parameters

Parameter	Normal Reference Range	Parameter	Normal Reference Range
RBC ($\times 10^{12}/L$)	1.85-3.5	Total protein (g/L)	3.0-4.9
HGB (g/dl)	9.27-13.00	Albumin (g/L)	2.6-3.58
PCV (%)	22.0-35.0%	Glucose (mmol/L)	117-299
MCV (fl)	90.0-140.0	Cholesterol (mmol/L)	2.0-4.5
MCH (pg)	33.0-47.0	Triglycerides (mmol/l)	0.55-0.92
MCHC (g/dl)	26.0-35.0	HDL (mmol/L)	1.5-1.9
WBC ($\times 10^9/L$)	20.5-56.0	LDL (mmol/L)	1.3-2.6
Lymphocyte	45.0-70.0		

Source: Cynthia *et al.* (2010)

Aengwanich *et al.* (2004)

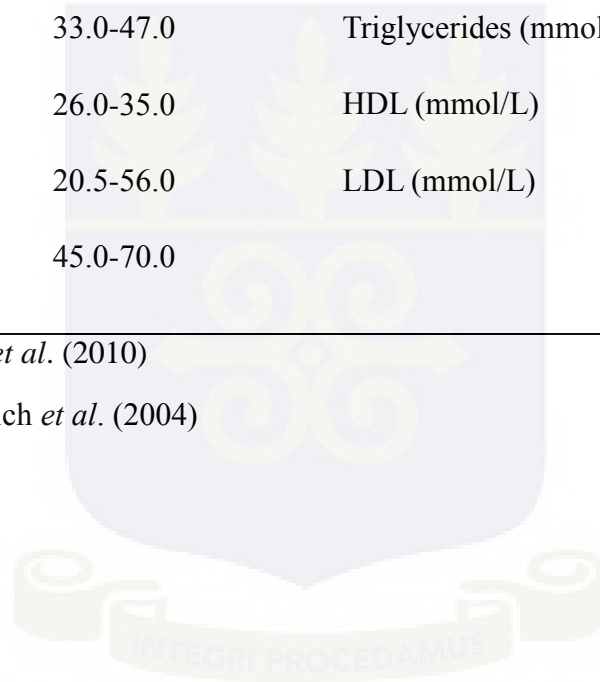


Table 9: Plasma protein fractions and Plasma aminotransferase activity and thyroid hormones levels of broiler chicks fed various levels of *Moringa oleifera* leaves meal under heat stress condition.

Items	Treatment				Significance
	T1	T2	T3	T4	
Total protein (g dLG ¹)	3.91±0.04 ^b	4.11±0.23 ^{ab}	4.42±0.03 ^a	4.44±0.01 ^a	**
Albumin(g dLG ¹)	1.75±0.01	1.76±0.04	1.77±0.01	1.80±0.03	NS
Globulin(g dLG ¹)	2.16±0.05 ^b	2.35±0.21 ^{ab}	2.65±0.02 ^a	2.64±0.03 ^a	
AST (U LG ¹)	197.300±1.45 ^a	159.300±4.37 ^b	142.600±1.76 ^c	139.300±1.76 ^c	**
ALT (U LG ¹)	11.000±0.57	10.000±0.57	11.000±0.57	10.330±0.66	NS
T ₃ (ng dLG ¹)	3.550±0.34 ^b	4.250±0.03 ^{ab}	4.680±0.24 ^a	4.350±0.18 ^a	**
T ₄ (ng dLG ¹)	18.000±0.31 ^c	19.480±0.46 ^c	25.510±0.86 ^a	22.700±0.56 ^b	**
T ₃ /T ₄ ratio	0.197±0.02	0.218±0.01	0.184±0.01	0.191±0.01	NS

(Hassan and El-Moniary, 2015) Means within rows with no common superscripts differ significantly, p<0.01, NS: Non-significant.

2.3.7 Effect of *Moringa oleifera* on carcass characteristics of broilers

Aderinola *et al.* (2013), conducted an experiment on the utilization of *Moringa oleifera* leaf as feed supplement in broiler diet. They observed the effect of *Moringa oleifera* on the carcass characteristics of the birds (Table 10).

Their results indicated that live weights, breast, thigh, drumstick and shank were highest at the inclusion levels of 2.0% MoLM.

The carcass weight was the highest at 0.5% MoLM inclusion and lowest at control while 1.0% MoLM and 1.5% MoLM were significantly similar to each other (Aderinola *et al.*, 2013).

Blanch and Grashorn (1995), Naazie and Akoto (2011), Zanu *et al.* (2012), observed yellow coloration of the bird's body parts such as beak and shanks when moringa leaf meal was fed to broilers. This could be credited to the presence of carotenoid and xanthophylls pigments in MoLM.

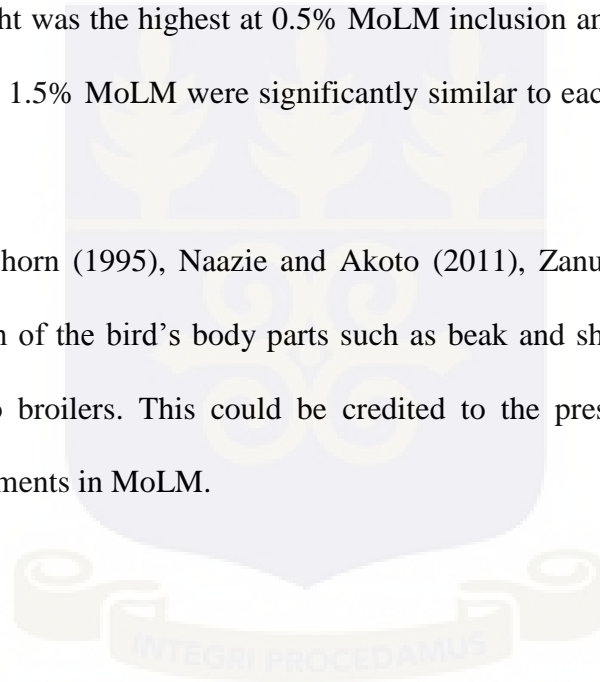


Table 10: Carcass/Primal Cuts and Organ Characteristics of broiler birds fed *Moringa oleifera* leaf meal based diets

Parameters	0%	0.5%	1.0%	1.5%	2.0%	SEM
Live weight	1767.00 ^a	1463.67 ^{bc}	1550.33 ^b	1378.67 ^c	1845.00 ^a	31.25
Carcass weight	1265.67 ^a	1009.00 ^c	1107.00 ^b	1122.00 ^b	1242.33 ^a	17.55
Carcass						
Breast	23.32 ^{ab}	23.74 ^{ab}	21.07 ^c	22.27 ^{bc}	24.11 ^a	0.26
Wings	11.74 ^a	11.61 ^a	12.16 ^a	10.19 ^b	11.68 ^a	0.10
Thigh	13.84	14.18	14.33	14.56	14.57	0.11
Drumstick	14.04 ^a	14.14 ^{ab}	13.48 ^b	13.29 ^b	14.94 ^a	0.15
Back	18.29 ^b	19.43 ^{ab}	20.07 ^a	20.00 ^{ab}	19.86 ^{ab}	0.26
Neck	6.47 ^b	5.96 ^c	7.00 ^a	6.51 ^b	6.76 ^{ab}	0.81
Head	4.65	5.24	4.70	5.02	5.06	0.09
Shank	7.44 ^b	7.23 ^b	7.16 ^b	7.33 ^b	7.95 ^a	0.85
Abdominal fat	1.26 ^a	0.79 ^b	0.69 ^c	0.48 ^c	0.58 ^c	0.60
Organs						
Liver	2.34 ^b	2.43 ^b	2.55 ^b	3.16 ^a	2.62 ^b	0.06
Lungs	0.59	0.58	0.61	0.64	0.58	0.02
Kidney	0.42 ^b	0.43 ^b	0.52 ^{ab}	0.57 ^b	0.58 ^b	0.02
Spleen	0.11 ^b	0.11 ^b	0.15 ^a	0.13 ^b	0.72 ^c	0.01
Gizzard	3.65 ^b	4.06 ^b	3.66 ^b	4.70 ^a	3.65 ^b	0.09
Proventriculus	0.56	0.53	0.61	0.65	0.58	0.03

Source: (Aderinola *et al.*, 2013)Means in the same row with different superscripts are significantly ($P < 0.05$) different.

2.4 The digestive tract of poultry

The tremendous amounts of feed handled by commercial poultry breeds require an optimally functioning digestive tract (Bradhey, 1990; Birger, 2014).

The digestive system in the domestic fowl is very simple but efficient when compared to many other species, such as cattle (Bradhey, 1990; Dingle, 1990).

According to Bradhey (1990), in the process of evolution, those avian species that developed simple but effective digestive systems were more able to fly and hence survive, as the simple digestive system would be lighter in weight. It is necessary that the diet provided to fowls be of high quality and easily digestible due to the simplicity in the structure and function of their digestive system.

The digestive system consists of the alimentary canal along which the food passes after eating to where the residual wastes are eliminated from the body, together with the liver and the pancreas (Nielsen, 2004).

The digestive system is responsible for the ingestion of food, its breakdown into its constituent nutrients and their absorption into the blood stream, and the elimination of wastes from that process (Bradhey, 1990; Nielsen, 2004).

The liver produces bile and is associated with the metabolism of nutrients together with a number of other functions. The main function of the pancreas is the production of digestive enzymes and special compounds called hormones (Svihus, 2010).

The alimentary canal is a long tube-like organ that starts at the beak and ends with the vent or cloaca in the abdominal region. Generally, the alimentary canal has layers of muscle that run lengthwise and around it and is lined with mucous membranes. Glands that produce important digestive juices are found in different locations of the canal (Jackson and Duke, 1995).

The wall of the alimentary canal absorbed the nutrients from the food, after it has been digested, then pass the nutrients into the circulatory system for transport to the liver or other parts of the body. Then the cloaca or vent helps to eliminate the remaining waste from the body (Chaplin *et al.*, 1992).

2.5 The standard antibiotic and benefits

Antibiotics are large group of chemical substances, such as penicillin or streptomycin, produced by various microorganisms and fungi, having the capacity in dilute solutions to inhibit the growth of or to destroy bacteria and other microorganisms, used chiefly in the treatment of infectious diseases (McDonald *et al.*, 1997).

They are widely used for the prevention, control and treatment of diseases and infections.

Antibiotics have been used in animal feed for about 50 years ever since the discovery not only as an anti-microbial agent, but also as a growth-promoting agent and improvement in performance (McDonald *et al.*, 1997).

Currently, the following antibiotics are used in livestock and poultry feed: chlortetracycline, procaine penicillin, oxytetracycline, tylosin, bacitracin, neomycin sulfate, streptomycin, erythromycin, linomycin, oleandomycin, virginamycin, and

bambermycins. In addition to these antibiotics, which are of microbial origin, there are other chemically synthesized antimicrobial agents that are also sometimes used in animal feeds (McEwen and Fedorka-Cray, 2002).

These include three major classes of compounds: arsenical, nito-furan, and sulfa compounds. Arsenical compounds include arsanilic acid, 3-nitro-4-hydroxy phenylarsonic acid, and sodium arsanilate; nitro-furan compounds include furazolidone and nitro-furazone; sulfamethazine, sulfathiazole, and sulfaquinoxaline (McEwen and Fedorka-Cray, 2002; Collingnon *et al.*, 2009).

The benefits of antibiotics in animal feed include increasing efficiency and growth rate, treating clinically sick animals and preventing or reducing the incidence of infectious disease. By far the major use of antibiotics among these, however, is increased efficiency, thus, a more efficient conversion of feed to animal products, and an improved growth rate (McEwen and Fedorka-Cray, 2002).

In chicken feed, for example, tetracycline and penicillin show substantial improvement in egg production, feed efficiency and hatchability, but no significant effect on mortality. Chlorotetracycline, oxytetracyclin and penicillin also show an improved growth rate, but little effect on mortality. Antibiotics in animal feed, in general, are used regularly for increased efficiency and growth rate than to combat specific diseases (Collingnon *et al.*, 2009).

2.6 Risks of antibiotics in animal feed

After animals have been fed with antibiotics over a period of time, they retain the strains of bacteria which are resistant to antibiotics.

