UNIVERSITY OF EDUCATION, WINNEBA

GROWTH, REPRODUCTIVE PERFORMANCE, EGG QUALITY AND BLOOD PROFILE OF QUAILS (*Coturnix coturnix japonica)* FED DIETS CONTAINING GRADED LEVELS OF *MORINGA OLEIFERA* LEAF MEAL

MARTIN OFORI JNR

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DEPARTMENT OF ANIMAL SCIENCE EDUCATION

FACULTY OF AGRICULTURE EDUCATION

A THESIS IN THE DEPARTMENT OF ANIMAL SCIENCE EDUCATION, COLLEGE OF AGRICULTURE, SUBMITTED TO THE SCHOOLOF GRADUATE STUDIES IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF MASTER OF PHILOSOPHY (ANIMAL REPRODUCTIVE PHYSIOLOGY) IN THE UNIVERSITY OF EDUCATION, WINNEBA.

NOVEMBER, 2020

DECLARATION

STUDENTS' DECLARATION

I, Martin Ofori Jnr., hereby declare that this thesis, with the exception of quotations and references contained in published work which have all been identified and duly acknowledged, is entirely my own original work, and it has not been submitted, either in part or whole, for another degree elsewhere.

SIGNATURE: …………………………………….

DATE: …..………………………………………

SUPERVISORS' DECLARATION

We hereby declare that, the preparation and presentation of this thesis was supervised in accordance with the guidelines for supervision of thesis as laid down by the University of Education, Winneba.

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DEDICATION

I dedicate this thesis to Mrs. Olivia Ofori, Nyamekye Bimpong Ofori, Nhyiraba Agyeiwaa Ofori, Mary Konadu Ofori and the late Mr. and Mrs. Ofori.

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LIST OF ABBREVIATIONS

AFE	Age at first egg
BAS	Basophil
CF	Crude Fibre
CHOL	Cholesterol
CM	Centimetres
CP	Crude protein
DM	Dry Matter
EE	Ether Extract
ELISA	Enzyme-linked immune absorbent assay
EOSIN	Eosinophil
FCR	Feed conversion ratio
FL	Femtoliters
FSH	Follicle Stimulating Hormone
g	Grammes
g/dl	Grammes per decilitre
Hb	Haemoglobin
HDEP	Hen-day egg production
HU	Haugh unit
Kg	Kilogramme
LYMPH	Lymphocytes
MCV	Mean cell volume
MCHC	Mean cell haemoglobin concentration
ME	Metabolizable Energy
ML	Millilitre

mm	millimetres
MOLM	*Moringa oleifera* leaf meal
MON	Monocytes
nmol/l	Nanomoles per litre
NEU	Neutrophil
PCV	Packed cell volume
PG	Picograms
pH	Power of hydrogen
RBC	Red blood cells
SW	Shell weight
ST	Shell thickness
TSP	Total serum protein
WBC	White blood cell
WHO	World Health Organization
YH	Yolk height
YW	Yolk weight

ABSTRACT

This study was conducted to investigate the effect of different levels of *Moringa oliefera* leaf meal (MOLM) on growth, reproductive performance, and haematological characteristics of the Japanese quail (*Coturnix coturnix japonica*) in Ghana. The study was conducted from April, 2019 to August, 2019. A total of one-hundred and twenty (120) brown Japanese day-old quails were obtained from Arko Farms Ltd., Kumasi and used for the experiment. The birds were allocated to four treatments with three replications. The details of the treatment groups are as follows: control (where no MOLM was added to the diet), followed by 5 %, 10 % and 15 % of *Moringa oleifera* leaf meal inclusion levels which were coded as 0% MOLM, 5% MOLM, 10% MOLM and 15% MOLM respectively. Each replicate had ten (10) birds which gave a total of thirty (30) birds per treatment in a complete randomized design (CRD). A mating ratio of 1 male: 4 females were used. Data collected were subjected to analysis of variance with the aid of GenStat version 11.1 (2008). Results from the study showed that daily and total feed intake decreased ($P < 0.05$) with increasing dietary *Moringa oleifera* leaf meal. Bodyweight and bodyweight gain increased ($P < 0.05$) with increasing dietary *Moringa oliefera* leaf meal. Birds fed *Moringa oleifera* diets had better ($P < 0.05$) feed conversion ratio than those fed control diet. Fertility was highest ($P = 0.010$) in birds fed diet that contained 15 % *Moringa oleifera* leaf meal, followed by birds fed with diets that had 10 % and 5 % *Moringa oleifera* leaf meal. The least fertility was observed among birds fed the control diet. Birds fed diet that contained 15% *Moringa oleifera* leaf meal had shorter days (42 days) to the onset of egg production ($P = 0.001$) and was followed by 10% and 5 % inclusion levels respectively while birds fed the control diet spent longer days to onset of egg laying. Increasing *Moringa oleifera* leaf meal in the diet resulted in increasing bodyweight at first egg, egg weight at first egg-laying and hen-day egg production. Dietary MOLM had significant (P < 0.05) effect on external and internal egg quality but not (P > 0.05) on shell weight, albumin weight and yolk pH. Egg diameter, egg weight and egg length were highest (P < .001) in eggs laid by birds fed 15 % MOLM and lowest in the control diet. Shell thickness was highest (P = 0.002) in the control diet and significantly lowest in 15 % MOLM diet. Albumin weight, yolk weight, yolk height, yolk pH and yolk colour were highest (P < 0.05) in 15 % MOLM diet and lowest in the control diet. Birds fed diet that contained 10 % MOLM recorded the highest (P < 0.05) albumin pH and Haugh unit. *Moringa oleifera* leaf meal inclusion in the diet showed no significant (P > 0.05) influence on hormonal, haematological and biochemical parameters. This study concludes that feeding quails with *Moringa oleifera* leaf meal up to 15 % inclusion level promotes better feed utilization and enhances rapid growth, reduces age at first egg laying, increases egg weight and hen-day egg production and also increases economic efficiency. The study also concludes that egg quality and fertility of Japanese quails increased with increasing levels of *Moringa oleifera* leaf meal in the diet. It is recommended that, for rapid growth, early attainment of puberty, high bodyweight gain and high egg quality and fertility as well as increased economic efficiency, quails diet should be formulated to contain *Moringa oleifera* leaf meal up to 15 % inclusion level.

Keywords: Japanese quail (*Coturnix coturnix japonica*), dietary *Moringa oleifera* leaf meal, growth performance, laying performance, external and internal egg quality, reproductive performance, haematological parameters, biochemical indices and hormonal profile.

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background of the Study

Traditional keeping of local poultry plays a crucial role in improving nutrition and life of people living in the rural communities (Atuahene *et al.,* 2010). The poultry industry in Ghana is one of the largest industries which offer employment opportunities to many people especially the youth. Farmers also use poultry droppings as manure to fertilize farmlands for higher yield and income (FAO, 2014). Meat and eggs from quails are important sources of protein and income. The quail is a small avian species which belongs to the Pheasant family. The black breasted (*Coturnix coromandelica*) type is bred for meat and also as a singing bird while the brown coloured Japanese quail (*Coturnix coturnix japonica*) is used for the commercial production of meat and eggs (Daikwo, 2011).

In many parts of the world, quails are raised mainly for their gamey flesh and quality eggs. The bird has a taste similar to other game birds and has many nutritional qualities that make it a worthwhile addition to the diet. Quail meat has a higher protein content of approximately 29 % as compared to 20 % for domestic fowl (Maurice and Gerry, 2005). Japanese quail (*Coturnix coturnix japonica*) is a fast-growing bird with a short generation gap as compared to all other domestic poultry birds. A broiler quail can be sold at five weeks and layers start laying at the age of 6 weeks and continue laying eggs up to 24 weeks of age (Khaldari *et al.,* 2010). The bird requires a smaller housing system and less labour intense as compared to chicken and other domestic livestock. The bird is a promising genetic resource with higher returns, which makes it suitable for production.

The success of quail meat production has been strongly related to improvements in growth, egg quality and carcass yield. To sustain and improve the quail industry in Ghana, good management and proper feeding at a cheaper cost are indispensable. Therefore, there is a need to increase quail production thereby reducing the cost of production to meet the demand for animal protein in the country. An alternative way to reduce the cost of quail production is the use of available plant-based protein such as moringa (Gakuya *et al.,* 2014). Moringa leaves and seeds have high levels of lipids and proteins which make it suitable as a poultry feed ingredient. Moringa leaves are also rich in carotenoids, calcium, methionine and cystine but generally deficient in minerals particularly iron and are used as vitamin A supplement (Gadzirayi *et al.,* 2012). Every part of the *Moringa oleifera* tree, from the roots to the leaves has beneficial properties to both humans and animals. All parts of the moringa tree are edible and have long been consumed by humans. The numerous benefits from the moringa plant make it suitable to be added to quails diet to reduce mortality and enhance growth performance (Andrew, 2011).

1.2 Problem Statement

In Ghana, there is a high demand for quail eggs due to its medicinal properties (Akram *et al.,* 2008). Despite the high demand for quail eggs and meat in Ghana, its productivity has been constrained by several factors such as high cost of production due to high cost of inputs especially in terms of feed, disease outbreaks, egg size and nutrition. Poor nutrition remains the most widespread technical constraint to good animal performance in Ghana (Naazie and Akoto, 2011). This becomes more critical during the dry season when feed availability is not only inadequate, but the quality becomes extremely poor. A well-formulated diet provides adequate nutrients including protein, vitamins and minerals essential for normal growth and physiological function of quails (Atuahene *et al.,* 2010).

The nutritional characteristics of the *Moringa oleifera* leaves are excellent so it can easily be used as a fresh forage material for feeding quails (Fayeye *et al.,* 2005). The leaves are rich in protein, carotenoids, and ascorbic acid and the pod is rich in the amino acid lysine. Despite the high crude protein content of moringa leaf meal, there is little information available on the use of this unconventional feed resource, especially as an alternative protein resource for commercial quail production (Hermogenes *et al.,* 2014). Moreover, little research work has been carried out to investigate the effect of different levels of *Moringa oliefera* leaf meal on the growth performance of Japanese quails (*Coturnix coturnix japonica*) in Ghana.

1.3 Objectives of the Study

The main objective of the study was to investigate the effect of different levels of dietary *Moringa oliefera* leaf meal (MOLM) on the growth and reproductive performance, egg quality, hormonal levels and blood profile of the Japanese quail (*Coturnix coturnix japonica*) in Ghana.

The specific objectives of the study were to determine the effect of different levels of *Moringa oliefera* leaf meal on:

i. Growth performance
ii. Laying performance and egg quality.
iii. Fertility and hatchability of quail eggs.
iv. Hormonal and blood profile of quails.
v. Economic efficiency of production.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 The Quail (*Coturnix coturnix japonica*)

Japanese quail (*Coturnix coturnix japonica*) is an important livestock in poultry production (Plate 2.1). As quail farming has increased all over the world, studies have examined the genetic diversity of domestic quail populations as well as physiological and genetic factors affecting economic traits, such as growth rate, egg-laying rate, and disease resistance to maximize productivity and profitability (Daikwo, 2011). The bird is also used in several biological studies as a laboratory animal because of its useful biological properties, including a short generation interval and small body size (Plate 2.1). Many laboratory and mutant lines with unique characteristics, such as feather colour, egg colour, morphology, and hereditary disorders, have been developed (Maurice and Gerry, 2005).

The life span of the bird ranges from two to four years. An adult quail can weigh between 150 to 200 grams (Arinze, 2013). Layers start laying eggs from 6 to 7 weeks of age. Each egg weighs between 7 to 15 grams (Abdel-Azeem, 2005). Quails can lay more than 300 eggs per year. Their eggs are very colourful. Presence of light increases egg productive efficiency of quails. The bird usually lay eggs in the afternoon and it takes about 17 days to hatch the eggs (Arinze, 2013). A newly hatched quail chick weighs around 6 to 7 grams. For successful breeding purpose, one male to five female quails is adequate (George, 2002). Day-old chicks during the brooding period are very sensitive and take about two weeks to be strong enough. Eggs of 9 to 11 grams weight with smooth and hard eggshell are perfect for hatching and producing chicks (Daikwo, 2011).

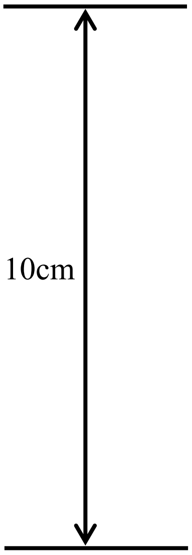

Plate 2.1: The Quail

2.1.1 Domestication and distribution of quail

Japanese quail was domesticated in Japan in the 12th century owing to its pleasant song (Akram *et al.,* 2010). The birds were reportedly introduced from Japan to the United States twice, in the 1870s and the early 20th century, as a game bird (George, 2002). Commercial quail production began around 1910 in Japan and became active in the 1930s (Maurice and Gerry, 2005). During this period, Japanese quail was selected for various characteristics, such as body size and plumage colour in Japan. Since the 1930s, domestic quail for egg and meat production was exported from Japan to the United States, Europe, and all other parts of the world. The recovered commercial populations were again exported to foreign countries and were rapidly distributed around the world including Ghana. Therefore, most domestic Japanese quail that are bred worldwide today are likely descendants of populations that were re-established in Japan after World War II (Sharp, 1988).

2.1.2 Taxonomy of Quails

The name quail is a collective name for several genera of mid-sized birds generally placed in the order Galliformes. Old World quails are placed in the family Phasianidae, and New World quails are placed in the family Odontophoridae (Khaldari *et al.,* 2010). Various sub-species then developed from this, including the European quail, *Coturnix coturnix coturnix*; the Eurasian quail, *Coturnix coturnix communis*, and the Japanese quail, *Coturnix coturnix japonica* (Daikwo, 2011).

Table 2.1: Taxonomy of the Japanese quail (Coturnix coturnix japonica)

Kingdom	Animalia
Phylum	Chordata
Class	Aves
Order	Galliformes
Family	Phasianidae
Genus	Coturnix

Source: USDA (2000).

2.1.3 Breeds of Quails

Twenty types of wild quail exist along with 70 domestic breeds/strains all over the world, including laboratory and commercial lines (Akram *et al.,* 2010). The brown Japanese quail (*Coturnix coturnix japonica)* is commonly found in Ghana. This type of quail is mostly used for commercial production due to its large size, higher meat and egg production. This breed contains more meat and produces more eggs than the others (Aggrey, 2003). Button quail (also known as King Quail, Chinese-Painted Quail and Blue-breasted quail) are rarely kept for food production because they are smaller and produce fewer eggs. The birds are kept in large aviaries to clean the leftover seeds that fall to the floor. California, Gambel, Bobwhite, Scaled quails, etc. are less common and are rarely kept as pets (Dogara, 2013).

2.2 Quail (*Coturnix coturnix japonica*) Production

2.2.1 Quail Farming

Quail farming is raising quails commercially (like other poultry birds) for profitable eggs and meat production (NVRI, 2011). Quail farming business is very easy, lucrative and entertaining. It's very easy to maintain a quail farm because quails are among the smallest species of poultry birds. Commercial quail farming in all over the world has spread tremendously. Currently, throughout the world, people are entering into quail farming business commercially for meat and eggs (Dogara, 2013). Quail farming is very profitable like other farming ventures, such as chicken, turkey or duck farming business. Almost all types of weather conditions are suitable for starting quail farming business.

2.2.2 Production and Consumption of Quails in the World

France, Spain, Italy, China and the US are the largest producers, with other countries far behind productivity. However, some initiatives to foster production were launched in places such as India, Australia and Canada (George, 2002). These regions are either trying to tap into some local advantages in production or have an eye on a specific export market. According to data provided by Lin-Qilu from Nanjing Agriculture University, China would be once again, the largest meat producer. He estimates that the country has around 80 million quail housed exclusively for that purpose (Dhaliwal *et al.,* 2004). Next is Spain, which in 2016 produced an estimated 9,300 tonnes of quail meat according to Arinze (2013). This represents less than 5 % of the author's estimated figures for the production of special kinds of the country's poultry meat (less than 1 % of common broiler production). The author explains that Spain has a highly concentrated production structure, with 5 companies dominating the scene. The country exports much more than it imports, and is by far France's main trading partner in both directions. Over the past few years, exports fluctuated around 2,000 tonnes.

