COMPARATIVE EVALUATION OF GREEN SHANKED INDIGENOUS CHICKEN FOR PRODUCTION AND EGG QUALITY TRAITS

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A DISSERTATION SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN TROPICAL ANIMAL PRODUCTION OF SOKOINE UNIVERSITY OF AGRICULTURE. MOROGORO, TANZANIA.

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ABSTRACT

A study was undertaken at Sokoine University of Agriculture to investigate the influence of shank colour on egg quality traits and production performance. The study involved green shanked Indigenous (GSI) chickens, yellow shanked Indigenous (YSI) chickens and Rhode Island Red (RIR) genetic groups. The genetic groups were reared under the same environment and management. A total of 240 blood plasma samples were used in assessment of plasma cholesterol content while, 120 egg samples were used to assess egg yolk cholesterol and other egg quality traits. RIR differed significantly ($P \leq 0.05$) from GSI and YSI genetic groups in terms of egg number, egg weight, egg mass, laying intensity, yolk ratio and yolk albumin ratio. However, there was no significant difference between the indigenous genetic groups for these parameters as well as fertility, hatchability, growth rate and survival rate. The mean egg weights were 40.1 ± 0.8, 42.3 ± 0.9 and 52.0 ± 0.7 gm while the laying intensities were 46.7 ± 1.76, 46.8 ± 1.7 and 76.7 ± 1.7% for GSI, YSI and RIR genetic groups, respectively. There was no significant difference in egg yolk cholesterol, whilst plasma cholesterol differed significantly between RIR and indigenous types. The mean egg yolk cholesterol were 196.2 ± 7.2, 210.1 ± 7.2 and 201.8 ± 7.2 mg/dl for GSI, YSI and RIR respectively, while the blood plasma cholesterol were 210.4 ± 7.5, 196.5 ± 7.5 and 152.1 ± 7.5 mg/dl for GSI, YSI and RIR, respectively. Furthermore, the study revealed that, egg yolk cholesterol increased gradually with age while plasma cholesterol decreased with age in all genetic groups of this study. Total blood plasma cholesterol level increased when ndigenous types entered into brooding stage resulting in cyclic pattern between laying and brooding.

DECLARATION

I, **Leonard Joseph**, do hereby declare to the Senate of Sokoine University of Agriculture that the work presented here is my original work and has neither been submitted nor being concurrently submitted for degree award in any other institution.

_____ _____

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The above declaration confirmed by

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DEDICATION

This work is firstly dedicated to my Almighty God for His abundance blessings and secondly to my beloved wife Flora, my sons Isaiah and Ian for their love, patience and encouragement during the whole period of my study. My Mother Yosina Marwa, my late Father Joseph Marwa as well as my brothers and sisters for having laid down the foundation of my studies.

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LIST OF ABBREVIATIONS AND ACRONYMS

AR	Albumen Ratio
AW	Albumin Weight
BWSM	Body Weight at Sexual Maturity
C.V	Coefficient of variation
COSTECH	Commission of Science and Technology
CP	Crude Protein
DASP	Department of Animal Science and Production
DF	Degree of freedom
EDTA	Ethylene Diamine Tetra acetic Acid
EM90D	Egg Mass at First 90-Days
EN90D	Egg Number at First 90-Days
ESI	Egg Shape Index
EV	Egg Volume
EW	Egg Weight
GLM	General Linear Model
GSI	Green Shanked Indigenous
L	Egg Length
LDL	Low Density Lipoprotein
LI90D	Laying Intensity at First 90 Days
ME	Metabolisable energy
MLDF	Ministry of Livestock Development and Fisheries
NBS	National Bureau of Statistics
OTC	Ox-tetracycline

PC	Plasma Cholesterol
r.p.m.	Revolution per minute
RIR	Rhode Island Red
SAS	Statistical Analysis Systems
SE	Standard Error
SR	Shell Ratio
SUA	Sokoine University of Agriculture
SW	Shell Weight
W	Egg Width
WHO	World Health Organization
wt	Weight
YAR	Yolk Albumin Ratio
YC	Yolk Cholesterol
YR	Yolk Ratio
YSI	Yellow Shanked Indigenous
YW	Yolk Weight

