EGG CHOLESTEROL LEVEL AND BLOOD BIOCHEMICAL PROFILE OF SIX SPECIES OF POULTRY UNDER EXTENSIVE MANAGEMENT SYSTEM

Cover Page

BY

Baraka Tahir NUHU

DEPARTMENT OF BIOLOGICAL SCIENCE,
FACULTY OF SCIENCE,
AHMADU BELLO UNIVERSITY,
ZARIA, NIGERIA.

OCTOBER, 2016

Fly Leaf

EGG CHOLESTEROL LEVEL AND BLOOD BIOCHEMICAL PROFILE OF SIX SPECIES OF POULTRY UNDER EXTENSIVE MANAGEMENT SYSTEM

Title Page

BY

Baraka Tahir, NUHU

B. SC. (ED) BIOLOGY. 2009, AHMADU BELLO UNIVERSITY, ZARIA.
M.SC/SC/41592/2012-2013

A DISSERTATION SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES AHMADU BELLO UNIVERSITY, ZARIA IN PARTIAL FULFILLMENT OF REQUIREMENTS FOR THE AWARD OF MASTER OF SCIENCE DEGREE IN EDUCATION BIOLOGY

DEPARTMENT OF BIOLOGICAL SCIENCES,
FACULTY OF SCIENCE,
AHMADU BELLO UNIVERSITY,

ZARIA, NIGERIA

OCTOBER, 2016

DECLARATION

I hereby declare that the work in this dissertation entitled **"EGG CHOLESTEROL LEVEL AND BLOOD BIOCHEMICAL PROFILE OF SIX SPECIES OF POULTRY UNDER EXTENSIVE MANAGEMENT SYSTEM"** was carried out by me in the department of Biological Science. The information derived from literatures has been duly acknowledged in the text and a list of references provided. No part of this dissertation was previously presented for another higher Degree or Diploma at any university.

Baraka Tahir NUHU	.....	.....
Name of Student	Signature	Date

CERTIFICATION

This dissertation titled "**EGG CHOLESTEROL LEVEL AND BLOOD BIOCHEMICAL PROFILE OF SIX SPECIES OF POULTRY UNDER EXTENSIVE MANAGEMENT SYSTEM"** by Baraka Tahir, NUHU meets the regulations governing the award of the degree of Masters of Science in Biological Science of Ahmadu Bello University, Zaria and is approved for its contribution to knowledge and Literary presentation.

---------- ----------

Dr. M. A. Adelanwa Date
Chairman, Supervisory Committee

---------- ----------

Dr. M.R. Hassan Date
Member, Supervisory Committee

---------- ----------

Prof. A. K. Adamu Date
Head, Biological Science Department,
Ahmadu Bello University, Zaria.

---------- ----------

Prof. K. Bala Date
Dean, School of Postgraduate Studies,
Ahmadu Bello University, Zaria.

DEDICATION

To the three most important people in my life, my husband Ahmadu Dahiru Usman and my parent Dr. Nuhu Tahir Tajuddeen and Hajiya Rahmatu Haruna Nuhu for their support, prayer, patience and understanding.

ACKNOWLEDGEMENTS

All praise be to Almighty Allah for His protection, guidance and for granting me the spirit of endurance throughout the duration of this work. To Him be the glory.

I am particularly indebted to Dr. M. A. Adelanwa and Dr. M. R Hasssan, my supervisors who despite their overburdened schedule of duties, never relented in their effort in seeing that I was not handicapped at any stage of the research. Their advice and devotion to duty, especially by reading my dissertation and rendering useful and constructive suggestions made the production of the findings of this work possible.

I also wish to thank my Husband and parents for their patience, support and advice. A thank to all my children for their patience throughout the period of my study. This gave me the impetus and courage to accomplish this noble task. May Allah (SAW) reward them all.

The following people have in one way or the other made the production of this dissertation a success, Mal. Yunusa, of Department of Veterinary Medicine, Obamedo Titi Nekpen, Department of Animal Science, Saminu and Isma'il Attah who all tirelessly rendered assistance to me during my laboratory work.

Finally, I also specially thank my friends, colleagues, course mates and all my lecturers for their constant encouragement and care for my success.

ABSTRACT

Six different poultry species (Indigenous chicken, Broiler, Turkey, Geese, Duck and Guinea fowl) were studied under extensive system of management to investigate the effect of rearing system on egg quality, cholesterol level and the blood biochemical profile. Birds used for the study were obtained from four different locations (Zangon Shanu, Bomo, Samaru and Kurmin Bomo) in Sabon Gari Local Government Area of Kaduna State. Eighteen (18) birds were randomly selected from the flock with three birds (3) per strain as replicates. Three eggs were collected daily per replicate for the determination of external and internal egg quality parameters (egg weight, egg length, egg breadth, egg shape index, shell thickness, yolk width, yolk height and yolk index). Blood samples (2ml) were collected from the same birds at the end of the laying phase for the determination of blood biochemical profile, heamatological parameters and cholesterol levels. Data collected was analyzed using the General Linear Model of the SAS (2002) Software. Statistically significant means were separated using the Duncan Multiple Range Test (DMRT). Results obtained from the study showed that the geese had significant ($P<0.05$) better external and internal egg parameters for most of the parameters while indigenous chicken and guinea fowl had the least results for external and internal egg parameters. Biochemical indices, showed significant ($P<0.05$) differences in most of the parameters except high density lipoprotein (HDL) which was not significant ($P>0.05$) among the treatments. The calcium (Ca^{2+}) and phosphorus (PO_4^{2-}) contents of the blood were all within a similar range ($P<0.05$) for the species except for duck which had a lower value of 2.06mg/dl. Also, duck had lowest values for blood total cholesterol (3.33mg/dl), low density lipoprotein (2.20mg/dl) and triglycerides (0.43mg/dl). However, lowest values of

PO_4^{2-} were observed in guinea fowl (0.84mg/dl) compared to duck (1.60mg/dl). Other biochemical indices such as total cholesterol (5.63mg/dl), high density lipo-protein (1.27mg/dl) and low density lipo-protein (3.93mg/dl), were significantly ($P<0.05$) better in goose than other species. Guinea fowl had higher albumin content (45.00mg/dl) compared to indigenous chicken (26.33mg/dl). The egg cholesterol level differed significantly ($P<0.05$) in the poultry species with highest level obtained in guinea fowls (15.30mg/dl) compared to indigenous chicken (8.83mg/dl), broiler (9.50 mg/dl) and duck (9.50 mg/dl). Indigenous chicken had higher value for glucose (176.33mg/dl) compared to geese (47.67mg/dl), though least for cholesterol. Duck and turkey have higher values ($P<0.05$) for egg total protein than broiler (53.33 vs. 28.67mg/dl). The results of heamatological parameters showed that all the parameters measured were significantly ($P<0.05$) different amongst the species. However, the monocytes, eosinophiles and bands were not significantly ($P>0.05$) different from each other. It was therefore concluded that differences exist among the various species of poultry birds studied with guinea fowl (15.30mg/dl) having the highest total cholesterol values for egg quality parameters while the lowest value (8.83mg/dl) was obtained in indigenous chicken. However, duck (3.33mg/dl) had lowest values for total cholesterol in the blood and higher values for total protein (53.33mg/dl), while indigenous chickens had the least value for egg cholesterol compared to the nutritional standard for hen (410.00mg). Hence, egg and meat of duck and indigenous chickens are safer to consume compared to other poultry species; and should therefore be promoted in our farming systems.

TABLE OF CONTENT

Cover Page …… i
Fly Leaf …… ii
Title Page …… iii
Declaration …… iv
Certification …… v
Dedication …… vi
Acknowledgements …… vii
Abstract …… viii
Table of Contents …… x
List of Figures …… xiii
List of Tables …… xiv
List of Plates …… xv
List of Abbreviation …… xvi

CHAPTER ONE

1.0 INTRODUCTION …… 1
1.1 Statement of the Research Problems …… 2
1.2 Justification …… 3
1.3 Aim …… 3
1.4 Objectives …… 3
1.5 Hypotheses …… 4

CHAPTER TWO

2.0 LITERATURE REVIEW …… 5
2.1 Poultry Production in Nigeria …… 5
2.2 Description of Poultry Species in Nigeria …… 6
2.2.1 Guinea fowl …… 7
2.2.2 Ducks …… 8
2.2.3 Geese …… 12
2.2.4 Turkeys …… 12
2.3 Production Systems Used in Nigeria …… 13

2.3.1 Intensive System …… 13
2.3.1.1 Deep Litter System …….. 13
2.3.1.2 Slatted Floor System …… 13
2.3.1.3 Battery Cage System …… 13
2.3.2 Semi Intensive …… 14
2.3.3 Extensive System …… 15
2.3.3.1 Free-Range Extensive Systems …… 15
2.3.3.2 Backyard Extensive Systems …… 15
2.4 Egg Production in Various Poultry Species ……. 15
2.4.1 Uses and Importance of Egg Produced …… 16
2.5 Blood Biochemical Profile of Various Species …… 17
2.5.1 Effect of Extensive Management on Haematological and Blood Biochemical Profile …….. 17
2.6 Lipids in Eggs ……..18
2.7 Cholesterol Levels in the Eggs of the Various Species ……... 20
2.7.1 Lipoproteins the transporter of cholesterol …….. 21
2.8 Relationship between the Various Haematological, Biochemical Parameters and Cholesterol ……. 21
2.9 Production and Quality of Eggs ……... 22
2.10 Advantages of Egg Consumption for Human Health ……..26
2.10.1 Environmental Effect on Egg Quality ……. 29

CHAPTER THREE

3.0 MATERIALS AND METHODS ……. 31
3.1 Sources of the Experimental Birds …….. 31
3.2 Design and Management of Experimental Birds ……33
3.3 Determination of Egg Quality Parameters …… 40
3.4 Determination of Haematological Parameters ……42
3.5 Determination of Blood Chemistry …….. 43
3.6 Data Analysis …… 44

CHAPTER FOUR

4.0 RESULTS …… 45

4.1 The External and Internal Egg Parameters of Some Poultry Species ……... 45

4.2 The Biochemical Indices of Some Poultry Species ……...49

4.3 Egg Quality Levels of Some Poultry Species …… 52

4.4 The Haematological Parameters of Some Poultry Species …….. 54

CHAPTER FIVE

5.0 DISCUSSION ……... 56

5.1 External and Internal Egg Parameters of Some Poultry Species …….. 56

5.2 Biochemical Indices of Different Poultry Species …… 56

5.3 The Egg Cholesterol Levels ……. 58

5.4 The Haematological Parameters …….. 59

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATIONS ……. 60

6.1 Conclusion …… 60

6.2 Recommendations ……. 61

References ……. 62

LIST OF FIGURES

3.1 Map of Nigeria, Kaduna State and Sabongari Local

Government Areas Showing location of study are…….… 32

LIST OF TABLES

2. 1: Lipid content of eggs …… 20

2. 2. Nutritional composition of hen eggs (Quantities represent an edible portion of about 100 g) ……..……...…... 29

4. 1: The external egg parameters of six different species of poultry birds …… 45

4. 2: Internal Egg parameters for the six different poultry species 41

4. 3: Effect of different species of poultry birds on the biochemical indices ..…….. 44

4. 4: The egg cholesterol of six different species of poultry birds 52

4. 5: Effect of different species of poultry birds on some haematological parameters……55

LIST OF PLATES

1: Entrance to one of the pens housing the experimental chicken in the research locality ……...……. 34

2: Entrance to another pen housing the experimental turkeys in the research locality …….……..…….…….…….. 35

3: A herd of guinea fowls in one of the research localities ……..…..…… 36

4: Ducks in one of the research localities …….……. 37

5: Turkeys in one of the research localities …….……..…… 38

6: Chickens feeding in one of the research localities ……..... 39

LIST OF ABBREVIATION

1. LDL: Low Density Lipoprotein
2. HDL: High Density Lipoprotein
3. ALP: Alkaline phosphatase
4. ALB: Albumin
5. TG: Triglyceride
6. TC: Total Cholesterol
7. U/A: Uric Acid
8. LYMP: Lympocyte
9. MONO: Monophil
10. EOSI: Eosinophil
11. RBC: Red Blood Cells
12. WBC: White Blood Cells

CHAPTER ONE

1.0 INTRODUCTION

The poultry industry is a highly profitable business in Nigeria (Adebambo *et al.,* 1999) and it is one area of animal production with significant contribution to human food production in egg and meat. Poultry products provide protein of high biological value (Epstein, 1990). Nigeria is endowed with many poultry species which are indigenous to the country and includes: the domestic fowl, pheasant, quail, guinea fowl, pigeon, turkey, goose and Muscovy ducks (Oluyemi and Roberts, 2007). These have lived, adapted and reproduced for several years in the Nigeria environment. Food and Agriculture Organization (2001) estimated poultry population in Nigeria to be about 33million.

With the ever growing population and improvement in the living standard of Nigerians, the demand for egg and other poultry products will continue to grow. As this increase continues, the quality of food, a substantial part of which is formed by the poultry and other agricultural animals becomes increasingly important with growing consumer awareness for healthy aspect of food. The health concerns include not only pathogens or traces of contaminations but also the compositions and nutritional values of the products (Mennicken *et al.,* 2005).

Egg is the only complete food material because it contains all of the six classes of food. Its nutritive quality for both man and for the transformation of a fertile egg into a living organism makes it a perfect biological composition (Trziszka, 2000). As a complete food, eggs are inexpensive and low calorie source of nutrients such as folate, riboflavin, selenium, choline vitamin-12 and vitamin A, K and D. The lipid matrix of the egg yolk serves to enhance the bio-availability of nutrients such as lutein and zeaxanthin (Herron and Fernadez, 2004).

The physiology and chemistry of blood are being used daily as indicators for various diseases in birds (Harr, 2002; Hauptmanova *et al.,* 2006). However; these values are affected by different factors such as nutrition, age and sex and presence or absence of disease (Fudge 2000; Kececi and Col, 2011).

In many species of birds, normal values for biochemical factors have been measured and a comprehensive data base was established as their blood profiles (Albokhadaim *et al.,* 2012). However, there is no sufficient information about the egg cholesterol levels and blood biochemical profile of the six poultry species in Nigeria.

1.1 Statement of the Research Problems

Some disease populations such as type II diabetics and hyperlipidemics (those with high blood triglycerides) are at greater chance for low density lipoprotein (LDL) increases in these populations relative to eggs consumption. No studies have currently shown an increase in risk of coronary heart disease, suggesting that measuring circulating cholesterol levels may be poorly indicative of heart disease from egg intake. Most dietary deficiency diseases are caused by a lack of protein, vitamins, or minerals. Cholesterol content of chicken eggs continues to receive considerable attention since the cholesterol levels in eggs are concern to humans who are trying to lower the intake of dietary cholesterol through other sources. Though many authors have examined the relationships and possible differences amongst the poultry species, conclusions from such studies has not been agreed on and comparisons between the poultry species under extensive system of management has not been made with respect to the blood chemistry and egg cholesterol status. Therefore this study was undertaken to investigate the cholesterol levels and blood biochemical profile of the six poultry species under extensive management system.