2.2.3 Quails Production in Africa

Quail farming in the African continent has not increased rapidly as expected, but quail has been farmed around the world for so many years now. In Kenya and other African countries, many people got into quail farming for the "get rich quick scheme" and it was bound to fail. Quail egg is sold ten times more than chicken eggs which are four times bigger and so quail farming is much profitable (Musa *et al.,* 2008). Many farmers in Kenya, Nigeria and other African countries still keep quails and the price has stabilized to almost the desired price for the final consumer and that is what it was supposed to have been in the first place. Some poultry farmers in Kenya, Ghana and Nigeria are also campaigning for quail farming to increase the productivity of the bird (Aggrey, 2003). So far quail production in the African continent is very low as compared to Europe, Asia and the American continent.

2.2.4 Quail (Coturnix coturnix japonica) Farming in Ghana

The climate and natural condition of Ghana are very suitable for quail rearing. The bird can be reared in this country throughout the year and shows a good performance in meat and egg production (Musa *et al.,* 2008). It has a shorter life cycle and its production requires less capital and land. The bird serves as a source of income in addition to chicken and ducks for its immense potentiality for meat and egg production (Daikwo, 2011). With the rapid increase in total population and urbanization in Ghana, the demand for poultry products is on the increase. Quail farming as a supplement to chicken and duck farming has the unique advantage of tapping the growing market demand for quail meat and eggs (George, 2002). Quail does not only supply animal protein in the form of meat and eggs, but also provides a source of income to most poultry farmers. These farms are producing meat, eggs and quail-chicks/pullets. Quail farming is very entertaining and can easily be done at the backyard (George, 2002). However, quail farming has not yet been popularized in rural areas in Ghana (Aboul-Hassan, 2000).

2.2.5 Marketing of Japanese Quails (Coturnix coturnix japonica)

Quail meat and eggs are very tasty and highly enriched with nutrient elements. So, there is already an established market for quail. Quail birds are small in size and cheap in price and all types of people can purchase. It is easy to market quail products. Farmers can easily sell the eggs and meat at the local market (NVRI, 2011). Commercial quail farming can be a great source of employment and can provide extra income to farmers.

2.3 Reproductive Characteristics of Quails

2.3.1 Age at sexual maturity

Sexual maturity determines when the quail will lay its first egg. After a pullet reaches maturity, hours of light, bodyweight of the bird and body fat percentage come together to determine when the pullet will lay its first egg (Daikwo, 2011). The age at sexual maturity may also vary according to quail breed, nutritional management and season of production. In domestic chicken, pullets of modern breeds start egg laying around 18 to 21 weeks of age. According to Abdel-Azeem (2005), the bodyweight at sexual maturity, egg weight of first 10 eggs and mean egg weights at 12–23 weeks of age have been reported as 122.9–128.2 g, 8.99 –9.72 g and 9.47–10.15 g respectively. Maurice and Gerry (2005) reported that the age of sexual maturity was 48.9–49.6 days in quails. Dogara (2013) reported that average age at sexual maturity of Japanese quails was 44.9 days, while their 126-days egg production was 55–64.9. Also, egg weight in these quails was determined as 10.8– 11.4 g for the 18th week of age. Khaldari *et al.* (2010) found that hen-day egg production percentage was 77– 93.1 % while egg weight was 10 –13 g with 62.6–120.4 g weekly total egg mass in quails aged 14 weeks.

2.3.2 Weight at sexual maturity

Bodyweight is regarded as a measure to predict the weight of an egg at the first lay in poultry production. An adult quail weighs between 150 to 200 grams. Abdel-Azeem (2005) observed a positive correlation (r ¼0.330) between age at sexual maturity and bodyweight at sexual maturity and reported that a heavier bodyweight resulted in late maturation. This relationship was per the results (r ¼ 0.29) of Dogara (2013). The determined body weights at sexual maturity of 221.6, 235.0, and 245.0 reported by Dogara (2013) were in line with those of Khaldari *et al.* (2010) but higher than those of Maurice and Gerry (2005).

2.4 Laying Ability and Egg Production of Quails

Female quails start laying eggs from their 6 to 7 weeks of age. The birds lay more than 300 eggs per year. The birds usually lay its eggs in the afternoon and each egg weights between 7 to 15 grams. Their eggs are very beautiful. Presence of light increases the egg productive efficiency of quails. It takes about 17 days to hatch their eggs. Egg production in quails depends on temperature, feeding, water, care and other management practices (Kwari *et al.,* 2011). To get the desired egg production from quails, light plays a vital role. Numerous studies conducted by different researchers such as Dogara (2013) have shown that quail pullets which reach sexual maturity very early can lay more eggs as compared to pullets which delay in egg-laying. However, bodyweight of quail pullets determines the birds laying ability and the number of eggs that can be laid within the production cycle. NVRI (2011) reported that, among the different breeds of quails, the black variety can lay an average of 90 eggs per year whilst the brown quails can lay 130 eggs.

2.4.1 *External and internal egg characteristics of quails*

The physical and chemical properties of quail eggs play a critical role in embryo development and influence fertility and hatchability. The role played by the physical and chemical properties of quail eggs, have the potential to meet the demands of fast-growing quail embryos regarding nutrition, physical protection, and subsequent smooth hatching procedure to produce viable chicks (Sharp, 1988). Both egg external quality parameters, such as egg weight, eggshell thickness, egg surface area, egg diameter and egg volume, and internal egg quality traits, such as yolk weight and height, yolk pH, albumen height and weight may directly or indirectly influence hatchability results (Dudusola, 2010). For example, egg weight affects both hatchability and hatchling weight. Similarly, internal egg quality traits, such as yolk and albumen contents, influence embryo development and hatchling livability (USDA, 2000).

Eggshell protects and supplies calcium, and other minerals to the embryos and allows gas and water exchange between the embryos and the external environment, which is essential for the success of the entire incubation and hatching processes. Specifically, gas exchange occurs by diffusion through microscopic pores on the surface of the eggshell, and hence, depends on pore counts and eggshell thickness (Aggrey, 2003). Both pore counts and eggshell thickness modify eggshell water-exchange properties and so influence egg weight loss percentage (EWL%) during incubation. Both lower pore numbers-high eggshell thickness or higher pore count-low eggshell thickness impair gas exchange, ultimately causing embryonic mortality (King *et al.,*2011).

Most studies investigating the influence of egg internal quality parameters on embryonic development and hatchability traits have focused on albumen and yolk quality. In addition to supplying essential nutrients for embryo growth and development, the albumen also protects embryos from exposure to pathogenic microorganisms (Musa *et al.,* 2008) and hatchability rates have been linked to changes in albumen quality (Abdel-Azeem, 2005). Yolk morphometric measurements can be obtained by mathematical calculations and yolk amount and composition are known to impact of post-hatching yolk sac nutrient reservoirs. Several major (egg storage time and conditions, and hen strain and age) and minor (nutrition in specific cases) factors have been connected to changes in internal egg quality traits (Aboul-Hassan, 2000). Maurice and Gerry (2005) Experimented on laying performance, egg quality and hatching results in brown quail genotype. The study compared egg characteristics of quails fed diets contained graded levels of MOLM. Reports indicated albumin weight (6.98±0.05), albumin height (4.53±0.07), yolk height (10.34±0.09), yolk weight (3.61±0.06), Haugh unit (89.57±0.34).

Eggs contain comparatively more protein, phosphorus, iron, vitamin A, B1 and B2 and are used for local medicine in most rural areas and the eggs are very expensive (Akram *et al.,* 2008).

2.4.2 Incubation and hatching of quail eggs

Japanese quail eggs can be hatched through artificial means or natural means (Khaldari *et al.,* 2010). In Ghana, most smallholder farmers give quail eggs to local chicken to sit on the eggs for 17-20 days (USDA, 2000). Under the artificial incubation system of hatching eggs, 12 to 15 eggs may be set under a local chicken. With the artificial incubation, quail eggs are set in the incubator throughout the incubation period. The artificial incubation is normally used by commercial farmers where more than 500 chicks can be hatched within 17 and 20 days (Daikwo, 2011).

Storage and incubation conditions such as temperature and humidity are important for hatchability of quail eggs. The recommended storage conditions of quail eggs are 10 to 18 ºC with relative humidity of 70 to 80 % (Dogara, 2013). Fumigation between 12 hours and 4 days after setting the eggs affect the developing embryos. Quail eggs take 17 to 20 days to hatch (USDA, 2000). According to NVRI (2011), Bobwhite quail eggs take 20-24 days to hatch. The normal incubation period for quail eggs is 17 to 20 days for crossbreds and 18 to 24 days for local breeds.

2.4.3 Fertility and hatchability of quail eggs

According to Arinze (2013), fertility and hatchability are among the most important parameters of reproductive traits which are most sensitive to environmental and genetic influences either low or high. Quail egg fertility refers to the percentage of incubated eggs that are fertile. Clear eggs may contain truly infertile or (fertile) embryos that died earlier (Dhaliwal *et al.,* 2004). Infertility in quail egg is the failure of a true pair to produce eggs with viable embryos. It differs from low hatchability where fertile eggs fail to hatch. Poor fertility among quail eggs depends largely on nutritional management such as, inadequate dietary calcium, sodium and energy. Poor nutritional management can interfere directly with egg laying and fertility (John and Kenaleone, 2014).

Quail eggs stored from 0 up to 20 days at 7.5 ± 1 °C averaged 87.7 % of hatchability. It is known that optimum hatchability after long-term storage (> 14 days) can be achieved when storage temperature is about 12 °C for chicken eggs (George, 2002). Despite these reports, Japanese quail eggs stored in a domestic refrigerator (7.5 ± 1 °C) presented high levels of hatchability that varied between 75 % and 95 %. The reason that 12 °C is the optimum for long term storage is that this temperature is the lowest possible for sufficient moisture-holding capacity to prevent dehydration of the embryo. According to Akram *et al.* (2008), hatchability decreased by the 16th day of storage, reaching 75 % in eggs stored for 20 days.

Some researchers reported a decrease in hatchability due to storage in turkey eggs, Japanese quail eggs (NVRI, 2011) broiler eggs and ostrich eggs (Arinze, 2013). Khaldari *et al.* (2010) stored Japanese quail eggs at 9-12°C and 70 - 75 % RH up to 15 days and found the following hatchability of fertile eggs: 90 % for eggs stored up to 3 days, 88.74 % for eggs stored from 4 up to 6 days, 67.96 % for eggs stored from 7 up to 9 days, 72.45 % for eggs stored from 10 up to 12 days, and 50.31 % for eggs stored from 13 up to 15 days. NVRI (2011) studied quail egg hatchability from 4 days up to 38 days of storage (13.3 ºC) and found 78.6 % of hatchability for 4 days, 76.9 % for 8 days, 72.4 % for 13 days, 59.7 % for 18 days and 47.5 % for 23 days of storage.

2.5 Blood Characteristics of Japanese Quails

Blood is a body fluid in animals that delivers necessary substances such as nutrients and oxygen to the cells and transports metabolic waste products away from those same cells (Ewuola *et al.,* 2012). Blood indices are important physiological and nutritional indicators of the body. Total protein and albumin are indicators of the protein status of the blood. Packed cell volume (PCV) gives useful health information especially when the animal has not shown any clinical signs of ill health (Gbolabo *et al.,* 2015). Red blood cell indices (mean corpuscular volume, MCV, the mean corpuscular haemoglobin, MCH, and the mean corpuscular haemoglobin concentration, MCHC) help diagnose anaemic conditions while the classification of anemia have been achieved using the MCV and red cell distribution width, (RDW) (Hassan and El-Moniary, 2015). Generally, the absence of differences in various haematologic parameters, especially, when it is within the normal range implies that there is no infection, inflammation or stress (Khaldari *et al.,* 2010). The most abundant cells in quail blood are red blood cells. These contain haemoglobin, an iron-containing protein, which facilitates oxygen transport by reversibly binding to this respiratory gas and greatly increasing its solubility in the blood (NVRI, 2011).

2.5.1 Haematological characteristics of quails

In veterinary science, haematology is the study of the physiology and pathology of the cellular elements of blood including the diagnosis, treatment, and prevention of diseases of the blood, bone marrow, and immunologic, haemostatic, and vascular systems (Ewuola *et al.,* 2012). Haematology also refers to the study of the numbers and morphology of the cellular elements of the blood that is erythrocytes, leucocytes, and thrombocytes and the use of results in the diagnosis and monitoring of disease in quails. Several physiological and physical factors can affect the results of haematology assays and make it difficult to establish reference values (USDA, 2000). The importance of haematological analysis is for diagnosis and treatment of quail diseases (Sharp, 1988). Changes in haematological parameters in quails also assist in the determination of an animal's physiological status and stress due to nutritional, environmental and pathological factors (Nobakht and Mehmannavaz, 2010).

2.5.2 Biochemical characteristics

Biochemical parameters of blood help in diagnosing specific poultry health conditions such as hen pathology and can serve as a basic knowledge for studies in immunology and comparative avian pathology (Bonadiman, 2009).

Serum biochemical parameters include; albumin, cholesterol, globulin, triglycerides, high density lipoprotein, low density lipoprotein, and total serum protein (Colville, 2002). Serum biochemical determinations can be carried out using commercial test kits such as Quimica Clinica Aplicada (QCA) test kits (QCA, Spain), Randox tests kits (Randox, UK) for total proteins and albumin. Total serum proteins can be determined by the direct Biuret method (Lubran, 1978) and serum albumin also determined by the Bromocresol green method (Doumas *et al.,* 1971). Serum globulin can be calculated as the difference between the serum total proteins and serum albumin (Colville, 2002) while serum total bilirubin can be determined by the use of Jendrassik-Grof method (Doumas *et al.,* 1973). The serum cholesterol can be determined by the enzymatic colorimetric method (Allain *et al*., 1974). Mean values for some serum biochemical parameters of the Japanese quail were reported by Onyinyechukwu *et al.* (2017) with the minimum and maximum values in parenthesis as follows: total proteins (TP) 5.19 g/dl [2.75 – 7.84], albumin (ALB) 3.25 g/dl [1.08 – 5.47], globulin (GLB) 1.94 g/dl [1.00 – 3.11], albumin: globulin (A/G) 1.73 [0.43 – 3.81], total cholesterol (TCHOL) 146.69 mg/dl [33.33 – 266.67], total bilirubin (TBIL) 2.37 mg/dl [0.89 – 4.32], uric acid (UA) 16.02 mg/dl [1.27 – 29.27] and creatinine (CREAT) 0.44 mg/dl [0.15 – 0.92]. The serum biochemistry parameters obtained in this study differed from those of Scholtz *et al.* (2009) who found considerably higher results, while the total proteins, globulin, albumin, uric acid and creatinine levels were similar to those obtained by Prakash (2013).

Biochemically, sex related differences have been observed among matured quails with females having higher albumin, globulin, total protein, uric acid and total cholesterol concentrations than males. These differences could be explained by the physiological changes in the female quail due to egg laying (Walzem *et al.,* 1999). During the laying period, hepatic synthesis of triglycerides, phospholipids and cholesterol is increased. These lipids make up the lipoproteins, which are circulated in the blood and incorporated into the oocytes of the ovaries. Thus, laying birds have higher circulating concentrations of triglycerides and cholesterol in contrast to male birds (Coenen *et al*., 1994).