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

Poultry accounts for more than 30% of all animal protein requirement worldwide (Pernin and Pedersen, 2000) and it is estimated that the sector will account for 40% or more in 2020 due to a dramatic shift in preference from red meat to poultry meat and their products (Rosegrant *et al*., 2001). In Tanzania, chicken population is estimated to be 43.7 million of which 41.9 million (96%) are indigenous, 1.3 million (2.7%) are layers and 0.6 million (1.3%) are broilers (NBS, 2012). The chickens are kept in many parts of the world irrespectively of the traditions, life standards or religious taboos concerning consumption of eggs and/or chicken meat (Tadelle, 2003).

Indigenous chickens are widely distributed due to their high degree of adaptability to prevailing condition in rural environments. They possess high genetic variance in their performance, hardiness, disease tolerance and ability to breed naturally with ability to survive on little or no inputs and adjust for fluctuations in feed availability (Adedeji *et al*., 2008; Ajayi, 2010). They attain the market body weight of 1 kg and above at about 16 and 20 weeks of age under intensive and extensive management systems, respectively. Their market weight is attained at rather late ages compared to 8 weeks for meat type chickens, and 12 weeks for the crosses between local chickens and meat type chickens under intensive management (Theerachai *et al.,* 2003). However, indigenous chickens possess some inherent advantages which include better flavour of meat and egg, good fertility and hatchability. On top of that their

meat and egg taste are preferred over those of exotic chickens (Dessie and Ogle, 2001; Adedeji *et al*., 2008).

The indigenous chickens have been contributing considerably to household income, nutrition and cultural aspect for the majority of rural people (Pedersen, 2002; Mlozi *et al*., 2003; Muchadeyi *et al*., 2005; Alabi *et al*., 2006). Nutritionally, they are also good source of calcium, phosphorus, retinol, α-tocopherol and folate. In addition vitamin B and D are also found in plenty particularly in eggs (Ekue *et al*., 2002).They exist in different phenotypic groups representing different genetic entities with different productivity potentials (Msoffe *et al*., 2004). Their performance vary substantially and no single genetic group meets all the attributes of high egg production, good egg quality traits, fertility, hatchability, survivability, high growth rate and heavy weight at slaughter (Msoffe *et al*., 2001; Fayeye *et al*., 2005). The phenotypic expression of some traits is likely to have effects on egg quality traits including internal egg quality traits such as sterols, phospholipids, and triglycerides, which in turn, influence the egg cholesterol level.

1.2 Problem Statement and Justification

Despite of their nutritive value, eggs are considered to be the major source of dietary cholesterol with the consequence of higher risk of arteriosclerosis and coronary heart disease (Kritchevsky and Kritchevsky, 2000; Kritchevsky, 2004). The presence of cholesterol in eggs has created a negative attitude of consumers towards eggs as documented by Chen *et al*., (2005). According to Ramesh *et al.,* (2009), the quantity of egg intake should be within the safety limits.

Thus, there is a need to explore ways of producing eggs of low cholesterol content. According to Baumgartner *et al*., (2008), cholesterol content could be reduced through different approaches including genetic selection strategy. Some breeds have natural low egg cholesterol content. For example, the Green Legged Partridge which is native to Poland is reported to have green shanks, but also a good forager, broodier and lay cream-white to pale grey eggs and their eggs are of low cholesterol content (Partyka *et al.,* 2007). In Tanzania green legs/shanks have been observed in some indigenous chicken genetic groups. However, no studies have been carried out to explore, evaluate and understand their relationships with production traits and egg quality traits including cholesterol content.

This study aimed at assessing and comparing the influence of shank colour gene of Indigenous chicken on blood and egg yolk cholesterol as well as production traits. The established information is expected to be useful to poultry breeders in designing breeding strategies for production of eggs of high quality traits so as to satisfy the health consciousness of a wide range of consumers.