1.2 Justification

In Nigeria, more emphasis is laid on the production of domestic fowl to the neglect of other species of poultry. As a result, domestic fowl constitutes 91% while guinea fowl, duck, turkey and others constitute 4, 3 and 2% respectively (Adenowo *et al.*, 1999). There are no any social or religious stigmas attached to the use of poultry meat in human diet. Hence the demand is high for live birds from local markets either for home consumption or as gifts at the time of festivities such as Christmas, New Year, Easter, Id El-Fitri, etc. Restaurants, hotels and supermarkets in Nigeria are noted for fast food business that involves the sale of products like chicken burger, egg rolls among others. Besides, fowl meat has good potential for export worldwide while exportation of eggs into some West African countries is a lucrative business Samuel (2007).

The household poultry production system is based on scavenging indigenous domestic chickens accompanied by local chickens, pigeons, guinea fowls, ducks or turkeys (Elagib *et al.*, 2012). The haematological and serum biochemical parameters provide valuable information on the immune status of animals (Kral and Suchy, 2000). Such information, apart from being useful for diagnostic and management purposes, could equally be incorporated into breeding programmes for the genetic improvement of indigenous chickens. It is desirable to know the normal physiological values under local conditions for proper management, feeding, breeding, prevention and treatment of diseases.

1.3 Aim

To evaluate the internal and external egg parameters, haematological and blood profiles of six different poultry species reared extensively.

1.4 Objectives

i. To compare the egg morphometric parameters of the six different poultry species reared extensively.

ii. To determine the biochemical parameters (blood profile) of the six different poultry species

iii. To determine the egg quality of six different species of poultry reared extensively

   a. egg weight,
   b. egg length,
   c. egg breadth,
   d. egg shape index,
   e. shell thickness,
   f. yolk width,
   g. yolk height and
   h. yolk index.

iv. To determine the haematological parameters of the six different poultry species reared extensively.

1.5 Hypotheses

i. There is no difference in the egg morphometric parameters of the six poultry species under extensive management system.

ii. The biochemical parameters (blood profile) of the six different poultry species does not differ significantly ($p<0.05$).

iii. The egg quality parameters of the six different bird species are the same.

iv. There is no difference in the haematological parameters of the six poultry species under extensive management system.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Poultry Production in Nigeria

Poultry keeping is making an important contribution to the livelihood of the most vulnerable rural households in developing countries (FAO, 2004). Over the last decade, the consumption of poultry products in developing countries has grown by 5.8% per annum, faster than that of human population growth, and has created a great increase in demand (FAO, 2004).

The domesticated birds of importance in the tropics include domestic fowls, the common duck, Muscovy ducks, goose, turkey, peafowl, Japanese quail, guinea fowl, pigeons and the ostrich. Domestic fowls are by far the most important in the tropics and they probably originated from four wild species namely: *Gallus gallus, G.varius, G. sonnerati and G. lafayetti.* Some authorities consider that *G. gallus* is the only ancestor of the domestic fowl while others believe that all the four wild species contributed genes to the domestic fowl (Samuel, 2007). The center of domestication is unknown. However, in view of the very wide distribution of the wild species, it is possible that there were several centers of domestication. In terms of distribution, there are more domestic fowls in the non-tropical than in the tropical regions of the world, with more than one-third of all domestic fowls (Samuel, 2007).

Poultry plays an important economic, nutritional and socio-cultural role in the livelihood of rural households in many developing countries, including Nigeria. Poultry include fowl, turkey, duck, goose, ostrich, guinea fowl, etc. Their production not only have a major

impact on the economy but also contribute significantly to human food as a primary supplier of meat, egg, raw materials to industries (feathers, waste products), source of income and employment to people compared to other domestic animals (Avila,1985; Demeke, 2004). Poultry are efficient converters of feed to egg and meat within a short period of time. In terms of nutritive value, poultry egg rank second to cow milk (Amos, 2006). Agriculturists and nutritionists have generally agreed that developing the poultry industry of Nigeria is the fastest means of bridging the protein deficiency gap presently prevailing in the country (Amos, 2006).

Modern commercial poultry egg production started in Nigeria in the early 1960s. Ever since, it has assumed relatively important position in the Nations livestock economy. The contribution of poultry products (meat and eggs) to total livestock output increased from 26% in 1995 to 27% in 1999 while increase in production of eggs alone accounted for about 13% during the same period (Ojo, 2002).

2.2 Description of Poultry Species in Nigeria

All species of poultry are used by rural smallholders throughout the world. The poultry species commonly found in Nigeria are: chickens, guinea fowl (*Numida meleagus),* ducks (*Cairina spp;* including Muscovy ducks), pigeons (*Columba livea*), turkeys *(Meleagus gallapavo)* and geese (*Anser anser*). (Amos, 2006; Samuel, 2007).

2.2.1 Guinea fowl

Guinea fowl are native to West Africa but are now found in many parts of the tropics, and are kept in large numbers under intensive systems in France, Italy, the former Soviet Union and Hungary. In India, guinea fowl are raised in parts of the Punjab (Shingari *et al.,*

1994), Uttar Pradesh, Assam and Madhya Pradesh, usually in flocks of a few hundred birds. Guinea fowl are seasonal breeders, laying eggs only during the rainy season, under free-range conditions. They are very timid, roosting in trees at night, and although great walkers, they fly very little.

Guinea fowl thrive in both cool and hot conditions, and their potential to increase meat and particularly egg production in developing countries deserves better recognition. The first egg is normally laid at about 18 weeks of age, and unlike many indigenous birds (which produce a single clutch a year), guinea hens lay continuously until adverse weather sets in. In West Africa, laying is largely confined to the rainy season. Guinea hens under free-range conditions can lay up to 60 eggs per season, while well-managed birds under intensive management can lay up to 200 eggs per year. The guinea hen "goes broody" (sits on eggs in the nest) after laying, but this can be overcome by removing most of the eggs. A clutch of 15 to 20 eggs is common, and the incubation period for guinea fowl is 27 days. Domesticated guinea fowl under extensive or semi-intensive management in Nigeria were reported to lay 60 to 100 eggs with a fertility rate of 40 to 60 percent (Avila, 1985; Demeke, 2004).

Domesticated guinea fowl are of three principal varieties: Pearl, White and Lavender. The Pearl is by far the most common. It has purplish-grey feathers regularly dotted or "pearled" with white. The White guinea fowl has pure white feathers while the Lavender has light grey feathers dotted with white. The male and female guinea fowl differ so little in appearance (feather color and body weight [1.4 to 1.6 kg]) that the inexperienced farmer

may unknowingly keep all males or all females as “breeding” stock. Sex can be distinguished at eight weeks or more by a difference in their voice cry.

Domesticated guinea hens lay more eggs under intensive management. French Galor guinea hens can produce 170 eggs in a 36-week laying period. For example, from a setting of 155 eggs, a fertility rate of 88 percent and hatchability of 70 to 75 percent, it is possible to obtain 115 guinea keets (chicks) per hen. In deep litter or confined range conditions, a 24-week laying period can produce 50 to 75 guinea keets per hen. (Onyeanusi, 2007)

2.2.2 Ducks

Duck is the common name for a large number of species in the Anatidae family of waterfowl which also includes swans and geese. The ducks are divided among several subfamilies in the family Anatidae; they do not represent a monophyletic group (the group of all descendants of a single common ancestral species) but a form taxon, since swans and geese are not considered ducks. Ducks are mostly aquatic birds, mostly smaller than the swans and geese, and may be found in both fresh water and sea water. The overall body plan of ducks is elongated and broad, and the ducks are also relatively long-necked, albeit not as long-necked as the geese and swans. The body shape of diving ducks varies somewhat from this in being more rounded. The bill is usually broad and contains serrated lamellae, which are particularly well defined in the filter-feeding species. In the case of some fishing species the bill is long and strongly serrated. The scaled legs are strong and well developed, and generally set far back on the body, more so in the highly aquatic species. (Obinne et al 2000). The wings are very strong and are generally short and pointed, and the flight of ducks requires fast continuous strokes, requiring in turn strong

wing muscles. Three species of steamer duck are almost flightless, however. Many species of duck are temporarily flightless while moulting; they seek out protected habitat with good food supplies during this period. This moult typically precedes migration (Obinne et al 2000).

Ducks have several advantages over other poultry species, in particular their disease tolerance. They are hardy, excellent foragers and easy to herd, particularly in wetlands where they tend to flock together. In Asia, most duck production is closely associated with wetland rice farming, particularly in the humid and subtropics. An added advantage is that ducks normally lay most of their eggs within the three hours after sunrise (compared with five hours for chickens). This makes it possible for ducks to freely range in the rice fields by day, while being confined by night. A disadvantage of ducks (relative to other poultry) when kept in confinement and fed balanced rations, is their high feed wastage, due to the shovel-shape of their bill. This makes their use of feed less efficient and thus their meat and eggs more expensive than those of chickens (Farrell, 1986). Duck feathers and feather down can also make an important contribution to income. (Obinne et al 2000)

Different breeds of ducks are usually grouped into three classes: meat or general purpose; egg production; and ornamental. Ornamental ducks are rarely found in the family poultry sector. Meat breeds include the pekin, muscovy, rouen and aylesbury. Egg breeds include the brown Tsaiya of Taiwan Province of China, the Patero Grade of the Philippines, the Indian Runner of Malaysia and the Khaki Campbell of England. All these laying breed ducks originate from the green-headed Mallard *(Anasplatyrhyn chosplatyrhynchos).* The average egg production of the egg breeds is approximately 70 percent (hen-day basis). The

Indian Runner, Khaki Campbell, Pekin and Muscovy are the most important breeds in rural poultry.

2.2.2.1 The Indian Runner

This is a very active breed, native to Asia, and ideal for free-range. It is a very good egg layer and needs less water than most other breeds, requiring only a basin in which it can immerse its beak up to the nostrils. It is the most graceful and elegant of all ducks on land with its upright carriage and slim body. It stands at an angle of about 80^{o} to the ground but when startled can be almost perpendicular. (Obinne et al 2000).

2.2.2.2 The Khaki Campbell

Originally bred in England, this breed is derived from three breeds: the wild Mallard, the Rouen and the Indian Runner. The female has an overall khaki colour, and the male has a bronze-green head. The female is best known for her prolific egg laying ability, with an average of 90 percent (on a hen/day basis) with an average 73 gram egg weight. (Obinne et al 2000).

2.2.2.3 The Pekin

Originally bred in China, this attractive meat breed is favoured by commercial producers throughout the world. It is large and meaty with an upright stance and a broad round head. It has white to lemon-yellow plumage and a yellow skin. It is hardy, a reasonable layer, and grows rapidly. Although timid, it is docile and easily confined by low fences. It is well suited to both large, specialized duck farms and smallholdings. Pekin ducks are the major meat duck breed in Thailand, Malaysia, Philippines, the Democratic People's Republic of Korea and China. (Obinne et al 2000).

2.2.2.1 The Muscovy duck

This is not genetically a duck or a goose, but is more similar to the goose *(Anseridae).* It eats grass, as do geese, and has a similarly long egg incubation period of 36 days (compared with that of ducks - 28 days). It is popular in areas where there is little wetland rice production, since it does not require swimming water. The female Muscovy is an excellent brooding mother. It is often used as a foster brooder-mother for other species such as ducks, chickens and guinea fowls. It is a poor layer, producing only 30 to 40 eggs per year under extensive management. The male Muscovy can become very large (4.5 to 5.5 kg) while the female is smaller (2.3 to 2.8 kg). The feather colouring is usually a combination of black and white, ranging from mostly black to mostly white. The male has characteristic red fleshy outcrops around the eyes called *caruncles*. The Muscovy is the predominant waterfowl in Africa and Latin America, as it thrives well under free-range conditions. Numbers are increasing in parts of Asia where lean; red meat is popular (Hahn *et al.,* 1995). When mated with breeds of domestic ducks, they produce infertile hybrid offspring ("mule" ducks). These mule ducks are a major source of duck meat in Taiwan Province of China. A three-way cross-system is used for white mule duck production.

Firstly, Pekin drakes are crossed with white Tsaiya ducks to produce a cross-bred female line called the Kaiya duck. These are then crossed with large white Muscovy drakes, usually by artificial insemination. The resulting progeny is a mule duck, which is sterile but grows rapidly. It has good carcass composition with more meat and less fat than the Pekin. These three-way crosses have the added advantages of the high egg production of the Tsaiya, the high growth rate of the Pekin and the good carcass quality and meat texture

of the Muscovy. Their white feathers are more valuable as down than those of darker-feathered ducks.

2.2.3 Geese

Geese are less important in family poultry production, except in China, where mainly local breeds are kept and for a few European breeds such as the Toulouse and White Roman, used for cross-breeding purposes. The great variety in breed size of geese permits their use under various management conditions. At the less intensive levels of production preferred by most family producers, smaller-sized birds (weighing approximately 4 kg, such as the Lingxhianor Zie breeds in China) are easier to manage. Geese are high in the broodiness trait, and have a consequent low egg production of 30 to 40 hatching eggs (in three to five laying cycles) per year. (Izunobi 2002; Omoruyi et al 1999)

At the other extreme are breeds of high fertility (and egg number), which are smaller and are selected specifically for use in breeding flocks for their lack of broodiness. Breeds such as the Zie may lay 70 to 100 eggs annually. The importance of the wide gene pool variety in China is significant for the Asian region in particular and for the world in general. (Omoruyi et al 1999; Izunobi 2002)

2.2.4 Turkeys

These birds are native to Latin America. The breeds kept by rural producers in the tropics usually have black feathers, as distinct from the white-feathered breeds that are raised intensively. Where there are no geese and ostriches, they are the largest birds in the farming system. Body weight ranges from 7 to 8 kg in males and from 4 to 5 kg in hens.

They have good meat conformation, produce about 90 eggs per year and have medium to good hatchability. They are more susceptible to disease than either chicken or ducks.