2.5.3 Hormonal characteristics

Hormones are chemical messengers that are produced by glands in the endocrine system (Nobakht and Mehmannavaz, 2010). Hormones travel through the bloodstream to the tissues and organs, delivering messages that tell the organs what to do and when to do it (Sharp, 1988). Hormones are important for regulating most major bodily processes, so a hormonal imbalance can affect a wide range of bodily functions (Khaldari *et al.,* 2010).

Hormones are responsible for all the activities as well as behaviour in quails. Good hormonal levels have a positive effect on the growth rate, egg production and reproductive performance; therefore, any imbalances will highly affect the birds' productivity (NVRI, 2011). Hormonal imbalances occur in quails when there is too much or too little of a hormone in the bloodstream. Because of their essential role in the body, even small hormonal imbalances can cause side effects throughout the body (USDA, 2000).

Moringa oleifera has a significant source of vitamins A, B, C, E and K which enhance reproduction (Peter, 2008).

2.6 Importance and Constraints to Quail Farming

2.6.1 Importance of quail farming

Quail meat is a game meat with extremely low cholesterol values which makes it preferable by most consumers. The meat is very nutritious in micronutrients and a wide range of vitamins. It is therefore recommended for people with high cholesterol levels and individuals who want to maintain a low level of cholesterol in the blood (Abdel-Azeem, 2005). Research by Dudusola (2010) revealed that quail eggs are healthier than other eggs consumed by humans in terms of nutritious value. Unlike chicken eggs, quail eggs can be consumed by all people. This is because quail eggs are rich in choline (a chemical essential for brain function) and have low cholesterol value as well. Other benefits of quail eggs include treatment of anaemia, removal of toxins and heavy metals from the blood and strengthening of the immune system and heart muscle (Sharp, 1988).

Quail eggs also improve vision, enhance good memory and brain activity, slows down the ageing of organs, improves skin complexion and others (Dudusola, 2010). Quail eggs can be eaten with shells to boost the immune system and restore the body's calcium deficiency. It is worth noting that the shells must be well washed (Maurice and Gerry, 2005). The intake of other eggs such as the chicken eggs can result in certain allergic reaction in some consumers (Maurice and Gerry, 2005). On the other hand, quail eggs are allergy-free and help to fight allergy in the human body. This is possible because of ovomucoid, a protein found in the egg white (Daikwo, 2011).

Aside from the health benefits of consuming quail eggs and meat, quail farming can be a business opportunity for any individual who embarks on such endeavor (Dogara, 2013). That is, one can choose to sell the meat, eggs or live birds to earn profit. Comparing other poultry farming to quail farming, the quail farmer enjoys several merits unlike other poultry farmers. In other words, quail farming requires minimum floor space due to the small size of quails. There will be no need to spend extra money on large pieces of land in quail farming (Aggrey, 2003).

Additionally, there is a low cost of setting up production. One does not need a lot of initial capital to commence a quail farm since the quails are relatively cheaper as compared to other birds due to their small size and easy to get (Khaldari *et al.,* 2010). Quail farming does not require special education to set up. There is also a high tendency to increase in the number of quails due to the fast growth rate and the ability of female quails to lay eggs at seven weeks old (Dogara, 2013).

2.6.2 Constraints to quail farming

Quail feed is quite expensive. In Ghana, quail is not yet popular because of some unique characteristics. It is a sensitive bird and cannibalism rate is very high. Management is uncommon at the farmer level, high chick mortality, egg production peculiarity, low body and egg weight are common challenges. Low level of dietary protein affects growth and egg production of quail negatively (George, 2002). The chicks are very small and weigh between 8g and 10 g, and mortality is very high among chicks. In extreme cold conditions the chick mortality can be 100 % due to small body size of the quail, more heat is therefore needed in the brooding condition which is another problem at the farmer's level (Maurice *et al.,* 2005). Absence of adequate warm temperature and exposure to high speed cool winds leads to clustering of young ones which results in high mortality. Lack of education and low levels of literacy make access to information difficult and commonly undermine the confidence and skills needed by farmers to go in large scale production whether at village, community, local or national level.

Studies have shown a strong association between the education of women, economic development and proper livestock husbandry (Dhaliwal *et al.,* 2004). Lack of education deprives the farmers knowledge and means of producing more on the farm (Arinze, 2013). Management abilities and practices determine the difference between success and failure. The limited availability of effective disease treatments makes proper management an absolute necessity (Maurice and Gerry, 2005).

2.7 Nutrient Requirements of Quails

The nutrients that comprise a quail diet are water, protein, carbohydrate, fat, minerals, and vitamins. Although all are essential, adequate water may be considered the single most important nutrient. Fresh clean water should be provided continuously to all birds, especially under the tropical environment. Quails require at least twice, as much in weight of water as required in weight of dry feed (Aggrey, 2003). Quals may require more water if there are excess salts in the feed or during the hot dry season (NVRI, 2011).

2.7.1 Water requirement of quails

The amount of water required is dependent on the environmental temperature and relative humidity, the composition of the diet, rate of growth, egg production, and efficiency of kidney absorption of water in individual birds (Daikwo, 2011). Fresh clean water should be provided continuously to all birds, especially under tropical environments. Quails require at least twice, as much in weight of water as required in weight of dry feed (Aboul-Hassan, 2000). Newly hatched quail is about 75-80 % water (Musa *et al.,* 2008). The water level falls as the bird ages, but the need for water remains. The water requirement of quail chick changes with age, and with quantity and quality of feed dry matter (Dhaliwal, 2004). Water intake is typically 3:1-4:2 g/g body weight at 12-29 days of age which stabilizes at around 2 g/g body weight thereafter. The water to feed ratio for the above period is 2:0 - 2:3 respectively (Amevor, 2017).

2.7.2 Protein requirement of quails

Protein provides the amino acids for tissue growth and egg production. The dietary protein requirement of quail is influenced by metabolizable energy content and the ingredients used to formulate the diets. The earlier investigators raised their quail flocks successfully on turkey starter diets containing about 25-28 % crude protein (Sharp, 1988). Abdel-Azeem (2005) have shown that a dietary crude protein level of 24 % is needed in a starter diet for quail and the protein content may be reduced to 20 % by 3rd week of age. Protein is the most expensive nutrient and must be provided from a high-quality source (Moyo, 2011).

Protein quality is generally based on the amino acid composition of the feedstuff and the availability of these amino acids from the feedstuff through digestion in the gut of the quail. Amino acids are considered as the building blocks of proteins. Quail diets consist mainly of plant materials (Maurice and Gerry, 2005). The most commonly used plant products are maize, soybean meal, sorghum, and rice or wheat bran. Methionine and lysine are generally low in plant products. Animal protein products such as fish meal, and meat, among others are good sources of most of the essential amino acids, but are usually more expensive than plant protein ingredients (John *et al.,* 2014).

2.7.3 Energy requirement of quails

The amount of food intake depends upon the metabolizable energy (ME) content of the diet, age of the birds, their reproductive status and the ambient temperatures. An energy requirement of 2,600 to 3,000 kcal ME/kg diet for growing quail has been reported from temperate regions (Khaldari *et al.,* 2010). whereas, findings under the tropic condition indicated an energy requirement of about 2,800 kcal ME/kg for growing quails (Akram *et al.,* 2008) and 2,550 kcal ME/kg for laying quails (Dogara, 2013). Though raising the dietary energy levels from 2,600 to 2,800 kcal ME/kg did not influence the gain in weight, it affected significantly the efficiency of feed utilization as the feed consumption was reduced significantly (Etalem *et al.,* 2013). The main energy source is provided by the grains and cereals which are the main ingredients in most feed.

2.7.4 *Vitamins requirement of quails*

Vitamins may be categorized as fat-soluble, (A, D, E, and K) and water-soluble (the B-complex vitamins) (George, 2002). Many vitamins are quite stable but some deteriorate rapidly on exposure to heat, sunlight, or air (George, 2002). Housed quails are entirely dependent on the vitamins that are present in their compounded feed in the correct amount and proportions, for they have no access to the natural supply of these nutrients. The principal feature of vitamin A is its function in ensuring adequate growth and as a means of assisting in the birds' resistance to disease. Vitamin A is essential for normal vision, egg production, and reproduction (USDA, 2000).

Laying quails receiving insufficient vitamin A produce fewer eggs and eggs produced frequently do not hatch. For egg production and fertility of females, a level of 2,500 I.U. vitamin A/kg diet was required (Aggrey, 2003). The hatchability and survival of newly-hatched chicks were better with 3,200 I.U. vitamin A/kg diet. Vitamin D is associated with sunlight, for sunlight provides irradiation that stimulates the manufacture of vitamin D in the skin of the bird. Unfortunately, laying quails are seldom exposed to direct sunlight, so the body synthesis of vitamin D is limited. A deficiency of vitamin E in semi-purified diets containing isolated soybean protein and starch did not affect the body weight, feed consumption, or egg production of Japanese quail. However, it caused sterility in males, which was overcome by restoring 40 I.U. vitamin E/kg to the diet for about 2 weeks. The fertility and hatchability of quail eggs were severely depressed after the birds were fed a conventional diet containing glucose and soybean meal, but deficient in vitamin E for 20 weeks (Banj*o,* 2012).

2.7.5 Mineral requirement of quails

Minerals are observed to be present in feed ingredients such as fish meal, meat, bone meal and milk products, but good supplemental sources of calcium and phosphorus are. Oyster shell, limestone, tricalcium phosphate or calcium carbonate (Dhaliwal *et al.,* 2004). The main function of calcium and phosphorous is in the make-up of the bones of the body. Calcium is essential for the deposition of eggshell. Calcium and phosphorus are required in sufficient quantity and correct proportions. The young quail needs a minimum of 0.8 % of the diet as calcium and 0.45 % as available phosphorus, whilst the laying quail needs about 2.5 % to 3% of calcium since this is the main constituent of the eggshell (Musa *et al.,* 2008). Magnesium is an essential constituent of tissues and body fluids. It serves as activators of important enzymes involved in intermediary metabolism (Arinze, 2013). It has been shown that when magnesium is absent in diets, quails grow slowly, exhibit convulsions and may eventually die (NVRI, 2011). Also, deficiency of magnesium will lead to a rapid drop in egg production.

Sodium and chloride are also needed for protein digestion and acid-base equilibrium in the body. The growing Japanese quail fed a purified type of diet containing 0.042-0.051 % sodium has been observed to have poor growth, high mortality, adrenal enlargement, elevated haematocrit, and depressed plasma sodium suggestive and electrolyte haemostasis (Daikwo, 2011). A dietary sodium level of 0.1 % overcame these difficulties (Aboul-Hassan, 2000). Natural feedstuffs usually require supplemental feeding of salt (NaCl) to satisfy the quail's requirement for sodium and chloride This is usually added to the feed at amounts of not less than 0.25 to 0.35 %.

2.8 Origin of Moringa

According to Abbas and Ahmed (2012) *Moringa oleifera,* is a native to India, the Red Sea area and/or parts of Africa including South Africa and Ghana. Moringa (*Moringa oleifera*), according to Juniar *et al.* (2008) belongs to the *Moringaceae family.* Although, *Moringa oleifera* is native to India, currently, it has been planted around the world and is naturalized in many countries including Ghana (Safa, 2014: Zanu *et al.,* 2012). It is a fast-growing, drought-resistant tree native to sub-Himalayan tracts of northern India, Pakistan, Bangladesh and Afghanistan (Abbas and Ahmed, 2012). It is now growing worldwide in the tropics and subtropics (AbouSekken, 2015). There are 13 species of moringa trees in the family Moringaceae (Birger, 2014). Of these species, *Moringa oleifera* is the most widely known. Its leaves and pods have been reported to be of great nutritional value and contain many vitamins and minerals.

This rapidly-growing tree also known as horseradish tree or drumstick tree was utilized by the ancient Romans, Greeks and Egyptians (Gbolabo *et al.,* 2015). All parts of the moringa tree are edible and have long been consumed by humans. Naazie and Akoto (2011) reported the many uses of moringa as follows: alley cropping (biomass production), animal forage (treated seed-cake), biogas (from leaves), domestic cleaning agent (crushed leaves), blue dye (wood), fertilizer (seed-cake), foliar nutrient (juice expressed from the leaves), green manure (from leaves), gum (from tree trunks), honey and sugar cane juice-clarifier (powdered seeds), honey (flower nectar), medicine (all plant parts), ornamental plantings, biopesticide (soil incorporation of leaves to prevent seedling damping off), the pulp (wood), rope (bark), tannins for tanning hides (bark and gum), and water purification (powdered seeds) (Kakengi *et al.,* 2003).

2.8.1 Moringa oleifera leaves as feed

In tropical countries, forage quality is often too low to meet the nutritional requirement of animals. Furthermore, supplementation with conventional concentrates is generally too costly and the levels of concentrate feeding are therefore low. New low-cost alternatives to commercial concentrates are needed and moringa is one possible option (AbouSekken, 2015). However, the first critical step in its general use in livestock diets is precise and reliable knowledge of its chemical composition, digestibility and nutritional value. Other practical issues in connection with the use of moringa as a feedstuff are the labour requirement and how well it can be conserved. Such information is particularly vital in the current context, where farmers are trying to achieve more sustainable production throughout the year (Cynthia *et al.,* 2010).

Plate 2.2: Moringa oleifera Leaves

Moringa plant can grow and produce leaves at a faster rate which make the plant available year-round and very useful for feeding poultry birds (Du *et al.,* 2007; Dudusola, 2010b). According to Onu and Aniebo (2011), *Moringa oleifera* leaves would be of great use in treating malnutrition among farm animals to increase productivity. The leaf has many important vitamins and minerals. The leaves have 7 times more vitamin C than oranges and 15 times more potassium than bananas (Plate 2.2). It also has calcium, protein, iron, and amino acids, which help the body to heal and build muscle. It's also packed with antioxidants, substances that can protect cells from damage and may boost the immune system. Some of these antioxidants can also lower blood pressure and reduce fat in the blood and body (Olabode and Okelola, 2014).

2.8.2 Nutritive value of Moringa oleifera leaves

According to Safa and Tazi (2012), moringa leaf meal contain 12 MJ/Kg of metabolizable energy, 23 % crude protein, 79.7 % digestibility, 19.25 % CF, 7.13 % ash, 41.98 % NFE, 0.33 % P and 8.64 % Ca. It also contains an adequate amount of cystine, carotene, ascorbic acid, iron and methionine (Olugbemi, 2010; Ebenebe *et al.,* 2012). *Moringa oleifera* leaves are packed with nutrients important for farm animals. Moringa leaf meal has 27 % crude protein, a crude protein percentage of 25- 27 %, suggesting that the leaves are a good source of protein for poultry birds (Mahmood and Al-Daraji, 2011). The high proportion of this protein is available in the leaves (Safa and Tazi, 2012).

Table 2.2 Proximate Composition of Moringa leaves

Parameter	Percentage (%)	Reference
Dry matter (DM)	86	Kakengi *et al.* (2007)
Crude protein (CP)	29.71	
Crude fibre (CF)	22.5	
Ether Extract (EE)	4.38	
Calcium	27.9	
Phosphorus	0.26	
Dry matter (DM)	83.22	Oduro *et al.* (2008)
Crude protein (CP)	27.51	
Crude fibre (CF)	19.25	
Ether Extract (EE)	2.23	
Ash	7.13	

In 2007, Kakengi reported the proximate composition of MOLM as shown in the Table 2.2. Oduro *et al.* (2008) also analyzed the content of moringa leaf meal and their findings are presented in Table 2.2. According to Kakengi *et al.* (2007), *Moringa oleifera* leaf meal do not only serve as protein sources but also provide some necessary vitamins, minerals and also oxycarotenoids which cause yellow colour of broiler skin, shank and egg yolk. Furthermore, these leaves also have a high total antioxidant capacity (260 mg/ 100 g), total polyphenols (260 mg/100 g), quercetin (100 mg/100 g), kaempferol (34 mg/100 g) and β-carotene (34 mg/100 g) (Etalem *et al.,* 2013).