1.3 Objectives

1.3.1 Main objective

The main objective of this study was to explore the association of shank colour gene with improved egg quality and production traits of indigenous chickens.

1.3.2 Specific objectives

i. To evaluate the effect of shank colour on plasma and egg yolk cholesterol

ii. To determine the effect of shank colour on egg production

iii. To determine the effect of shank colour on external and internal egg qualities

iv. To evaluate the effect of shank colour on growth and survival rate

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Productive Performance of Indigenous Chicken

Indigenous chickens have been associated with low productivity in comparison with exotic layers and broilers. This is mainly due to their inherent genetic traits as documented by Pedersen (2002). Their weight at sexual is in the range of 1600 – 2000 g (ARC, 2005). The study done by Lwelamira *et al*., (2008a) reported the weight of 1647 g for medium ecotype of Tanzania under intensive management and was attained after 168 days. Comparative study done by Sarkar *et al*., (2008) under intensive management system shows that indigenous chicken attain the weight of 1250 g at 90 days while exotic cockerel layers and broilers attain the same weight at 70 and 28 days respectively.

Indigenous egg production varies among ecotypes as reported by Lwelamira *et al.,* (2008b). For example the medium ecotype of Tanzania produces 49 eggs with 42g at the first 90 days of production while kuchi ecotype produces 45 eggs with 45g. Apart from their differences in productive performance, the inputs for indigenous chicken are very minimal as they have ability to scavenge for their feeds.

2.2 Egg Quality Traits

Statesman, (1977) described egg quality as the characteristics of an egg that affect its acceptability by the consumers. A number of factors influence the egg quality; these include breed/strain/variety, temperature, relative humidity, rearing practices and season (Washburn, 1990).

The knowledge and information on the structure of egg and its various parameters is essential for an understanding of egg quality, fertility, embryo development and diseases of the poultry (Islam and Dutta, 2010). Many studies have revealed significant differences in internal and external egg quality traits across the genotypes of both indigenous and exotic strain of chicken (Islam *et al*., 2001; Basmacioúlu and Mustafa, 2005; Olawumi and Ogunlade, 2008; Malago and Baitilwake, 2009; Rajkumar *et al*., 2009; Islam and Dutta, 2010; Sola-Ojo, *et al.,* 2011). However, some other findings have reported statistical insignificant difference in internal and external egg quality traits across the genetic groups. For example Bonekamp *et al.* (2010) found that the egg mass of the brown heavy breed and the white light breed are insignificantly different. Furthermore, Garcaoa-Lapez *et al*., (2007) reported the statistical insignificant difference in weights of egg, yolk and egg shell for Plymouth Rock, RIR and their Hybrids while Sanjeewa *et al*., (2011) found no difference in egg quality parameters between village chickens and the commercial strain except for ash and fat contents. Other authors reported differences due to genotype and environment of rearing (Nahar *et al*., 2007; Onagbesan *et al*., 2007; Jones *et al.*, 2010; Momoh *et al*., 2010).

External egg quality traits, particularly egg weight, shell weight, width and length are important parameters to consider during selection for improvement in live weight of the local chicken (Paulo *et al.*, 2011). Egg weight influences egg quality and reproductive fitness of the chicken. It plays a significant role in the process of embryo development and successful hatching while the size of the hatching egg influences body weight of chicks up to maturity (Islam *et al*., 2001; Farooq *et al*., 2001).

Egg weight in local chickens can be predicted using egg width, egg length and shell weight as these factors are significantly correlated (Proudfoot and Hulan, 1981). The egg weight gradually increases as hen's age increases reflecting the positive correlation between egg weights and age of the laying hen (Niranjan *et al*., 2008). This weight is positively correlated to yolk, albumen and shell that the egg contains and varies with genetic groups of chickens (Pandey *et al*., 1986).