2.3 Production Systems Used in Nigeria

2.3.1 Intensive

This system is used by medium to large-scale commercial enterprises, and is also used at the household level. Birds are fully confined either in houses or cages. Capital outlay is higher and the birds are totally dependent on their owners for all their requirements; production however is higher. There are three types of intensive systems: (Akinsanmi 1994)

2.3.1.1 Deep Litter System

Birds are fully confined (with floor space allowance of 3 to 4 birds/m2 within a house, but can move around freely. The floor is covered with a deep litter (a 5 to10 cm deep layer) of grain husks (maize or rice), straw, wood shavings or a similarly absorbent (but non-toxic) material. The fully enclosed system protects the birds from thieves and predators and is suitable for specially selected commercial breeds of egg or meat producing poultry (layers, breeder flocks and broilers). (Obinne et al 2000)

2.3.1.2 Slatted Floor System

Wire or wooden slatted floors are used instead of deep litter, which allow stocking rates to be increased to five birds/m2 of floor space. Birds have reduced contact with faeces and are allowed some freedom of movement. (Akinsanmi 1994; Izunobi 2002)

2.3.1.3 Battery Cage System

This is usually used for laying birds, which are kept throughout their productive life in cages. There is a high initial capital investment, and the system is mostly confined to

large-scale commercial egg layer operations. Intensive system of rearing indigenous chickens commercially is uncommon, a notable rare exception being in Malaysia, where the industry developed in response to the heavy demand for indigenous chickens in urban areas (Supramaniam, 1988). However, this accounts for only two in every 100 000 (0.002 percent) of that country's indigenous chickens.

The above management systems frequently overlap. Thus free-range is sometimes coupled with feed supplementation, backyard with night confinement but without feeding, and poultry cages in confined spaces (Branckaert and Guèye, 1999).

2.3.2 Semi Intensive

These are a combination of the extensive and intensive systems where birds are confined to a certain area with access to shelter. They are commonly found in urban and peri-urban as well as rural situations. In the "run" system, the birds are confined in an enclosed area outside during the day and housed at night. Feed and water are available in the house to avoid wastage by rain, wind and wild animals. (Akinsanmi 1994; Ovwigho 2009)

In the European system of free-range poultry keeping, there are two other types of housing. The first of these is the "ark" system, where the poultry are confined overnight (for security against predators) in a building mounted on two rails or skids (usually wooden), which enable it to be moved from place to place with draught power. A typical size is 2 × 2.5 m to hold about 40 birds.

The second type of housing is the "fold" unit, with a space allowance (stock density) for adult birds of typically 3 to 4 birds per square meter (birds/m^2), both inside and (at least

this) outside. The fold unit is usually small enough to be moved by one person. Neither of these two systems is commonly found in developing countries.

2.3.3 Extensive System

2.3.3.1 Free-Range Extensive Systems

In Africa, Asia and Latin America, 80 percent of farmers keep poultry in the first two extensive systems. Under free-range conditions, the birds are not confined and can scavenge for food over a wide area. Rudimentary shelters may be provided, and these may or may not be used. The birds may roost outside, usually in trees, and nest in the bush. The flock contains birds of different species and varying ages. (Akinsanmi 1994; Izunobi 2002)

2.3.3.2 Backyard Extensive Systems

Poultry are housed at night but allowed free-range during the day. They are usually fed a handful of grain and water in the morning and evening to supplement scavenging.

2.4 Egg Production in Various Poultry Species

Globally, egg production is growing rapidly (39% over 10 years) with Asian countries in particular having the high rates of increase; China and India with increase of 42% and 67% respectively (Scanes, 2007). Nigeria hosts more than 45% of the poultry in the West African sub region (WHO, 2006) and its poultry population is estimated at 140 –160 million comprising of 72.4 million chicken, 11.8 million ducks, 4.7million guinea fowl, 15.2 million pigeon and 0.2 million turkeys (FAO, 2006). This figure accounts for 71.38% of the total livestock kept in the country and supplies 17% of animal protein need of the population (Oji and Chukwuma, 2007).

The Ministry of Agriculture and National Resource (1998) and Eduvie (2002) stated that Nigerian poultry industry is dominated by small-holder farmers who on the aggregate raise bulk of the birds for egg production and meat, but individually rear less than 1000 birds using different production strategies in consonance with little resources available to them. Farming in general, has to use available inputs as efficiently as possible to achieve optimum production (Udoh and Akintola, 2001) and (Etim *et al*., 2005).

2.4.1 Uses and Importance of Egg

Poultry refers to all birds of economic value to man as source of meat, egg and fibre. Egg production involves the use of good layer birds for the purpose of table egg production (Ogunlade and Adebayo, 2007). Eggs are major sources of animal protein in human diet. According to Oji and Chukwuma (2007) the poultry goes a long way in providing animal protein for the populace because it yields quickest returns and provides for meat and eggs in a very short time. Poultry eggs nearly approach a perfect balance of all food nutrients. The yolk and albumen contain 17.5 and 10% protein respectively by weight. It was also found by the Food and Agricultural Organization of the United Nations (FAO, 1990) that eggs rank second to cow milk in terms of nutritive value and is the most economically produced animal protein.

Animal protein is an essential part of human nutrition because of its biological significance. Iwena (2007) reported that proteins are required for the growth of young ones, formation of gametes in reproduction, formation of digestive juices, repair of worn-out tissues or cells, production of anti-bodies as well as enzymes and hormones in the

body. Tijjani *et al*. (2006) reaffirmed that animal proteins are more "biologically complete" than vegetable proteins with regards to their amino-acids composition.

2.5 Blood Biochemical Profile of Various Species

Several factors including physiological conditions, environmental conditions, diet content and age affect the blood profiles of healthy birds (Alodan and Mashaly, 1999; Vecerek *et al*., 2002; Odunsi *et al*., 1999; Kurtoglu *et al*., 2005 and Seiser *et al*., 2000).

In avian medicine, interpretation and sensible utilization of blood profiles are often limited by lack of values for physiological parameters relevant to the individual avian species and in each species to breeding lines, production types amongst others (Kral and Suchy, 2000). Comparison of reported values for biochemical parameters among different species of bird indicates that biochemical parameters values of birds are species-dependent and significant differences between plasma and serum values have also been reported (Hrubec *et al*., 2004).

2.6 Lipids in Eggs

Egg is an important components of human diet. There are many types of poultry species' eggs consumable as a protein and amino acid supplement. Statistical data released by Food and Agricultural Organization shows that the total world production of chicken eggs amounts to about 1220 billion per year yielded mainly by chickens but also coming from other poultry species as 86 billion eggs per year (7% of whole egg production). The question arises whether there are interspecies differences in poultry eggs quality which may affect the egg nutritive value and quality as human food.

Different types of fatty acids are contained in eggs and they include: saturated fatty acids (SFA), monounsaturated fatty acids (MUFA) and polyunsaturated fatty acids (PUFA) – Chow (1992). Availability or lack, thereof, of these fatty acids has profound effect on human health. For instance, an inadequate intake of PUFA, especially docosahexaenoic acid (DHA, C22:6n-3), negatively influences brain growth and functional parameters in human infants (Hoffman *et al*., 2004; Poławska *et al*., 2013). Poultry egg is one of the best sources of omega 3 in all over the world and must regularly be consumed especially by growing individuals (Sauerwald *et al*., 1997). The fatty acid composition of poultry egg may be affected, among others, by diet, age and geographic allocation (Milinsk *et al*., 2003).

Table 2.1 shows the mean percentage content of lipids in nine strains of poultry as reported by Polat *et al*. (2013)

Table 2.1: Lipid content of eggs the total lipid content of eggs of nine poultry species

Poultry species	**Lipid content (%)**
Chicken	33.42
Goose	31.27
Duck	30.61
Turkey	32.76
Peacock	33.02
Guinea fowl	32.97
Pheasant	31.75
Quail	30.63
Partridge	33.22

Source: Polat *et al*., 2013

2.7 Cholesterol Levels in the Eggs of the Various Species

Cholesterol is an organic chemical substance present naturally in the body. It is an essential structural component of the cell membrane and is required for their proper functioning because it influences membrane permeability and fluidity. (Mc Namara, 2000a). Cholesterol is also an important component of the hormonal systems of the body and is involved in the manufacture of bile acids, steroid hormones, and vitamin D (Mc Namara, 2000b). The liver produces 75% of the cholesterol that circulates in the blood. The other 25% comes from food. At normal level or less, cholesterol plays an important role in helping cells do their jobs. However, high cholesterol levels increases the risk of developing cardiovascular diseases (Jose *et al*., 2015).

Cholesterol as reported by (McNamara, 2000; Nijke *et al*., 2010; Rong *et al*., 2013) provides both structure and function to the body. The authors also reported that cholesterol is required to build and maintain membranes; modulates membrane permeability and fluidity. Furthermore it aids in layer compaction of cholesterol-rich cell membranes (of Schwann cells) form myelin sheath which surround nerve fibers and provide insulation for efficient conduction of nerve impulses. Cholesterol is converted in the liver to bile which is then stored in the gall bladder. Bile contains bile salts, which solubilize/emulsify the water-insoluble fats in the digestive tract and aid in the absorption of fat molecules, as well as the fat-soluble vitamins A, D, E, and K. Cholesterol is involved in the synthesis of vitamin D and the steroid hormones, including the adrenal gland hormones (adrenocortisol and aldosterone), as well as the sex hormones progesterone, estrogens and testosterone (Rong *et al*., 2013; Jose *et al*., 2015).

2.7.1 Lipoproteins (the transporter of cholesterol)

Cholesterol has been reported by several authors to be slightly soluble in water so it is insoluble in blood (Masson *et al*., 2003). Therefore it is transported by lipoproteins which are chemicals made up of lipids and proteins. Lipoproteins are classified according to their densities. The more lipid and less protein a lipoprotein has, the less dense it is. Therefore the following has been reported by Masson *et al*. (2003) as the types of lipoproteins present in blood (Masson *et al*., 2003).

1. Very-low-density lipoprotein (VLDL).
2. Intermediate-density lipoprotein (IDL).
3. Low-density lipoprotein (LDL).
4. High-density lipoprotein (HDL).

2.8 Relationship between the Various Haematological, Biochemical Parameters and Cholesterol

Blood plays an important role in the transportation of nutrients, metabolic waste products and gases around the body (Zhou *et al.,* 1999). Moreover, blood represents a means of assessing clinical and nutritional health status of animals (Olorode and Longe, 2000). Haemato-biochemical profiles are most commonly used in nutritional studies for various (Adeyemi *et al.,* 2000; Pavlak *et al.,* 2005; Onyeanusi, 2007; Schmidt *et al.,* 2009; Arora, 2010)

. The full blood count examines mostly the cellular components of blood whereas biochemical testing focuses on its chemical constituents (Hrubec *et al.,* 2002). It has been shown that data from blood profiles could be exploited in the improvement of chicken stocks (Ladokun *et al.,* 2008). In addition, blood parameters help in the diagnoses of

specific poultry pathologies and might serve as basic knowledge for studies in immunology and comparative avian pathology (Bonadiman, 2009).

Studies on various poultry type demonstrate that haemato-biochemical profiles of chickens are correlated with a number of factors such as gender, nutrition, rearing temperature, stocking density and stress conditions. Other studies revealed that serum protein may be used as an indirect measurement of dietary protein quality (Alikwe *et al.*, 2010), whereas significant reduction in red and white blood corpuscles indicates haemolytic anaemia and exposes the birds to high risk of infection (Akporhuarho, 2011).

Fluctuations or variations in haemato-biochemical profiles have been reported in chickens of the same age and sex, and reared under the same conditions but sampled at different times of the day (Azeez *et al.*, 2009), due to changes in daily physical and metabolic activities (Islam *et al.*, 2004), feed replacement (Ugwu *et al.*, 2008, Adeyemo *et al.*, 2010, Oloyede *et al.*, 2010, Saied *et al.*, 2011), polluted water (Akporhuarho, 2011) and ecotypes (Elagib and Ahmed, 2011). Recently it has been demonstrated that serum lipid and serum cholesterol decreased significantly in post-hatch broiler chicks (Ali *et al.*, 2011).

2.9 Production and Quality of Eggs

Egg quality is a general term that relates to various external and internal standards that are imposed on the eggs (Koelkebeck, 2003). Some of these standards are based on subjective measures of egg quality and some are based on a more quantitative measure of egg quality. Egg quality has an influence on egg acceptance or rejection by the consumer. Egg

quality defects are deviations in external and internal standards of the egg that affect the quality. (Koelkebeck, 2003)

In this sense, because eggs are a conventional food containing nutrients that play fundamental roles beyond basic nutrition, their promotion as functional foods should be considered (Herron and Fernandez, 2004). Eggs are of particular interest from a functionality point of view, because they offer a moderate calorie source (about 150 kcal/100 g), a protein of excellent quality, great culinary versatility and low economic cost (Carrillo *et al*., 2012), which makes eggs within reach to most of the population. Eggs are also relatively rich in fat-soluble compounds and can, therefore, be a nutritious inclusion in the diet for people of all ages and at different stages of life. In particular, eggs may play a particularly useful role in the diets of those at risk of low-nutrient intakes such as the elderly, pregnant women and children (Natoli *et al*., 2007). Additionally, it can be mentioned that eggs can be consumed throughout the world, having no restrictions on religious grounds (Abeyrathe *et al*., 2013). However, eggs are a controversial food for nutritionists and health agencies, because of the saturated fat content (about 3 g/100g) and cholesterol content (about 200–300 mg/100 g) (Li *et al*., 2013).

Exterior quality includes egg weight, egg shape, colour, shell thickness, shell weight, shell density, texture, egg surface area, and cleanliness (USDA, 2000; Hussain, 2011). The eggs should be uniform in colour, size and shape. The shell of each egg should be smooth, clean and free of cracks. Egg weight, shape and colour are external characteristics that influence grading, price, consumer preference and hatchability (King'ori, 2011a; King'ori, 2012b). Poor egg shell quality has been of major economic concern to commercial egg

producers (Washburn, 1982; Roland, 1988). Information from egg grading facilities indicates that 10% of eggs are downgraded due to egg shell quality defects.

The shell has at least six significantly different layers beginning with two shell membranes between the albumen and the interior surface of the shell. These layers are followed by three regions of calcified materials, and completed with a thin organic material on the outer surface called the cuticle (Bell, 2007). Within the different layers are crystalline interfaces, hundreds of hidden fault lines, and thousands of pores (tiny tunnels which travel from outer to inner surfaces of the shell). The small amount of organic matter mostly consists of matrix proteins (mixture of proteins and polysaccharides rich in sulphated molecules) and shell pigment. The matrix proteins are critically important in determining the egg shell structure and serves as foundation for the deposition of calcium carbonate during the mineralization process (Burley *et al.,* 1989; Lavelin *et al.,* 2000; Gupta, 2008). Without the matrix proteins, the crystal structure would be too brittle to keep its form.