Table 2.3: Mineral Contents of Dried Moringa oleifera Leaves

Mineral	**Dry leaf meal**
Calcium (%)	3.65
Phosphorus (%)	0.30
Magnesium (%)	0.50
Potassium (%)	1.50
Sodium (%)	0.164
Sulphur (%)	0.63
Zinc (mg/kg)	31.03
Copper (mg/kg)	8.25
Iron (mg/kg)	490
Manganese (mg/kg)	86.8
Selenium (mg/kg)	363.00
Boron (mg/kg)	49.93

Source: Moyo *et al*. (2011)

Moringa oleifera seeds contain higher amounts of relatively stable oleic acids followed by palmitic acid and behenic acids (Ebenebe *et al.,* 2012). Therefore, apart from being an important nutritional agent, *Moringa oleifera* possesses a wide range of additional biological activities including antioxidant, tissue protective (liver, kidneys, heart, testes, and lungs), analgesic, antiulcer, antihypertensive, radioprotective, and immune modulatory actions (Nkukwana *et al.,* 2014). There is adequate literature on the nutritional value of *Moringa oleifera* leaves with varying nutritional content according to different authors (Moyo *et al*., 2011).

Table 2. 4: Nutritional Qualities of Moringa oleifera Leaf Meal

Nutritive value	**Dry leaf meal**	**Source**
Crude protein	25.1-30.29	(Olugbemi *et al.,* 2010a; Moyo *et al.,* 2011)
Neutral detergent fibre	11.40-21.9	(Moyo *et al*., 2011; Amevor, 2017)
Acid detergent fibre	8.49-11.4	(Moyo *et al*., 2011; Amevor, 2017)
Gross energy (MJ/kg DM)	18.7	(Ewuola *et al.,* 2012)
Ether extract	5.4	(Hasin *et al.,* 2006)
Lysine	1.1-1.64	(Amevor, 2017; NRC, 2006.)
Histidine	0.6-0.72	(Amevor, 2017; NRC, 2006)
Threonine	0.8-1.36	(Amevor, 2017; NRC, 2006)
Arginine	1.2-1.78	(Amevor, 2017; NRC, 2006)
Methionine	0.30	(Hermogenes *et al.,* 2014)
Total phenolics	2.02-2.74	(Moyo *et al*., 2011; Amevor, 2017)
Tannins	0.53	(Hermogenes *et al.,* 2014)
Condensed tannins (mg/g)	3.12	(Hermogenes *et al.,* 2014)

Moringa oleifera has been reported to possess several nutrients (Table 2.3), including: calcium, magnesium, potassium, iron, Vitamin A, and Vitamin C and crude protein content that varies from 16 to 40 % (Ayssiwede *et al.,* 2011; Hassan and El-Moniary, 2015). *Moringa oleifera* used as a feed supplement can improve daily and total intake, digestibility, feed conversion and maximize productivity (Abou-Elezz *et al.,* 2011; Banjo, 2012). *Moringa oleifera* leaves are highly digestible when consumed because of their immense nutritional qualities such as neutral detergent fibre (NDF), acid detergent fibre

(ADF); crude protein (CP); gross energy (GE); ether extract (EE)) and amino acids profile (Hermogenes *et al.,* 2014) (Table 2.4).

2.8.3 Phytochemicals in Moringa Leaves

Moringa species are rich in compounds containing the simple sugar, rahmnose, and it is rich in a fairly unique group of compounds called glucosinolates and isothiocyanates (Aengwanich *et al.,* 2004). Some of the compounds that have been isolated from moringa preparations which are reported to have hypotensive, anticancer and antibacterial activity include 4-(4'-O-acetyl-a-L-rhamnopyranosyloxy) benzyl isothiocyanate, 4-(L-rhamnopyranosyloxy) benzyl isothiocyanate, niazimicin, pterygospermin, benzyl isothiocyanate, and 4-(a-L-rhamnopyranosyloxy) benzyl glucosinolate. Antioxidant activity of these compounds has also been reported (Moyo *et al.,* 2011). Seeds of moringa contain a glucosinolate that on hydrolysis yields 4-(a-L-rhamnosyloxy)-benzyl isothiocyanate, an active bactericide and fungicide (Akangbe, 2014*)*

2.8.4 Antimicrobial activity of Moringa oleifera leaf meal

Presence of alkaloids, flavonoids (mainly quercetin and kaempferol), saponins and tannins in all extracts have been linked to various physiological actions in humans and animals (King'Ori, 2011; FAO, 2014). Flavonoids have a hydroxyl group that confers antioxidant activity on *Moringa oleifera* hence its use as a therapeutic agent (Nobakht and Mehmannavaz, 2010). As a result, *Moringa oleifera* has been used over the years as a traditional remedy for some disease conditions. This is because of its rich phytochemical that contain effective antibacterial, antimycotic, antiviral and potential anticancer activity. For instance, the antiviral activity of MOLM leaf extracts against foot and mouth disease has been documented (Aye and Adegun, 2013).

2.8.5 Anti-nutritional factors in Moringa oleifera leaves

Anti-nutritional factors are compounds mainly organic, which when present in a diet, may affect the health of the animal or interfere with normal feed utilization. Anti-nutritional factors may occur as natural constituents of a plant in animal feeds, as artificial factors added during processing or as contaminants of the ecosystem (Atuahene *et al.,* 2010). Ingestion of feed containing such substances induce, in some cases, chronic intoxication and in others interfere with the digestion and utilization of dietary protein and carbohydrate and also interfere with the availability of some minerals. This affects efficiency and growth rate and, consequently, the production of the edible products (Brown and Pentland, 2007).

Anti-nutritional factors are classified as tannins, phytates, trypsin inhibitors, saponins, oxalates and low levels of cyanide. Phytate is an organically bound form of phosphorus in plants. Phytates in foods bind with essential minerals such as calcium, iron, magnesium and zinc in the digestive tract, resulting in mineral deficiencies (Olugbemi *et al.,* 2010). Phytates in foods bind minerals to form insoluble salts, thereby decreasing their bioavailability or absorption (Ashong and Brown, 2011). Tannins are plant polyphenols, which can form complexes with metal ions and with macro-molecules such as proteins and polysaccharides (Dey and De-Partha, 2013). Dietary tannins reduce feed efficiency and weight gain in chicks. Saponins are glycosides, which are steroid saponins and triterpenoid saponins (Kwari *et al.,* 2011). High levels of saponins in feed adversely affect intake and growth rate in poultry (Andrew, 2011).

2.9 Effect of *Moringa oleifera* Leaf Meal on Poultry Production

2.9.1 Effect of Moringa oleifera leaf meal (MOLM) on the survivability of chicken

Moringa plant and its extracts play a part in immune modulation which helps the immune system to fight against diseases. The effect of *M. oleifera* leaves as immunomodulatory agents were studied in normal and immune suppressed mice models. Pre-treatment with *Moringa* extract inhibited cyclophosphamide bone marrow suppressive effect on phagocytic activity in mice. Furthermore, various doses of *Moringa oleifera* caused a significant increase in the level of white blood cell counts and immunoglobulin levels which result in a significant reduction in chicks' mortality (Banjo *et al.,* 2012). However, Kakengi *et al.* (2007) observed no significant effect on mortality and survivability rates of 3 weeks old broilers that were fed diets substituted with 0.5 %, 1.0 %, 2.0 % and 3.0 % levels of MOLM. Melesse *et al.* (2013) also reported no significant effect of diets containing MOLM at 0 %, 2.5 %, 5 %, and 7.5 % levels on mortality and survivability rates of broiler chickens.

2.9.2 Effect of Moringa oleifera leaf meal on growth performance

Aderinola *et al.* (2013), *Moringa oleifera* leaves did not contain any factors that could limit feed consumption. Though feed intake was similar in their studies, feed conversion ratio was significantly low in birds fed with *Moringa oleifera* leaves ($P < 0.05$). Better growth performance was also observed by Melesse *et al.* (2011) with Red Island Rhode fed diet containing up to 6 % of *Moringa stenopetala* leaf meal. Akangbe (2014) also fed broilers with broiler diet supplemented with 0.1, 0.2 and 0.3 % MOLM and observed significant improvement in growth performance especially among birds on 0.3% MOLM. Results of Akhouri *et al.* (2013) revealed that *Moringa oleifera* leaves are rich in minerals, vitamins and especially protein with eight essential amino acids. Thus, the improvement of chicken growth may be attributed to those essential nutrients contained in *Moringa* leaves.

According to Ayssiwede *et al.* (2011) birds fed MOLM gained significantly (P < 0.05) higher weight than birds fed the control diet. The improved weight gain of birds fed MOLM diets could be attributed to a higher protein content of the diets which were efficiently metabolized for growth. The reduced weight gain of birds on highest MOLM diet could be partly ascribed to the higher crude fibre content of the diet which may have impaired nutrient digestion and absorption (Abbas and Ahmed, 2012). The lower weight gain of birds fed diet with higher crude protein content might also be due to the negative effect of the anti-nutritional factors present in MOLM on the birds. *Moringa oleifera* leaves contain 1-23 g of tannin in every 1 kilogram of leaves (David *et al.,* 2009).

According to Ebenebe *et al.* (2012), there were significant (P < 0.05) variations in the feed intake of the birds among the treatments. Feed consumption was significantly (P < 0.05) increased with increasing inclusion level of MOLM up to 5% but a marked reduction in the feed consumption of birds fed on 0% of MOLM diets. Abbas (2013) observed that unpalatability nature of a feedstuff will consequently prevent chicks from consuming an adequate quantity of the feed. There was a significant improvement in the feed conversion ratio of the birds fed MOLM based diets.

2.9.3 Effect of Moringa oleifera leaf meal on sexual maturity of poultry birds

Sexual maturity in poultry birds is related to the breed and strain, nutritional management, seasonal variation and day length (Abbas and Ahmed, 2012). Nobakht and Moghaddam (2012) reported that, the inclusion of *Moringa oleifera* leaf meal at 0 %, 5 %, 10 %, and

15 % in the laying hens' diets significantly reduced age at sexual maturity with the increased levels of *Moringa oleifera* leaf meal in the diet. Banjo (2012) experimented to evaluate the inclusion of *Moringa oleifera* leaf in the diet of laying hens. The level of inclusion of *Moringa oleifera* leaf meal ranged from 0 % which served as the control i.e. T0, T1 (1 %), T2 (2 %) and T3 (3 %) in the diet. The study showed that birds fed T2 i.e. 2 % *Moringa oleifera* leaf meal recorded significantly higher ($P < 0.05$) egg size, egg specific gravity, shell colour, shell weight, percentage shell, shell thickness and yolk and albumen than T1 and T3.

2.9.4 Effect of MOLM on laying performance

Average egg weight significantly increased as a result of the inclusion of *MOLM* when compared to a control which contained no MOLM (Kaijage *et al.,* 2003). Olugbemi *et al.* (2010b) reported that, the inclusion of *Moringa oleifera* leaf meal at 0 %, 5 %, 10 %, and 15 % in the laying hens' diets linearly increased egg-laying percentage and egg mass, while egg weight and feed intake showed a significant increase with increasing levels of *Moringa oleifera* leaf meal with a significant effect on feed conversion ratio. Banjo (2012) showed that laying hens fed 2 % *Moringa oleifera* leaf meal recorded significantly higher ($P < 0.05$) number of eggs laid than 0% and 3% and also significantly ($P < 0.05$) the highest egg weight at 3% inclusion level.

2.9.5 Effect of Moringa oleifera leaf meal on egg characteristics

Etalem *et al.* (2014) reported that inclusion of MOLM at 0 %, 5 %, 10 %, and 15 % in the laying hens' diets linearly increased egg size, egg specific gravity, shell colour, shell weight, percentage shell and shell thickness showed a significant increase with increasing levels of MOLM in the diet. Laying hens fed 2 % *Moringa oleifera* leaf meal recorded significantly higher ($P < 0.05$) egg size, egg specific gravity, shell colour, shell deformation, shell weight, percentage shell, shell thickness and yolk and albumen than 0% and 3% MOL diets (Banjo, 2012)

Ebenebe *et al.* (2013) compared egg characteristics of white and pearl Guinea fowls. Reports indicated albumin weight (21.9±0.19; 21.70±0.23), albumin height (5.62±0.06; 5.74±0.07), yolk height (16.1±0.11; 16.40±0.08), yolk weight (12.80±0.12; 13.50±0.15), Haugh unit (82.1±0.05; 82.7±0.56), shell weight (5.74±0.06; 5.70±0.06) and shell thickness (0.40±0.01; 0.44±0.01) for white and pearl Guinea fowls, respectively.

2.9.6 Effect of Moringa oleifera leaf meal on fertility and hatchability

Fertility, hatchability, and chick quality parameters appeared to be not negatively affected by the dietary MOLM. Hatchability of fertile eggs was improved in the birds fed diets containing MOLM as compared to the control diet in dominant layers (Portugaliza and Fernandez, 2012). MOLM contains higher levels of zinc and vitamin E, which have a beneficial effect on hatchability of eggs (Park *et al*., 2004; Mahmood and Al-Daraji., 2011; Moyo *et al.,* 2012). With increasing zinc concentration in the diets, there was an increased hatchability of Brown parent stock layers (Price, 2000). Brown and Pentland (2007) reported that zinc helps in protecting the structure of the genetic material or the DNA chromatin in the sperm nucleus, a structure important for successful fertilization.

2.9.7 Effect of Moringa oleifera leaf meal on haematological indices

Moringa leaf meal has been reported to have a significant effect on haemoglobin, erythrocyte count, mean cell haemoglobin (MCHC), lymphocytes (LYM), white blood cell (WBC) and platelets (PLT) (Safa and Tazi, 2012). Safa (2014) observed significant ($P <$

0.05) differences in serum and haematological characteristics of birds fed diets containing 0 % MOLM, 0.5 % MOLM, 1 % MOLM, 1.5 % MOLM and 2 % MOLM. Safa (2014) also showed that mean PCV values were significantly different (P < 0.05) from each other and were in agreement with the results of Sanni *et al.* (2000) who reported significant differences (P < 0.05) in the different inclusion levels.

2.9.8 Effect of Moringa oleifera leaf meal on biochemical indices

Abbas (2013) reported biochemical values as follows; Total serum protein, 67.30g/L albumin, 31.03 g/dL, globulin, 36.29 g/dL and cholesterol, 3.40mmol/L). Similarly, Abbas and Ahmed (2012) also reported biochemical values as follows; Total serum protein, 52.1 g/dL; albumin, 42.1 and cholesterol, 2.57. Higher inclusion levels of moringa leaf meal in the diets considerably increased plasma total protein levels (Kwari *et al*., 2011, Nuhu, 2010). Results from Oduro *et al.,* (2008) showed that there were significant differences (P < 0.05) among treatment groups in total serum protein, albumin and cholesterol. The globulin count showed no significant difference (P > 0.05) among treatments.

2.9.9 Effect of Moringa oleifera leaf meal on hormonal profile

John and Kenaleone (2014) observed a significant (P < 0.05) difference in follicle stimulating hormone, luteinzing hormone, prolactin and progesterone of birds fed diets containing 0.5 % MOLM, 1 % MOLM, 1.5 % MOLM and 2 % MOLM. The authors further observed that increasing the inclusion levels of moringa leaf meal in the diet considerably increased luteinzing hormone and prolactin. Findings from John and Kenaleone (2014) also showed that the mean oestrogen and testosterone values were significantly different (P < 0.05) from each other and were in agreement with the results of Akhouri *et al.* (2013) who reported significant differences ($P < 0.05$) in the different inclusion levels.