Egg yolk accounts for slightly over 30% of total egg weight. However, albumen represents the largest proportion of the egg being estimated to be 58.5% of the total egg of which 88% is water and 12% is protein (Hunton, 1987). The yolk also contains substantial amount of vitamin A and D arising from the feed (Robinson, 1987). Other nutritional profile includes proteins, vitamins, fat and antioxidant contents. Due to the presence of fat and antioxidant contents, yolk mass is related to the amount of cholesterol in egg (Abdullahi *et al*., 2003; Sparks, 2006).

2.3 The Egg Lipids

Cholesterol and triglycerides are the major storage lipid forms of energy in animals (McDonald *et al*., 1996). Cholesterol is a precursor of several bioactive steroids such as sex hormones and adrenal hormones and bile acid. In chicken's egg, high levels of cholesterol are found in the yolk serving as the important source of cholesterol esters in the developing embryo (Shrimpton, 1987). Eggs have been shown to be the largest source of dietary cholesterol whereby as one egg contains about 200 – 250 mg of cholesterol depending on its size (Griffin, 1992). In human, the diet with high level of cholesterol has a great influence on the elevation of blood cholesterol levels

(Weggemans *et al*., 2001; Olugbemi *et al*., 2010). According to Weggemans *et al*., (2001) human body normally produces cholesterol for its normal function, but the blood cholesterol levels elevate when dietary cholesterol is increased.

2.4 Impact of Egg Yolk Cholesterol on Egg Acceptability

Human sensitivity towards food safety requirement has been a challenge towards food products and diets including egg and egg products. The negative publicity of dietary cholesterol on human health has caused a significant decrease in egg consumption per capita in the world (Herron and Fernandez, 2004; Elkin, 2006; Sparks, 2006). This is possibly due to the awareness that egg is in the group of foods with high dietary cholesterol levels and the general knowledge that high dietary cholesterol levels result in high blood cholesterol and consequently a higher risk of arteriosclerosis and coronary heart disease (Kritchevsky and Kritchevsky, 2000; Kritchevsky, 2004).

For a heath person to avoid the elevation of blood cholesterol level and reduce the risk of coronary heart disease, the daily dietary cholesterol consumption should not be more than 300 mg per capita/day as recommended by WHO (Baumgartner *et al*., 2008). The person with cardiovascular disease, diabetes or high LDL (low density lipoprotein) is advised to limit the cholesterol intake to not more than 300 mg per day (Simopoulos, 2000; Weggemas *et al*., 2001). This implies that, consumption of one egg per day will raise the blood cholesterol level by 200-250 mg which can cause healthy risk for persons with cardiovascular disease, diabetes or high LDL. In order to overcome overconsumption of cholesterol, people need to reduce or eliminate

other source of cholesterol for the rest of the day and the likely food to be omitted is the egg.

2.5 Egg Cholesterol and Poultry Breeding

Cholesterol level differs between eggs. The differences are principally influenced by genetics of the laying hen (Elkin, 2006; Chowdhary *et al*., 2002), age and environment of rearing such as free ranging or cage rearing (Shafey *et al*,. 1998 and Zemkova *et al*., 2007) and the dietary habits of the laying chicken (Chowdhary *et al*., 2002; Pistekova *et al*., 2006; Yildiz *et al*., 2006).

Investigations of the lipid metabolism of the laying chicken have shown that most of the cholesterol found in the egg is synthesized in the liver (Connor *et al.*, 1965; Weiss *et al.*, 1967; Andrews *et al.*, 1968; Naber, 1976, 1983; Kuksis, 1992). Naber, (1983) found that a hen weighing 1.7 kg and fed a cholesterol-free diet typically synthesizes 300 mg of cholesterol per day and according to Simopoulos, (2000) a large egg contains 220 mg of cholesterol. Thus, the egg represents a major excretory route for cholesterol elimination from the hen while faecal neutral sterols and bile acids form the secondary route (Burczak *et al.*, 1980; Sim *et al.*, 1980; Naber, 1983; Cho *et al.*, 1987).