The chicken egg shell is made up of 95-97% calcium carbonate crystals, 0.3% phosphorous and magnesium and traces of sodium, potassium, zinc, manganese, iron and copper and organic matter (Arias *et al.,* 2001; Nys *et al.,* 2004; Hunton, 2005; Neospark, 2012). The structure and composition of the avian egg shell serves to protect the egg against damage and microbial contamination, prevention of desiccation, regulation of gas and water exchange for the growing embryo, and provides calcium for embryogenesis. The egg shell should be as strong as possible to maximize the number of eggs reaching the consumer. No single factor is usually responsible for egg shell quality. Factors related to

egg shell quality include nutrition (the nutrient balance and intake levels of the ration), health (the flock's general health and previous health history), flock management and its age, environmental conditions and breeding (the strain and breed of the flock) along with other factors (Bell, 2007; Neospark, 2012). About 5-7% of eggs produced do not reach the consumer; 2-3% of the damage is due to problems during laying and 3-4% during the process after laying.

Internal quality refers to egg white (albumen) cleanliness and viscosity, size of the air cell, yolk shape and yolk strength and involves functional, aesthetic and microbiological properties of the egg yolk and albumen. The proportions of components for fresh egg are 32% yolk, 58% albumen and 10% shell (Encyclopedia Britannica, 2012). Egg albumen is the clear liquid contained within an egg. Its primary purpose is to protect the egg yolk and provide additional nutrition for the growth of the embryo. It is rich in proteins and contains almost no fat, unlike the egg yolk, which has a high fat value. The egg yolk is the yellow spherical part of an egg that is surrounded by the albumen. It is the part of the egg which feeds the developing embryo (King'ori, 2011).

The poultry egg is of a high nutritional value to man that is mainly attributed to egg albumen and egg yolk which are the edible components. They supply all essential amino acids for humans, and provide several vitamins and minerals, including retinol (vitamin A), riboflavin (vitamin B2), folic acid (vitamin B9), vitamin B6, vitamin B12, choline, iron, calcium, phosphorous and potassium. The egg has chemicals and components (Froning, 1998) that have multiple uses in biotechnology, chemical, food, pharmaceutical

and art (painting and photography) industries (Egg Tempera painting, 2011; Germadios *et al*, 1996; Messier, 1991).

In the production of poultry eggs, the aim is to produce eggs with a high hatchability, consumer preference, and of the best grade that fetch the highest price (King'ori, 2011a, King'ori, 2012b). However, there are certain defects that affect negatively the external and internal quality of the egg causing losses to the producer, retailer and consumer. No single factor is usually responsible for egg shell quality. Factors related to egg shell quality include nutrition (the nutrient balance and intake levels of the ration), health (the flock's general health and previous health history), flock management and its age, environmental conditions and breeding (the strain and breed of the flock) along with other factors (Bell, 2007; Neospark, 2012).

2.10 Advantages of Egg Consumption for Human Health

Eggs are an inexpensive and highly nutritious food, providing 18 vitamins such Vitamin A, Vitamin D, Vitamin E, Vitamin B_{12} and minerals such Iron, the composition of which can be affected by several factors such as hen diet, age, strain as well as environmental factors (Fraeye *et al*., 2012; Samman *et al*., 2009). Nevertheless, although different compositions have been reported by several authors (Natali *et al*., 2007; Samman *et al*., 2009), on average, the macronutrient content of eggs include low carbohydrates and about 12 g per 100 g of protein and lipids, most of which are monounsaturated (Harron and Fernadez, 2004; Kassis *et al*., 2010; USDA, 2015) and supply the diet with several essential nutrients (Table 2.2). Some of these nutrients, such as zinc, selenium, retinol and tocopherols, are deficient in people consuming concentrate diet from grains that are not

mostly use in Nigeria. The antioxidant activity of zinc, selenium, retinol and tocopherols can protect humans from many degenerative processes, including cardiovascularv diseases (Natali *et al*., 2007).

There is also scientific evidence that eggs contain other biologically active compounds that may have a role in the therapy and prevention of chronic and infectious diseases. The presence of compounds with antimicrobial, immunomodulator, antioxidant, anti-cancer or anti-hypertensive properties have been reported in eggs (Abeyrathe *et al*., 2013).

Lysozime, ovomucoid, ovoinhibitor and cystatin are biologically active proteins in egg albumen, and their activity prolongs the shelf life of table eggs (Rakonjac *et al*., 2014a). Additionally, eggs are an important source of lecithin and are one of the few food sources that contain high concentrations of choline (Zeisel *et al*., 2003; Harron and Fernadez, 2004).

Lecithin, as a polyunsaturated phosphatidylcholine, is a functional and structural component of all biological membranes, which acts in the rate-limiting step of the activation of membrane enzymes such as superoxide dismutase. It has been suggested that ineffective activation of these antioxidant enzymes would lead to increased damage of membranes by reactive oxygen species.

In addition, lecithin increases the secretion of bile, preventing stagnation in the bladder and, consequently, decreases the lithogenicity (Harron and Fernadez, 2004).

Table 2.2 summarises the nutritional composition of hen eggs as reported by Jose *et al*. (2015)

Table 2.3. Nutritional composition of hen eggs (Quantities represent an edible portion of about 100 g).

Component (Unit)	**Amount**	**Component (Unit)**	**Amount**
Egg shell (%)	10.5	Calcium (mg)	56.0
Egg yolk (%)	31	Magnesium (mg)	12.0
Egg white (%)	58.5	Iron (mg)	2.1
Water (g)	74.5	Phosphorus (μg)	180.0
Energy (Kcal)	162	Zinc (mg)	1.44
Protein (g)	12.1	Thiamine (mg)	0.09
Carbohydrates (g)	0.68	Riboflavin (mg)	0.3
Lipids (g)	12.1	Niacin (mg)	0.1
Saturated fatty acids (g)	3.3	Folic acid (μg)	65.0
Monounsaturated Fatty acids (g)	4.9	Cyanocobalamin (μg)	66.0
Polyunsaturated Fatty acids (g)	1.8	Pyridoxine (mg)	0.12
Cholesterol (mg)	410	Retinol equivalents (μg)	227.0
Iodine (μg)	12.7	Potassium (mg)	147
Tocopherols (μg)	1.93	Carotenoids (μg)	10
Selenium (μg)	10	Cholecalciferol (μg)	1.8

Source: Jose *et al*., 2015

Another important nutritional component from eggs is phosvitin, a phosphoglycoprotein present in egg yolk and represents about 7% of yolk proteins. It has a specific amino-acid composition, comprised of 50% serine, and 90% of which are phosphorylated. This specific structure makes phosvitin a strong metal chelator and, by this mechanism, it acts as an important melanogenesis inhibitor to control excessive melanin synthesis in the melanocytes of animal and human skins (Jung *et al*., 2012). It was suggested that egg-yolk phosvitin has the potential to be used as a natural bioactive compound as a hyper-pigmentation inhibitor for human skin (Jung *et al*., 2012).

Other interesting egg components from the nutritional point of view are the carotenoids. Carotenoids are natural pigments in hen egg yolks that confer its yellow color, which can range from very pale yellow to dark brilliant orange. Egg carotenoids represent less than 1% of yolk lipids, and are mainly composed of carotene and xanthophylls (lutein, cryptoxanthin and zeaxanthin) (Kassis *et al*., 2010; Skrwan and Englamalerova, 2014; Rakonjac *et al*., 2014b).

2.10.1 Environmental Effect on Egg Quality

During exposure to warm environmental temperature, the hen reacts by increasing its rate of breathing (panting) in order to cool itself. This causes the lowering of carbon dioxide in the blood and produces a condition termed "respiratory alkalosis".(King'ori, 2012a) The pH of the blood becomes alkaline and the availability of calcium for the egg shell formation is reduced. This disturbance in acid-base balance causes an increase in soft-shelled eggs during summer. Respiratory alkalosis also causes increased carbonate losses

through the kidney resulting in competition between kidney and uterus for carbonate ion, consequently resulting in poor egg shell thickness (King'ori, 2012a).

The shell is formed by the activity of cells lining the oviduct and uterus. Under stress the secretions of these cells become acidic and the cells can be damaged or destroyed. In extreme cases, stress induced effects can result in egg shells that have excess deposits of calcium -a sort of powdery "bloom" on the surface and result in misshapen eggs (King'ori, 2012b).

Assessment of Interior egg quality involves breaking the egg to inspect its contents. Two interior measurements in common use are the measurement of yolk color using the Roche Yolk Color Fan, and the measurement of Haugh units which also characterize the freshness of an egg (USDA, 2000; Or-Yehuda, 2007).

Egg quality is influenced by nutrition, breed, climatic factors, flock management (age, housing, disease control), and post-lay handling of eggs. Egg quality is determined by the external (shell) and internal (albumen and yolk) qualities. The same parameters are part of the grading criteria.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Location of the Experimental Birds

The birds were randomly selected from four villages:

Zangon Shanu,

Bomo,

Samaru and

Kurmin Bomo

These villages are all located in Sabon Gari Local Government Area of Kaduna State.

Figure 3.1 shows the locations of the villages from the samples were drawn.

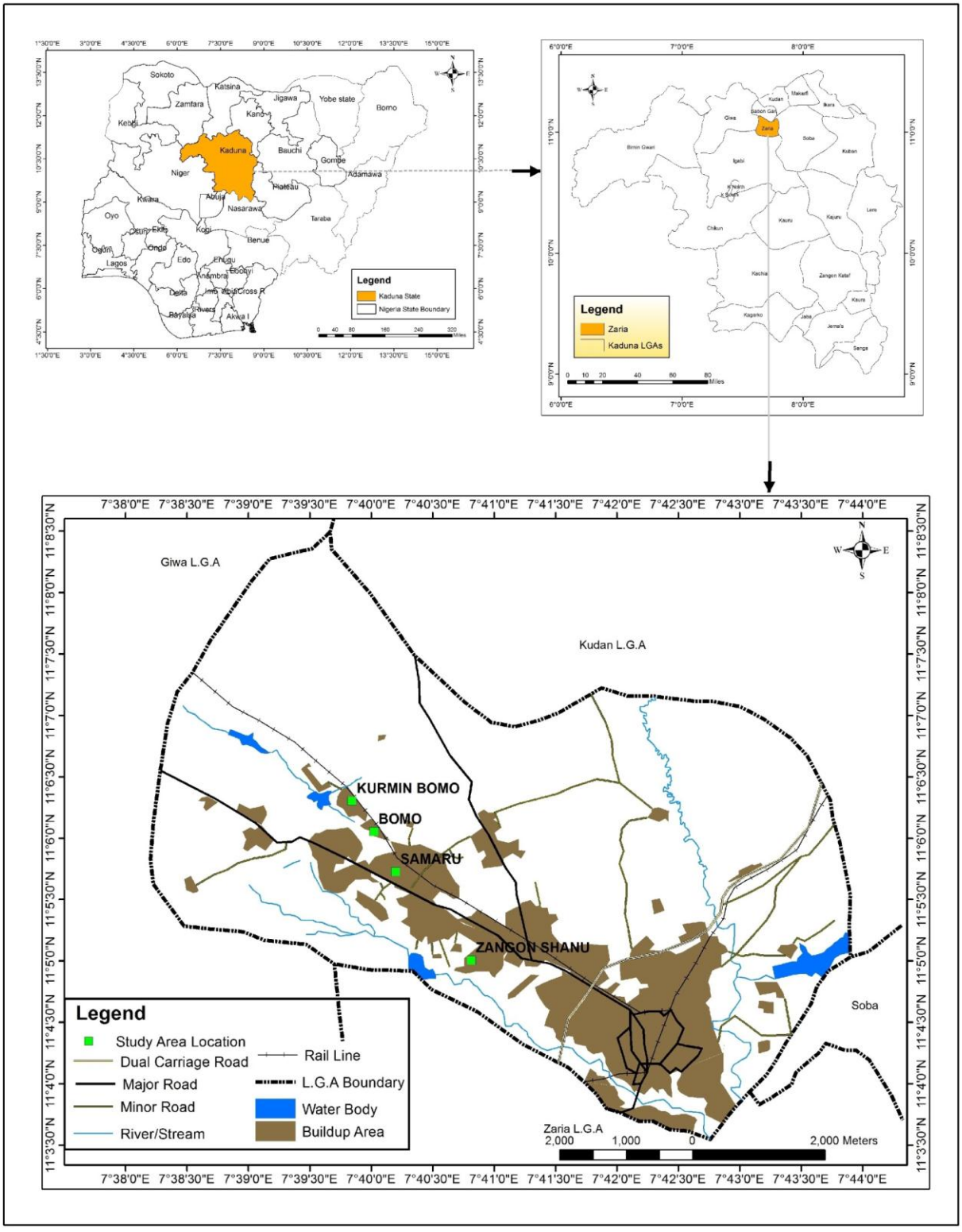


Figure 3.1: Map of Nigeria, Kaduna State and Sabongari Local Government Area Showing location of study area
Source: Modified from the Administrative Map of Kaduna and Sabo, 2016.

3.2 Design and Management of Experimental Birds

A total of eighteen (18) birds consisting of three (3) birds per specie as replicates were used for the study. The birds were obtained at laying stage and were kept under the free range system in their owner's homes. The birds were fed with whole grains (sorghum and millet) in the morning as supplement before going out to feed on other household wastes and insects. Clean water was provided *ad libitum.* All birds had free access to laying nests and boxes in their cages. Eggs laid per day from the birds were carefully collected, weighed and kept for further analysis and determination of quality parameters. Completely randomized designed was used for designing the experiment.



Plate 1: A flock of guinea fowls in one of the experimental sites



Plate : Ducks in one of the experimental sites



Plate 5: Turkeys in one of the experimental sites



Plate 6: Chickens feeding in one of the experimental sites

3.3 Determination of Egg Quality Parameters

Eggs were collected once daily, weighed and recorded per replicate. Three (3) eggs representing the average weight of the eggs from each replicate were used forth-nightly to determine the egg quality parameters throughout the 13 weeks experimental period. Each egg was assessed separately for its internal and external egg quality parameters. External quality parameters were egg weight, egg length, egg breadth, egg shape index and shell thickness (was measured with micrometer screw gauge). Individual egg weights were measured using a sensitive electronic balance (FEJ-1500 a series) citizen scale to the nearest 0.01g. After weighing, measurement of various internal egg quality parameters such as albumen height, albumen diameter and yolk height, yolk diameter was done using a vernier calliper. The egg length was measured as the distance between the two extremes while the egg breadth was measured as the diameter of the egg at its widest circumference to the nearest 0.01mm. The egg shape index was calculated using the formula described by Sauveur (1988).