These bacteria proliferate in the animal. Through interaction, the resistant bacteria are transmitted to the other animals, thus forming a colonization of antibiotic resistant bacteria. The bacteria flourish in the intestinal flora of the animal, as well as, in the muscle. As a result, the faeces of the animal often contain the resistant bacteria. Transfer of the bacteria from animal to human is possible through many practices (Avorn *et al.*, 2010).

Along with the previous sources of contamination, humans can get infected by eating meat from animals with resistant bacteria. Even though cooking reduces the survival of the bacteria, some may still survive and infect the human (Kim *et al.*, 2005).

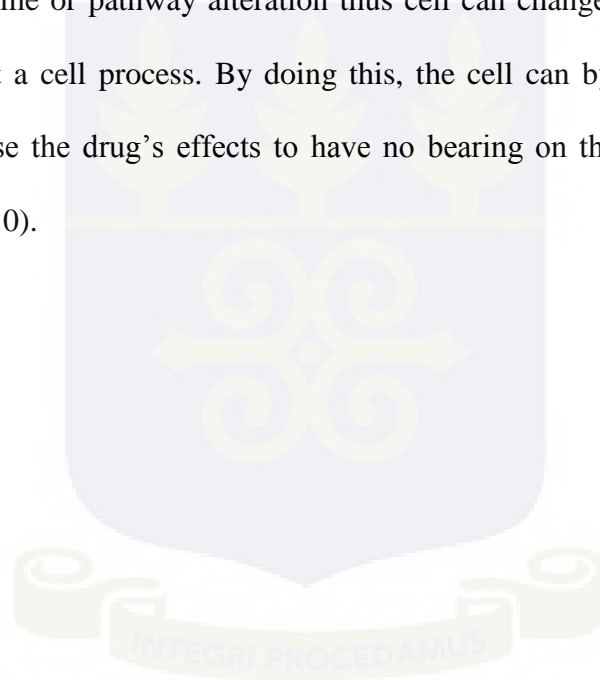
Garofalo *et al.* (2007), cited several general methods or mechanisms through which a bacterium cell can become resistance to an antibiotic. These mechanisms are: There is decreased cell permeability to the drug, thus the cell can change its membrane structure so that the drug cannot enter the cell and perform its function.

The cell alters the drug binding/recognition site by changing the structure of the membrane surface; the site which previously allowed the drug to bind to the cell can no longer do so.

There is a chemical modification of the antibiotic by cleaving a portion of the molecule or adding a substituent group, the properties of the active molecule in the antibiotic can be altered such that it is rendered harmless to the cell (Kim *et al.*, 2005).

There is an active transport system which ensures the transport of drug molecules out of the cell. In many cases, this is done via a drug/proton antiport system. With this mechanism, H⁺ ions are pumped into the cell as drug molecules are pumped out (Kim *et al.*, 2005).

There is an Enzyme or pathway alteration thus cell can change the pathway or enzyme used to carry out a cell process. By doing this, the cell can bypass the enzyme that is affected and cause the drug's effects to have no bearing on the functioning of the cell (Avorn *et al.*, 2010).



2.7 Nutritional requirements of broilers

The nutrient requirements of broilers are well known and are shown in the table below.

Table 11: Nutrient requirement of broilers as percentages or units per kilogram of diet (90 percent dry matter)

Nutrient	0 to 3 weeks	3 to 6 weeks	6 to 8 weeks
ME kcal/g	3,200	3,200	3,200
Crude protein %	23.00	20.00	18.00
Amino acids			
Arginine %	1.25	1.10	1.00
Glycine + serine %	1.25	1.14	0.97
Histidine %	0.35	0.32	0.27
Isoleucine %	0.80	0.73	0.62
Leucine %	1.20	1.09	0.93
Lysine %	1.10	1.00	0.85
Methionine %	0.50	0.38	0.32
Methionine + cysteine %	0.90	0.72	0.60
Phenylalanine %	0.72	0.65	0.56
Phenylalanine + tyrosine %	1.34	1.22	1.04
Proline %	0.60	0.55	0.46
Threonine %	0.80	0.74	0.68
Tryptophan %	0.20	0.18	0.16
Valine %	0.90	0.82	0.70
Fat			
Linoleic acid %	1.00	1.00	1.00
Macro-minerals			
Calcium %	1.00	0.90	0.80
Chlorine %	0.20	0.15	0.12
Magnesium (mg)	600	600	600
Non-phytate phosphorus %	0.45	0.35	0.30
Potassium %	0.30	0.30	0.30
Sodium %	0.20	0.15	0.12
Water soluble vitamins			
B ₁₂ (mg)	0.01	0.01	0.007
Biotin (mg)	0.15	0.15	0.12
Choline (mg)	1300	1000	750
Folacin (mg)	0.55	0.55	0.50
Niacin (mg)	35	30	25
Pantothenic acid (mg)	10	10	10
Pyridoxine (mg)	3.5	3.5	3.0

Source: (Nelson, 1994)

The problem of nutrient requirement of broilers has been to improve profit and product quality, necessitating the use of non-conventional feedstuffs. On a per unit basis, protein ingredients are the most expensive and so replacing them is paramount. One such unconventional feedstuff is *Moringa oleifera* (Ogbe, 2012).

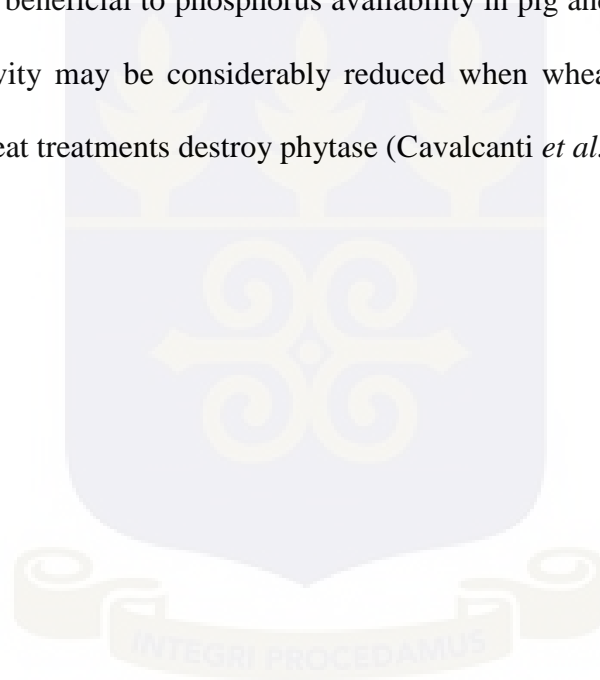
2.8 Wheat bran (WB)

Wheat bran, a by-product of the dry milling of common wheat (*Triticumaestivum* L.) into flour, is one of the major agro-industrial by-products used in animal feed. Wheat bran represents roughly 50% of wheat offals and about 10 to 19% of the kernel, depending on the variety and milling process (Ash *et al.*, 1992). Wheat bran is mainly fibre and as such is low in carbohydrate (Göhl, 2002). Protein, minerals, oil and fibre are mainly found in the outer layers of the grain, and wheat bran is richer in these nutrients than the whole grain.

Wheat bran is relatively rich in protein (14-19% DM, sometimes higher) and minerals (4-7% DM), notably calcium (0.07-0.2% DM) and phosphorus (0.9-1.3% DM). Its oil content (3-5% DM) is higher than that of the whole grain. However, a product marketed as bran should contain relatively high amounts of fibre: crude fibre 7-14% DM, NDF 35-54% DM, ADF 9-16% DM and low amounts of ADL 2-4% DM. Wheat bran should also contain about 15-30% DM of starch (Göhl, 2002).

Fibre is the main limitation for the utilization of wheat bran in animal nutrition, predominantly in monogastrics. For that reason, the energy values of wheat bran (DE, ME, NE) are always lower than those of the whole grain, in all animal species (Göhl, 2002).

Wheat bran also contains pentosans, which have antinutritional activities in birds and result in decrease nutrient utilization and poor growth. However, Bolton and Blair, 1974 explicitly stated that pentosans are digestible by poultry. Wheat bran has a high phytase activity, which is beneficial to phosphorus availability in pig and poultry diets. However, this phytase activity may be considerably reduced when wheat bran is processed into pellets because heat treatments destroy phytase (Cavalcanti *et al.*, 2004).



The table below shows the Crude protein and essential amino acids in Wheat bran (DM basis)

Table 12: Crude protein and essential amino acids in Wheat bran (DM basis)

Main analysis	Unit	Avg
Dry matter	% as fed	87.0
Crude protein	% DM	17.3
Crude fibre	% DM	10.4
NDF	% DM	45.2
ADF	% DM	13.4
Lignin	% DM	3.8
Ether extract	% DM	3.9
Ash	% DM	5.6
Starch (polarimetry)	% DM	23.1
Total sugars	% DM	7.2
Gross energy	MJ/kg DM	18.9
Minerals	Unit	Avg
Calcium	g/kg DM	1.4
Phosphorus	g/kg DM	11.1
Potassium	g/kg DM	13.7
Sodium	g/kg DM	0.1
Magnesium	g/kg DM	4.5
Manganese	mg/kg DM	114
Zinc	mg/kg DM	89
Copper	mg/kg DM	13
Iron	mg/kg DM	155
Amino acids	Unit	Avg
Alanine	% protein	4.6
Arginine	% protein	6.8
Aspartic acid	% protein	7.0
Cystine	% protein	2.1
Glutamic acid	% protein	19.0

Source: (Nelson, 1994)

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Experimental location and duration of study

The experiment was conducted between October 2016 to May, 2017 at the Livestock and Poultry Research Centre (LIPREC) of the College of Basic and Applied Sciences, University of Ghana, Legon. LIPREC is located about 8 km off the Legon-Aburi road from the 'Ritz junction' at Madina within the Coastal Savannah zone and on latitude 05^o40'N and longitude 00^o16'W. The annual rainfall is between 128-1709 mm and is distributed bimodally. The major rainy season spans between April and July and the minor rainy season occur from September to November. The mean monthly temperature is 26.9^oC. The area is covered by natural grassland of medium tussock growth with scattered fire-resistant trees and shrubs (Osei-Amponsah, 2010; GSS, 2014).

3.2 Source of birds

Broiler Day-old-chicks (Cobb 500) were imported from Belgium. In all, a total of 448 birds were used in the experiment. The birds were managed from day old to 8 weeks under the same housing and management practices.

3.3 Management, feeding and watering of birds

Moringa oleifera leaves were harvested from Akatsi in the Volta Region. The cut branches were de-leafed and the leaves were air dried under shade for a period of 3-4 days. The leaves were then milled to produce the leaf meal (MoLM). A two-stage feeding regime comprising a starter and finisher was used. For both feeding regimes, four diets

were formulated to be iso-nitrogenous, iso-caloric and containing 0% (control), 3%, 6% and 9% moringa leaf meal (MOLM) inclusion.

Table 13: Percentage Composition of Broiler Starter and finisher Diets

Ingredient	Starter				Finisher			
	MoLM 0%	MoLM 3%	MoLM 6%	MoLM 9%	MoLM 0%	MoLM 3%	MoLM 6%	MoLM 9%
MoLM	0	3	6	9	0	3	6	9
Maize	51	49	48	45.77	55	51.7	50	47.87
SBM	33.3	32.3	30.07	28.7	26.2	26.5	24.97	23.5
Tallow	4	4	4.2	4.8	5	5	5.2	5.8
Threonine	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Ca ₂ HPO ₄	2	2	2	2	2	2	2	2
Limestone	2	2	2	2	2	2	2	2
NaCl	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Lysine	0.2	0.2	0.23	0.23	0.3	0.3	0.33	0.33
Methionine	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Wheat bran	6	6	6	6	8	8	8	8
Premix	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Cost (GH¢)	1.92	1.91	1.89	1.85	1.90	1.91	1.89	1.85
Total	100	100	100	100	100	100	100	100

Table 14: Cost (GH¢) of Ingredients on per kilogram (Cost per Kg GH¢)

Ingredient	Weight of Ingredient per bag in Kg	Cost per bag GH¢	Cost per kg GH¢
Maize	50	62.00	1.24
SBM	50	120.00	2.40
Fat/Tallow	20	100.00	5.00
Ca(PO ₄) ₂	25	155.00	6.20
Limestone	50	18.00	0.36
NaCl	70	48.00	0.69
Lysine	25	225.00	9.00
Methionine	25	600.00	24.00
Wheat bran	25	15.00	0.60
Broiler premix	25	125.00	5.00
Moringa	40	30.00	0.75

Table 15: Calculated nutrient compositions of the various diets

	Starter				Finisher			
	0%	3%	6%	9%	0%	3%	6%	9%
Protein %	22	22.2	22.24	22.4	21.3	20.8	21.1	21.2
Energy (MJ/Kg ME)	11.9	11.92	12.1	12.1	13.1	13.08	13.2	13.3
Crude fat (%)	6	6.3	6.3	6.4	6.6	6.5	6.7	6.6
Fibre (%)	3	3.02	3.04	3.2	5	5.1	5.3	5.4
Lysine	1.3	1.3	1.3	1.32	1.2	1.2	1.21	1.2
Methionine	0.62	0.62	0.62	0.62	0.5	0.51	0.49	0.5
Calcium	1.4	1.4	1.42	1.4	1.2	1.2	1.21	1.2
Phosphorus (Total)	0.87	0.87	0.86	0.87	0.7	0.7	0.72	0.71
P. Available	0.5	0.5	0.5	0.5	0.45	0.44	0.45	0.44

Before the experiment commenced, all the day old chicks were given an anti-stress treatment of glucose, vitamins and minerals in water for the first 3 days, weighed in groups of sixteen and kept on deep litter in experimental pens of about 0.7m x 0.8m in floor area during the brooding stage. Sunlight was used as a source of light during the day and fluorescent bulbs were used to illuminate the pens at night and pots containing charcoal with fire were also used to provide birds with warmth. In the brooder house, deep litter management system was used in keeping the birds and wood shavings were used as litter materials to cover the floor.