Egg cholesterol is accumulated in the egg yolk. Thus, the yolk mass is related to the amount of cholesterol in the egg and it varies with age of the laying hen (Abdullahi *et al*., 2003; Sparks, 2006). Variation in egg yolk cholesterol concentrations among different genetic groups of chicken might be due to inherent genetic differences or the interaction between diets and strain (Han and Lee, 1992; Chowdhary *et al.*,

2005). Findings from other studies (Naber, 1976; Elkin, 2006) have indicated that yolk cholesterol content can be decreased either genetically (by selection), or by nutrition profile or by the combination of both approaches. According to Baumgartner *et al.*, (2008), very few selection experiments have been conducted and only in short term. The main limiting factor being a very laborious and expensive analysis of yolk cholesterol. Despite of the cost, a research with any reduction in cholesterol content in egg yolk is worthy because the lower the yolk cholesterol content in egg, the more eggs will be recommended for consumption.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Study Area

The study was carried out at Department of Animal Science and Production, Sokoine University of Agriculture (SUA). The University is situated in Morogoro municipality at latitude 5.7 to 10^{o}S and longitude 35.6 to 39.5^{o}E, with an elevation of 525 m above sea level. The relative humidity at the study area is about 81%, with monthly mean minimum and maximum temperatures of 18.7^{o}C, and 30.1^{o}C, respectively. Sokoine University of Agriculture was selected as the study area due to the convenience of accessibility to the laboratory and infrastructures.

3.2 Management of Experimental Chickens

Both the Green Shanked Indigenous (GSI) Chickens and Yellow Shanked Indigenous (YSC) Chicken for the study were sampled from the same eco-climatic region in Singida District, at Mtinko division, Kijota and Ilongero wards whereby three villages were involved namely Sekoutule (from Ilongero ward), Nduu and Mitonto (from Kijota ward). The chickens were all phenotypically characterized as medium sized birds with multi-variety plumage and mixed combed types but with unique distinctive shank colour. The source for Rhode Island Red (RIR) exotic layers was the Interchick Company. Pullets bought were those that had just attained maturity age before the first egg. The active breeding cocks were also sampled. The local ecotype fowls were transported to SUA where the study was done. All experimental chickens were maintained on floor pens in a deep litter system being supplied with standard layers mash (Table 2). Water was provided *ad libitum* and

routine disease management were done. Vaccinations were done against Newcastle and fowl pox.

3.3 Experimental Set Up

Forty eight pullets, i.e. 16 GSI, 16 YSIC and 16 RIR of approximately 6 months old were used in the study. Eight indigenous cocks (4 GSI and 4 YSI cocks) were incorporated in the study for breeding. The pullets were randomly allocated to 4 replicates using a Completely Randomised experimental Design.

Table 1: Calculated composition of chicken feeds

Ingredient	**Percent in diet of chicken feeds**	
	Chicks' mash	Layers' mash
Maize	35.0	48.0
Maize bran	25.0	10.0
Rice polishing	0.0	15.0
Fish meal	15.0	6.0
Sunflower seed cake	15.0	7.0
Cotton seed cake	8.0	8.0
Bone meal	0.7	2.5
Limestone	0.7	2.5
Broiler premix	0.3	0.0
Layers premix	0.0	0.5
Salt	0.3	0.5
Total	100	100
CP (%)	19.1	16.2
ME (MJ/Kg)	11.3	11.4

Each replicate was allocated with 4 pullets and one cock of the same shank colour. In each treatment, replicate birds were assigned identification numbers and wing

tagged. All experimental chicken were housed under the same feeding regime. A preliminary period of 30 days was instituted before data collection to allow acclimatization of the birds to confinement and experimental diet as well as attaining the maturity weight (the weight at first egg). After attaining maturity weight, egg quality traits were assessed for 8 weeks while egg production assessment was done in 12 weeks. Concurrently, eggs from YSI and GSI were collected, labelled and incubated. After hatching, data for hatchability, growth and survival rates in hatched chicks from YSI and GSI for 5 consecutive weeks.