ESI = EB/EL

Where;

ESI- egg shape index

EB- egg breadth (mm)

EL- egg length (mm)

The eggs were broken around the equator and were emptied out unto a clean Petri dish (care being taken to keep the yolk intact). The albumen and yolk heights were measured, the albumen height was taken at three different points and the average was obtained. The yolk width was taken as the widest circumference of the yolk while the yolk height was

measured as the distance between the base of the Petri dish and the highest point of the yolk. The yolk was then separated from the albumen and the yolk was weighed. The weight of albumen was calculated by subtracting the weight of yolk and shell from the weight of the whole egg. Haugh unit was calculated from the measured height of albumen and weight of the egg using the formula outlined by Haugh (1937).

$$HU = 100\log_{10}(h - 1.7w^{0.37} + 7.6)$$

Where;

HU = Haugh Unit

h = Observed height of the albumen in millimeters

W = Weight of the eggs in grammes

The shell weight was taken after removal of remaining albumen and subsequent air dried for 12 hours. This was used to calculate the egg shell index using the formula described by Iposu *et al*. (1994).

$$I = 100SW/S$$

Where;

I – Egg shell index

SW – Shell weight

S – Surface area (cm)

S was calculated from egg weight using the equation

$$S = k.EW\ 2/3$$

Where k has a value of 4.67 for egg weight less than 60g.

EW – Egg weight

The thickness of the egg shell were obtained by average measurement of three areas (the blunt end, the pointed end and the middle part of the egg) using a micrometer screw

gauge. Egg yolk, height and width were measured using Vernier calliper and the values obtained were used to calculate the yolk index.

$$YI = YW/YH$$

Where;

YI – yolk index

YW – yolk width

YH – yolk height

Percentage shell was determined by using the formular:

Shell percentage = (shell weight/egg weight) x 100

Percentage yolk was determined using the formula

Percentage yolk = (yolk weight/egg weight) x 100

Egg specific gravity (ESG) was estimated based on weight of egg and shell.

$$ESG = EW/ \{(0.9680 (EW – SW) + (0.4921)\}$$

Where:

ESG – egg specific gravity

EW - egg weight

SW – shell weight

3.4 Determination of Haematological Parameters

At the end of the laying phase of the birds, 2mls of blood samples for serum biochemical tests were collected from the brachial vein of each of the birds. A total of eighteen birds were used. Also, 2mls of blood samples were separately collected into small plastic bottles (vials) containing 1mg/ml of EDTA for analysis of hematological parameters.

The haematological study was carried out in the Parasitological Laboratory of the Faculty of Verterinary Medicine, Ahmadu Bello University, Zaria according to the method of Campbell (1988). Red blood cell count (RBC), total white blood cell count (WBC counts) were determined using haemacytometer. The differential white blood cell counts were made on monolayer blood films fixed and stained with Geimser-Wright's stain. Packed cell volume (PCV) was measured using microhaematocrit reader. The samples were analyzed for hemoglobin (Hb) concentration

3.5 Determination of Blood Chemistry

In order to minimize biochemical parameters changes, sera were immediately separated and centrifuged at 2500rpm for 5 minutes as recommended (Hrubec *et al*., 2002). This was carried out in the Haematology Laboratory of the Ahmadu Bello University Teaching Hospital, Zaria.

Serum biochemical parameter values were determined by using an auto-analyzer spectophotometer (Technicon RA 1000TM, Hartwell, LA, USA) and different kits in various wavelengths as follow;

Total Protein: Serum total protein concentration was determined as mg/dl by using Pars-Azmun kits with Biuret method at 540-546 nm wavelengths.

Albumin: Serum albumin concentration was determined as mg/dl by using Pars-Azmun kits with the bromcresol green method at 546 nm wavelength.

Calcium: Serum calcium concentration was determined as mg/dl by using Pars-Azmun kits with cresol phthalein complex method at 550-590 nm wavelengths.

Chloride: Serum chloride concentration was determined as meq/l by using Pars-Azmun kits with chem. Enzyme method at 500-550 nm wavelengths.

Cholesterol: Serum cholesterol concentration was determined as mg/dl by using Pars-Azmun kits with chod-pap method at 546 nm wavelength.

Glucose: Serum glucose concentration was determined as mg/dl by using Pars-Azmun kits with god-pap method at 500-546 nm wavelengths.

Magnesium: Serum glucose concentration was determined as mg/dl by using Pars-Azmun kits with xylidyn-blue test at 500 nm wavelength.

Phosphorus: Serum phosphorus concentration was determined as mg/dl by using Pars-Azmun kits with UV method at 340 nm wavelength.

Triglyceride: Serum triglyceride concentration was determined as mg/dl by using Pars-Azmun kits with gpo-pap enzymatic method at 546 nm wavelength.

3.6 Data Analysis

Data obtained was subjected to analysis of variance, using the General Linear Model of SAS (2002). Significant differences among treatment means were separated using the Duncan's multiple Range Test in SAS package.

CHAPTER FOUR

4.0 RESULTS

4.1 The External and Internal Egg Parameters of Some Poultry Species

Table 4.1 shows the external egg parameters of the six different poultry species reared extensively. There was significant ($P<0.05$) difference in all the external egg parameters in the six poultry species. Egg weight was significantly ($p<0.05$) highest in geese (142.40g) followed by turkey (72.63g) in which it did not differ significantly ($p<0.05$) from duck (67.60g), but did differ from broiler (57.30g). In another vein, Indigenous chicken (35.80g) and guinea fowl (37.83g) did not differ significantly ($p>0.05$) from each other in terms of their egg weight. The height of egg observed in geese (87.37mm) was significantly ($p<0.05$) higher than the values for other poultry species. Broiler (56.43mm) and Duck (59.43mm) did not differ significantly ($p>0.05$) from each other; similarly, indigenous Chicken (49.70mm) and Guinea fowl (50.07mm) were significantly ($p>0.05$) similar. Geese (54.67mm) egg width was better than all the poultry species; it was followed by Duck (45.83mm) and Turkey (45.67mm) which did not vary significantly ($p>0.05$) from each other. In the same way, guinea fowl egg width (37.10mm) and indigenous Chicken (37.07mm) did not differ significantly ($p>0.05$) from each other but was significantly ($p<0.05$) lower than values of 42.90mm obtained for broiler egg. Geese (1.60) produced the best egg shape index, followed by turkey (1.43) and the lowest was observed in other species which did not differ significantly ($p>0.05$) among themselves.

Table 4. 1: The external egg parameters of six different species of poultry birds

	Species						
	T_1	T_2	T_3	T_4	T_5	T_6	
Parameters	**I/chicken**	**Broiler**	**Turkey**	**Geese**	**Duck**	**G/fowl**	**SEM**
Egg wt (g)	35.800^{d}	57.300^{c}	72.633^{b}	142.400^{a}	67.600^{b}	37.833^{d}	2.21
Egg ht (mm)	49.700^{d}	56.433^{c}	65.400^{b}	87.367^{a}	59.433^{c}	50.067^{d}	1.12
Egg width (mm)	37.067^{d}	42.900^{c}	45.667^{b}	54.667^{a}	45.833^{b}	37.100^{d}	0.68
Egg shape index	1.340^{c}	1.313^{c}	1.430^{b}	1.596^{a}	1.303^{c}	1.350^{c}	0.02
Egg specific gravity	1.137^{c}	1.140^{c}	1.130^{c}	1.173^{b}	1.150^{bc}	1.233^{a}	0.01
Shell wt (g)	3.733^{d}	5.833^{c}	6.767^{bc}	17.433^{a}	7.367^{b}	6.700^{bc}	0.43
Shell th (mm)	0.280^{d}	0.370^{c}	0.430^{b}	0.613^{a}	0.350^{c}	0.590^{a}	0.02
Shell %	10.540^{bc}	10.190^{bc}	9.317^{c}	12.247^{b}	10.873^{bc}	17.640^{a}	0.63
Shell index	3.387^{bc}	3.273^{bc}	2.990^{c}	3.933^{b}	3.493^{bc}	5.663^{a}	0.20

^{abcd} = Means with different superscript within the same row for a trait differ significantly ($P<0.05$), I = Indigenous, G= guinea, wt = weight, th = thickness, SEM = Standard error of mean.

The egg specific gravity was significantly ($p<0.05$) higher in Guinea fowl (1.23), followed by geese (1.17 which was comparable to duck (1.15) and the later was comparable to turkey (1.13), broiler (1.14) and indigenous chicken (1.14). The shell weight was found to be significantly ($p<0.05$) higher in Geese (17.43g). This was followed by duck (7.37g) in comparable to turkey (6.77g) and guinea fowl (6.70g) and later was comparable to turkey (5.83g) while the lowest was recorded in indigenous chicken (3.73g). There was significant ($p<0.05$) egg shell thickness in geese (0.61) and guinea fowl (0.59) followed by turkey (0.43) and duck (0.35) which was significantly ($p<0.05$) higher than the one in indigenous chicken (0.28). the highest and lowest shell percentage was found in guinea fowl (17.64) and turkey (9.32); similar result was observed for shell index.

The variation in internal egg parameters for the poultry species is shown in Table 4.2 below. The amount of yolk weight (g) was significantly ($p<0.05$) highest in Geese (43.53) but Duck (26.83) and Turkey (26.17) did not differ significantly ($p>0.05$). Similarly, Guinea fowl (11.60) and indigenous Chicken (0.67) did not show significant ($p>0.05$) different but were significantly ($p<0.05$) lower than the yolk weight in Broiler. The yolk height (mm) did not vary significantly ($p>0.05$) between Geese (21.73) and Duck (19.93) but did from other species. Turkey yolk height (17.60) was significantly ($p<0.05$) second highest. There was no significant different ($p>0.05$) of yolk height among indigenous Chicken (14.27), Broiler (15.30) and Guinea fowl (15.27). The yolk width (mm) was significantly (67.43) higher in Geese (67.43) compare to other poultry species. There was no significant ($p>0.05$) differemce in the yolk width of Broiler (47.57), Turkey (49.70) and Duck (50.67) but differed from Guinea fowl (40.90) and indigenous Chicken (41.40).

Table 4. 2: Internal Egg Parameters for the Six Different Poultry Species

	Species						
	T_1	T_2	T_3	T_4	T_5	T_6	
Parameters	**I/chicken**	**Broiler**	**Turkey**	**Geese**	**Duck**	**G/fowl**	**SEM**
Yolk wt (g)	9.667^{d}	18.760^{c}	26.167^{b}	43.533^{a}	26.833^{b}	11.600^{d}	1.34
Yolk ht (mm)	14.267^{c}	15.300^{c}	17.600^{b}	21.733^{a}	19.933^{a}	15.267^{c}	0.62
Yolk width (mm)	41.40^{c}	47.567^{b}	49.700^{b}	67.433^{a}	50.667^{b}	40.900^{c}	1.83
Yolk %	26.747^{c}	32.800^{b}	36.020^{ab}	30.593^{bc}	39.713^{a}	30.713^{bc}	1.70
Yolk index	0.347^{ab}	0.323^{b}	0.357^{ab}	0.323^{b}	0.393^{a}	0.377^{ab}	0.02
Albumen wt (g)	27.167^{c}	32.173^{bc}	38.967^{b}	76.000^{a}	31.500^{c}	17.033^{d}	2.28
Albumen width (mm)	48.333^{c}	71.533^{a}	66.833^{ab}	74.100^{a}	61.950^{abc}	54.667^{bc}	4.81
Albumen ht (mm)	8.900^{bc}	5.767^{bc}	9.633^{bc}	13.667^{a}	9.933^{b}	7.700^{c}	0.59
Albumen %	75.373^{a}	56.050^{b}	53.687^{bc}	53.340^{bc}	46.593^{c}	45.360c	2.67
Albumen index	0.183^{a}	0.127^{b}	0.147^{ab}	0.187^{a}	0.163^{ab}	0.143^{ab}	0.02
Haugh unit	100.533^{ab}	94.000^{c}	94.833^{bc}	102.567^{a}	97.133^{abc}	94.233^{c}	2.91

^{abcd} = Means with different superscript within the same row for a trait differ significantly ($P<0.05$), wt= weight, I= Indigenous, G= guinea, ht=height, SEM= Standard error of mean.

There was significant ($p<0.05$) amount of yolk percentage in Duck (39.71) comparable to Turkey (36.02). There was also significant ($p<0.05$) yolk percentage in Broiler (32.80) comparable to geese (30.59) and Guinea fowl (30.71) while indigenous Chicken (26.75) recorded the least. Duck (0.39) recorded the highest significant ($p<0.05$) yolk index comparable to guinea fowl (0.38), turkey (0.36) and indigenous Chicken (0.35) while Broiler (0.32) had the lowest. Geese (76.00) was found to be significantly ($p<0.05$) higher in the albumin weight (g), this was followed by turkey (38.97) comparable to Broiler (32.17). Indigenous Chicken (27.17) and duck (31.50) were significantly ($p>0.05$) similar while the lowest was recorded in guinea fowl (17.03). The width (mm) of albumin was significantly ($p<0.05$) highest in Broiler and geese (74.10) comparable to turkey (66.83) and duck (61.95) while the lowest was recorded in indigenous Chicken (48.33) comparable to guinea fowl (54.67). There was significant ($p<0.05$) albumin height (mm) in geese (13.67) followed by duck (9.930 comparable to Indigenous Chicken (8.90), Broiler (5.77) and turkey (9.63) while the least was recorded in guinea fowl. The highest albumin percentage was obtained from indigenous Chicken (75.37) and the lowest from duck (46.59) and guinea fowl (45.36). The albumin index was relatively higher in indigenous Chicken (0.18) and Geese (0.19) comparable to turkey (0.15), duck (0.16) and guinea fowl (0.14) while Broiler (0.13) recorded the least. Haugh unit was significant ($p<0.05$) in geese (102.57) comparable to Indigenous Chicken (100.53) and duck (97.13) while Broiler (94.00) and guinea fowl (94.23) were significantly ($p<0.05$) the least.