2.10 Economic Efficiency of MOLM in quail Production

The poultry industry in Ghana is one of the largest industries which offer employment opportunities to many people especially the youth (FAO, 2014). Japanese quail (*Coturnix coturnix japonica*) is used for the commercial production of meat and eggs (Daikwo, 2011). Feed is the major cost item in commercial layer production and the efficient the feed, the better the cost of production whereas eggs are the major products in commercial layers, the higher the egg production the better the profit (Faroq *et al*., 2001; 2002). Higher cost of feed is associated with lower profitability of laying hens whiles higher laying percentage are associated with higher profitability (Altahat *et al*., 2012). Critical limits for various cost components should be used as a guideline to adjust budget in commercial egg production to ensure higher net profit per bird (Altahat *et al*., 2012).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Location and Duration of Study

The study was conducted at the Poultry Unit of the Department of Animal Science Education, University of Education, Winneba, Mampong-Ashanti campus, Ghana, from 1st April, 2019 to 30th August, 2019. Asante Mampong is the capital town of the Mampong Municipality of the Ashanti Region. Asante Mampong is located 60 km North-East of Kumasi on the Kumasi - Ejura road. Asante Mampong lies in the transitional zone between the Guinea savanna zone of the north and the tropical rain forest of the south of Ghana. Asante Mampong lies between latitude 07° 04' N and longitude 01° 24' W with an altitude of 457 m above sea level. The vegetation is transitional savanna woodland. Maximum and minimum annual temperatures recorded during the study period were 30.6 °C and 21.2 °C, respectively (Meteorological Service Department, 2019). Rainfall pattern in the district is bimodal, occurring from April to July (major rainy season) and again from August to November (minor rainy season), with about 1224 mm per annum. The dry season occurs from December to March (Meteorological Service Department, 2019).

3.2 Experimental Birds, Treatments and Design

One-hundred and twenty (120) day-old brown Japanese quail (*Coturnix coturnix japonica*) were obtained from Ako Farms Ltd., Kumasi. The day-old chicks were brooded for two weeks under same housing and management practices and reared in separate pens.

The birds were allotted to four treatments with three replications. The various experimental coops were labeled per their experimental treatment and replicates. The treatments for the experiment comprised the control and three different levels of dietary MOLM. The details of the treatment groups were as follows: 0% MOLM, 5 %, 10 % and 15 % of MOLM inclusion levels coded as 0%MOLM, 5% MOLM, 10% MOLM, and 15% MOLM respectively. Every treatment (T) had three (3) replications comprising of ten (10) which gave a total of thirty (30) birds per treatment. Completely randomized design (CRD) was used for the experiment. The birds in each replicate were housed in one pen. A male was paired with four females.

3.3 Sources of Feed Ingredients

Ingredients used for the formulation of the experimental diets were maize, tuna fish, anchovy, soya bean, wheat bran, MOLM, premix, dicalcium phosphate and sodium chloride (common salt). The ingredients were purchased mainly from the open market in Kumasi. Experimental diets and calculated analysis used for the study are shown in Table 3.1.

3.3.1 Processing of Moringa oleifera leaf meal (MOLM)

Moringa leaves were harvested from *Moringa olifera* trees from an orchard at Abountem a community near Asante Mampong. The cut branches from the tree were spread out on concrete floor and allowed to dry for a period of 3 days a under shade and aerated conditions. The leaves were then separated from the twigs before milling in a hammer mill with a sieve size of 2 mm to produce the leaf meal (Plate 3.1). Processed moringa leaves were packaged in airtight bags and stored until use. Moringa leaf meal was mixed with con

Plate 3.1: Moringa oleifera leaf meal (MOLM)

3.4 Management of Birds

3.4.1 Housing

The birds were kept in an open-sided partitioned deep litter house building made of cement blocks and roofed with corrugated iron sheets (Plate 3.2). The house was made up of separate pens (Plate 3.3). Day-old chicks were housed and raised in pens as shown in Plate 3.3. A total of twenty-four (24) experimental pens were used for housing the birds. At the brooding stage, lighting systems were natural during the day and artificial at night using 80 watts electric bulbs. The brooder house was made of separate concrete floored chambers and could house about ten birds at a time. The sides of the deep litter houses were covered with wire mesh (Plate 3.2 and 3.3).

Plate 3.2: Quail house

Plate 3.3: Cages for housing quails

3.4.2 Feeding

Quails were fed on daily basis with different levels of MOLM inclusion in the diet. The various composition of the experimental diet as well as the nutrient compositions of the starter, grower and breeder diets are presented in Tables: 3.1, 3.2 and 3.3 respectively. Feed and water were supplied *ad libitum* in removable plastic feeding troughs (Plate 3.4) and a 500 ml bottle designed for the birds (Plate 3.5) respectively.

Table 3.1: Composition of experimental Starter Diets

Feed ingredients	**(0% MOLM)**	**(5% MOLM)**	**(10% MOLM)**	**(15% MOLM)**
Moringa	0.00	5.00	10.0	15.0

Maize	57.5	56.0	52.5	52.0
Wheat bran	11.0	9.50	9.50	6.00
Soya bean meal	8.50	9.00	8.00	7.00
Tuna fish meal	8.00	6.50	6.00	6.00
Anchovy fish meal	12.0	11.0	11.0	11.0
Oyster shell	1.50	1.50	1.50	1.50
Dicalcium phosphate	0.50	0.50	0.50	0.50
Vitamin premix*	0.50	0.50	0.50	0.50
Salt	0.50	0.50	0.50	0.50
Total	100	100	100	100
Calculated nutrient composition of starter diets				
Crude protein (%)	22.08	22.14	22.09	22.43
Crude fibre (%)	3.432	3.275	3.269	3.096
Moisture (%)	9.91	9.7515	9.7125	9.622
Ether extract (%)	4.4015	4.3345	4.322	4.275
ME (Kcal/Kg)	2828.5	2857	2863	2869

** Vitamin premix provided the following per kg of diet: Fe 100mg, Mn 110mg, Cu 20mg, Zn 100mg, Se 0.2mg, Co 0.6mg, sanoquin 0.6mg, retinal 2000mg, cholecalciferol 25mg, α-tocopherol 23000mg, menadione 1.33mg, cobalamin 0.03mg, cobalamin 0.03mg, thiamin 0.83mg, riboflavin 2mg, folic acid 0.33mg, biotin 0.03mg, pantothenic acid 3.75mg, niacin 23.3mg, pyridoxine 1.33mg*

Table 3.2: Experimental grower diets and calculated Analysis

Feed ingredients	**(0% MOLM)**	**(5% MOLM)**	**(10% MOLM)**	**(15% MOLM)**
Moringa	0.00	5.00	10.0	15.0
Maize	63.0	62.5	56.0	58.0
Wheat bran	22.0	20.5	15.0	17.0
Soya bean meal	3.00	2.00	3.00	2.00
Tuna fish meal	4.00	3.00	4.00	2.00
Anchovy fish meal	5.00	4.00	5.00	3.00
Oyster shell	1.50	1.50	1.50	1.50
Dicalcium phosphate	0.50	0.50	0.50	0.50
Vitamin premix*	0.50	0.50	0.50	0.50
Salt	0.50	0.50	0.50	0.50
Total	100	100	100	100
Calculated nutrient composition of grower diets				
Crude protein (%)	15.575	15.575	15.59	15.57
Crude fibre (%)	4.184	3.947	3.923	3.862
Moisture (%)	10.068	9.881	9.839	9.783
Ether extract (%)	4.506	4.421	4.406	4.438
ME (Kcal/Kg)	2702	2700	2700	2704

** Vitamin premix provided the following per kg of diet: Fe 100mg, Mn 110mg, Cu 20mg, Zn 100mg, Se 0.2mg, Co 0.6mg, sanoquin 0.6mg, retinal 2000mg, cholecalciferol 25mg, α-tocopherol 23000mg, menadione 1.33mg, cobalamin 0.03mg, cobalamin 0.03mg, thiamin 0.83mg, riboflavin 2mg, folic acid 0.33mg, biotin 0.03mg, pantothenic acid 3.75mg, niacin 23.3mg, pyridoxine 1.33m*

Table 3.3: Composition of breeder experimental diets

Feed ingredients	(0% MOLM)	(5% MOLM)	(10%MOLM)	(15%MOLM)
Moringa	0.00	5.00	10.0	15.0
Maize	55.0	52.0	50.0	50.0
Wheat bran	19.5	19.5	15.5	14.5
Soya bean meal	4.00	4.00	2.50	2.00
Tuna fish meal	4.50	4.50	4.00	3.00
Anchovy fish meal	8.00	6.00	5.00	6.50
Oyster shell	7.50	7.50	7.50	7.50
Dicalcium phosphate	0.50	0.50	0.50	0.50
Vitamin premix*	0.50	0.50	0.50	0.50
Salt	0.50	0.50	0.50	0.50
Total	100	100	100	100
Calculated nutrient composition of Breeder Diets				
Crude protein (%)	17.01	17.045	17.038	17.1
Crude fibre (%)	3.843	3.801	3.655	3.504
Moisture (%)	9.453	9.348	9.257	9.163
Ether extract (%)	4.232	4.193	4.208	4.159
ME (Kcal/Kg)	2823	2819	2819	2817

* *Vitamin premix provided the following per kg of diet: Fe 100mg, Mn 110mg, Cu 20mg, Zn 100mg, Se 0.2mg, Co 0.6mg, sanoquin 0.6mg, retinal 2000mg, cholecalciferol 25mg, α-tocopherol 23000mg, menadione 1.33mg, cobalamin 0.03mg, cobalamin 0.03mg, thiamin 0.83mg, riboflavin 2mg, folic acid 0.33mg, biotin 0.03mg, pantothenic acid 3.75mg, niacin 23.3mg, pyridoxine 1.33mg*

Plate 3.4: Feeder for quails

Plate 3.5: Drinker used for the quails

3.4.3 Health care, identification and recording

1. The day-old quails were given glucose on arrival at the farm to provide quick energy, and to ease them from travelling stress.
2. Multivitamin was given periodically as prophylaxis to the experimental birds. Deworming was done with Levamisole (180 mg/l for 3 days) via drinking water. The medication regime is shown in Table 3.4.
3. Drugs and medications used during the experimental period included Antibiotics and Coccidiostat.
4. Birds were observed for signs of ill-health and the right steps taken to restore health.
5. Routine management practices such as regular cleaning of pen, feeders and drinkers and regular records taking were carried out throughout the experimental period.

Table 3.4: Vaccination and medication regimen of experimental birds

Age (days)	**Medication**
1	Marek's vaccine (Subcutaneous)
6	Antibiotics
7	Gumboro Intermediate
14	Newcastle vaccine in water (HB1)
28	Lasota vaccine in water
35	Gumboro Intermediate/Plus
70	Lasota Vaccine in water
98	Dewormer

3.5 Parameters Measured:

3.5.1 Growth parameters

The following growth parameters were measured: daily feed intake (FI), total feed intake (FI), daily body weight gain (BWG), body weight gain (BWG), and feed conversion ratio (FCR).

i. Feed intake:

Daily feed was weighed with A&D Weighing EK-6000i electronic balance (A&D Co. Ltd, USA) before given to the birds. The difference between feed supplied to a replicate and left-over feed at the end of each day was recorded as daily feed intake. These were added up at the end of each week to give weekly consumption values. The weekly consumption value was then divided by the number of birds to obtain the average weekly feed consumed per bird.

Feed intake (g) =Feed given (g) - Feed left over (g)

ii. Bodyweight and bodyweight gain:

Birds were weighed at the start of the experiment (initial weight) and also at weekly intervals using A&D Weighing EK-6000i electronic balance (A&D Co. Ltd, USA). Weight measured at the end of the previous week was deducted from that of the current week to obtain the weight gained for the week. Birds were weighed in batches using a box on a toppan balance.

The weekly body weight gain was then divided by the number of birds in a replicate to obtain average weekly body weight gain per bird.

iii. Feed conversion ratio:

Feed conversion ratio was calculated as the ratio of feed consumed to weight gained for each replicate by dividing the weekly feed consumed by the respective weight gains of the replicates for that week. That is,

$$\text{Feed Conversion Ratio} = \frac{\text{Average Feed Intake}}{\text{Average body weight gain}}$$

3.5.2 Laying performance

The following laying performances were measured: age at first egg (days), egg weight at first egg laying (g), % Hen-day egg production and average monthly egg production.

i. Age at first egg (days): The age at first egg was estimated to be the age at which five percent of the pullets laid their first egg. After the pullets in each replicate had laid their first eggs the average (mean) age at first egg-lay was calculated for each treatment.

ii. Egg weight at first egg laying: Egg weight at first egg-laying (g) was determined by weighing individual eggs collected daily with the use of A&D Weighing EK-6000i electronic balance.

iii. Hen-day egg production (HDEP): Hen-day egg production was determined for daily egg production.

$$\text{HDEP}\ (\%) = \frac{\text{Total number of eggs collected a day}}{\text{Total number of birds}} \times 100$$

iv. Egg weight: Egg weight (g) was determined by weighing individual eggs collected daily with the use of *A&D Weighing EK-6000i* electronic balance.

v. Feed conversion ratio was expressed as a gain to feed ratio.

$$\text{Feed Conversion Ratio} = \frac{\text{Average Feed Intake}}{\text{Average egg mass}}$$

3.5.3 Parameters of External and Internal Egg Characteristics

Parameters measured from the external egg characteristics were egg weight, shell weight and shell thickness. The weights of the eggs were determined with the aid of an electronic weighing scale. The shells were cleaned, washed and air-dried at room temperature until a constant weight was obtained. Shell weight was calculated as the difference between the egg weight and the weights of yolk and the albumin. Shell thickness was determined from the broad end, narrow end and the middle of the shell using micrometre screw gauge and the average of the three measurements was taken as shell thickness in millimetres (USDA, 2000).

The destructive method was applied to measure internal egg characteristics such as albumen weight, albumen height, albumen pH, egg weight, egg diameter, shell thickness, yolk weight, yolk height, yolk colour, yolk pH, and Haugh unit. The above mentioned internal qualities were determined by cracking and breaking gently each egg onto a clean petri dish and measurements were taken with the aid of a vernier caliper sensitive to 0.01 mm. The yolk and albumen were carefully separated and weighed using the electronic weighing scale. The colour of the yolk was measured using the Yolk Colour Fan measurement, which consists of 1-16 strips ranging from pale to orange yellow in colour (DSM® 10lK Colour Fan (USA)) and the higher the value the yellower the yolk. Haugh unit measures the quality of the egg and it was calculated using the following formula adopted from Haugh (1937).

$$HU = 100 \log (H - 1.7w^{0.37} + 7.6)$$

Where, HU = Haugh Unit

H =Albumen height (mm)

W= Egg weight (g)

3.5.4 Reproductive performance

The following reproductive parameters were measured

Age at first egg (sexual maturity): The age at first egg (sexual maturity) was estimated to be the age of five percent (5%) hen-day egg production in a treatment.

Egg weight at sexual maturity: Eggs produced at sexual maturity were weighed using A&D Weighing EK-6000i electronic balance and recorded in grammes (g).

Fertility: Fertility was calculated based on total fertile eggs and total eggs set by candling.

$$\text{Fertility (\%)} = \frac{\text{Total number of fertile eggs}}{\text{Total number of egg set}} \times 100$$

Percent hatchability: The percentage hatchability was determined by expressing the total number of eggs hatched as a percentage of total number of fertile eggs.

$$\text{Hatchability (\%)} = \frac{\text{Total number of eggs hacthed}}{\text{Total number of fertile eggs}} \times 100$$

3.5.5 Parameters of blood profile

Blood samples from each bird were collected from the ulnar/basilica vein (under the wing) of the bird for haematological and biochemical analysis using a sterilized disposable syringe and needles. Blood samples were collected in the morning. A cotton swab soaked in methylated spirit was used to dilate the veins and to prevent infection. Blood analysis was carried out at the Soyuz Medical Diagnosis and Laboratory, Kumasi. Six (6) mls blood samples were obtained by puncturing the brachial vein of the underside of the web of the wing of each of the quails using needles and syringes. An initial three 3ml blood was taken into the labelled sterile universal bottle containing Ethylene-Diamine-Tetra-Acetic Acid (EDTA) as anticoagulant. This was used to determine the haematological components within an hour of sample taken. Another three (3) ml of blood was collected from the same birds into labelled sterile sample bottle without anticoagulant and used to determine the biochemical components. The SYSMEX Haematological Auto-Analyser was used for the haematological analysis (Keller, 1984). The blood sample for the serum biochemical assay was allowed to clot at room temperature. The clotted samples were spun in the centrifuge to separate the blood cells from the serum.