3.4 Cholesterol Determination

3.4.1 Yolk cholesterol determination

A total of 120 egg samples were used in yolk cholesterol determination. Two eggs were collected from each replicate group at a time and the data were collected in 5 times with intervals of 14-days. The sampled eggs were used in the yolk cholesterol study.

A commercial diagnostic cholesterol reagent kit (Erba Diagnostic Mannheim GmbH) was used for cholesterol determination. The sampled eggs were broken to separate the yolks and then 1ml of the yolk was drawn with a pipette and diluted with 1ml buffer pH 7.4 (10 mmol sodium phosphate/l, 100 mmol NaCl/l). Then, 1000µl of a working reagent (supplied in the kit) was diluted with 10 µl of distilled water and placed in a cuvette and then inserted into a spectrophotometer set at 670 nm in order to take the blank absorbance reading. Then 1000 µl of the working reagent was again mixed with 10 µl of the calibrator and put in a cuvette and then placed in the

spectrophotometer to obtain the absorbance of the calibrator. Lastly, 1000 µl of the working reagent was mixed with 10 µl of the test sample from each sample and incubated at room temperature for 10 minutes, there after the sample was taken and put in a cuvette and the absorbance read. The addition of the yolk sample to the reagent resulted into plain to purple colours of various degrees depending on the concentration of cholesterol in the sample. The absorbance of the test sample was then recorded.

Yolk cholesterol concentration was calculated using the following formula;

Ch_c, mg/dl = $(A_{ts}/A_c) \times C_c \times D_f$

Where Ch_c = Cholesterol concentration

A_{ts} =Absorbance of test sample

A_c=Absorbance of calibrator

C_c= concentration of calibrator

D_f=Dilution factor

3.4.2 Blood plasma cholesterol determination

A total of 240 blood samples were used in the blood plasma cholesterol study. The blood samples of four birds per replicate were collected at a time. The data were collected in 5 times with intervals of 14 days. The blood samples were taken from the wing vein of the birds by using a sterile needle where by 1 ml of blood was extracted from each bird and placed in individual vacutainer test tube containing Ethylene diamine tetra acetic acid (EDTA). The samples were properly shaken to mix with the EDTA in order to prevent coagulation of the blood and within two

hours of collection the samples were taken to the laboratory for blood plasma cholesterol analysis. The vacutainer tubes were placed in a centrifuge and centrifuged at 3000 r.p.m. for 10 minutes in order to separate the plasma. A commercial diagnostic cholesterol reagent kit (Erba Diagnostic Mannheim GmbH) was used for plasma cholesterol determination using the same procedure as described in yolk cholesterol determination. The spectrophotometer was set at 505nm. Plasma cholesterol was determined using the formula as described in section 3.4.1 above.

3.5 Weight at Sexual Maturity

Weight of birds at sexual maturity was taken when at least 50% of the purchased pullets in each of the genetic groups had started laying.

3.6 Egg Production, Fertility and Hatchability

Egg production was assessed as the total number of eggs for the first 90 days of laying (early egg production phase), just after sexual maturity of GSI, YSI and RIR genetic groups. Number of eggs produced per bird, average egg weight and laying intensity for the first 90 days of laying was determined.

The reproductive traits assessed were fertility and hatchability of the GSI and YSI genetic groups. A total of 180 eggs from indigenous genetic groups were incubated over four different periods in order to determine the fertility and hatchability. Candling of the incubated eggs was done twice at 7 and 14 days after incubation. The percentage fertility of the eggs was calculated as follows:

Fertility = $(T_{eg} - T_{infeg} / T_{eg}) \times 100$

Where T_{eg} was the total number of eggs incubated and T_{infeg} the total number of infertile eggs.

The percentage hatchability of the eggs was calculated using formula below:

Hatchability = $(T_{heg} / T_{veg}) \times 100$

Where T_{heg} was the total number of hatched eggs and T_{veg} the total number of viable eggs (after the first candling).