4.2 The Biochemical Indices of Some Poultry Species

Table 4.3 shows the biochemical indices of the six different poultry species reared extensively. The parameters considered in this study all showed significant ($P<0.05$) difference amongst the species. There was significant ($p<0.05$) amount of Ca^{2+} (mg/dl) concentration in Turkey (2.42) comparable to Geese (2.35) and indigenous Chicken (2.29) while duck (2.06) was the lowest comparable to Broiler (2.17) and guinea fowl (2.15). The highest PO_4^{2-} (mg/dl) was recorded in duck (1.60) and the lowest in guinea fowl which were both comparable to Indigenous Chicken (1.32), Broiler (1.00), turkey (1.450 and Geese (1.15). The ALP contents did not differ significant ($p>0.05$) among Indigenous Chicken (109.33), Turkey (107.00) and duck (104); similarly, ALP level in Broiler (48.00), Geese (56.33) and Guinea fowl (71.33) did not differ significantly ($p>0.05$). The uric acid was significantly ($p<0.05$) highest in broiler (220.00) comparable to geese (160.00) and duck (173.33). Similarly, Indigenous chicken (60.00) and guinea fowl (86.67) were significantly ($p>0.05$) the same but comparable to turkey (106.67). Guinea fowl (45.00) showed the highest significant ($p<0.05$) albumin concentration comparable to Broiler (42.330, geese (36.33) and duck (41.00) while indigenous Chicken (26.33) had the lowest albumin level. The level of total cholesterol (mg/dl) was significantly ($p<0.05$) more in geese (5.63) and lower in duck (3.33) in which were both comparable to indigenous Chicken (4.90), Broiler (4.57), turkey (4.10) and guinea fowl (4.07). There was no significant ($p>0.05$) difference in the amount of high density lipo-protein among the species of poultry birds used in this study.

Table 4.3: Effect of different species of poultry birds on blood biochemical indices

	Species						
	T_1	T_2	T_3	T_4	T_5	T_6	
Parameters	**I/chicken**	**Broiler**	**Turkey**	**Geese**	**Duck**	**G/fowl**	**SEM**
Ca^{2+} (mg/dl)	2.293^{ab}	2.173^{bc}	2.423^{a}	2.350^{ab}	2.060^{c}	2.150^{bc}	0.07
PO_4^{2-} (mg/dl)	1.320^{ab}	1.000^{ab}	1.453^{ab}	1.150^{ab}	1.600^{a}	0.843^{b}	0.20
ALP (mg/dl)	109.33^{a}	48.00^{b}	107.00^{a}	56.33^{b}	104.00^{a}	71.33^{b}	9.61
U/A (mg/dl)	60.00^{c}	220.00^{a}	106.67^{bc}	160.00^{ab}	173.33^{ab}	86.67^{c}	21.63
ALB (mg/dl)	26.33^{c}	42.33^{ab}	28.00^{bc}	36.33^{abc}	41.00^{ab}	45.00^{a}	4.38
TC (mg/dl)	4.90^{ab}	4.57^{ab}	4.10^{ab}	5.63^{a}	3.33^{b}	4.07^{ab}	0.54
HDL (mg/dl)	0.967^{a}	1.467^{a}	1.367^{a}	1.267^{a}	0.967^{a}	1.500^{a}	0.19
LDL (mg/dl)	3.333^{ab}	3.000^{ab}	2.600^{ab}	3.933^{a}	2.200^{b}	2.133^{b}	0.48
TG (mg/dl)	1.700^{a}	0.967^{ab}	0.833^{b}	0.900^{ab}	0.433^{b}	0.900^{ab}	0.24

^{abc}= Means with different superscript within the same row for a trait differ significantly ($P<0.05$), Ca^{2+}= Calcium ion, PO_4^{2-} =phosphorus, TG= Triglyceride, TC= Total Cholesterol, HDL= High Density Lipo-protein, LDL= Low Density Lipo-protein, U/A= Uric acid, ALB= Albumin, SEM= Standard error of mean.

The low density lipo-protein was found to be highest in geese (3.93ml/dl) and the lowest was obtained in duck (2.20ml/dl) and guinea fowl (2.13ml/dl) in which the former and the later were comparable to indigenous chicken (3.33ml/dl), Broiler (3.00ml/dl) and Turkey (2.60ml/dl). The glyceride contents of indigenous chicken (1.70ml/dl) was significantly ($p<0.05$) higher than that of duck contents (0.83ml/dl) which were both comparable to Broiler (0.97ml/dl), geese and guinea fowl having 0.90mg/dl each.

4.3 Egg Quality Levels of Some Poultry Species

Table 4.4 shows the egg cholesterol levels of the six different poultry species reared extensively. From this result, the three egg cholesterol parameters considered were all significantly ($P<0.05$) different. The glucose level in the indigenous/local Chicken (176.33ml/dl) was higher when compared to the value obtained in other species followed by broiler (115.00ml/dl), turkey (79.67ml/dl), guinea fowl (73.67ml/dl) and duck (58.00ml/dl) while geese (47.67ml/dl) had the least value. The result obtained for total protein had significantly ($P<0.05$) similar values for guinea fowl (54.67ml/dl), with turkey and duck having 53.33ml/dl each, then indigenous/local chicken (41.33ml/dl) and the least was recorded in broiler (26.67ml/dl) which were comparable to geese (35.33ml/dl) amongst the six species. The egg cholesterol level was significantly ($p<0.05$) higher in guinea fowl (15.30ml/dl) and the lowest were obtained in indigenous Chicken and Broiler in which did not differ from the value obtained in turkey (12.00ml/dl) and Geese (12.30ml/dl)

Table 4. 4: The egg quality of six different species of poultry birds

	Species						
	T_1	T_2	T_3	T_4	T_5	T_6	
Parameters (mg/dl)	**I/chicken**	**Broiler**	**Turkey**	**Geese**	**Duck**	**G/fowl**	**SEM**
Glucose	176.33^{a}	115.00^{b}	79.67^{b}	47.67^{b}	58.00^{b}	73.67^{b}	22.77
Total protein	41.33^{b}	28.67^{c}	53.33^{a}	35.33^{bc}	53.33^{a}	54.67^{a}	5.52
Egg Cholesterol	8.83^{b}	9.50^{b}	12.00^{ab}	12.30^{ab}	9.50^{b}	15.30^{a}	2.32

^{abc}= Means with different superscript within the same row for a trait differ significantly ($P<0.05$), SEM= Standard error of mean.

4.4 The Haematological Parameters of some Poultry Species

Table 4.5 shows the egg cholesterol levels of the six different poultry species reared extensively. From this result, all parameters differed significantly ($P<0.05$) except in the monocytes, eosinophils and bands which were not significantly ($P>0.05$) different from each other in all the species. The pack cell volume (PCV) in Turkey (45.00ml/dl), geese (43.67ml/dl), duck (50.00ml/dl) and guinea fowl (44.00ml/dl) were significantly ($p<0.05$) highest followed by indigenous chicken (33.67ml/dl) and the lowest was recorded in broiler (25.33ml/dl). Similar, the same trend of significant ($p<0.05$) increase as noted in PCV were also observed in haemoglobin concentration in all the species of poultry. The amount of white blood cell was significantly ($p<0.05$) highest in broiler (24.00ml/dl) only and did not differ significantly ($p>0.05$) in the other species. Red blood cell counts were significantly ($p<0.05$) higher in broiler (5.93ml/dl), turkey (5.60ml/dl) and duck (6.17ml/dl) while geese (3.17ml/dl) had the least in which they were comparable to indigenous chicken (4.93ml/dl) and guinea fowl (4.50ml/dl). There was no significant ($p<0.05$) difference in hematocrit value between turkey (21.00ml/dl) and guinea fowl (26.33ml/dl). In the same vein, there was no significant ($p>0.05$) increase in hematocrit contents of duck (5.67ml/dl), Indigenous chicken (6.67ml/dl), geese (7.00ml/dl) and broiler (11.00ml/dl). The lymphocyte count differed significantly ($p<0.05$) in indigenous chicken (95.33ml/dl) only from guinea fowl (69.00ml/dl) but were comparable with broiler (82.33ml/dl). There was no significant ($p>0.05$) variation in monocytes, eosinophil and bands of all the species of poultry. The highest and lowest monocytes contents were found in guinea fowl (2.67ml/dl) and 0.67ml/dl in indigenous chicken and geese respectively. Indigenous chicken (3.00ml/dl) recorded the highest eosinophil and it was

absent in turkey and guinea fowl. Duck had the highest band of 5.00ml/dl while it was absent in Indigenous chicken and turkey.

Table 4. 5: Effect of different species of poultry birds on some haematological parameters

	Species						
	T_1	T_2	T_3	T_4	T_5	T_6	
	I/chicken	**Broiler**	**Turkey**	**Geese**	**Duck**	**G/fowl**	**SEM**
PCV (%)	33.667^{b}	25.333^{c}	45.000^{a}	43.667^{a}	50.000^{a}	44.000^{a}	2.52
Hb (g/dl)	11.200^{b}	8.400^{c}	14.967^{a}	14.533^{a}	16.333^{a}	15.000^{a}	0.87
WBC ($x10^{9}$/l)	3.500^{b}	24.400^{a}	8.333^{b}	6.267^{b}	6.300^{b}	5.767^{b}	3.34
RBC	4.933^{ab}	5.933^{a}	5.600^{a}	3.167^{b}	6.167^{a}	4.500^{ab}	0.69
Hematocrit	6.667^{b}	11.000^{b}	21.000^{a}	7.000^{b}	5.667^{b}	26.333^{a}	3.22
Lymp. (%)	95.333^{a}	82.333^{abc}	77.667^{bc}	88.333^{ab}	86.667^{ab}	69.000^{c}	4.66
Mono. (%)	0.667^{a}	3.333^{a}	1.333^{a}	0.667^{a}	1.667^{a}	2.667^{a}	0.91
Eosi. (%)	3.000^{a}	2.333^{a}	0.000^{a}	2.333^{a}	1.000^{a}	0.000^{a}	1.49
Bas.	0.000^{a}	1.000^{a}	0.000^{a}	1.333^{a}	5.000^{a}	2.000^{a}	2.27

^{abcd}= Means with different superscript within the same row for a trait differ significantly ($P<0.05$), PCV= Packed cell volume, HB=Haemoglobin, WBC=White blood cell, RBC=Red blood cell, Hemato=Hematocrit, Lymp=Lympocytes, Mono=Monocyte, Eosi=Eosinophil , Bas. = Basophil

CHAPTER FIVE

5.0 DISCUSSION

5.1 External and Internal Egg Parameters of Some Poultry Species

Comparison of the production of bigger and heavier egg and quality traits of eggs from different poultry species shows that geese had higher values than the other species in terms of egg weight (142.40g), egg height (87.37g), diameter (54.67), shape index (1.60), shell weight (17.43g) and shell thickness (0.61). This could be due to the good genes responsible for egg production in geese as well as their size and genetic make-up compare to the various poultry species studied. The result of this study is in consonance with the report of Lin *et al*. (2004); Bawa *et al*. (2011) and Tuleun *et al*. (2013) that egg mass or weight can be used as criterion in assessment of nutritional stress due to the management practice especially if they are obtained from birds of the same age, strain and health status. The egg weight from this study is within the normal range of the various species (Lin *et al*., 2004; Rakonjac *et al*., 2014b).

5.2 Biochemical Indices of Different Poultry Species

Several factors including physiological conditions, environmental conditions like weather, system of rearing, diet content, breed/strain and age affect the blood profiles of birds (Alodan and Mashaly, 1999; Vecerek *et al*., 2002; Odunsi *et al*., 1999; Kurtoglu *et al*., 2005; Seiser *et al*., 2000).

In this study the biochemical profiles of the six species of poultry revealed that there was a significant ($p<0.05$) difference between the six species in all the parameters measured. These findings were in agreement with the findings of Pampori and Saleem (2007) who found a significant effect of sex on various physiological and biochemical parameters.

These results also agreed with the findings of Gaikwad and Raote (2000) in broiler chicken, Kumar and Balachandran (2005), Pampori (2003) in white leghorn and Rajgude *et al*. (2005) in domestic chicken of Kashmir. The discrepancy with results from this study when compared with some of the results from these authors may be due to the breed and environmental condition differences and experimental sample size and location.

Turkey had the highest serum concentration such as Ca^{2+} (2.42), PO^{2-} (1.45), ALP (107.00) in the biochemical parameters (Table 4.3) which was followed by duck and indigenous chicken. The significant differences observed in serum concentrations of most biochemical parameters in the six different species observed in this study is in agreement with previous reports that values of some biochemical parameters are age-dependent (Jose *et al*., 2013; Polat *et al*., 2015). As some of the biochemical parameters affect the out-come of immune responses against some poultry diseases, therefore, results from this study may provide some useful information in regards to selection of genetically-improved-resistance species for poultry industry. For example, serum calcium concentrations affect immune responses and antibody titers of Newcastle disease and are dependent on serum calcium concentration (Jose *et al*., 2013).

In contrast, however, no significant difference was recorded for uric acid in cock and hen of the indigenous chicken of Kashmir (Pampori and Saleem, 2007) and serum urea did not vary in broiler chickens due to diets (Polat *et al.*, 2011). The reason for such variations might be due to the differences in renal functions associated with metabolic activities in different genotypes of the chicken species.

Earlier studies have shown that a strong correlation exists between calcium concentration and weight of the reproductive organs in Guinea fowls (Onyeanusi 2007), and that a negative association between high temperature and serum calcium prevails (Elagib *et al.* 2008).

5.3 The Egg Cholesterol Levels

The highest egg cholesterol concentration was observed in guinea fowl (15.3mg/dl) which did not differ from the values 12.00 and 12.30mg/dl found in turkey and goose respectively. However, the lowest cholesterol values of 8.83, 9.50 and 9.50mg/dl were obtained in eggs of indigenous chicken, broiler and duck respectively. This observation fell within the range reported for chicken eggs (Freeman, 1994). The results of this study revealed that there was significant difference between the six species in plasma cholesterol. This confirms the findings of (Mustonen *et al*., 2009; Krimpen *et al*., 2011) who reported that types of fat used in the diet, genetic differences, sex differences and age differences affect plasma cholesterol amongst poultry birds.

The result also revealed that serum protein may be used as an indirect measurement of dietary protein quality; this is in agreement with the report of (Alikwe *et al.* 2010) though this study is in variance with the former author as dietary protein was not considered. The possible difference may be as a result of the system of rearing and environment. In contrast, no significant differences in the serum glucose in Nigerian indigenous chickens were shown by an earlier study (Ladokun *et al.*, 2008).

5.4 The Haematological Parameters

The haematological parameters (Table 4.5) showed that Duck proved to be better in PCV (50.00MG/DL), Hb (16.33) and RBC (6.17) while indigenous chicken was better in lymphocytes (95.33mg/dl). In avian medicine, interpretation and sensible utilization of blood profiles are often limited by lack of values for physiological parameters relevant to the individual avian species and each strain to breeding lines, production type. This is in consonance with the report of Kral and Suchy (2000). The results of this study is in comparison with the value reported for biochemical parameters among different species of birds including ostrich (Mushi *et al*., 1998), captive birds (Polo *et al*., 1998), Sea-birds (Work, 1996), and broiler species (Qaisar *et al*., 1996), which indicates that biochemical parameters values of birds are species-dependent and differences between plasma and serum values. This agrees with the report of (Hrubec *et al*., 2004).