Completely randomised design was used to assign the birds into 7 groups of which each contained 64 birds per treatment and 16 birds per replicate, thus four replicates each, this gives a total of 28 experimental units.

At the end of the fourth week, the birds were transferred into bamboo pens (Cage house) with dimension of about 2m (length) × 2m (breadth) × 1.5m (height). Birds in each replicate were group fed and water provided *ad libitum*.

The birds were given water and feed once daily in the morning. The amount of feed provided in each pen was weighed and the leftovers were weighed and the feed wasted was calculated (feed wasted= feed provided – feed leftover) the next day in order to determine the feed intake by the birds.

The experimental birds were fed with starter diets from the 1st week to the 4th week and from the 5th week to the 8th week the birds were fed with finisher diets.

3.4 Proximate analysis

Samples of the Moringa Leaf Meal (MoLM) were subjected to proximate analysis according to Association of Official Analytical Chemist (AOAC, 1984) to determine the Dry matter, Crude Protein, Crude fibre, Ether Extract (Fat) and Ash.

Table 16: Proximate Composition of Moringa Leaf Meal (MoLM)

Proximate fraction	%
Dry Matter	88.20
Crude protein	31.62
Crude fibre	11.45
Ash	14.95
Ether extract	10.92



3.5 Feeding and watering of birds (feeding management of birds)



Plate 2: Experimental birds eating experimental diet and drinking water containing antibiotic (keproceryl-wsp).

3.5.1 Prophylactic Measures Taken

The birds were given routine prophylaxis and vitamins and minerals via drinking water. In addition, those birds on treatment five, six and seven were given the antibiotics (Keproceryl-wsp) via drinking water.

Throughout the experiment, the proper medication programme was followed. The birds were vaccinated with the first and second Newcastle disease vaccines when they attained four and twenty days of age, they were also vaccinated against Gumboro at 14 days of age. Coccidiostat (Keptox) was provided in the second week and also during the sixth week.

3.6 Antibiotic used (Keproceryl-wsp)

Keproceryl-wsp is an effective antibiotic used throughout the experiment (used for experimental birds on treatment T5, T6, and T7) for the treatment of diseases caused by Gram-positive and Gram-negative bacterial like fowl cholera, CRD, infectious coryza, intestinal infections, pullorum, streptococcal and staphylocoecal infections, etc. it can be administered in case of vitamin deficiencies and stress in poultry, pigs, valves, sheep and goats.

3.7 Parameters Measured

Parameters determined were; Average Daily Feed intake, weekly weight gain, carcass characteristics such as breast weight, liver weight, thigh weight, neck weight, kidney weight, full gizzard weight, empty gizzard weight, full intestine weight, empty intestine

weight, head weight, shanks weight, heart weight, full proventriculus weight, empty proventriculus weight, dressing percentage and abdominal fat content.

Haematological parameters such as haemoglobin (Hb), Packed Cell Volume (PCV), Red Blood Cell (RBC), White Blood Cell (WBC), Lymphocytes, MCV, MCH and MCHC.

Blood biochemical parameters: total proteins, albumin, glucose, triglycerides, cholesterol, HDL-cholesterol, LDL-cholesterol.

3.8 Data collection procedures

From the beginning to the end of the entire experiment, feeds supplied and leftovers were recorded in each treatment's replicates using appropriate weighing scale. The differences between amount of feed given and the leftovers were used to calculate the feed intake of the birds.

The birds were also weighed every week ending throughout the eight-week experimental period. Which was used to calculate the weight gain.

3.9 Haematology and Serum Biochemistry Analysis

At the end of the 8th week, blood samples were collected from two birds each per replicate making a total of eight birds per treatment, and a total of 56 birds by inserting a new sterile needle into the wing vein of the birds and extracting 2 mls of blood which was placed inside sterile Vacutainer test tubes containing Ethylene Diamine Tetra Acetic Acid (EDTA).

The blood samples were shaken to mix with the EDTA in order to prevent coagulation. The samples were then analysed for Red Blood Cells (RBC), Packed Cell Volume/Haematocrit (PCV), Haemoglobin (Hb) and White Blood Cells (WBC), Mean

Corpuscular Volume (MCV), Mean Corpuscular haemoglobin (MCH) and Mean Corpuscular Haemoglobin Concentration (MCHC), using the Abbott Diagnostics Cell Dyn 3500 (Abbott Diagnostics, Abbott Park, IL) automated haematology analyzer. Again, blood samples were obtained from birds by the same procedure mentioned above and drawn into plain vacutainer tubes to determine the blood cholesterol, triglyceride, High-density Lipoprotein (HDL), Low-density Lipoprotein (LDL) levels, total protein, albumin and glucose. The blood samples were allowed to coagulate and after coagulation, blood samples were centrifuged and then serum was collected for analysis. Serum biochemistry was determined by using Cobas integral 400 plus chemistry analyser at Noguchi Memorial Institute for Medical Research, University of Ghana, Legon.

3.10 Carcass Features Evaluation

At the end of 8th week, the experimental birds were individually weight after overnight fast (except for water).

From each replicate, two experimental birds were randomly picked, totaling 56 birds. Before they were euthanized, their live weights were taken. Euthanization was done by severing the carotic arteries. After bleeding, the birds were immersed in hot water for two minutes to loosen their feathers. Feather plucking machine was used to remove the feathers. After defeathering, the carcass weight was taken and recorded. The following weights were taken after dressing the carcass: Cold carcasses weights were recorded, breast weight, liver weight, thigh weight, neck weight, kidney weight, full gizzard weight, empty gizzard weight, full intestine weight, empty intestine weight, head weight, shanks weight, heart weight, full proventriculus weight, empty proventriculus weight, dressing percentage and abdominal fat content.

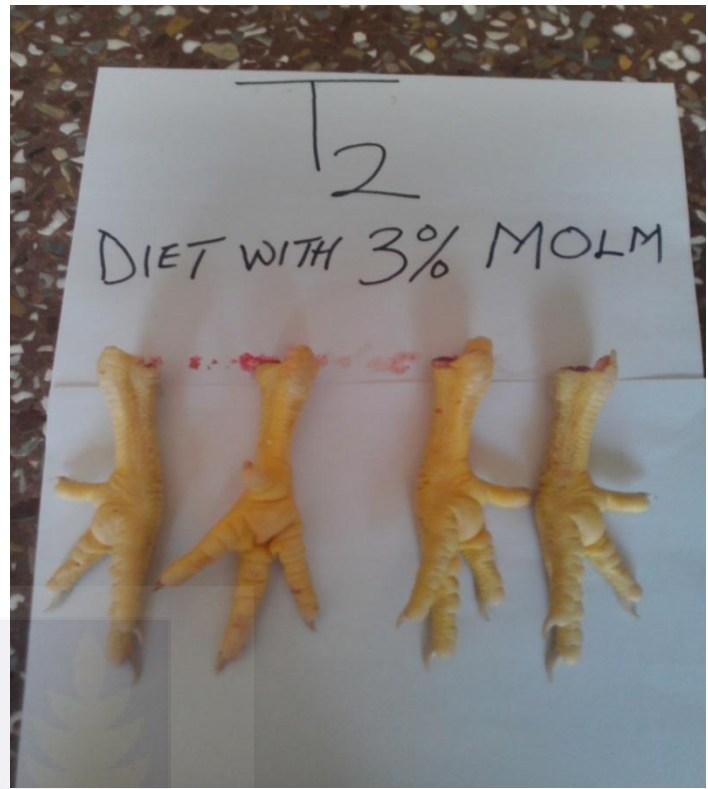
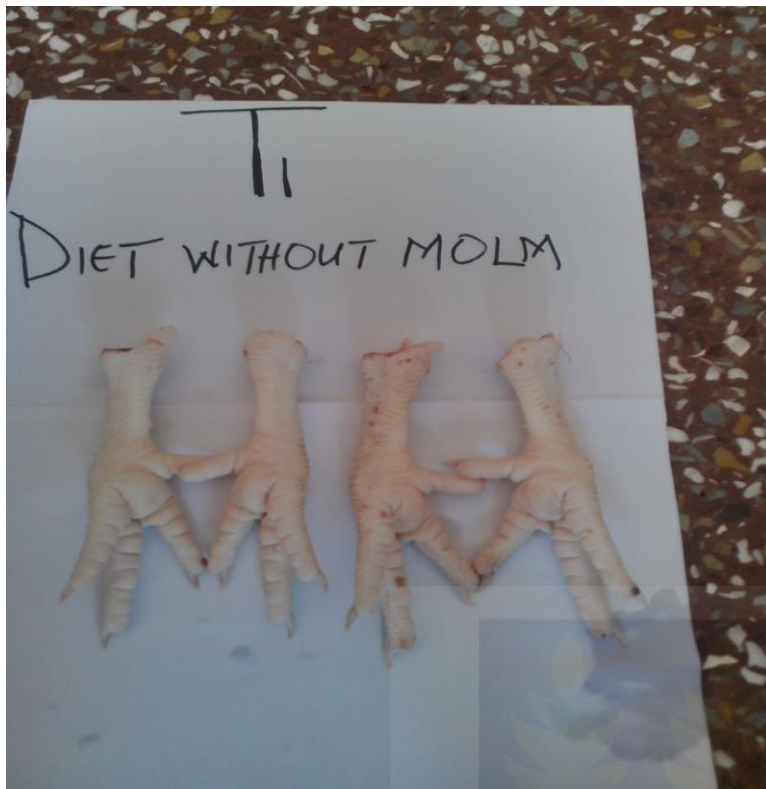


Plate 3: Pictures showing yellow colouration or no colouration of shanks of birds on different treatment diets



Plate 4: Yellow colouration of carcasses caused by Xanthophyll and Carotenoids in Moringa

3.10.1 Dressing Percentage

The eviscerated and the be-headed bird with shanks removed, and gizzard and neck also removed is the dressed carcass.

Dressing percentage was calculated using the relation below.

Dressing % = Wt. of dressed carcass/live wt. of bird \times 100

3.10.2 Abdominal Fat

The abdominal fat was removed from the abdominal region (after overnight chilling) of each bird, weighed and recorded.

3.11 Cumulative feed intake

The cumulative feed intake was computed from zero to eight (0-8) weeks. This was computed as; Feed intake/bird = initial wt. of feed – final wt. of feed divided number of birds in a replicate.

3.12 Feed conversion ratio

It is the measure of the amount of feed utilised to produce a kilogram of body weight. It was evaluated by dividing the amount of feed utilised from the 0-8 weeks by the gain in average weight of the birds over the same period, thus; feed intake (g)/ gain in weight (g).

3.13 Cumulative live weight gain

This is a measure of the gain in weight over the experimental period of 0-8 weeks. Weight gain was calculated on weekly basis and they were summed, thus (final wt. – initial wt) g.

3.14 Cumulative cost per gain

The cost of feed per kilogram live weight gain in Ghana cedis was calculated for the whole experimental period. It was calculated by multiplying the unit cost of feed by the amount consumed. It was computed on per bird and per week basis and then cumulated over the experimental period. The cost per unit gain data was subjected to analysis of variance (ANOVA) using GenSTAT and means were separated using the LSD.