Serum samples were stored at -20ºC after centrifugation at 500 *g* for 15 minutes until assay was performed for biochemical and hormonal analysis.

Haematological parameters were determined in full blood count (FBC) by using Mindray 5 parts Haematology Analyzer *BC*-5300 and included (RBCS) (Haemoglobin (Hb), Red blood cells (RBC), Mean Corpuscular Volume (MCV), Mean Corpuscular Haemoglobin (MCH), and Mean Corpuscular Haemoglobin Concentration (MCHC)) and Leukocytes (White blood cells, neutrophil, lymphocytes, eosinophil, basophil and platelet) (Aengwanich *et al.,* 2004).

Biochemical parameters were analyzed on Mindray BA-88A Biochemistry auto-analyzer (Shenzhen Mindray Bio-medical electronics Co., Ltd, China) and included;

i. Total serum protein, albumin, globulin and cholesterol concentrations. The serum was then used for the analysis as follows; the total protein (TP) was determined using Biuret method as described by Keller (1984).

ii. Blood albumin was determined using the Bromocresol Green (BCG) method Sharp, (1988).

iii. Total cholesterol (TC) was estimated using the CHOP-PAP method by Roeschlau *et al.* (1974).

iv. Globulin level was also calculated (Sharp, 1988).

v. Globulin content was determined by subtracting albumin from the total protein (Keller, 1984).

vi. The assay procedure was performed on Mindray® Microplate Reader MR 96 A (Shenzhen Mindray Bio-medical Electronics Co., Ltd, China) and parameters included Serum enzyme-linked immunosorbent assay (ELISA) Progesterone, Estradiol, Prolactin, Luteinizing Hormone (LH) and Follicle Stimulating Hormone (FSH).

3.6. Economic Efficiency of MOLM in Quail Production

The economic efficiency of MOLM in quail production was determined in three phases (phase 1: starter, phase 2: grower and phase 3: breeder) using the prevailing market prices of all the feed ingredients used for each treatment, total feed intake, total feed cost, total body-weight, feed cost per bodyweight gain, Hen-day egg production, egg weight, and egg mass. The price per kilogram of feed was multiplied by the total kilograms of feed consumed per bird to get the cost of feed consumed per bird.

Feed cost per bodyweight gain was determined by dividing the total feed cost by total bodyweight gain in kilograms. In phase 1 and 2, feed cost per kilogram bodyweight gain was determined by dividing the cost of feed per bird by kilogram bodyweight gain per bird. In phase 3, feed cost per egg mass was determined by dividing total feed cost by egg mass.

3.7 Statistical Analysis

The data collected were analyzed using the one-way analysis of variance (ANOVA) with the aid of GenStat version 11.1 (2008), according to the procedure of Steel and Torrie (1980). Treatment means were separated by the least significant difference (LSD) to determine which of the treatments had significance difference or not at 5 % probability level.

CHAPTER FOUR

4.0 RESULTS

4.1 Proximate Composition of *Moringa oleifera* Leaf Meal (MOLM)

4.1.1 Proximate composition of MOLM

Results on proximate composition of MOLM are presented in Table 4.1. The proximate components of MOLM used contained 13.88 % moisture, 28.87 % crude protein, 21.65 % crude fibre, 4.339 % ether extracts, 7.18 % of total ash and 24.08 % nitrogen-free extracts.

Table 4.1: Proximate composition of Moringa oleifera leaf meal

Parameter	Percentage (%)
Moisture	13.88
Crude protein	28.87
Crude fibre	21.65
Ether extracts	4.339
Total Ash	7.18
Nitrogen Free Extract	24.08

4.2 Effect of Dietary *Moringa oleifera* Leaf Meal (MOLM) on Growth Performance

4.2.1 Effect of MOLM on daily feed intake

The effect of dietary MOLM on daily feed intake is shown in Table 4.2.

Table 4.2: Effect of Graded Levels of MOLM on Daily Feed Intake (g/bird)

Age (weeks)	0% MOLM	5% MOLM	10% MOLM	15% MOLM	S.E.M	L.S.D	P-Value

1-3	4.217[a]	3.467[b]	3.430[b]	3.297[b]	0.1443	0.3327	<.001
4-6	6.157[a]	5.927[b]	5.930[b]	5.827[b]	0.0931	0.2147	0.040
7-9	8.963[a]	8.720[b]	8.587[c]	8.510[c]	0.0555	0.1279	<.001
10-12	9.793	9.787	9.697	9.730	0.1548	0.3570	0.907

[abc]= Means bearing different superscripts in the same row are significantly different (P<0.05); % = percent; MOLM = Moringa oleifera Leaf Meal; S.E.M = standard error of means; LSD = least significant difference; P = probability of main effects

Table 4.2 showed that graded levels of MOLM had significant (P < 0.05) effect on daily feed intake across the period of study except at 10-12 weeks of age (P = 0.907). Daily feed intake in Japanese quails decreased with increasing levels of MOLM in the diet. Birds fed with the control diet consumed more feed as compared to the test treatment groups (P < 0.05). Birds fed with 15 % MOLM recorded the lowest (P < 0.05) daily feed intake throughout the experimental period, followed by 10 % and 5 % respectively. However, no significant differences occurred in 10 – 12 weeks old birds (P = 0.907).

4.2.2 Effect of MOLM on total feed intake

Results from Table 4.3**,** show the effect of different levels of MOLM on total feed intake.

Table 4.3: Effect of Graded Levels of MOLM on Total Feed Intake (g/bird)

	0%	**5%**	**10%**	**15%**			
Age (weeks)	**MOLM**	**MOLM**	**MOLM**	**MOLM**	**S.E.M**	**L.S.D**	**P-Value**
1-3	88.60[a]	72.80[b]	72.10[b]	69.30[b]	3.00	6.91	<.001
4-6	129.27[a]	124.44[b]	124.53[b]	122.34[b]	1.994	4.599	0.044
7-9	188.25[a]	183.07[b]	180.32[c]	178.71[cd]	1.149	2.650	<.001

10-12	205.7	205.5	203.6	204.4	3.26	7.53	0.910

[abcd]= Means bearing different superscripts in the same row are significantly different (P<0.05); % = Percent; MOLM = Moringa oleifera Leaf Meal; S.E.M = standard error of means; LSD = least significant difference; P = probability of main effects

Different levels of MOLM inclusion in the diet had significant (P < 0.05) effect on total feed intake at 1-3 weeks, 4-6 weeks and 7-9 weeks of age. Different levels of dietary MOLM did not influence on total feed intake at 10-12 weeks (P = 0.910). Increasing dietary MOLM resulted in decreasing feed intake. Results from this study revealed that at 1-3 weeks, 4-6 weeks and 7-9 weeks old birds fed control diet recorded the highest (P < 0.05) total feed intake followed by 5 % MOLM and 10 % MOLM respectively and the least by birds fed with 15 % MOLM dietary inclusion level.

Total feed intake of birds reared on the control diet had significantly (P < 0.05) higher feed intake as compared to that of birds on 5% MOLM and 10% MOLM. Birds on 5% and 10% MOLM diets had significantly higher feed intake as compared to birds fed 15% MOLM diet.

4.2.3 Effect of MOLM on BodyWeight

The effect of *Moringa oleifera* leaf meal (MOLM) on bodyweight is shown in Table 4.4. The initial body-weight (day old) was not significantly different (P = 0.721) and indicated that no group had weight advantage over the other but MOLM during weeks 3, 6, and 9 had a significant (P < 0.05) effect on bodyweight of quails (Table 4.4).

At week three, birds fed on control diet (0% MOLM) and diet that had 10% MOLM recorded significantly (P < 0.05) highest bodyweights followed by those on 15% MOLM. The 5% MOLM treated birds recorded the least bodyweight (P < 0.001). Quails on 15% MOLM recorded the highest bodyweights at 6, 9 and 12 weeks as compared to their counterparts fed the control diets (0 % MOLM) over the same period. Bodyweight increased with increase in MOLM in diets as well as increase in age (weeks) of quail birds.

Table 4.4: Effect of Graded Levels of MOLM on BodyWeight (g/bird)

Age (weeks)	0% MOLM	5% MOLM	10% MOLM	15% MOLM	S.E.M	L.S.D	P-Value
Day old	6.53	6.73	6.81	7.00	0.405	0.933	0.721
3	39.75^{a}	34.40^{b}	39.06^{a}	38.27^{a}	0.839	1.934	< 0.001
6	82.46^{d}	85.71^{c}	88.25^{b}	90.00^{a}	0.645	1.488	< 0.001
9	158.18^{c}	163.34^{b}	163.89^{ab}	165.80^{a}	0.886	2.044	< 0.001
12	202.17^{b}	207.67^{ab}	210.00^{a}	210.00^{a}	2.464	5.681	0.040

^{abcd}= Means bearing different superscripts in the same row are significantly different (P<0.05); % = percent; MOLM = Moringa oleifera Leaf Meal; SEM = standard error of means; LSD = least significant difference; P = probability of main effects

4.2.4 Effect of graded Levels of MOLM on Daily BodyWeight Gain

The effect of MOLM on daily bodyweight gain is shown in Table 4.5. The different levels of MOLM had significant (P < 0.05) effect on daily weight gain at 1-3 weeks and 4-6 weeks of age respectively. However, no significant (P > 0.05) differences were observed in 7-9 weeks and 10-12 weeks old quails. Birds at 1- 3 weeks and 4 – 6 weeks of age fed 15% MOLM recorded the highest (P < 0.05) daily weight gain and the least in birds fed with 0 % MOLM. This indicates that, daily weight gain in Japanese quails was positively influenced by the levels of MOLM in the diets.

Table 4.5: Effect of graded levels of MOLM on daily bodyweight gain (g/bird)

Age (Weeks)	0% MOLM	5% MOLM	10% MOLM	15% MOLM	S.E.M	L.S.D	P-Value

1-3	1.313^{c}	1.490^{b}	1.533^{a}	1.581^{a}	0.0345	0.0795	<.001
4-6	2.033^{c}	2.443^{a}	2.347^{b}	2.460^{a}	0.0543	0.1252	<.001
7-9	3.607	3.693	3.603	3.613	0.0487	0.1123	0.274
10-12	2.093	2.220	2.197	1.997	0.1111	0.2561	0.242

^{abc}= Means bearing different superscripts in the same row are significantly different (P<0.05); % = percent; MOLM = Moringa oleifera Leaf Meal; SEM = standard error of means; LSD = least significant difference; P = probability of main effects

4.2.5 Effect of MOLM on total bodyweight gain

The effect of different levels of MOLM on total bodyweight gain is presented in Table 4.6. Different levels of MOLM inclusion in the diet influenced bodyweight gain at 1-3 and 4-6 weeks of age (P < 0.05).

Table 4.6: Effect of graded levels of MOLM on total bodyweight gain (g/bird)

Age (weeks)	% MOLM	5% MOLM	10% MOLM	15% MOLM	S.E.M	L.S.D	P-Value
1-3	33.22^{a}	27.67^{c}	32.25^{ab}	31.27^{b}	0.674	1.554	<.001
4-6	42.71^{b}	51.31^{a}	49.19^{a}	51.73^{a}	1.140	2.630	<.001
7-9	75.71	77.62	75.64	75.80	1.057	2.438	0.258
10-12	43.99	46.66	46.11	41.87	2.350	5.419	0.237

^{abc}= Means bearing different superscripts in the same row are significantly different (P<0.05); % = percent; MOLM = Moringa oleifera Leaf Meal; SEM = standard error of means; LSD = least significant difference; P = probability of main effects

Quails fed control diet had a significantly (P < 0.05) higher total bodyweight gain as compared to birds reared on diets that contained 5% and 15% MOLM but not 10% MOLM during first three weeks. Quails raised on 10% and 15% MOLM on the other hand had similar values but were significantly (P < 0.05) higher in total bodyweight gain as compared to birds fed 5% MOLM diet. Birds fed diets that contained MOLM had a significantly (P < 0.001) higher total bodyweight gain as compared to the control (Table 4.6). Total bodyweight gain however, did not vary (P > 0.05) from 7 – 12 weeks.

4.2.6 Effect of MOLM on feed conversion ratio

The effect of dietary MOLM on feed conversion ratio is shown in Table 4.7. The different levels of dietary MOLM had significant (P < 0.05) effect on feed conversion ratio across the period of study except at 10-12 weeks age (P > 0.078). Birds fed 15 % MOLM diet had better feed conversion ratio (P < 0.05) followed by 10 % MOLM (P < 0.05) and 5% MOLM (P < 0.05) from week 1 to week 9. However, birds fed control diet had the poorest (P < 0.05) feed conversion ability. This indicates that feed conversion efficiency was improved by addition of MOLM in the diets.

Table 4.7: Effect of graded levels of MOLM on feed conversion ratio

Age	0% MOLM	5% MOLM	10% MOLM	15% MOLM	S.E.M	L.S.D	P-Value
1-3 Weeks	2.663^{a}	2.640^{a}	2.237^{b}	2.217^{b}	0.1099	0.2535	0.004
4-6 Weeks	3.027^{a}	2.433^{bc}	2.530^{b}	2.363^{c}	0.0806	0.1859	<.001
7-9 Weeks	2.487^{a}	2.363^{b}	2.383^{b}	2.357^{b}	0.0359	0.0828	0.022
10-12 Weeks	4.683	4.420	4.417	4.880	0.1744	0.4021	0.078

^{abc}= Means bearing different superscripts in the same row are significantly different (P<0.05); %= percent; MOLM = Moringa oleifera Leaf Meal; SEM = standard error of means; LSD = least significant difference; P = probability of main effects

4.3 Effect of Graded Levels of Dietary MOLM on Reproductive Performance

Table 4.8 shows the effect of different levels of dietary MOLM on reproductive performance. With the exception of percent hatchability (P = 0.786), all reproductive traits considered in this study were significantly (P < 0.05) affected by the inclusion of MOLM in the diet. In terms of age at first egg, quails on 15% and 10% MOLM spent shorter days (P < 0.05) as compared to the control and 5% MOLM (P < 0.001). Higher levels of MOLM in diets resulted in higher bodyweights at first egg, weight of first eggs laid and hen-day egg production (P < 0.01). Fertility was highest (P = 0.010) in birds fed on 15% MOLM, followed by 10%MOLM, 5% MOLM and the least fertility in quails fed on 0 % MOLM.

Table 4.8: Effect of graded levels of MOLM on reproduction

Parameters	0% MOLM	5% MOLM	10% MOLM	15% MOLM	S.E.M	L.S.D	P-Value
AFE (days)	55.67^{a}	53.00^{a}	50.33^{ab}	40.67^{c}	1.581	3.646	<.001
BWFE (g)	86.64^{c}	128.83^{b}	147.89^{a}	147.22^{a}	1.244	2.868	<.001
EWFE (g)	7.50^{c}	10.93^{b}	11.67^{ab}	12.17^{a}	0.443	1.023	<.001
HDEP (%)	41.67^{b}	42.67^{b}	42.77^{b}	49.67^{a}	1.599	3.686	0.004
Fertility (%)	50.0^{b}	64.4^{ab}	74.4^{a}	78.9^{a}	6.53	15.05	0.010
Hatchability (%)	95.5	94.8	97.0	97.3	2.87	6.63	0.786

^{abcd}= Means bearing different superscripts in the same row are significantly different (P < 0.05); % = percent; MOLM = Moringa oleifera Leaf Meal; S.E.M = standard error of means; LSD= least significant difference; P = probability of main effects; AFE = Age at first egg; BWFE = body weight at first Egg; EWFE = egg weight at first egg laying; HDEP= hen-day egg production.