The full blood count examines mostly the cellular components of blood whereas biochemical testing focuses on its chemical constituents (Hrubec *et al.* 2002). It has been shown that data from blood profiles could be exploited in the improvement of chicken stocks (Ladokun *et al.* 2008). In addition, blood parameters help in the diagnoses of specific poultry hen pathologies and might serve as basic knowledge for studies in immunology and comparative avian pathology. Whereas (Akporhuarho, 2011) reported that significant reduction in red and white blood corpuscles indicates haemolytic anaemia and exposes the birds to high risk of infection irrespective of the bird species.

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

In the Northern Guinea Savanna of Nigeria, there is dearth of information on blood and egg cholesterol levels and haemato-biochemical profiles of available poultry species found around the area. Results from this study indicated that extensive system of management of poultry birds has effect on blood cholesterol, blood biochemical and egg quality parameters. Blood biochemical parameters could serve as a baseline data, which could be exploited in the diagnosis of healthy birds, combarting diseases, improvement of the desirable species as well as for designing appropriate breeding strategies for poultry birds in the country. Therefore, the following were established in this study:

i. Goose had the highest external and internal egg parameters such as egg weight (142.40g), height (87.37mm), width (54.67mm), index (1.60), shell weight (17.43g) and shell thickness (0.61mm) as well as internal parameters, e.g. yolk (43.53g), height (21.73mm), width (67.43mm), albumins weight (76.00g), width (74.10mm), height (13.67mm), index (0.19) and haugh unit (102.57) were also better

ii. The egg quality of glucose was best in indigenous chicken (176.33 mgl/L), while total protein (54.67 mg/dl) and egg cholesterol (15.30 mg/dl) were better in guinea fowl.

iii. The biochemical parameters of turkey (Ca^{2+} 2.423mg/dl, ALP 107.00mg/dl), geese (LDL 3.933mg/dl, TC 5.63mg/dl) and duck (Po_4^{2+} 1.600mg/dl, ALP 104.00mg/dl) were slightly better than the other species of poultry observed in this study.

iv. The haematological parameters was significantly better in turkey in terms of PCV (45.00mg/dl), Hb (14.97mg/dl), RBC (5.60mg/dl) and haematocrit (21.00mg/dl).

6.2 Recommendations

i. Similar studies should be conducted in other geographic locations of Nigeria to clearly observe every difference so as to use the data obtained from different areas in finding solutions that could be beneficial to researchers and poultry farmers in Nigeria.

ii. Eggs of duck and turkey could be incorporated into diets of infants and diabetic patients in Nigeria to address the issue of malnutrition of both infants and adults.

iii. Meats of guinea fowl could be promoted for its higher albumin content which forms the body's main defense mechanism (immuno-globulins).

iv. Eggs of indigenous chickens could be used to supply energy in the body especially in patients that are suffering from low energy in hospitals.

REFERENCES

Abeyrathne, E.D., Lee, H.Y. and Ahn, D.U. (2013). Egg white proteins and their potential use in food processing or as nutraceutical and pharmaceutical agents- A review. *Poultry Sci*ence, **92**: 3292–3299.

Adebambo, O.A., Ikeobi, C.O.N., Ozoje, M.O and Adenowo, J.O. (1999). Colour variations and performance characteristics of the indigenous chickens of Southwest Nigeria. *Nigeria Journal of Animal Production,* **26**: 15-22.

Adenowo,J.A., Awe, F.A., Adebambo, O.A. and Ikeobi, C.O.N. (1999). Species variations in chemical composition of local poultry eggs. Proceedings of the **26**th Annual Conference of the Nigerian Society of Animal Production (NSAP), Ilorin, Nigeria. Page 278-280.

Adeyemi, O.A., Fasina, O.E. and Balogun, M.O. (2000). Utilization of full fat jatropha seeds in broiler diet: Effect on haematological parameters and blood chemistry. *Proc. **25**th Conf. Nigerian Socirty of Animal Production* held at Michael Okpara University of Agriculture, Umudike, Nigeria, March 19- 23, Page 108-109.

Adeyemo, G.O., Ologhobo, A.D. and Adebiyi, O.A. (2010). The effect of graded levels of dietary methionine on the haematology and serum biochemistry of broilers. *International Journal Poultry Sci*ence, **9**(2): 158- 161.

Akporhuarho, P.O. (2011). Effect of crude oil polluted water on the haematology of cockerel reared under intensive system. *International Journal of Poultry Science,* **10**(4): 287-289.

Albokhadaim, I., Thnaian, A. and El-Bahr, S.M. (2012). Investigation of selected biochemical parameters of local chickens with different ages and sex in Al-ahsa, Saudi Arabia. *Pakistan Journal of Biological Sciences,* **15**(17): 827-832.

Ali, O.H.A., Malik, H.E.E. and Elhadi, H.M. (2011). Changes in the concentrations of liver total lipids, serum total lipids and serum cholesterol during early days post-hatch in broiler chicks. *Asian Journal of Poultry Sci*ence, **5**: 51-55.

Alikwe, P.C.N., Faremi, A.Y. and Egwaikhide, P.A. (2010). Biochemical evaluation of serum metabolites, enzymes and haematological indices of broiler-chicks fed with varying levels of rumen epithelial scraps in place of fish meal proteins. *Resource Journal of Poultry Sci*ence, **3**(2): 27-31.

Alodan, M.A. andMashaly, M.M. (1999). Effect of induced molting in laying hens on production and immune parameters. *Poultry Science,* **78**: 171-177.

Amos, T. T (2006). Analysis of Backyard Poultry Production in Ondo State, Nigeria. *International Journal of Poultry Science,* **5**(3): 247 – 250.

Arias, J.L. and Fernandez, M.S. (2001). "Role of extracellular matrix molecules in shell formation and structure". *World's Poultry Science Journal*, **57**: 349–357.

Arora, K.L. (2010). Differences in hemoglobin and packed cell volume in blood collected from different sites in Japanese quail (*Coturnix japonica*). *International Journal Poultry Sci*ence, **9**(9): 828-830.

Avila, M., (1985). Intra and inter-household decision making in the Mangwende and Chivi Communal Areas: Preliminary results, Farming System Research Unit, Harare. **35**(4): 344-356

Azeez, O.I., Oyagbemi, A.A. and Oyewale, J.O. (2009). Diurnal fluctuation in haematological parameters of the domestic fowl in the hot humid tropics. *International Journal Poultry Sci*ence, **8**(3): 247-251.

Bawa, G.S., Lombin, L.H., Karsin, P., Musa, Payi, U.E. and Shamaki, D. (2011). Responses of Japanese quails to varying dietary protein levels in the Tropics. *Nigerian Journal of Animal Production*, **38**(1): 43 - 54.

Bell, D. (2007). Egg shell quality: Its impact on production, processing and marketing economics. All Tech Inc. 98(22): 243-265

Bonadiman, S.F., Stratievsky, G.C., Machado, J.A., Albernaz, A.P., Rabelo, G.R. and Damatta, R.A. (2009). Leukocyte ultrastructure, hematological and serum biochemical profiles of ostriches (*Struthio camelus*).*Poultry Sci*ence, **88**(11): 2298-2306.

Burley, R.W. and Vadehra, D.V. (1989). The Avian Egg: Chemistry and Biology. New York, Wiley.

Campbell, T.W. (1988). Avian Haematology and Cytology. Iowa State University Press, USA. **58**(32): 544-556

Carrillo, S., Rios, V.H., Calvo, C., Carranco, M.E., Casas, M. and Perez-Gil, F. (2012). *N*-3 fatty acid content in eggs laid by hens fed with marine algae and sardine oil and stored at different times and temperatures. *Journal of Applied Physiology*, **24**: 593–599.

Chow, K.C. (1992). Fatty acids in foods and their health implications. Marcel Dekker Press, New York. **45**(10): 224-237

Demeke, S (2004). Egg Production and Performance of local white leghorn hens under intensive and rural household conditions in Ethiopia. *LRRD*, **16**: 2-6.

Eduvie, L.O. (2002). "Poultry Production as an Important Component of Nigeria's Livestock Subsector." A Training Manual, National Training Workshop on Poultry Production in Nigeria in NAPRI, ABU, Shika, Zaria, Nigeria. **3**(10): 85-96

Elagib, H.A.A., Elamin, K.M., Ahmed, A.D.A. and Malik H.E.E. (2012). Blood biochemical profile of males and females of three indigenous chicken ecotypes in Sudan. *Journal of Veterinary Advances,* **2**(12): 568-572.

Elagib, H.A.A. and Ahmed, A.D.A. (2011). Comparative study on haematological values of blood of indigenous chickens in Sudan. *Asian Journal Poultry Sci*ence, **5**: 41-45.

Elagib, H.A.A., Mohamad, H.E. and Elzubeir, E.A. (2008). The effects of methionine and energy levels on haematological and biochemical indices in broiler under hot climate. *Resources of Journal of Poultry Science,* **2**: 15-20.

Encyclopedia Britannica (2012). eb.com. Downloaded on June 2012.

Eshiette, N.O. and Okere, C.A. (1990): A survey of poultry production system in the humid tropics of Southern-Eastern Nigeria. In: proceedings of an international workshop on rural poultry Development. Held at O.A.U., Ile-Ife, 13-16 Nov. 1989, Page 232-242.

Etim, N. A., Udoh, E. J. and Awoyemi, T. T. (2005)."Measuring Technical Efficiency of Urban Farms in Uyo Metropolis". *Global Journal of Agricultural Science,* **4**: 91-95.

FAO: Statistical database (2011). Available at: http://faostat.fao.org. Rome, Italy.

FAOSTAT (2001). Food and Agricultural Organization Statistical Data Base.

Food and Agricultural Organization (1990). "The State of Food and Agriculture", Vol. **4**. (Rome).

Food and Agricultural Organization (2006). "High Bird Flu In Africa After Outbreak In Nigeria". *http://www.fao.org/newsroom/en/news/2006/1000226/index.html*.

Fraeye, I., Bruneel, C., Lemahieu, C., Buyse, J., Muylaert, K. and Foubert, I. (2012). Dietary enrichment of eggs with omega-3 fatty acids: A review. *Food Resource International*, **48**: 961–969.

Freeman, B.M. (1994). Appendix: Biochemical and physiological data. Physiology and Biochemistry of Domestic Fowl. Academic press. INC (London) LTD. Edited by, B.M. Freeman, **5**: 410,416,418.

Froning, G.W. (1998). Recent advances in egg products research and development. Presented at the University of California Riverside and Modesto egg processing workshop. **3**(1): 30-38

Fudge, A.M. (2000). Labouratory Medicine: Avian and exotic pets. **1st** Edition, Saunders, United Kingdom, Page 486.

Gaikwad, A.V. and Raote (2000). Haematological and biochemical alterations in experimental toxoplasmosis of poultry. *Indian Journal of Animal Science,* **70**:1138-1140.

Germadios, A., Weller, C.L., Hanna, M.A. and Froning, G.W. (1996). Medicinal and barrier properties of egg albumen films. *Journal of Food Science,* **61**: 585-589.

Gupta L (2008). Factors influencing shell quality. vitech. http://www.thepoultrysite.com/articles/

Harr, K.E. (2002). Clinical chemistry of companion avian species: A review. *Veterinary clinical pathology,* **31**: 140-151.

Haugh R.R., (1937). The Haugh unit for measuring egg quality. United States Egg Poultry. *Mag.,* **43**, 552-573.

Hauptmanova, K., Maly, M. and Literak, I. (2006). Changes of haematological parameters in common pheasant throughout the year. *Veterinary Medicine,* **51**: 29-34.

Herron, K.L. and Fernandez, M.L. (2004). Are the current dietary guidelines regarding egg consumption appropriate? *Journal of Nutrition,* **134**(1): 187-293.

Hoffman D.R., Theuer R, C., Castańeda Y.S., Wheaton, D.H., Bosworth, R.G., O'Connor, A.R., Morale, S.E., Wiedemann, L.E. and Birch, E.E. (2004).Maturation of visual acuity is accelerated in breast-fed term infants fed baby food containing DHA-enriched egg yolk. *Journal of Nutrition,* **134**: 2307-2313.

Hrubec, T.C., Whichard, J.M., Larsen, C.T. and Pierson, F.W. (2004). Plasma versus serum: Specific differences in biochemical analytic values. *Journal of Avian Medicine and Surgery,***16** (2): 101-105.

Hussain, M.F. (2011). Studies on some factors influencing some egg quality characteristics in Riyadh vicinity.

Iwena, O.A. (2007). "Essential Agricultural Science for Senior Secondary Schools".*Tonad Publishers Limited. Ogun, Nigeria.* Page 197.

Islam, M.S., Lucky, N.S., Islam, M.R., Ahad, A., Das, B.R., Rahman, M.M. and Siddiqui, M.S.I. (2004). Haematological parameters of Fayoumi, Assil and local chickens reared in Sylhet region in Bangladesh. *International Journal of Poultry Sci*ence, **3**(2): 144-147.

Iposu, S.O., Onwuka, C.F.I. and Eruvbetin, D. (1994). The relationship between selected egg quality traits and egg size. *Nigeria Journal of Animal Production*, **21**(1 and 2): 156 -160.

Izunobi, N.D., (2002). Poultry Husbandry: An IntegratedApproach for Tertiary Students Extension AgentsPolicy Makers and Farmers. Ihiala (Nigeria): NADSpublishers.

Jose, M.M., Xaquin A., Redondo-Valbuena, C., Roca-Saavedra, P., Jose, A.R., Alexandre L., Carlos, M.F. and Alberto, C. (2015). Egg and egg-derived foods: Effects on human health and use as functional foods. *Journal of Nutrients*, **7**: 706-729.

Jung, S., Kim, D.H., Son, J.H., Nam, K., Dong, D.U. and Jo, C. (2012). The functional property of egg yolk phosvitin as a melanogenesis inhibitor. *Food Chemistry*, **135**: 993–998.

Kassis, N., Drake, S.R., Beamer, S.K., Matak, K.E. and Jaczynski, J. (2010). Development of nutraceutical egg products with omega-3-rich oils. *LWT-Food Science Technology*, **43**: 777–783.

Kececi, T. and Col, R. (2011). Haematological and biochemical values of the blood of pheasants (*Phasianus colchicus*) of different ages. *Turkish Journal of Veterinary and Animal Science*, **35**: 149-156.

King'ori, A.M. (2012a). Poultry egg external characteristics: egg weight, shape and shell colour. *Resource Journal Poultry Science*, **5**: 14-17.

King'ori, A. M. (2012b). Egg Quality Defects: Types, Causes and Occurrence: A Review. *Journal of Animal Production Advances*, **2**(8): 350-357.