Thus;
$$\frac{\text{Unit cost of feed} \times \text{amount of feed consumed}}{\text{Gain in weight}}$$

3.15 Mortality

Mortalities were also recorded as they occur during the experiment.

3.16 Statistical analysis

All data collected on performance, carcass characteristics and blood analysis results were subjected to statistical analysis using the Generalized Linear Model procedure of the Statistical Analysis System Institute (SAS Inst. Inc. Cary, NC, 1999). Significant differences among means were separated using the Student Newman-Kuels (SNK) Test. The 5% probability level was used for determining significance among treatments.

CHAPTER FOUR

4.0 RESULTS

4.1 Effects of MoLM on the performance of broiler chickens

The effect of dietary treatments on the growth performance (Average Daily Feed Intake, Average Daily Gain, Feed Conversion Ratio, Final Body Weight and Mortality) of the broilers fed the experimental diets is presented in Table 17.

None of the parameters measured for growth performance: Average Daily Feed Intake (ADFI), Average Daily Gain (ADG), Feed Conversion Ratio (FCR), Final Body Weight (FBW) were significantly influenced ($P>0.05$) by the inclusion of MoLM and or antibiotics (Table 17).

The birds on control treatment (T1= 0% MoLM without antibiotics) had the highest mortality and no mortality was observed in chickens given 3% MoLM, 6% MoLM, 9% MoLM, 3% MoLM with antibiotics, 6% MoLM plus antibiotics and 9% MoLM with antibiotics. There were a total of thirteen (13) mortalities out of the total (448) used throughout the experiment. These mortalities represented 2.90% and were recorded among birds under the control (T1) diet.

There were no significant differences among treatments for cost per unit weight gain. Birds on treatment T4 (9% MoLM without antibiotics) and T7 (9% MoLM with antibiotics) had the least cost of feed per birds of GH¢/kg 1.656 and GH¢/kg1.636 respectively. However those on T1 (control) had the highest (GH¢/kg1.677) cost of feed per bird.

Table 17: Effects of diets containing graded levels MoLM on the performance of broiler chickens

Parameters	Dietary Treatments							SEM	P-value
	T1	T2	T3	T4	T5	T6	T7		
	(Control)	(3%MoLM)	(6%MoLM)	(9%MoLM)	(3%MoLM+A)	(6%MoLM+A)	(9%MoLM+A)		
ADFI (g)	126.09	125.53	125.28	124.20	125.62	125.41	124.80	4.37	1.00
ADG (g)	28.94	29.81	28.84	28.68	30.52	30.24	29.72	3.63	0.99
FCR	1.277	1.309	1.272	1.277	1.335	1.337	1.310	0.08	0.99
FBW (g)	2301.09	3116.07	3046.88	3107.77	3245.31	3179.69	3140.63	275.3	0.18
Feed cost/ kg gain (GH¢)	1.677	1.664	1.663	1.656	1.651	1.650	1.636	0.149	1.00
Mortality	2.90%	0%	0%	0%	0%	0%	0%	-	

Mean values without superscript in the same row are not significantly different ($P>0.05$).

Note: ADFI= Average Daily Feed Intake; ADG= Average Daily Gain; FCR= Feed Conversion Ratio; FBW= Final Body Weight.

The trend in growth or weight gain for the seven experimental treatments is shown in Fig.

1. It is obvious from the figure that growth on all treatments was similar and there was no difference in the final weight.

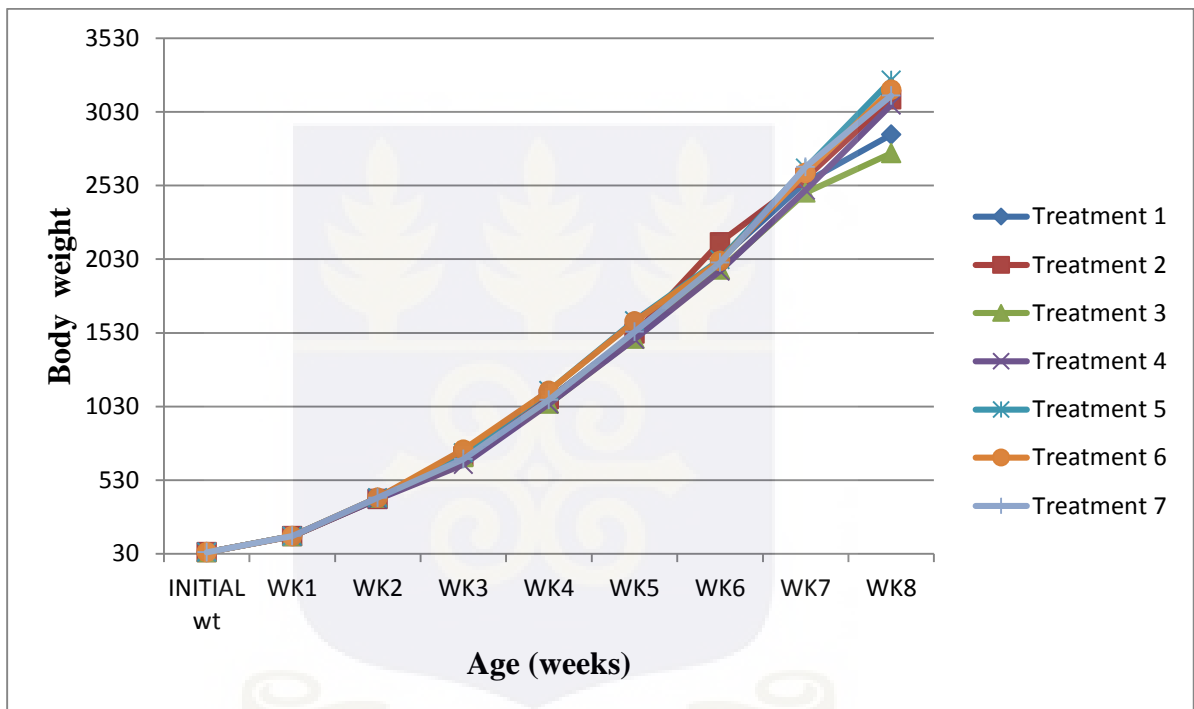


Figure 1: Weight of birds/g over the experimental period by treatment

Similarly, the experimental birds in all treatments shown similar trend in cumulative feed intake throughout the experimental period as shown in Fig. 2.

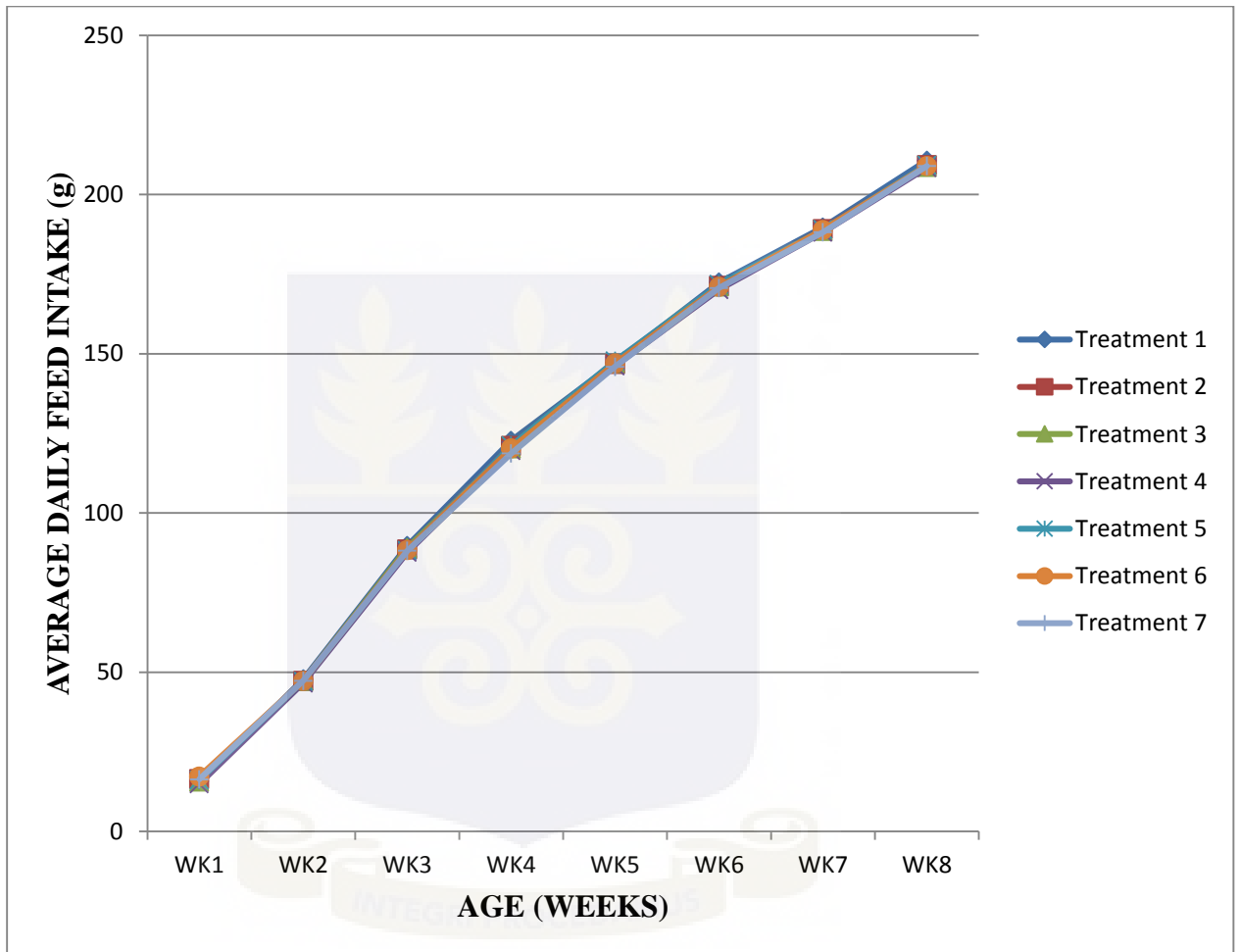


Figure 2: Cumulative feed intake (g)/ bird over the experimental period

4.2 Effects of MoLM on the carcass characteristics of broiler chickens

The effect of dietary treatments on carcass traits of the broilers fed the experimental diets are presented in Tables 18 and 19.

There were no significant differences ($P>0.05$) among the treatments for live weight, weight after bleeding, weight after defeathering, dressing percentage, empty gizzard weight, empty crop weight, full intestinal weight, empty intestinal weight, liver weight, heart weight, and thigh weight. However, there were significant differences ($P<0.05$) among the treatments for carcass weight, full gizzard weight, full crop weight, neck weight, shank weight, head weight, lung weight, breast weight and abdominal fat weight.

Carcass weight for birds on Control diet (T1), birds on 3% MoLM without Antibiotics (T2), 9% MoLM without Antibiotics (T4), 6% MoLM with Antibiotics (T6) and birds on 9% MoLM with antibiotics were similar ($p>0.05$), however they are significantly lower ($p<0.05$) than those birds on diets containing 3% MoLM with antibiotics but significantly higher ($P>0.05$) than that for birds on 6% MoLM without antibiotics (T3). Birds on T5 (3% MoLM with antibiotics) had the highest ($P<0.05$) carcass weight (2874.13g) compared to those on other diets whereas those on 3% (MoLM without antibiotics) T2 had the lowest (2414.31g).

The full gizzard weights were similar for birds on the Control diets (T1), 9% MoLM without antibiotics (T4), 6% MoLM with antibiotics (T6) and birds on 9% MoLM with antibiotics and more so there was a similar result among birds on 3% MoLM without antibiotics (T2) and 3% MoLM with antibiotics (T5).

However, birds on T2 (3% MoLM without antibiotics) had the highest (93.99g) full gizzard weight whilst those on T3 (6% MoLM without antibiotics) had the least (86.76g) full gizzard weight.

Similar full crop weights were recorded among dietary treatments, T1, T2, T4 and T5 but they were significantly different ($P < 0.05$) from birds on T3, T6 and T7. Whilst birds on T6 had the highest (51.35g), those on T3 had the lowest (37.05g).