3.7 Egg Quality Assessment

A total of 120 egg samples were used in the study of egg yolk cholesterol and other egg quality traits. Two eggs were taken randomly from each replicate five times at 5 intervals of 14 days (ie 0, 14, 28, 42, and 56^{th} day). In each period 24 eggs were taken, eight from each genetic group. The eggs were numbered according to genetic groups and replication for easy identifications during egg traits study.

3.7.1 External egg quality traits

Eight external egg quality traits were studied. The traits were gross egg weight, egg length, egg width, egg volume, shell weight, Shell thickness, shell ratio, and egg shape index. All weights were measured by digital electronic balance in gram. Length and width of the eggs were measured by a vernier caliper in millimetre, Shell thickness was measured using micrometer screw gauge at the broad end, middle portion and narrow end of the shell and the average of the three measurements was taken as shell thickness in millimetre.

Egg volume was determined according to Islam and Data (2010), using the following formula:

$EV = \pi \times L \times W^2/6$

Where;

EV=egg volume

L=egg length

W=egg width

Egg length was taken as the distance from one end to the other. Egg width was determined at the widest diameter.

3.7.2 Internal egg quality traits

Five internal egg quality traits were evaluated namely; yolk cholesterol concentration (YC), yolk weight (YW), albumin weight (AW), yolk ratio (YR) and albumen ratio (AR).

Each egg was carefully broken and its contents poured into a petri-dish. The yolk and albumen were separated carefully with the help of a spoon and placed in separate petri-dishes of known initial weight. The weight of yolk was taken using digital electronic balance. The shells of the broken eggs were rinsed in warm water, air dried for 48 hours and weighed to determine the shell weight (SW). The AW was calculated by subtracting yolk weight and Shell weight (SW) from the gross egg weight (EW) as documented by Islam and Dutta (2010) as described bellow.

AW=EW-(YW+SW)

Other egg quality traits were obtained as documented by Olawumi and Ogunlade (2008) by using the following formulas;

Shell ratio, SR (%)=(SW/EW) × 100

Egg shape index, ESI (%)=(W/L) × 100

Yolk ratio, YR (%)=(YW/EW) × 100

Albumen ratio, AR (%)=(AW/EW) × 100

Where;

CY= yolk cholesterol concentration

YW = yolk weight

AW = albumin weight

YR = yolk ratio and

AR = albumen ratio

3.8 Productivity and Reproductive Performance Assessment

Parameters on weight at sexual maturity, egg production, fertility and hatchability were measured from the purchased pullets, while growth rate and survival rate were assessed on the hatched chicks. The fertility, hatchability, growth rate and survival rate assessment were done in indigenous genetic groups.

3.8.1 Growth rate

Chicks' body weights for both YSI and GSI genetic groups were taken at the age of 0, 1, 2, 3, 4, and 5^{th} weeks (0 being the hatch weight). The daily growth rate was calculated as:

Daily growth rate (gm/day)=$(Wt_2-Wt_1)/7$

Where Wt_1 was the weight at the beginning of the week; Wt_2 was the weight at the end of the week.

3.8.2 Survival rate

The records for survival during the rearing period (1^{st} -5^{th} weeks) were computed using the formula;

Survival rate (%)=(T_s/T_h) x 100

Where T_s=Total survived chicks

T_h=Total hatched chicks

3.9 Statistical Analysis

Significance of genetic group effects and the interactions with time on egg quality traits, egg and blood plasma cholesterol levels, productive and reproductive performance were assessed by using the General Linear Model (GLM) of Statistical Analysis Systems (SAS, 2004) and the following models were used:

The fixed effect of shank colour and genetic group on egg quality and egg production were analysed in accordance with the statistical model (1) bellow:

$$Y_{ijk} = \mu + G_i + W_j + (GW)_{ij} + e_{ijk} \quad \text{..... (1)}$$

Where:

Y_{ijk} = Observation of egg quality and production traits on i^{th} shank colour/ genetic group at j^{th} week of laying.