4.4 Effect of Dietary MOLM on Egg Quality

4.4.1 Effect of graded levels of MOLM on external egg characteristics

The effect of different levels of dietary MOLM on external egg characteristics is shown in Table 4.9. Different levels of MOLM in diet had significant ($P < 0.05$) effect on egg diameter, egg weight, egg length and shell thickness but not ($P > 0.05$) on shell weight. Egg diameter, egg weight and egg length was highest ($P < 0.05$) in 15% MOLM and least in 0% MOLM eggs. Shell thickness was highest ($P < 0.05$) among quails fed 0% MOLM and significantly lowest in eggs from quails fed 15% MOLM.

Table 4.9: Effect of graded levels of MOLM on external egg quality

Parameters	0% MOLM	5% MOLM	10% MOLM	15% MOLM	S.E.M	L.S.D	P-Value
ED (cm)	24.328^{c}	25.805^{b}	26.318^{a}	26.437^{a}	0.2392	0.4990	<.001
EGL (mm)	31.16^{c}	32.08^{b}	32.71^{b}	33.48^{a}	0.348	0.726	<.001
EGW (g)	10.17^{c}	12.83^{ab}	13.33^{ab}	14.00^{a}	0.500	1.043	<.001
EST (mm)	0.2517^{a}	0.2333^{b}	0.2367^{b}	0.2250^{b}	0.006	0.012	0.002
ESW (g)	1.527	1.523	1.458	1.525	0.0294	0.0612	0.082

^{abc}= Means bearing different superscripts in the same row are significantly different (P<0.05); % = percent; MOLM = Moringa oleifera Leaf Meal; S.E.M = standard error of means; LSD = least significant difference; P = probability of main effects; ED= egg diameter, EGW= egg weight, SW= egg shell weight; EST= egg Shell thickness, EGL= egg length.

4.4.2 *Effect of MOLM on internal egg characteristics*

Table 4.10 shows the effect of different levels of dietary MOLM on internal egg characteristics. The Different levels of MOLM inclusion in the diet showed no significant differences ($P > 0.05$) on ALBW weight and YLK pH. However, all other parameters were influenced by the different levels of MOLM inclusion in the diet. Albumin weight, yolk weight, yolk height, yolk pH and yolk colour were highest ($P < 0.05$) for 15% MOLM and lowest in eggs of quails fed 0% MOLM. Eggs laid by quails fed 10% MOLM recorded the highest ($P < 0.05$) albumin pH and Haugh unit and least in those fed 0% MOLM diet ($P < 0.05$).

Table 4.10: Effect of graded levels of MOLM on internal egg quality

Parameters	0% MOLM	5% MOLM	10% MOLM	15% MOLM	S.E.M	L.S.D	P-Value
ALBH (mm)	4.738	4.758	4.715	4.797	0.0304	0.0634	0.081
ALBW (g)	4.667^{c}	5.237^{b}	5.457^{ab}	5.695^{a}	0.1834	0.3826	<.001
ALB pH	3.297^{c}	3.318^{b}	3.465^{a}	3.333^{b}	0.0587	0.1224	0.039
HU	89.67^{c}	89.21^{c}	92.08^{a}	91.25^{b}	0.341	0.711	<.001
YLKW (g)	3.97^{b}	6.07^{a}	6.42^{a}	6.78^{a}	0.383	0.800	<.001
YLKH (g)	10.27^{b}	10.87^{b}	11.25^{a}	11.87^{a}	0.326	0.679	<.001
YLK pH	3.238	3.250	3.387	3.185	0.0758	0.1582	0.083
YC	7.54^{c}	10.92^{b}	12.41^{a}	12.58^{a}	0.603	1.259	<.001

abc= Means bearing different superscripts in the same row are significantly different (P<0.05); % = percent; MOLM = Moringa oleifera Leaf Meal; S.E.M = standard error of means; LSD = least significant difference; P = probability of main effects; ALBH= albumin height; ALBW= Albumin weight; ALB pH = albumin pH; HU=haugh unit; YLKW= yolk weight; YLKH= yolk height; YLK pH= yolk pH; YC= yolk colour.

4.5 Effect of Dietary MOLM on Hormonal and Blood Profile of the Quail

4.5.1 Effect of MOLM on haematological parameters

Results of the effect of MOLM on haematological parameters are presented in Table 4.11**.** The Different levels of MOLM inclusion in the diet showed no significant difference (P > 0.05) on haematological parameters.

Table 4.11: Effect of graded levels of MOLM on haematological parameters

Parameters	0% MOLM	5% MOLM	10% MOLM	15% MOLM	S.E.M	L.S.D	P-Value
BAS ($x10^9/\mu l$)	0.001	0.003	0.167	0.333	0.1900	0.396	0.269
EOS ($x10^9/\mu l$)	3.67	1.50	2.33	3.50	1.263	2.634	0.298
Hb (g/dL)	14.97	17.73	13.28	14.22	1.754	3.658	0.099
LYM ($x10^9/\mu l$)	40.0	47.0	41.2	45.7	7.41	15.46	0.740
MCH (pg)	56.2	55.4	57.1	53.7	3.63	7.56	0.810
MCHC (g/dL)	39.70	37.12	37.12	35.97	1.417	2.955	0.090
MCV (fL)	141.8	141.3	147.5	149.7	7.80	16.28	0.643

MON ($x10^9/\mu l$)	5.50	2.83	5.67	5.83	1.584	3.304	0.217
NEU ($x10^9/\mu l$)	50.8	48.7	50.7	44.7	7.28	15.19	0.818
PCV (%)	39.5	47.0	37.8	40.2	5.61	11.71	0.395
PLT ($x10^9/L$)	39.8	37.2	36.3	32.5	5.56	11.59	0.625
RBC ($x10^{12}/L$)	2.72	3.33	2.89	2.98	0.442	0.923	0.577
WBC ($x10^9/L$)	212.1	228.7	214.8	195.8	13.40	27.95	0.142

^{abcd}= Means bearing different superscripts in the same row are significantly different (P < 0.05); % = percent; MOLM = Moringa oleifera Leaf Meal; S.E.M = standard error of means; LSD = least significant difference; P = probability of main effects; BAS=Basophil; EOS= eosinophil; Hb=Haemoglobin; LYM= lymphocytes; MCV= mean cell volume; MCH= mean cell haemoglobin; MCHC= mean cell haemoglobin concentration; MON=Monocytes; NEU= Neutrophil; PCV= packed cell volume; PLT = platelets; RBC= red blood cells, WBC=white blood cell.

4.5.2 Effect of MOLM on biochemical parameters

Table 4.12 shows the effect of different levels of MOLM on biochemical and hormonal parameters. Dietary treatments showed no significant (P > 0.05) effect on biochemical and hormonal parameters.

Table 4.12: Effect of graded levels of MOLM on biochemical and hormonal parameters

Parameters	**0% MOLM**	**5% MOLM**	**10% MOLM**	**15% MOLM**	**S.E.M**	**L.S.D**	**P-Value**
Biochemical Parameters							
ALB (g/L)	25.0	25.3	23.5	23.0	3.49	7.28	0.888
TC (mg/dl)	4.47	6.20	5.60	4.82	1.064	2.219	0.382
GLB (g/L)	35.7	31.5	36.2	29.2	7.14	14.90	0.724
HDL (mmol/l)	0.055	0.210	0.045	0.058	0.1125	0.234	0.421

LDL (mmol/l)	3.52	5.08	4.48	3.90	0.952	1.985	0.397
TRG (mmol/l)	1.98	2.02	2.00	1.90	0.536	1.118	0.996
VLDL (mmol/l)	0.903	0.917	0.983	0.863	0.2599	0.542	0.973
TSP (*g/L*)	60.7	60.3	59.7	52.2	9.64	20.11	0.787
Hormonal Parameters							
FSH *(IU/ml)*	0.334	0.370	0.304	0.266	0.0843	0.175	0.654
LH *(IU/ml)*	1.55	2.05	1.87	2.40	0.751	1.567	0.718
Oestrogen (*pg/ml*)	38.1	24.1	45.8	50.4	18.85	39.32	0.537
Prog *(ng/dl)*	2.06	1.33	1.79	1.17	0.498	1.039	0.285
Prolactin *(ng/ml)*	29.83	28.78	27.31	30.08	2.480	5.173	0.677
Testosterone *(ng/dl)*	2.41	2.55	2.27	2.53	0.789	1.646	0.984

[abc]= Means bearing different superscripts in the same row are significantly different (P<0.05); % = percent; MOLM = Moringa oleifera Leaf Meal; S.E.M = standard error of means; LSD = least significant difference; P = probability of main effects; ALB=albumin; TC = cholesterol; GLB= globulin; TRG= triglycerides; HDL = high density lipoprotein; LDL = low density lipoprotein; TSP= total serum protein; FSH = follicle stimulating hormone; LH= luteinizing hormone; Prog =progesterone

4.6: Economic efficiency of MOLM in quail production

Table 4.13: Economic efficiency of MOLM in the production of starter Quails

Parameters	0% MOLM	5%MOLM	10% MOLM	15% MOLM
Per kilogram feed cost (GHC)	2.15	2.039	1.97	1.93
Total feed intake (kg)	88.6	72.8	72.1	69.30
Total feed cost (GHC)	0.19	0.15	0.14	0.13
Total body weight gain (kg)	0.033	0.028	0.032	0.031
FCPBWG (GHC/kg)	5.72:1	5.42:1	4.34:1	4.157:1

GHC5.40=1$ at the time of the experiment, MOLM= Moringa oleifera leave meal, *FCPBWG = Feed cost per body; GHC =Ghana cedis.*

Analysis of economic efficiency of feed (Table 4.13) showed that total cost of feed was higher GHC5.72 per kilogram weight gain for quails on the control diet as compared to the test diets (GHC5.42, GHC4.34, and GHC4.16 for 5% MOLM, 10% MOLM, and 15% MOLM respectively). There was a trend of decreasing total cost of feed per kilogram bodyweight gain as the quantity of MOLM levels increased in diet from 0% MOLM to 15% MOLM. Moreover, feed cost per bodyweight gain (FCPBWG) was high (GH₵5.42:1kg) among birds fed on the control diet (0% MOLM) as compared to birds reared on treatment diets (GHC5.42:1kg, GH₵4.341:1kg, and GH₵4.157: 1kg for 5% MOLM, 10% MOLM, and 15% MOLM respectively).

Table 4.14.: Economic efficiency of MOLM in the production of grower Quails

Parameters	**0% MOLM**	**5%MOLM**	**10% MOLM**	**15% MOLM**
Per kilogram feed cost (GHC)	1.55	1.43	1.46	1.296
Total feed intake (kg)	129.27	124.44	124.53	122.34
Total feed cost (GHC)	1.55	0.18	0.18	0.16
Total body weight gain (kg)	0.043	0.051	0.049	0.052
FCPBWG (GHC/kg)	3.61:1	3.53:1	3.67:1	3.08:1

GHC5.40=1$ at the time of the experiment, MOLM= Moringa oleifera leave meal; *FCPBWG = Feed cost per bodyweight gain; GHC =Ghana cedis.*

Analysis of economic efficiency of feed (Table 4.14) showed that per kilogram feed cost (GHC) was high (GHC1.55) in the control diet as compared to the kilogram feed cost in the treatment diets (GHC1.43, GHC1.46, and GHC1.29 for 5% MOLM, 10% MOLM, and

15% MOLM respectively). Total cost of feed was higher (GHC1.55) in the control diet as compared to the treatment diets (GHC0.18 GHC0.18 and GHC0.16 for 5% MOLM, 10% MOLM, and 15% MOLM respectively). Total body weight gain (kg) was also positively affected with the inclusion of MOLM as quails on control diet (0% MOLM) gain less weight (0.043kg) as compared to quails on treatment diets (0.051kg, 0.049kg, 0.052kg for 5% MOLM, 10% MOLM, and 15% MOLM respectively).

Table 4.15: Economic efficiency of MOLM in production of layer Quails (breeders)

Parameters	**0% MOLM**	**5%MOLM**	**10% MOLM**	**15% MOLM**
Per kilogram feed cost	1.700	1.56	1.41	1.47
Total feed intake	188.25	183.07	180.03	178.71
Total feed cost	0.32	0.29	0.28	0.26
Egg mass	33.866	43.802	45.799	55.630
FCPEM (GHC/kg)	0.009:1	0.0066:1	0.0061:1	0.0046:1

GHC5.40=1$ at the time of the experiment, MOLM= Moringa oleifera leave meal; FCPEM = Feed cost per egg mass.

Analysis of economic efficiency of MOLM feed (Table 4.15) showed that egg mass increased with increasing levels of MOLM. The results further showed that feed cost per egg mass (GHC/kg) was relatively high (0.009:1) in the birds on the control diet (0% MOLM) as compared to those on the treatment diets as feed cost per egg mass (GHC/kg) decreased with increasing levels of MOLM (0.006:1, 0.0066:1, 0.0061:1, 0.0046:1 for bird on 5% MOLM, 10% MOLM, and 15% MOLM respectively).

CHAPTER FIVE

5.0 DISCUSSION

5.1. Proximate composition of *Moringa oleifera* leaf meal (MOLM)

Results on proximate composition of MOLM revealed significant values for crude protein, crude fibre, moisture, ether extracts, total ash, and nitrogen free extract (Table 4.1). The study recorded 28.87% of crude protein (Table 4.1) which was higher than 16.00% reported by Gidamis *et al.* (2003), 22.42% and 23.27% reported by Sarwatt *et al.* (2004) and Noula *et al.* (2006) respectively. It was however, lower than 30.30%, 31.4% and 32.1% reported by Moyo *et al.* (2011), Abas (2013) and Bonomi *et al*. (2018) respectively but similar to 28.95 % crude protein reported by Oduro (2008). The crude protein of 28.87% observed in this study suggests that MOLM can be used as a source of protein for quails. The crude fibre of 21.67% in the MOLM was higher than 19.25 % and 19.25 % reported by Oduro *et al.* (2008) and Nuhu (2010) respectively in their findings respectively but lower than 22.1 % reported by Kakengi (2003). Moisture content of 13.88% in the MOLM was lower than 30% and 88.75% recorded by Adeniji and Lawal (2012) and Oduro-Owusu *et al.* (2015) respectively. The ether extract value of 4.339% in this study was lower than 6.50% reported by Moyo *et al.* (2011) and 5.25% reported by Floidl *et al*. (2001). The ash content of 7.18% in the MOLM was lower than 9.00% observed by Oduro-Owusu *et al.* (2015), but similar to 7.98% and 7.13% recorded by Aye *et al.* (2004) and Nuhu (2010) respectively. Moyo and others in 2011 reported that *Moringa oleifera* leaf have varying nutritional content according to different authors. The variations in the nutrient content of MOLM and the differences in the proximate composition of MOLM reported in this study and those reported by other researchers could possibly be as a result of differences in agro-climatic conditions, age of plants at harvest, geographical location, micro and macro environmental factors, or to the different processing methods which determine the composition of ingredients used as feedstuff Ali *et al*. (2011). However, the general nutritional content of MOLM gives an indication of its suitability as a feed resource.