Birds on T1 (control diet), T3 (6% MoLM without antibiotics), T6 (6% MoLM+antibiotics) and T7 (9% MoLM+antibiotics) recorded similar head weights, (17.49g), (19.97g), (16.98g) and (17.87g) respectively compared to the other treatments. Lung weights of birds on 6% MoLM without antibiotics (T3) (115.54g), T4 (9% MoLM) (113.18g), T5 (3% MoLM with antibiotics) (115.49g), and T7 (9% MoLM with antibiotics) (111.05g) were similar ($P > 0.05$) to one another. Birds on control diet (T1) (137.22g), T2 (3% MoLM without antibiotics) (121.10g) and T6 (6% MoLM with antibiotics) (98.90g) were significantly different ($P < 0.05$). Birds on the control diet (T1) recorded the highest lung weight while those on diets containing 9% MoLM with antibiotics (T7) had the lowest.

Breast weight among the treatments were similar among the birds fed with T1 (115.85g), T4 (114.35g), T5 (113.49g), T6 (113.09g) and T7 (107.51g) but those birds on T2 (141.75g) and T3 (126.29g) showed significant difference ($P < 0.05$) for breast weight. Birds on the T2 (3% MoLM without antibiotics) had the highest ($P < 0.05$) breast weight (141.75g) than those on other diets while those on 9% MoLM with antibiotics) T7 had the lowest (107.51g).

Thigh weights across all the dietary treatments were not significantly ($P>0.05$) different.

Similar abdominal fat weights were recorded among dietary treatments, T1, T3, T6 and T7 but they were significantly different ($P<0.05$) from birds on T2, T4 and T5. However, birds on T4 and T5 were similar to each other. Whilst birds on T2 had the highest (23.14g), those on T5 had the lowest (13.94g). Identically, the abdominal fat content was similar ($P>0.05$) among T4 (9% MoLM) (14.05g) and T5 (3% MoLM + antibiotics) (13.94g) compared to the other treatments.

Birds on the 3% MoLM without antibiotics (T2) had the highest ($P<0.05$) abdominal fat weight (23.14g) as compared to those on other diets while those on (3% MoLM with antibiotics) T5 had the lowest (13.94g).

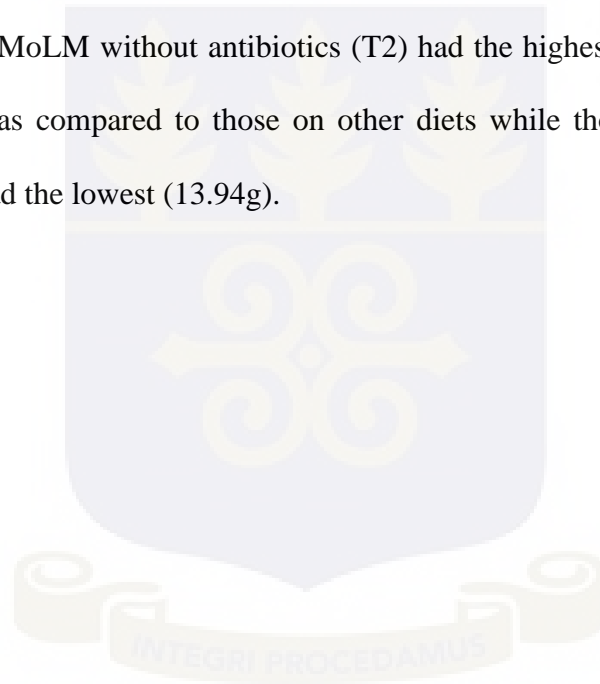


Table 18: Effects of diets containing graded levels of MoLM on the carcass characteristics of broiler chickens

Parameters (g)	Dietary Treatments							Sem	p-value
	T1	T2	T3	T4	T5	T6	T7		
LIVE wt	2975.22	3969.09	2837.94	3037.95	3125.25	3000.30	2838.01	91.17	0.21
Wt. after Bleeding	2731.67	2925.39	2597.97	2800.41	3000.52	2837.96	2662.92	107.90	0.13
Wt. after Defeathering	2685.41	2910.38	2525.37	2757.84	2973.09	2798.83	2631.96	106.92	0.06
Carcass wt.	2562.68 ^{ab}	2796.65 ^{ab}	2414.31 ^b	2634.84 ^{ab}	2874.13 ^a	2689.21 ^{ab}	2512.26 ^{ab}	101.71	0.03
Dressing %	74.25	75.73	74.01	74.35	75.38	74.47	74.36	0.453	0.856
Full Gizz wt	88.97 ^{ab}	93.99 ^a	86.76 ^b	88.58 ^{ab}	93.12 ^a	91.47 ^{ab}	90.42 ^{ab}	1.42	0.008
Empt gizz wt	62.68	60.55	64.25	65.88	60.92	72.00	77.47	5.11	0.195
Full crop wt	46.44 ^{ab}	45.15 ^{ab}	37.05 ^b	48.03 ^{ab}	43.75 ^{ab}	51.35 ^a	50.70 ^a	2.80	0.01
Emp crop wt	39.92	31.78	22.46	45.46	32.09	24.91	26.23	9.72	0.62
Full intes wt	109.73	104.22	106.46	100.75	99.81	102.28	100.45	6.15	0.55
Emp inte wt	60.45	59.86	60.72	58.96	58.87	60.43	60.76	4.63	0.11

Mean values with same superscript in the same row are not significantly different ($P>0.05$).

Table 19: Effects of diets containing graded levels of MoLM on the carcass characteristics of broiler chickens

Parameters (g)	Dietary Treatments							Sem	p-value
	T1	T2	T3	T4	T5	T6	T7		
Liver wt	8.73	11.44	10.14	5.82	12.19	6.99	10.19	1.48	0.06
Heart wt	123.54	135.21	119.66	135.22	150.30	108.82	129.39	9.68	0.10
Neck wt	77.74 ^{ab}	78.17 ^{ab}	71.15 ^b	87.71 ^{ab}	99.15 ^a	72.42 ^b	92.42 ^{ab}	5.44	0.003
Shank wt	54.78 ^a	59.95 ^a	45.09 ^{ab}	54.18 ^a	58.66 ^a	31.14 ^a	52.52 ^a	5.26	0.01
Head wt	17.49 ^{ab}	15.74 ^b	19.97 ^{ab}	14.54 ^b	23.34 ^a	16.98 ^{ab}	17.87 ^{ab}	1.79	0.03
Lung wt	137.22 ^a	121.10 ^b	115.54 ^{bc}	113.18 ^{bc}	115.49 ^{bc}	98.90 ^c	111.05 ^{bc}	5.15	0.004
Breast wt	115.85 ^b	141.75 ^a	126.29 ^{ab}	114.35 ^b	113.49 ^b	113.09 ^b	107.51 ^b	6.03	0.004
Thigh wt	69.34	72.22	63.14	65.52	76.39	69.60	61.05	4.87	0.32
Abdo fat wt	16.24 ^{ab}	23.14 ^a	17.85 ^{ab}	14.05 ^b	13.94 ^b	21.27 ^{ab}	21.25 ^{ab}	1.88	0.003

Mean values with same superscript in the same row are not significantly different ($P>0.05$).

4.3 Effect of MoLM on haematological parameters of broilers.

The effect of MoLM dietary treatments on the haematological characteristics (RBC count, HGB, PCV/HCT, MCV, MCH, WBC and lymphocyte) of the broilers fed the experimental diets are presented in Table 20. The results show that some blood haematological indices such as HGB, PCV, lymphocyte of the broilers were influenced ($p < 0.05$) by the dietary treatments. But there were no significant differences ($p > 0.05$) across the treatments in the RBC count, MCV, MCH, MCHC, and WBC.

The MCH values were similar ($P > 0.05$) among dietary treatments with birds on T1 (Control) having the highest value and those on T3 (6% MoLM without antibiotics) having the lowest value.

MCHC values were also similar ($P > 0.05$) among the dietary treatments, with birds on T7 (9% MoLM with antibiotics) recording the highest MCHC value (35.78g/dl) and those on T3 (6% MoLM without antibiotics) the least (33.09 g/dl).

WBC values were also not significantly different ($P > 0.05$) among the experimental treatments but animals fed with 6% MoLM with antibiotics (T6) recorded the highest WBC values ($232.78 \times 10^9/L$) and those fed T5 (3% MoLM with antibiotics) ($207.79 \times 10^9/L$) recorded the lowest WBC value.

Lymphocyte values were similar ($P > 0.05$) among treatment T1 (Control), T2 (3% MoLM without antibiotics), T3 (6% MoLM without antibiotics), T4 (9% MoLM without antibiotics), T5 (3% MoLM with antibiotics), and T6 (6% MoLM with antibiotics) but these values were significantly higher than those birds on T7 (9% MoLM with antibiotics; $P < 0.05$).

HGB values of birds on T4 (9% MoLM, no antibiotic) were the lowest and were only significantly different from those of birds on T6 (6% MoLM with antibiotics). Birds on T6 had similar ($P>0.05$) HGB values to those of the birds on the rest of the treatments. PCV values followed similar trend to that of HGB.



Table 20: Effects of diets containing graded levels of MoLM on haematological parameters of broilers.

Parameters	Dietary Treatments							SEM	P-Value
	T1	T2	T3	T4	T5	T6	T7		
RBC ($\times 10^{12}/L$)	2.36	2.34	2.24	1.96	2.15	2.51	2.37	0.13	0.11
HGB (g/dL)	10.31 ^{ab}	10.09 ^{ab}	9.50 ^{ab}	8.33 ^b	9.25 ^{ab}	10.89 ^a	10.68 ^{ab}	0.55	0.04
PCV (%)	30.49 ^{ab}	30.20 ^{ab}	28.70 ^{ab}	24.79 ^b	27.38 ^{ab}	32.29 ^a	29.53 ^{ab}	1.47	0.04
MCV (fl)	129.34	129.09	129.28	127.43	127.86	128.80	126.28	1.27	0.65
MCH (pg)	43.74	43.11	42.40	43.18	43.13	43.41	43.68	0.78	0.91
MCHC (g/dL)	33.81	33.40	33.09	33.84	33.74	34.45	35.78	0.82	0.36
WBC ($\times 10^9/L$)	227.45	225.71	222.23	210.08	207.79	232.78	231.39	7.91	0.20
LYMPHO (%)	97.70 ^a	97.49 ^a	97.59 ^a	97.46 ^a	97.55 ^a	97.28 ^a	95.66 ^b	0.40	0.02

Mean values with the same superscript are not significantly different ($P < 0.05$). SE= Standard error; Mean Corpuscular Volume= MCV; Mean Corpuscular Haemoglobin= MCH; Lympho= Lymphocytes; Mean Corpuscular Haemoglobin Concentration= MCHC; Haematocrit= HCT; Packed Cell Volume= PCV; Haemoglobin= HGB.

4.4 Effect of MoLM on blood biochemical parameters of broilers.

The effect of dietary treatments on the serum biochemical indices (total protein, albumin, glucose, cholesterol, triglycerides, high density lipoprotein, low density lipoprotein) of the broilers fed the experimental diets are presented in Table 21.

Birds on T4 had the lowest total protein content of the blood and this was significantly ($P<0.05$) different from the rest of the treatments. Birds on T5 had the next lowest protein content but this was similar ($P>0.05$) to values of T3, T6, T7. However, values of T1, T2, T3, T6, T7 were also similar ($P>0.05$). With respect to Albumin, all treatments were similar ($P>0.05$) except T4 which had a significantly lower value of 13.76 g/l.

Glucose levels in T7 were low and similar to those of T3, T4, T5 and T6, but were significantly lower ($P<0.05$) than those of T1 and T2 which in turn were similar ($P>0.05$).

The cholesterol and triglyceride levels were similar ($p>0.05$) among all the dietary treatments. T1, T2, and T3 had similar HDL values ($P<0.05$) which were significantly lower ($P<0.05$) than the rest of the treatments. T4 and T5 had similar ($P>0.05$) HDL values but T4 was significantly lower ($P>0.05$) than those of T6 and T7 whilst T5 was similar to T6 and T7.

Table 21: Effects of diets containing graded levels of MoLM on blood biochemical parameters of broilers.