King'ori, A.M. (2011). Review of factors that influence egg fertility and hatchability in poultry. *International Journal of Poultry Science*, **10**: 483-492.

Koelkebeck, K.W. (2003). What is egg quality and conserving it? The poultry site. **1**(2): 354-359

Kral, I. and Suchy, P. (2000). Haematological studies in adolescent breeding cocks. *Acta Veterinaria. Bmo.*, **69**: 189- 194.

Krimpen M.V., Veldkamp T., Binnendijk G., De Veer R., 2011 – Effect of four processed animal proteins in the diet on behavior in laying hens, *Applied Animal Behaviour Science* 132,138-145.

Kumar R, Balachandran C. (2005). Haematological and biochemical alterations in broiler chicken fed aflatoxin in and cyclopiazonic acid. *Indian Veterinary Journal*, **82**: 1255-1257.

Kurtoglu, F., Kurtoglu, V., Celik, T., Keceri, T. and Nizamlioglu, M. (2005). Effects of dietary boron supplementation on some biochemical parameters. **2**(1): 120-125.

Ladokun, A.O., Yakubu, A., Otite, J.R., Omeje, J.N., Sokunbi, O.A. and Onyeji, E. (2008). Haematological and serum biochemical indices of naked neck and normally feathered Nigerian indigenous chickens in a sub humid tropical environment. *International Journal Poultry Sci*ence, **7**(1): 55-58.

Lavelin I., Meiri, N. and Pines M. (2000). "New insight in egg shell formation". *Poultry Science*, **79**: 1014–7. PMID 10901204.

Li, Y., Zhou, C., Zhou, X. and Li, L. (2013). Egg consumption and risk cardiovascular diseases and diabetes: A meta-analysis. *Atherosclerosis*, **229**: 524–530.

Lin, Y.F., Chang, S.J. and Hsu, A.L. (2004). Effects of supplemental vitamin E during the laying period on the reproductive performance of Taiwan nature chickens. *British Journal of Poultry Sci*ence, **45**(6): 807 - 814.

Masson, L.F., McNeill, G. and Avenell, A. (2003). Genetic variation and the lipid response to dietary intervention: A systematic review. *American Journal of Clinical Nutrition*, **77**: 1098–1111.

McNamara, D.J. (2000b). Dietary cholesterol and atherosclerosis. *Biochimica et, Biophysica. Acta*, **1529**: 310–320.

Mennicken, L., Ponsuksili, S., Tholen, E., Thi Kim Kim, N., Steier, K., Peterson, J., Schellander, K. and Wimmers, K. (2005). Divergent selection for W3:W6 polyunsaturated fatty acid ratio in quail eggs. Archive Tierzucht Dummerstof, **48**: 527-534.

Messier, P. (1991). Protein Chemistry of Albumen Photographs. Topics in Photographic Preservation, **4**: 124-135.

Milinsk, M.C., Murakami, A.E., Gomes, S.T.M., Matsushita, M., and De Souza, N.E. (2003). Fatty acid profile of egg yolk lipids from hens fed diets rich in n-3 fatty acids. *Food Chemistry,* **83**: 287-292.

Ministry of Agriculture and National Resources, (1998).MANR Annual Report.

Mushi, E.Z., Binta, M.G., Chabo, R.G. and Ndebele, R.T. (1999). Haematological studies on apparently healthy Tswana indigenous chickens (*Gallus domesticus*) around Gaborone, Botswana. *International Network for family Poultry Development Newsletter*, **9**: 83-88.

Mustonen A.M., Kakela R., Asikainen J., Nieminen P. 2009 – Selective fatty acid mobilization from adipose tissues of the pheasant (Phasianus colchicus mongolicus) during food deprivation. *Physiological and Biochemical Zoology* 82 (5), 531-540.

Natoli, S., Markovic, T., Lim, D., Noakes, M. and Kostner, K. (2007). Unscrambling the research: Eggs, serum cholesterol and coronary heart disease. *Nutrition and Diet*, **64**: 105–111.

Neospark, (2012). Egg shell defects and dietary essentials. Hunton P. (2005). "Research on egg shell structure and quality: An historical overview". Revista Brasileira de Ciência Avícola, **7**: 67–71.

Njike, V., Faridi, Z., Dutta, S., Gonzalez-Simon, A.J. and Katz, D.L. (2010). Daily egg consumption in hyperlididemic adults-effects on endothelial function and cardiovascular risk. *Nutrition Journal,* **9:** 28–36.

Nys, Y., Gautron, J. Garcia-Ruiz, J.M. and Hincke, M.T. (2004). "Avian egg shell mineralization: biochemical and functional characterization of matrix proteins". *Comptes Rendus Palevol,* **3**: 549–62.

Obinne, J.I., Mmerede, F.C.U. and Emegha, I.O. (2000). *An assessment of duck production in Anambra State.* Proceeding of 4th annual conference of ASAN, held 14-16 September 1999 IITA conference center Ibadan. Nigeria. P 3-5.

Odunsi, A.A., Onifade, A.A. and Babatunde, G.M. (1999). Response of broiler chicks to virginiamycin and dietary protein concentrations in the humid tropics.

Ogunlade, I. and Adebayo, S. A. (2009). "Socio-economic status of women in rural poultry production in selected areas of Kwara State, Nigeria". *International Journal of Poultry Science,* **8**(1):55-59.

Oji, U.O. and Chukwuma, A.A. (2007). "Technical efficiency of small-scale poultry egg production in Nigeria: Empirical Study of Poultry Farmers in Imo State, Nigeria". *Research Journal of Poultry Science,* **1**(3-4): 16 -21.

Ojo, S.O. (2002). "Analysis of Factors of Productivity of Egg Production in Osun State, Nigeria".Proc. **27**th Annual Conference, Nigerian Society for Animal Production (N.S.A.P), March 17 – 21, Federal University of Technology, Akure, Nigeria.

Olorode, B.R. and Longe, O.G. (2000).Effect of replacing palm kernel cake with shear butter cake on quality characteristics, haematology and serum chemistry of laying hens. *Nigerian Journal Animal Prod*uction, **27**: 19-23.

Oloyede, O.B., Minari, J.B. and Muhammad, N.O. (2010). Evaluation of growth characteristics and haematological indices of broiler-chicks fed raw and processed Bambara groundnut seed as a component of poultry feed. *International Journal Poultry Sci*ence, **9**(7): 652-655.

Oluyemi, J.A. and Roberts, F.A. (2007). Poultry production in warm wet climates. Revised edition printed by Golden Wallet Press, Ibadan.

Onyeanusi, B.I. (2007). Calcium and phosphorus levels in Nigerian guinea fowls. *International Journal Poultry Sci*ence, **6**(8): 610-611.

Or-Yehuda, (2007). Egg quality measurement. In: Roland A (1988). Egg shell problems: estimates of incidence and economic impact. *Poultry Science,* **67**: 1801-1803.

Pampori, Z.A. and Saleem, I. (2007). Haematology serum chemistry and electro-cardiographic evaluation in native chicken of Kashmir. *International Journal of Poultry Science,* **6**(8): 578-582.

Pampori, Z.A. (2003). Field cum laboratory procedures in animal health care. 1st Ed. Daya pushing house and distributions, Delhi. **14**(5): 246-258.

Pavlak, M., Vlahovic, K., Jarcic, J., Dorc, A. and Zupancic, Z. (2005). Age, sexual and seasonal differences of haematological values and antibody status to *Chlamydophila*sp in feral and racing pigeons (*Columba livia*forma *domestica*) from an urban environment (Zagreb, Croatia). *European Journal of Wildlife Resource,* **51**(4): 271-276.

Polat, E.S., Citil, O.B. and Garip, M. (2013). Fatty acid composition of yolk of nine poultry species kept in their natural environment. Institute of Genetics and Animal Breeding, Jastrzębiec, Poland. *Animal Science Papers and Reports,* **31**(4): 363-368.

Polat, U., Yesilbag, D. and Eren, M. (2011). Serum biochemical profile of broiler chickens fed diets containing rosemary and rosemary volatile oil. *Journal of Biological and Environmental Science,* **5**(13): 23-30.

Poławska, E., Horbańczuk, J.O., Pierzchała, M., Strzałkowska, N., Jóźwik, A., Wójcik, A., Pomianowski, J., Gutkowska, K., Wierzbicka, A. and Hoffman, L.C. (2013).

Effect of dietary linseed and rapeseed supplementation on fatty acid profiles in the ostrich. Part 1 Muscles. *Animal Science Papers and Reports,* **31**(3): 239-248.

Polo, F.J., Peinado, V.I., Viscor, G. and Palomeque, J. (1998). Haematological and plasma chemistry in captive psittacine birds. *Avian Diseases* **42**: 523-535.

Qaisar, S., Hur, G., Rizvi, F. and Iqbal, J. (1996). Determination of blood values in three different species of broiler chicks. *Pakistani Veterinary Journal*, **16**: 115-118.

Rajgude, D.R., Pathak, V.P., Ingole, R.S. and Joshi, M.V. (2005). Biochemical alterations in the blood in experimental hypothyroidism in broilers. *Indian Veterinary Journal*, **82**: 1145-1148.

Rakonjac, S., Bogosavljevic-Boskovic, S., Pavlovski, Z., Skrbic, Z., Doskovic, V., Petrovic, M.D. and Petricevic, V. (2014a). Laying hen rearing systems: A review of major production results and egg quality traits. *World Poultry Science Journal*, **70**: 93–104.

Rakonjac, S., Bogosavljevic-Boskovic, S., Pavlovski, Z., Skrbic, Z., Doskovic, V., Petrovic, M.D. and Petricevic, V. (2014b). Laying hen rearing systems: A review of Chemicals composition and hygienic conditions of eggs. *World Poultry Science Journal*, **70**: 151–163.

Rong, Y., Chen, L., Zhu, T., Song, Y., Yu, M., Shan, Z., Sands, A. and Hu, F.B. (2013). Egg consumption and risk of coronary heart disease and stroke: Dose-response meta-analysis of prospective cohort studies. *British Medical Journal*, **346**: 8539–8551.

Saied, J.M., Al-Jabary, Q.H. and Thalij, K.M. (2011). Effect of dietary supplement yeast culture on production performance and hematological parameters in broiler chicks. *International Journal of Poultry Sci*ence, **10**(5): 376-380.

Samuel, S. A. (2007). Poultry farming: a veritable tool for employment Generation and poverty alleviation. *An Inaugural Lecture delivered at the University of Agriculture, Abeokuta*. Pp.2-6.

Samman, S.; Kung, F.P.; Carter, L.M.; Foster, M.J.; Ahmad, Z.I.; Phuyal, J.L.; Petocz, P. Fatty acid composition of certified organic, conventional and omega-3 eggs. *Food Chem.* **2009**, *116*, 911–914.

Sauerwald, T.U., Hachey, D.L., Jensen, C.L., Chen, H., Anderson, R.E. and Heird, W.C. (1997). Intermediates in endogenous synthesis of C22:6 omega 3 and C20:4 omega 6 by term and preterm infants. *Pediatry Research*, **41**: 183–187.

Sauveur, B. (1988). Reproduction des volailles et prodrection d'oeufs, INRA Paris. Page 385-391.

Scanes, C.G. (2007). "The Global Important of Poultry". *International Journal of Poultry Science*, **2(**3):21-25.

Schmidt, E.M.S., Paulillo, A.C., Martins, G.R.V., Lapera, I.M., Testi, A.J.P., Junior, L.N., Denadai, J. and Fagliari, J.J. 2009. Hematology of the bronze turkey *(Meleagris gallopavo*):Variations with age and gender. *Int. J. Poult. Sci*. **8**(8): 752-754.

Seiser, P.E., Duffy, L.K., McGuire, D., Roby, D.D., Golet, G.H. and Litzow, M.A. (2000). Comparison of pigeon guillemot, Cepphuscolumba, blood parameters from oiled and un-oiled areas of Alaska eight years after the Exxon Vadez oil spill. *Marie Pollution Bullet*, **40**: 152-164.

Skrivan, M. and Englamaierova, M. (2014). The deposition of carotenoids and α-tocopherol in hen eggs produced under a combination of sequential feeding and grazing. *Animal Feed Science Technology*, **190**: 79–86.

Tijjani, A. A., Alimi, T. and Adesiyan, A. T. (2006). "Profit Efficiency among Nigerian Poultry Egg Farmers: A Case Study of Aiyedoto Farm Settlement, Nigeria. *Research Journal of Agricultural Biological Sciences,* **2**(6):256-261.

Trziszka, T. (2000). In: Jajczarstwo, nauka, technologia, praktyka. *Wydawnictwo AR we Wrochawiu str*, 291-401. (In polish).

Tuleun, C.D., Adenkola, A.Y. and Yenle, F.G. (2013). Performance and erythrocyte osmotic membrane stability of laying Japanese quails (*Coturnix coturnix japanica*) fed varying dietary protein levels in a Hot-Humid Tropics. *Agriculture and Biology Journal of North America*, **4**(1): 6 – 13.

Udoh, E.J. and Akintola, J.O. (2001). "Land Management and Resource Use Efficiency among Farmers in South-Eastern, Nigeria*". Elshaddai Global Limited, Ibadan, Nigeria*.

Ugwu, S.O.C., Onyimonyi, A.E. and Ozonoh, C.I. (2008). Comparative performance and haematological indices of finishing broilers fed palm kernel cake, bambara offal and rice husk as partial replacement for maize. *International Journal of Poultry Sci*ence, **7**(3): 299-303.

United States Department of Agriculture (2000). Egg grading manual.

United States Department of Agriculture, USDA (2015). Nutrient Data Laboratory. Available online: https:// www.ars.usda.gov/main/site_main.htm?modecode=80-40-05-25.

Vecerek, V., Strakova, E., Suchy, P. and Voslarova, E. (2002).Influence of high environmental temperature on production and haematological and biochemical indexesbin broiler chickens. *Czek Journal of Animal Science*, **47**: 176-182.

Work, T.M. (1996). Weights, haematology, and serum chemistry of seven species of free-ranging tropical pelagic seabirds. *Journal of Wildlife Dis.,* **32**: 643-657.

Washburn, K.W. (1982). Influence, cause and production of egg shell breakage in commercial poultry production. *Poultry Science,* **32**: 43-61.

Zeisel, S.H., Mar, M.H., Howe, J.C. and Holden, J.M. (2003). Concentrations of choline-containing compounds and betaine in common foods. *Journal of Nutrition***, 133**: 1302–1307.

Zhou, W.T., Fujita, M. and Tammamto, S. 1999. Thermoregulatory responses and blood viscosity in dehydrated heat-exposed broilers (*Gallus domesticus*). *J. Thermal Bio.* **24**(3): 185-192.