5.2 Effect of Dietary (MOLM) on Growth Performance

5.2.1 Effect of dietary MOLM on daily and total feed intake

This study recorded a significant variation in daily and total feed intake between the test treatment groups and the control treatment from the starter phase, grower and finisher phase (Tables 4.2 and 4.3). Daily and total feed intake in Japanese quails decreased with increasing levels of MOLM in the diet. The reduction in daily feed intake among the test treatment groups could be due to the high levels of essential amino acid present in the MOLM diet which was accessible and efficiently utilized by the birds (Melesse *et al.* 2013). The highest feed intake observed among birds fed with the control diet could be attributed to the high palatability of the diet as compared to the dietary MOLM groups (Kakengi *et al.* 2003). This finding contradicts the report of Olugbemi *et al.* (2010a) who noted that addition of 10% and 20% MOLM to the laying hen diet increased daily and total feed intake. The result of the study is consistent with those reported for broilers, where inclusion of 5 % MOLM showed significant reduction in total and daily feed intake as compared to the 0 %, 3 % and 7 % MOLM containing experimental diets (Safa and Tazi, 2014). This result is also in agreement with Naazie and Akoto (2011) who reported that inclusion of MOLM in the diet of broilers significantly ($P < 0.05$) reduced daily and total feed intake and body weight gain as compared with birds on the control treatment. In contrast to the above finding, Etalem *et al*. (2014) reported that addition of MOLM on Dominant CZ layers up to 10 % had no significant effect on feed intake of laying hens. Similar to this finding and conversely to the current study, Juniar *et al.* (2008) observed that inclusion of dietary MOLM at 10 % inclusion level did not produce significant effects on feed consumption.

5.2.2 Effect of Dietary MOLM on bodyweight, daily bodyweight and bodyweight gain

This study recorded a significant increase in bodyweight, daily weight gain, and body weight gain of Japanese quails with increasing dietary MOLM up to 15 % (Tables 4.4, 4.5 and 4.6 respectively). The significant variation observed in bodyweight, daily weight gain and bodyweight gain may be credited to the high crude protein content in the 15 % MOLM diet which enhanced nutrient digestion and absorption. This could be attributed to the fact that the leaf of *Moringa oleifera* contains vitamins such as vitamin B, vitamin C, vitamin A, beta-carotene, and vitamin K, manganese, and proteins among other essential nutrients (Olugbemi, 2010) which enhanced rapid growth of Japanese quails. The significant improvement in bodyweight, bodyweight gain and daily weight gain of Japanese quails in the present study may be attributed to rich content of nutrients in MOLM (Table 4.1) (Kakengi *et al*. 2003) and antimicrobial properties of *Moringa.* (Aye *et al*. 2013).

This finding is in agreement with an observation made by Kakengi *et al*. (2007) who observed that, the inclusion of MOLM in diets of broilers significantly ($P < 0.05$) enhanced bodyweight and body-weight gain, therefore quails fed MOLM diet grew faster as compared to quails fed control diet. The findings in this study also compared favourably with the work of Safa and Tazi (2012) who observed that birds fed diet that contained 5 % MOLM obtained significantly ($P < 0.05$) higher bodyweight gain in contrast to birds fed the control diet. This result is in agreement with Olugbemi *et al.* (2010) who reported higher bodyweight gain of broilers with increasing levels of MOLM in the diet. In other trials, addition of MOLM up to 10% in diets had no significant effect on bodyweight of Dominant CZ hens (Etalem *et al*., 2014). Gakuya *et al.* (2014) reported non-significant effect of dietary MOLM on bodyweight, bodyweight gain and daily weight gain in broiler chicken.

5.2.3 Effect of dietary MOLM on feed conversion ratio

This study revealed that feed efficiency increased with increasing levels of MOLM in the diet. Quails fed diet that contained MOLM had superior feed conversion ratio as compared to the quails fed with the control diet (Table 4.7). The variation in feed conversion ratio observed in this study is an indication that diets containing MOLM can be more efficient in converting feed mass into increased bodyweight. The superior feed conversion ratios for quails on MOLM diets might have also contributed to the superior growth rate and weight gain by the birds on the MOLM diets as compared to quails fed with the control diet. Another possible reason may be that the nutrients in the test treatment groups met the minimum nutrient requirements for quail growth and reproduction. In line with the findings of the study, Melesse *et al*. (2011) reported that the use of *Moringa stenopetala* leaf meal in the diet of Rhode Island Red chicks produced significant increase in feed intake and feed conversion ratio when compared to birds on the control diet.

In the same way, Gadzirayi *et al.* (2012) observed significant differences in feed conversion ratio as evidenced by the variation in weight change in 0%, 25%, 50%, 75% and 100% MOLM in broilers. Similarly, Safa and Tazi (2014) reported that broilers supplemented with 5 % MOLM showed significantly better feed conversion ratio as compared to the 0%, 3% and 7% MOLM in the diets. However, result on feed conversion ratio observed in this study contradicts the finding of Etalem *et al*. (2014) who noted that addition of MOLM on Dominant CZ layers up to 10 % had no effect on feed conversion ratio of hens. Olugbemi *et al*. (2010b) also found that addition of 5 % MOLM to broilers' diet had no significant effect on feed conversion ratio when compared to a diet free of MOLM.

5.3 Effect of Dietary MOLM on Reproductive Performance

Results from Table 4.8 indicated a significant effect of dietary MOLM levels on fertility, age at first egg, bodyweight at first egg, egg weight at first egg laying and hen-day egg production. The high percentage fertility observed among birds fed with MOLM diets could be due to high levels of crude protein as well as high levels of zinc and iron observed in the proximate analyses (Table 4.1). The mineral content of dried MOLM (Table 2.3) might have played a beneficial role in the production of fertile eggs and general fertility among quail birds. According to Brown and Pentland (2007), *Moringa oleifera* leaves contain high levels of zinc and reported that, zinc helps in protecting the structure of the genetic material or the DNA chromatin in the sperm nucleus, a structure important for successful fertilization. *Moringa* contains significant amount of iron, phosphorus, calcium, and is relatively rich in vitamin C (Park *et al*. 2004). The current study is in line with Moyo *et al.* (2011) and Mahmood and Al-Daraji (2011) who reported improved fertility and hatchability as a result of higher MOLM dietary inclusion. However, MOLM as an alternative feed ingredient in layer ration showed non-significant effect on fertility, hatchability and embryonic mortality (Etalem *et al.* 2014).

The significant differences observed for age at first egg, egg weight at first egg laying and hen-day egg production could be explained that the physiological processes occurring during rearing which underlie ovarian function are reflected solely in the body weight and protein nutrition of broiler breeders. Hence, increasing dietary MOLM increased fat mobilization for rapid growth and maturity, egg formation and enhance egg laying. The significant effect of MOLM on egg weight and egg production in the present study might be due to the presence of lysine and methionine in *Moringa* as reported by Safa (2014). The results of this study are supported by AbouSekken, 2015; Amevor, 2017; Safa and Tazi 2012, who reported that age at first egg, egg weight at first egg laying and hen-day egg production increased with increasing levels of MOLM in the diet

Contrary to the findings of the study, Olugbemi *et al.* (2010b) observed a non-significant effect ($P > 0.05$) on HDEP for hens fed a diet that contained MOLM at 0, 5, and 10 % of moringa leaf meal in the diet. In addition, Etalem *et al*. (2014) observed a non-significant effect of a diet containing *M. oleifera* leaf meal (MOLM) in layer rations at 5 % on HDEP. Similarly, Kwari *et al.* (2011) and Olabode and Okelola (2014) noted non-significant ($P < 0.05$) results on egg weight and egg production when fed *M. oleifera* leaf and twig meals at different levels ranging from 0.2 to 0.8 %.

5.4 Effect of Dietary MOLM on Egg Quality

Both external and internal egg qualities were affected positively by the inclusion of dietary MOLM at different levels in Japanese quails (Tables: 4.9 and 4.10). Weight of sampled eggs and albumen weight, egg length, egg diameter, yolk colour, shell thickness, yolk height, yolk weight and yolk pH were all improved by the inclusion of MOLM in the diet especially at 15 % MOLM inclusion. The significant differences observed could indicate that external and internal egg quality traits may be linked to protein levels in the diet. This observation conforms to the suggestion that the amino acids required for egg quality traits improve with increasing levels of MOLM in the diet (Kakengi *et al*., 2007).

Improvement of egg weight, yolk colour, shell thickness, yolk height, yolk weight and yolk pH in this study supports the findings of Kakengi *et al*. (2007) where substitution of sunflower with MOLM at 5 % levels in the diet showed a positive effect on egg quality traits. Improvement of albumen weight in this study agrees with the findings of Price

(2000) and Kaijage *et al*. (2004) but inconsistent for improvement of egg length, egg diameter. Nobakht and Mehmannavaz (2010) reported that increasing yolk weight was the main reason for the increment in albumen weight and this might explain the increase in albumen weight in groups fed diets supplemented with moringa leaf meal. The higher the Haugh unit, the more desirable is the egg quality (Fayeye *et al.,* 2005). According to Nobakht and Moghaddam (2012) there is a positive correlation between Haugh unit and quality of egg components (yolk and albumin). Egg albumen height and egg weight are indices for evaluation of Haugh unit. Indeed, increase in egg weight is related to increase in albumen weight and yolk weight, hence, improvement in egg quality.

MOLM is a good pigmenting agent of poultry products due to its high *xanthophyll* content (Etalem *et al*., 2013; Olugbemi *et al.,* 2010b). In this study, the yolk colour showed an increasing trend as the amount of MOLM increased in the ration. This was supported by the findings of different researchers with 5 and 10 % inclusion of MOLM in the layer ration (Kakengi *et al*., 2007; Olugbemi *et al.,* 2010b and Abou-Elezz *et al*., 2011). Egg yolk colour is a very important factor in consumer satisfaction and influences human appetite with a preference for golden yellow to orange yolk colour (Hasin *et al*., 2006). The intense yellowish yolk colour recorded in this study for eggs produced from birds on diets containing MOLM confirms its viability as a yolk-colouring agent, which can enhance the marketability of the eggs.

The range of Haugh unit observed in this study was 89.67-92.08 the lowest was from the control group and highest from 10 % inclusion level of dietary MOLM. The higher the value of the Haugh unit, the better the quality of eggs, which are classified according to the United States Department of Agriculture (USDA, 2000) as AA (100 to 72), A (71 to 60), B (59 to 30) and C (below 29) (USDA, 2000). This indicates that, the quality of the egg regarding the Haugh unit in the current study was under AA grade in diets which contain 5 %, 10 % and 15 % MOLM.

5.5 Effect of Dietary MOLM on Hormonal and Blood Profile of the Quail

This study revealed that different levels of MOLM inclusion in the diet did not influence haematological, biochemical and hormonal parameters (Tables 4.11 and 4.12). The health condition of experimental birds observed during the experimental period did not seem to have been affected by dietary MOLM. However, Du *et al*. (2007) reported that dietary MOLM may increase immune ability of the broilers. According to Sanni *et al*. (2000), it is generally known that haematological indices in poultry birds are affected by changes in daily physical and metabolic activities, nutrition, breed and sex. This is similar to the work done by Zanu *et al.* (2012) who stated that the inclusion of dietary moringa leaf meal at 5 %, 10 % and 15 % inclusion levels in broiler diets did not influence ($P > 0.05$) the haematological parameters of the blood. Similarly, the control diets and the MOLM diets had no effects ($P > 0.05$) on the MCV, MCH, MCHC, RBC 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). Moreover, the blood values recorded in this work are also in line with the normal blood values for the chicken (*Gallus domesticus*) reported by Jain (2009). Generally, the absence of difference in the various haematologic parameters, especially, when they are within the normal range implies that there is no infection, inflammation or stress (Khaldari *et al.*, 2010).

Because of the essential role that reproductive hormones such as follicle stimulating hormones, luteinizing hormone, progesterone, prolactin, oestrogen and testosterone play in the body, even small imbalances can cause side effects throughout the body (USDA, 2000). Reproductive performance of birds depend highly on hormones therefore any imbalance will highly affect the birds' productivity (NVRI, 2011).This indicates that MOLM is not likely to cause any detrimental effect when fed to quails at the present inclusion levels since the values obtained for these hormones fall within the normal ranges (Table 4.12) as reported by Jain (2009).

5.6. Economic efficiency of MOLM in quail production

The results on economic efficiency of MOLM in production showed that, it would cost less to gain per kilogram body-weight among starters and growers with MOLM inclusion diets (Tables 4.13 and 4.14). This suggests that MOLM has the potential of reducing feed cost of producing starters and growers. The consistent decrease in feed cost per kilogram body-weight of starters and growers fed 5% MOLM, 10% MOLM and 15% MOLM as compared with growers and starters on 0% MOLM suggests that increasing levels of MOLM in diets decreased cost per bodyweight gain. This can be attributed to the low cost of MOLM and the presence of adequate nutrients in MOLM (Table 4.1). Moreover, egg mass increased with increasing levels of MOLM in diet (Table 4.15). This results show that quails when fed with diet containing MOLM produce more eggs than when fed diet containing 0% MOLM. This can be attributed to the fact that quails like Guinea fowls are foragers and can better utilize feed containing forage such as MOLM, moreover, MOLM is rich in nutrients needed for egg production as indicated in the proximate analysis (Table 4.1).

CHAPTER SIX

6.0 SUMMARY, CONCLUSION AND RECOMMENDATION

6.1 Summary of Findings

6.1.1 Effect of Moringa oleifera Leaf Meal (MOLM) on growth performance

- Results from the study show that increasing dietary MOLM resulted in decreased daily and total feed intake.
- Bodyweight and weight gain increased with increasing levels of dietary MOLM.
- With respect to feed conversion ratio, birds fed with the MOLM had the highest feed conversion ability as compared to quails fed with diet containing no MOLM.

6.1.2 Effect of dietary MOLM on reproductive performance

- Birds fed control diets spent more days to sexual maturity.
- Increasing MOLM in the diet resulted in increasing bodyweight at first egg, egg weight at first egg laying and hen-day egg production.
- Fertility was highest in 15 % MOLM inclusion level, followed by birds fed with diets containing 10 % and 5 % MOLM inclusion levels.

6.1.3 Effect of dietary MOLM on egg quality

- Both external and internal egg quality traits were affected positively by the dietary inclusion of dietary MOLM at different levels in Japanese quails.
- Weight of sampled eggs and albumen weight, egg length, egg diameter, yolk colour, shell thickness, yolk height, yolk weight and yolk pH were all improved by the inclusion of MOLM in the diet especially at 15 % MOLM inclusion.

6.1.4 *Effect of dietary MOLM on hormonal and blood profile of the quail*

- This study revealed that hormonal, haematological and biochemical parameters were found not significantly ($P > 0.05$) influenced by MOLM.

6.1.5 Economic efficiency of dietary MOLM in quail production

- This study revealed that economic efficiency in the production of starter, grower and layer quails improved with the inclusion of MOLM in the diet especially at 15 % MOLM inclusion.
- MOLM therefore improved profitability from reduced feed cost.

6.2 Conclusions

It can be concluded from this study that:

- Feeding Japanese quails with MOLM up to 15 % inclusion level promotes better feed utilization and enhances rapid growth.
- 15 % inclusion level of MOLM in diet of Japanese quails reduced age at first egg laying, and increased hen-day egg production and egg weight.
- Egg quality, fertility and hatchability of Japanese quails increased with increasing levels of MOLM in the diet.
- Dietary MOLM in Japanese quails had no influence on hormonal, haematological and biochemical parameters.
- Economic efficiency of starter, grower and layer Japanese quails increased with increasing levels of MOLM in the diet.

6.3 Recommendations

This study makes the following recommendations:

- It is recommended to quail farmers that, for rapid growth, early maturity and higher bodyweight, quails diet should be formulated to contain MOLM up to 15 % inclusion level.
- Fertility and hatchability may be improved by dietary MOLM up to 15 % inclusion level.
- Quail farmers should feed their birds with dietary MOLM to improve egg laying, egg quality and overall egg production.
- Further studies should be carried out to determine the effect of dietary MOLM on carcass characteristics and sensory attribute of Japanese quail meat.
- It is recommended to quail farmers that, for efficient use of feed, reduced cost of production and increased profit during starter, grower and layer phases of quail production, quail's diet should be formulated to contain MOLM up to 15 % inclusion level.

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