Parameters	Dietary Treatments							SEM	P-value
	T1	T2	T3	T4	T5	T6	T7		
	(Control)	(3%MoLM)	(6%MoLM)	(9%MoLM)	(3%MoLM+A)	(6%MoLM+A)	(9%MoLM+A)		
Total protein (g/l)	34.48 ^a	35.15 ^a	33.31 ^{ab}	26.89 ^c	30.58 ^b	32.80 ^{ab}	33.71 ^{ab}	0.92	0.001
Albumin (g/l)	16.13 ^a	16.65 ^a	15.53 ^a	13.76 ^b	15.44 ^a	16.19 ^a	15.60 ^a	0.42	0.003
Glucose (mmol/l)	195.31 ^a	190.13 ^a	173.31 ^{ab}	166.49 ^{ab}	162.54 ^{ab}	153.90 ^{ab}	141.53 ^b	10.5	0.018
Cholesterol (mmol/l)	3.45	3.43	3.10	2.91	3.23	3.29	3.25	0.12	0.073
Triglycerides (mmol/l)	0.79	0.68	0.49	0.58	0.61	0.66	0.97	0.13	0.22
HDL (mmol/l)	1.53 ^c	1.54 ^c	1.65 ^c	2.40 ^b	2.77 ^{ab}	2.85 ^a	2.55 ^{ab}	0.11	0.001
LDL (mmol/l)	1.53 ^c	1.54 ^c	1.65 ^c	2.40 ^b	2.77 ^{ab}	2.85 ^a	2.55 ^{ab}	0.11	0.001

Mean values with the same superscript are not significantly different (P<0.05).

Note: High Density Lipoprotein (HDL), Low Density Lipoprotein (LDL)

CHAPTER FIVE

5.0 DISCUSSION

5.1 Effects of Moringa Leaf Meal (MoLM) on the performance of broiler chickens

The Average Daily Gain (ADG), Final Body Weight (FBW), Average Daily Feed Intake (ADFI) and Feed Conversion Efficiency (FCR) were similar ($P>0.05$) across all the dietary treatments (Table: 17). The similar results obtained for these performance parameters imply that, the inclusion of MoLM in broiler diets had no adverse effect on the performance of the experimental birds. It could also be that the experimental diets used contained all the necessary nutrients that were adequate for growth of birds. According to Nesheim (1990) mostly the performance of broilers is influenced by health, nutritional quality of diet, environmental temperature, water supply, stocking density, ventilation, light and feed supply. All these factors were kept similar as much as possible in this study.

In the work of Austic and Nesheim (1990), Ferket and Gernat, 2006, feed intake influences final body weight and feed conversion ratio. Therefore, it showed clearly that the similar final body weight and feed conversion ratio obtained in this study may also be due to the insignificant differences observed for the amount of feed intake among the experimental birds.

This results is in agreement with that of Olugbemi (2010), who reported that there were no differences in average daily feed intake, final weight and weight gain with increasing levels of moringa leaf meal (3%, 5% and 7%) included in cassava based diets.

Similarly, Du *et al.* (2007), observed no significant depression in growth performance of 3 weeks old broilers that were fed on diets substituted with 0.5%, 1.0%, 2.0% and 3.0% levels of *Moringa oleifera* leaf meal. Atuahene *et al.* (2008), also reported no significant effect of diets containing moringa leaf meal at 0%, 2.5%, 5%, and 7.5% levels on feed intake and FCR of broiler chickens. Safa and Tazi (2012), however reported that, feed intake, feed conversion ratio and Body Weight gain were significantly enhanced ($P < 0.05$) with the addition of moringa leaf meal in the experimental diets. This could be attributed to the higher crude protein content (in the MoLM) in Safa's study which was efficiently metabolized for growth as compared to the crude protein content obtained in this current study. However the formulated diets used in this study were prepared to be iso-nitrogenous and iso-caloric.

It is possible that the anti-nutritional factors and toxic materials present in the moringa leaf meal (MoLM) in this study were low as indicated earlier by Makker and Becker (1997) and Kakengi, (2007), or that the crude fibre content in all the treatment diets was negligible and hence did not impair nutrient digestion and absorption.

The current results indicate that the MoLM is acceptable to the birds and explains why the animals across all the treatments consumed the experimental diets evenly.

It has been noted that animals eat to meet their energy requirement (Kakengi, 2007). Birds of the same age and physiological state will consume more of a diet that is lower in energy compared to the one high in energy (Leeson, 2000; Nortey *et al.*, 2013; Hetland *et*

al., 2003; Hetland and Svihus, 2001). However, the diets used in this experiment were formulated to be iso-nitrogenous and iso-caloric.

The similarity among the growth parameters across the dietary treatment could be because the diets were formulated to be iso-nitrogenous and iso-caloric.

This similarity among the growth parameters may also be attributed to the fact that, birds fed the control diet and MoLM based diets with or without antibiotics adequately utilized the nutrients they consumed.

The crude extract of *Moringa oleifera* like other herbal drugs may contain digestion enhancing properties and stimulates favourable growth of good bacteria while decreasing bad microorganisms. This could influence the growth performance and hence gut microflora of poultry.

The birds on control treatment (T1= 0% MoLM with no antibiotics) had the highest mortality and no mortality was observed among birds on the other treatments.

There were thirteen (13) mortalities out of the total (448), representing 2.90% which occurred among birds on Control diet. This could be an indication of the medicinal value of Moringa Leaf Meal (MoLM). It could also be that the immune system of the birds on the MoLM treated diets with or without antibiotics were better off than those on the control diet. The medicinal potential of Moringa such as antimicrobial properties have been reported by Fahey *et al.* (2001). Also its capacity to improve the immune system and hence prevent or treat birds from diseases has also been reported by Nasir and Grashorn, 2009). This also consistently confirms that the effect of anti-nutritional factors in the MoLM treated diets were within the tolerable or acceptable limit.

Though there were no significant differences ($P>0.05$) among the dietary treatments, the cheapest feed costs/weight gain were from T4 (9% MoLM without antibiotics) and T7 (9% MoLM with antibiotics). The reduction in the cost/kg observed in this study as the level of MoLM increased from the control (no MoLM diet) (T1) to 9% MoLM with or without antibiotics could be due to the cheaper cost of moringa leaf meal (MoLM) (Table 14).

The performance of the birds in the current study suggests that MoLM can serve as a better part replacement for soybean meal without negatively affecting the performance of broiler birds.

5.2 Effects of MoLM on the carcass characteristics of broiler chickens

As shown in Table (18 and 19), addition of MoLM (3% to 9%) to broiler diets had no significant effects ($P>0.05$) on the live weight, weight after bleeding, weight after defeathering, dressing percentage, empty gizzard weight, empty crop weight, full intestinal weight, empty intestinal weight, liver weight, heart weight, and thigh weight. However, birds fed diets containing *Moringa oleifera* leaf meal recorded higher values for most of the carcass characteristics measured.

The comparable values obtained on the live weight, weight after bleeding, weight after defeathering, dressing percentage, empty gizzard weight, empty crop weight, full intestinal weight, empty intestinal weight, liver weight, heart weight, and thigh weight could be attributed to the comparable results observed for daily weight gain, daily feed intake, feed conversion ratio and final body weight gain. It has been reported by several researchers (Austic and Nesheim, 1990; Ferket and Gernate, 2006; Chiba, 2009) that feed

intake, weight gain and feed conversion efficiency influences carcass characteristics in birds.

The findings by Zanu *et al.* (2012) also showed that none of the parameters measured for carcass characteristics in birds fed diets containing 5%, 10% and 15% MoLM were affected significantly, however, they attributed their findings to be due to the high nutrient content of the experimental diets.

Ayssiwede *et al.* (2011), reported that there were no significant difference across treatments for carcass indices except for dressed weight, gizzard weight and breast weight among birds fed 8% and 16% MoLM compared to the control.

The findings on carcass features from the present study specifies that the commercial farmer can choose suitable alternatives (like MoLM) taking into consideration feed ingredients for preparing diets at reduced cost without negatively affecting the final yield and the value of carcass produced.

Carcass weight for birds on Control diet (T1), birds on 3% MoLM without Antibiotics (T2), 9% MoLM without Antibiotics (T4), 6% MoLM with Antibiotics (T6) and birds on 9% MoLM with antibiotics were similar ($p>0.05$), however they were significantly lower ($p<0.05$) than those birds on diets containing 3% MoLM with antibiotics (T5) but significantly higher ($p>0.05$) than that for birds on 6% MoLM without antibiotics (T3). This result is in agreement with the findings by Nkukwana *et al.* (2014), who reported that supplementing MoLM (0.1 to 2.5%) to the diets of broiler does not influence the carcass weight and relative weight of heart, spleen and liver.

The empty gizzard weights in all the treatments were similar. However there was a similarity in full gizzard weight of birds on the Control diets (T1), 9% MoLM without antibiotics (T4), 6% MoLM with antibiotics (T6) and birds on 9% MoLM with antibiotics and more so among the birds on 3% MoLM without antibiotics (T2) and 3% MoLM with antibiotics (T5).

In general guts fill permitting; monogastrics will eat more of a diet low in energy and nutrient density in an attempt to meet their daily nutrient needs (Nortey *et al.*, 2007; Whitney *et al.*, 2006). However the formulated diets used in this study were prepared to be iso-nitrogenous and iso-caloric. The gizzard is the centre of digestion in poultry. The gizzard functions as the pacemaker in the bird's digestive function, regulating and controlling Gastro Intestinal Tract (GIT) motility and vitality (Nortey *et al.*, 2013). The gizzard is responsible for grinding the feed and the intensity of this function depends on the coarseness of the grain. The gizzard function is enhanced when fed diets that contain high fibre. Therefore an enhanced gizzard function may translate into heavier musculature and weight. Retention time of feed in the gizzard depends on the fibre and coarseness of the feed particle size (Nortey *et al.*, 2013).

Leaf meals usually contain high fibre content, which consequently increases the fibre content of the diets (Adeniji and Lawal, 2012). The type and amount of fibre in a particular diet can influence digesta transit time (Hetland and Svihus, 2001).

Generally coarse insoluble fibre hastened digesta transit time (Mateos *et al.*, 2012). Coarse insoluble fibrous feed may actually accumulate in the gizzard and slow down the transit time especially in the proximal part of the gastrointestinal tract (Banfield *et al.* 2002); Hetland *et al.*, 2003; Gabriel *et al.*, 2008; Jimenex-Moreno *et al.*, 2011), reported

that the coarse fibre components of diets are associated with increased intestine and gizzard weights.

Therefore, the differences observed in this study for full gizzard weights and other gastrointestinal tract parts could be due to the increased crude fibre content in the levels of MoLM based diets. This is because the lowering of the transit time, particularly in the lower gastrointestinal tract followed by higher average daily feed intake could be the reason for the heavier full crop weights and full gizzard weights of birds given moringa leaf meal based diets.

The full crop weights were slightly heavier ($P < 0.05$) among birds fed diets with increasing levels of moringa leaf meal. In 2006, Jorgensen and friends stated that naturally, animals fed on diets that are high in fibre, tends to have more developed gastrointestinal tract. This showed that due to the fibre content in the MoLM based diets, it became necessary for the gastrointestinal tract (GIT) to hold feed for a longer time.

Manu-Barfo *et al.* (2012) reported that increased gut weights (gizzard and intestines) may finally reduce the dressed carcass weight, which will eventually affect the farmer's profit margin.

The varying levels of MoLM supplementation did not significantly influence the weights of the heart and the liver. The comparable weights obtained for these organs may be due to the balance of nutrients in all the diets as suggested by Omoikhoje *et al.* (2005). This may possibly mean that the inclusion of Moringa Leaf Meal (MoLM) into the broiler finisher diets had no severe health implications on the birds.

The abdominal fat content was similar ($P>0.05$) among but on (T1, T3, T6, and T7), while those on T4 and T5 also recorded similar ($P>0.05$) abdominal fat content as compared to other treatments. Generally, when animals develop beyond a certain weight, increase in body weight will tend to be towards more fat than lean. According to Jackson *et al.* (1982), adequate proportion of dietary ME (Metabolizable Energy) and amino acid is also required to control fat accumulation in broiler finishers.

5.3 Effects of xanthophyll

There was yellow colouration of the shanks, beaks and the skin observed among the broilers fed MoLM treated diets. This yellow colour was prominent or deeper as the inclusion levels of MoLM increased, thus 3% MoLM, 6% MoLM and 9% MoLM.

This yellow colouration observed indicates efficient absorption and utilization of the pigment xanthophyll's present in moringa. However, there was no yellow colouration of the birds on the control diet (T1) (Plate 3 and 4).

This observation was in agreement with the observations made by Zanu *et al.* (2012) and Naazie and Akoto (2011) who reported of yellow coloration of body parts of birds such as shanks and beak: This could be attributed to the presence of xanthophyll and carotenoid pigments in MoLM.

5.4 Effect of MoLM on haematological parameters of broilers.

The values of the haematological indices such as RBC, MCV, MCH, MCHC, WBC in blood of broilers were not significantly different ($P>0.05$) among the treatment groups. However, some differences were found for HGB, PCV and Lymphocyte (Table: 20). The lymphocyte results suggest there was an infection among the birds across all the treatments and also the RBC indices were not influence negatively by the inclusion of MoLM in the diets.

This is similar to the work done by Zanu *et al.* (2012) who stated that the inclusion of MoLM (5%, 10% and 15%) in the diets of broilers does not influence the haematological parameters of the blood.

The RBC transport oxygen from the lungs to the body tissues and transport carbon dioxide from the tissue to the lungs (Aengwanich *et al.*, 2004). The RBC values were not significantly different ($p>0.05$) among all the dietary treatments. However, the RBC values of birds on T1 to T7 falls within the normal reference range (1.85-3.5) reported by Aengwanich *et al.* (2004) (Table 8). This showed that the RBCs functioned efficiently, hence preventing occurrence of anaemia. Since RBC count is an important indicator of the functioning of the haematopoietic system in animals. Generally, haematological indices are affected by changes in daily physical and metabolic activities (Sanni *et al.*, 2000). Nutrition, breed and sex are the other factors which can affect RBC counts.

Olugbemi (2010) indicated that RBCs are responsible for the transportation of oxygen and carbon dioxide in the blood as well as manufacturing of haemoglobin. Therefore, higher values of RBC (that fall within the normal RBC reference range) indicate greater potential for the transportation functions and hence give a better health status of the birds.

RBC levels were not negatively influenced by the MoLM inclusions in this study, hence the normal RBC values of the experimental treatments. This is similar to the work done by Zanu *et al.* (2012) who stated that the inclusion of MoLM in the diets of broilers did not influence the RBC content of the blood.

Similarly, the control diets and the MoLM treated diets had no effects ($P>0.05$) on the MCV, MCH, MCHC and WBC levels. However, the values of MCV, MCH, MCHC fall within the normal reference range reported by Jain (2010), Aengwanich *et al.* (2004) and Cynthia *et al.* (2010) (Table 8).

WBC produces antibodies in the blood which help in the development of immunity thus protecting the body against pathogenic micro-organisms such as viruses, bacteria and fungi (Fudge, 2000; Alberts *et al.*, 2002; Birger, 2014; Iheukwumere *et al.*, 2008).

Though the WBC values were not significantly different ($P>0.05$) among all the experimental treatments, the values obtained were higher than the normal reference values ($20.5-56.0 \times 10^9/L$) reported by Aengwanich *et al.* (2004) and Cynthia *et al.* (2010) (Table: 8). High levels of white blood cells (WBCs) in the blood of birds are good indicator that the birds had an illness or infection. This could be an indication of an infection among the experimental birds although they seem healthy in appearance and the mortality level was very low. High WBC levels mean that the bodies of the birds were sending more and more white blood cells to fight off infections.

The health condition of experimental birds observed during the 8th week experimental period did not seem to have been affected by addition of MoLM in the experimental

diets, however Du *et al.* (2007) reported that dietary supplementation of *Moringa oleifera* may increase immune ability of the broilers.

T4 and T6 were significantly ($P < 0.05$) different, however they were similar to the other treatments.

Haemoglobin (HGB) is the principal protein component of the cytoplasm of a matured RBC and it contains a pigment consisting of haem (a metallic compound containing Fe^{2+}) part and a globin part (Simpraga *et al.*, 2005). The HGB is responsible for the transport of oxygen from the respiratory organs to the rest of the body and the transport of resultant CO_2 produced after tissue respiration back to the respiratory organs to be dispensed from the body (Klinken, 2002).

The low HGB values of T3 (6% MoLM), T4 (9% MoLM), and T5 (3% MoLM) may be due to the much consumption of anti-nutritional factors. This is in line with the work done by Tijani *et al.* (2016) who stated that the reduction in the HGB of the birds fed by MoLM can be attributed specifically to higher intake of phytate and oxalate.

Odetola *et al.* (2012) did similar work and they stated that increasing the levels of Moringa leaf meal in the diet was found to reduce the haematological indices in monogastric animals. However, the HGB values obtained in this study fell within the normal reference values (9.27-13.00 g/dl) reported by Aengwanich *et al.* (2004) and Cynthia *et al.* (2010). This showed that the metabolic rate of the birds functioned normally. This report also showed that there was no indication of anaemia since low concentration of haemoglobin in the blood is an indication of anaemia (Scope *et al.*, 2002).

According to Nworgu *et al.* (2007), feed that is high in protein, iron, calcium, magnesium, potassium and phosphorus enhance blood formation resulting in high HGB values. However, the HGB values obtained in this study showed that the diets given to the birds were well balanced.

Packed Cell Volume (PCV) is the proportion of the blood volume that is occupied by RBCs (Klinken, 2002). PCV values have been used to evaluate the physiological state of birds (Villegas *et al.*, 2004). The PCV reflects the efficiency of the oxygen carrying capacity of the blood (Villegas *et al.*, 2004).

PCV values below 35% is an indication of anaemia which according to Akinnyeni *et al.* (2010), leads to reduced oxygen carrying capacity of blood, increased pulse rate and consequently heart failure. Low PCV values could be an indication of mineral deficiencies, or bacterial and parasitic infections (Hoefe, 2011).

However, the PCV values obtained in this study fell within the normal reference values (22.0-35.0%) reported by Aengwanich *et al.* (2004).

The PCV levels indicate the nutritional status of birds (Aikhuomobhogbe and Orheruata, 2006). The differences among the treatments may be due to the variations in diets caused by MoLM inclusion. Since the PCV values fell within the normal PCV range it indicates that though there is presence of a toxic factor in MoLM, all the treatment groups had nutritional adequacy, because the PCV values obtained did not indicate malnutrition or under nutrition (Church *et al.*, 2004; Health and Olusanya, 2005). Therefore, this result confirmed that the inclusion of MoLM on broiler diet had little effect on the relative quantity of blood cells as compared with the total volume of blood.

Simpraga *et al.* (2005) reported that there is a positive correlation between PCV and HGB and this suggest that factors that affect HGB also influence PCV.

Moringa Leaf Meal (MoLM) based diets had no significant effect on MCV, MCH, and MCHC. Haematological variables such as MCV, MCH, and MCHC are vital indicators in the determination of morphological features of anaemia (Raukar and Mafuvadze, 2007). This indicates that the dietary treatment was nutritionally adequate for the birds.

Lymphocytes values were similar ($P>0.05$) among dietary treatments T1, T2, T3, T4, T5 and T6 while birds on T7 (95.66%) shows significant different ($p<0.05$) compared to other treatments.

The values obtained for lymphocytes ranges from 95.66--97.70% across the experimental treatments in this study. The values obtained were higher than the normal reference values (45-70%) reported by Aengwanich *et al.* (2004); and Cynthia *et al.* (2010). This may imply an infection among the birds across all the treatments.

Lymphocyte is a type of WBC that is part of the immune system (Haile and Chanie, 2014). They help fight off diseases. A high lymphocyte count is an increase in white blood cells. The lymphocytes values obtained in this study were higher than the normal lymphocyte values (Table 8). This indicated that the birds were sick but they show no sign of sickness or mortality. This might be because there was some Moringa Leaf Meal (MoLM) positive effect (influence) on the immune system of the birds that prevented birds from getting sick or dying.

Lymphocytes are in charge of specific adaptive immune responses (Alberts *et al.*, 2002, Nalubamba *et al.*, 2010, Haile and Chanie, 2014).

5.5 Effect of Moringa Leaf Meal (MoLM) on blood biochemical parameters of broilers.

The results showed that total protein was significantly higher in T2 (3%MoLM) and T1 (34.48g/l) (control) compared to those on T4 (9%MoLM; Table 21).

Birds on T2 (3% MoLM without antibiotics) had higher total protein value (35.15g/l). This indicates that the diet was relatively of good quality and that birds fed this diet were more efficient in protein metabolism and utilization. The higher total protein values obtained in T2 (3% MOLM without antibiotics) diet reflects the protein levels. Birds on diets T3 (6% MoLM), T5 (3% MoLM with antibiotics), T6 (6% MoLM with antibiotics) and T7 (9% MoLM with antibiotics) showed similar values ($P > 0.05$). This shows that their rate of protein metabolism and utilization were similar.

This finding is in line with the work done by Kout *et al.* (2015), who stated that the total protein was significantly improved in both the control and MoLM treated diets (2%, 4% and 6% MoLM). This indicated that the diets were relatively of good quality and protein metabolism and utilization was efficient. This also gives an indication of how efficient MoLM can be used to replace soya bean meal. According to Eggum (1970) total serum protein is usually a reflection of the protein quality feed. Even though the formulated diets used in this study were prepared to be iso-nitrogenous and iso-caloric, the low total protein value obtained for birds on the T4 treatment in table 21 could be because the diet (diet 4; T4) did not influence the serum protein of the birds. This could also be due to the high fibre content in MoLM in the diet (T4=9% MoLM without antibiotics) which might eventually reduced the rate of protein metabolism and utilization.

Total plasma protein has been reported as an indication of the protein retained in the animal's body (Akinola and Abiola, 1991). The relatively higher total protein content of broilers receiving dietary 3% MoLM without antibiotics might be an indication of the good protein content and quality MoLM. However, birds on T3, T4, T6, and T7 recorded low total plasma protein as compared to the control and T2. This could also be attributed to the fact that fibre content is higher in diets containing 6% MoLM and 9% MoLM which might reduce the rate of protein metabolism and utilization.

The values obtained were higher than the normal reference values (3.0-4.9g/l) reported by Aengwanich *et al.* (2004) and Cynthia *et al.* (2010). This could be attributed to the health condition of the birds judging from lymphocytes values even though there were no signs of sickness among birds and the high fibre contents in the MoLM based diets. Since abnormal physiological conditions of the animal can reduce the rate of protein metabolism and utilization.

The increased total serum proteins obtained in this study may result in a high protein metabolism in the organ of the chickens, as supported by Melesse *et al.* (2013).

T4 had significantly lower ($P < 0.05$) albumin values compared to the other treatments which were similar. These values were higher than the normal reference albumin values (2.6-3.58g/dl) reported by Cynthia *et al.* (2010); Aengwanich *et al.* (2004). This is an indication that there was an alteration in the normal systematic protein utilization and shows a high protein metabolism in the organ of the chickens, as supported by Melesse *et al.* (2013).

Even though the control diet (T1) also recorded high albumin value (16.13g/l), more mortality was recorded among birds under the control diet without antibiotic; this means

that immunity of birds fed different MoLM additives was improved compared to the control group. Studies indicated that albumin level varies with nutrition, hormonal balance, and stress (Thrall *et al.*, 2004). Makanjuola *et al.* (2014) found that 0.2%, 0.4% and 0.6% MoLM did not influence the serum total protein and albumin, but their inclusion levels were rather low.

The values of glucose in the dietary treatments numerically decreased from T1 to T7 (195.31-141.53) as the MoLM inclusion level increased in the diet. Glucose levels of birds on T1 and T2 were significantly ($P<0.05$) higher compared to T7. However, the values obtained fall within the normal reference values of 117-299mmol/l (Cynthia *et al.*, 2010). This showed that the birds efficiently utilized the carbohydrate content of the diets. However, there was decreasing trend of glucose utilization from treatments T1 to T7. This could be because fibre content increases as the MoLM level increases in the diets. This could slightly reduce digestibility and carbohydrate utilization.

By contrast, work done by Kout *et al.* (2015) showed that supplementing with 4% and 6% MoLM resulted in significant increase in the plasma glucose compared to control and 2% MoLM.

The cholesterol levels were not significantly different ($P>0.05$) among treatments. According to Kadim *et al.* (2008), high levels of saturated fat in diets increase blood cholesterol levels and in human increase the risk of cancer and obesity. But in this study the cholesterol levels were similar among treatments. This is an indication that the diets fed the birds did not contain high levels of saturated fat. The values obtained were within the normal reference values (2.0--4.5 mmol/l) reported by Aengwanich *et al.* (2004) and Cynthia *et al.* (2010).

Both the HDL and LDL values increased numerically as the MoLM inclusion increased. LDL values fell within the normal reference values 1.3 – 2.6 reported by Jain (2010). A high concentration of LDL might be considered abnormal in birds and could be expected to result in arteriosclerosis (Bavelaar and Beynen, 2003; Gennet and Libby, 2010; Asante *et al.*, 2014). Therefore, normal LDL and cholesterol levels obtained in this study showed no harmful effect of MoLM.

On the other hand, several researchers (Oayzdog˘an and Aksit, 2003; Bachorik *et al.* 1991) have shown that low HDL and high LDL are values associated with atherosclerosis. The HDL values of T1, T2 and T3 fell within the normal HDL value while the HDL values T4, T5, T6 and T7 were higher than the normal values.

This could be because, studies has shown that animals fed diets rich in cholesterol or saturated fat had low serum HDL and high carcass cholesterol or elevated blood cholesterol levels (Blanch and Grashorn, 1995). It could also be attributed to the fact that high levels of MoLM contains high hypocholesterolemic agent which could influence HDL and LDL levels.

Olugbemi (2010) investigated the potential of MoLM as a hypocholesterolemic agent that facilitate reductions of egg cholesterol content and low HDL which is an indication of arteriosclerosis

There were no significant differences ($P>0.05$) between treatments for triglycerides. The values obtained were within the normal reference values (0.55-0.92 mmol/l) reported by Aengwanich *et al.* (2004) and Cynthia *et al.* (2010).

CHAPTER SIX

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 CONCLUSIONS

1. The results of this study reveal that soybean meal can be partially replaced with Moringa Leaf Meal (MoLM) with or without inclusion of antibiotics (Keproceryl-wsp).
2. Total replacement of antibiotics (**keproceryl-wsp**) by Moringa Leaf Meal (MoLM) improved performance of birds.
3. The inclusion of MoLM in the diets had no harmful effect on the performance, health, blood indices and carcass characteristics of the birds. Therefore, MoLM prevents the birds from getting sick and dying.
4. The inclusion of MoLM in diets led to a reduction in feed cost to produce a kilogram body weight.
5. The inclusion of MoLM in diets shows that MoLM has the efficacy in reducing mortality in birds.

6.2 RECOMMENDATIONS

1. Similar experiment should be done to determine the effect of MoLM on egg quality of layers.
2. Further experiment should be done on broilers using **fresh** *Moringa oleifera* **leaves** to determine its effect on performance, carcass characteristics, blood parameters and organoleptic properties.
3. Further works should be carried out on broilers by using 100% Moringa Leaf Meal (MoLM) inclusion level to replace soybean meal completely to determine its effects on the performance, cost, carcass characteristics, blood profile and organoleptic properties of broiler birds.
4. Similar experiment should be conducted to put the control group on standard antibiotics.
5. MoLM is recommended to be used by the local and commercial poultry farmers, since MoLM can reduce production cost and also eliminates the use of standard antibiotics which is a major health concern with serious implications for human health.

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APPENDIX**ANALYSIS OF VARIANCE (ANOVA)****A. Analysis of variance (ANOVA) for productive performance (growth output)****APPENDIX 1:**

The SAS System

The GLM Procedure

1. Dependent Variable: adfi

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	512.325	85.388	0.02	1.0000
Error	1588	6856690.952	4317.815		
Corrected Total	1594	6857203.277			

2. Dependent Variable: adg

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	4783.488	797.248	0.04	0.9998
Error	217	4493850.954	20708.991		
Corrected Total	223	4498634.441			

3. Dependent Variable: fce

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	0.14484196	0.02414033	0.11	0.9946
Error	217	45.60825625	0.21017630		
Corrected Total	223	45.75309821			

4. Dependent Variable: final bw

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	3012017.536	502002.923	1.66	0.1774
Error	23	6975461.391	303280.930		
Corrected Total	29	9987478.927			

B. Analysis of variance (ANOVA) for carcass characteristics (carcass output)

APPENDIX 2:

1. Dependent Variable: livewt

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	584630.654	97438.442	1.47	0.2097
Error	49	3258073.790	66491.302		
Corrected Total	55	3842704.443			

2. Dependent Variable: cwasl

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	971076.321	161846.054	1.74	0.1322
Error	49	4564227.075	93147.491		
Corrected Total	55	5535303.396			

3. Dependent Variable: cwadef

Sum of Source	DF	Squares	Mean Square	F Value	Pr > F
Model	6	1180447.017	196741.169	2.15	0.0640
Error	49	4481016.883	91449.324		
Corrected Total	55	5661463.899			

4. Dependent Variable: chill

Sum of Source	DF	Squares	Mean Square	F Value	Pr > F
Model	6	1232230.614	205371.769	2.36	0.0441
Error	49	4261289.562	86965.093		
Corrected Total	55	5493520.176			

5. Dependent Variable: dress

Sum of Source	DF	Squares	Mean Square	F Value	Pr > F
Model	6	1241505.584	206917.597	2.50	0.0344
Error	49	4055259.954	82760.407		
Corrected Total	55	5296765.538			

6. Dependent Variable: fullgiz

Sum of Source	DF	Squares	Mean Square	F Value	Pr > F
Model	6	320.240896	53.373483	3.30	0.0083
Error	49	792.614125	16.175798		
Corrected Total	55	1112.855021			

7. Dependent Variable: empgiz

Sum of Source	DF	Squares	Mean Square	F Value	Pr > F
Model	6	1893.50970	315.58495	1.51	0.1951
Error	49	10250.75859	209.19915		
Corrected Total	55	12144.26828			

8. Dependent Variable: fullcrp

Sum of Source	DF	Squares	Mean Square	F Value	Pr > F
Model	6	1127.735711	187.955952	3.00	0.0142
Error	49	3071.639388	62.686518		
Corrected Total	55	4199.375098			

9. Dependent Variable: empcrp

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	3345.13617	557.52270	0.74	0.6220
Error	49	37049.25400	756.10722		
Corrected Total	55	40394.39017			

10. Dependent Variable: fullint

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	109.379725	18.229954	0.84	0.5457
Error	49	1064.221087	21.718798		
Corrected Total	55	1173.600812			

11. Dependent Variable: empint

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	414.217593	69.036265	1.86	0.1072
Error	49	1820.677400	37.156682		
Corrected Total	55	2234.894993			

12. Dependent Variable: liver

Sum of Source	DF	Squares	Mean Square	F Value	Pr > F
Model	6	257.848361	42.974727	2.46	0.0369
Error	49	855.519725	17.459586		
Corrected Total	55	1113.368086			

13. Dependent Variable: heart

Sum of Source	DF	Squares	Mean Square	F Value	Pr > F
Model	6	8444.08599	1407.34766	1.88	0.1040
Error	49	36768.72770	750.38220		
Corrected Total	55	45212.81369			

14. Dependent Variable: neck

Sum of Source	DF	Squares	Mean Square	F Value	Pr > F
Model	6	5393.58942	898.93157	3.80	0.0035
Error	49	11583.86393	236.40539		
Corrected Total	55	16977.45334			

15. Dependent Variable: shank

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	4758.83997	793.13999	3.59	0.0050
Error	49	10831.16418	221.04417		
Corrected Total	55	15590.00414			

16. Dependent Variable: head

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	406.528271	67.754712	2.63	0.0273
Error	49	1262.655950	25.768489		
Corrected Total	55	1669.184221			

17. Dependent Variable: lung

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	6414.43252	1069.07209	5.04	0.0004
Error	49	10391.80102	212.07757		
Corrected Total	55	16806.23354			

18. Dependent Variable: breast

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	6395.89127	1065.98188	3.66	0.0044
Error	49	14268.80471	291.20010		
Corrected Total	55	20664.69598			

19. Dependent Variable: thigh

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	1363.72954	227.28826	1.20	0.3224
Error	49	9284.03675	189.47014		
Corrected Total	55	10647.76629			

20. Dependent Variable: abd

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	660.230161	110.038360	3.88	0.0030
Error	49	1388.439737	28.335505		
Corrected Total	55	2048.669898			

C. Analysis of variance (ANOVA) for blood haematological and biochemical parameters.**APPENDIX 3:**

1. Dependent Variable: albumem

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	20.52250000	3.42041667	4.78	0.0032
Error	21	15.04062500	0.71622024		
Corrected Total	27	35.56312500			

2. Dependent Variable: protein

Sum of Source	DF	Squares	Mean Square	F Value	Pr > F
Model	6	193.1996429	32.1999405	9.48	<.0001
Error	21	71.3256250	3.3964583		
Corrected Total	27	264.5252679			

3. Dependent Variable: glucose

Sum of Source	DF	Squares	Mean Square	F Value	Pr > F
Model	6	8752.66964	1458.77827	3.34	0.0180
Error	21	9166.34250	436.49250		
Corrected Total	27	17919.01214			

4. Dependent Variable: cholest

Sum of Source	DF	Squares	Mean Square	F Value	Pr > F
Model	6	0.83053571	0.13842262	2.30	0.0729
Error	21	1.26375000	0.06017857		
Corrected Total	27	2.09428571			

5. Dependent Variable: triglyc

Sum of Source	DF	Squares	Mean Square	F Value	Pr > F
Model	6	0.59789286	0.09964881	1.53	0.2160
Error	21	1.36465000	0.06498333		
Corrected Total	27	1.96254286			

6. Dependent Variable: hdl

Sum of Source	DF	Squares	Mean Square	F Value	Pr > F
Model	6	8.32218571	1.38703095	29.39	<.0001
Error	21	0.99122500	0.04720119		
Corrected Total	27	9.31341071			

7. Dependent Variable: ldl

Sum of Source	DF	Squares	Mean Square	F Value	Pr > F
Model	6	8.32218571	1.38703095	29.39	<.0001
Error	21	0.99122500	0.04720119		
Corrected Total	27	9.31341071			

8. Dependent Variable: rbc

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	0.78488571	0.13081429	2.01	0.1101
Error	21	1.36852500	0.06516786		
Corrected Total	27	2.15341071			

9. Dependent Variable: hgb

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	19.33750000	3.22291667	2.63	0.0460
Error	21	25.69062500	1.22336310		
Corrected Total	27	45.02812500			

10. Dependent Variable: pcv

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	140.7908000	23.4651333	2.69	0.0423
Error	21	182.8489250	8.7070917		
Corrected Total	27	323.6397250			

11. Dependent Variable: wbc

Sum of Source	DF	Squares	Mean Square	F Value	Pr > F
Model	6	2361.195000	393.532500	1.57	0.2042
Error	21	5254.063125	250.193482		
Corrected Total	27	7615.258125			

12. Dependent Variable: mev

Sum of Source	DF	Squares	Mean Square	F Value	Pr > F
Model	6	27.4042857	4.5673810	0.71	0.6467
Error	21	135.4331250	6.4491964		
Corrected Total	27	162.8374107			

13. Dependent Variable: mch

Sum of Source	DF	Squares	Mean Square	F Value	Pr > F
Model	6	4.82214286	0.80369048	0.33	0.9135
Error	21	51.13812500	2.43514881		
Corrected Total	27	55.96026786			

14. Dependent Variable: mhc

Sum of Source	DF	Squares	Mean Square	F Value	Pr > F
Model	6	18.69928571	3.11654762	1.17	0.3609
Error	21	56.10500000	2.67166667		
Corrected Total	27	74.80428571			

15. Dependent Variable: lympho

Sum of Source	DF	Squares	Mean Square	F Value	Pr > F
Model	6	12.11464286	2.01910714	3.20	0.0217
Error	21	13.25500000	0.63119048		
Corrected Total	27	25.36964286			

16. Dependent Variable: mxd

Sum of Source	DF	Squares	Mean Square	F Value	Pr > F
Model	6	0.27339286	0.04556548	0.92	0.5024
Error	21	1.04375000	0.04970238		
Corrected Total	27	1.31714286			

17. Dependent Variable: hetro

Sum of Source	DF	Squares	Mean Square	F Value	Pr > F
Model	6	3.93928571	0.65654762	3.19	0.0218
Error	21	4.31750000	0.20559524		
Corrected Total	27	8.25678571			

18. Dependent variable: Feed cost/kg

Variate: FEED_COST_GH_Kg

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TRT	6	0.0321	0.0053	0.02	1.000
Residual	217	76.7370	0.3536		
Total	223	76.7690			

19. Dependent variable: Dressing %

Variate: DRESSING_%

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TRT	6	2.0813	0.3469	0.42	0.856
Residual	21	17.2691	0.8223		
Total	27	19.3504			