μ = General mean

G_i = Effect of i^{th} genetic group (i=1, 2, 3. ie green shanked indigenous, yellow shanked indigenous and exotic layers).

W_j = Effect of j^{th} week of laying (j=0, 2, 4, 6, and 8^{th} week of laying)

$(GW)_{ij}$ = Effect of interaction between i^{th} genetic group with j^{th} week of laying

e_{ijk} = Residual effect

The fixed effect of shank colour and genetic group on overall egg quality and egg production were analysed in accordance with the statistical model (2) bellow:

$Yij = \mu + Gi + eij$..... (2)

Where:

Y_{ij} = Observation of egg quality and production traits on i^{th} shank colour/genetic group

μ = General mean

G_i = Effect of i^{th} genetic group (i=1, 2, 3. ie green shanked indigenous, yellow shanked indigenous and exotic layers).

e_{ij} = Residual effect

The effect of shank colour trait on fertility and hatchability was analysed by model (3) bellow

$Y_{ij} = \mu + g_i + e_{ij}$ ……..... (3)

Where: Y_{ij} = Observation on fertility and hatchability and survival rate taken on the i^{th} genetic group.

μ = overall mean

g_i = fixed effect of the i^{th} genetic group

e_{ij} = Residual effect

The fixed effect of shank colour trait on growth rate were analysed by using model (4) bellow:

$Y_{ijk} = \mu + g_{ij} + (X_2 - X_1) + e_{ijk}$. ……..... (4)

Where:

Where: Y_{ij} = Observation on growth rate on the i^{th} genetic group.

μ = overall mean

g_i = fixed effect of the i^{th} genetic group

X_2 = Final genetic group mean weight after k^{th} period

X_2 = Initial genetic group mean weight after k^{th} period

e_{ij} = Residual effect

In addition, correlation analysis was done between some internal egg quality traits, particularly egg yolk cholesterol with plasma cholesterol, egg weight and yolk weight. Chi square was used to analyse the significance difference among genetic groups in survival rate and hatchability. Furthermore covatiate was included in growth rate analysis.

CHAPTER FOUR

4.0 RESULTS

4.1 Health Status of the Birds

The birds were in good health throughout the experimental period. However, there were some occasions in which running nose and fowl typhoid were observed on some birds in which fluban and OTC 20% were administered. Greenish and yellowish intensity of the shanks were found to diminish with time after confinement of the birds during the experiment. The intensity colouration decreased with time indicating the significant contribution of scavenging diet to the intensity of shank colouration.

4.2 Production Performance Assessment

4.2.1 Growth performance

Least squares means for weekly body weights of chicks belonging to the two indigenous genetic groups (YSI and GSI) are shown in Table 2 while daily mean body weight gains are shown in Table 3 and Fig.1. The mean hatch weight were 29.82 and 29.94 g for GSI and YSI, respectively while the weight at week 5 were 196.96 and 201.09 g for GSI and YSI, respectively. There were no significant difference ($P>0.05$) between YSI and GSI chickens ($P>0.05$) in hatch weight, average daily gain and body weight at the 5^{th} week of age. The effects of genetic group on body weight at sexual maturity (Table 4) show no significant difference ($P>0.05$).

Table 2:Least square means for body weight measurements up to 5th week for Indigenous chicken

Genetic group	Weekly weight (g)					
	Hatch wt	Week1	Week2	Week3	Week4	Week5
GSI	29.82 ± 0.37	42.74 ± 0.94[a]	76.83 ± 2.33[a]	116.62 ± 2.90	151.48 ± 4.48	196.96 ± 7.94
YSI	29.94 ± 0.40	47.17 ± 1.03[b]	84.38 ± 2.54[b]	124.96 ± 3.16	161.38 ± 4.88	201.09 ± 8.67
Overall	29.88 ± 0.27	44.77 ± 0.74	80.28 ± 1.77	120.44 ± 2.17	156.01 ± 3.33	198.85 ± 5.82

[ab]means within column with the same superscript are not significantly different (P>0.05)

Where; wt=weight

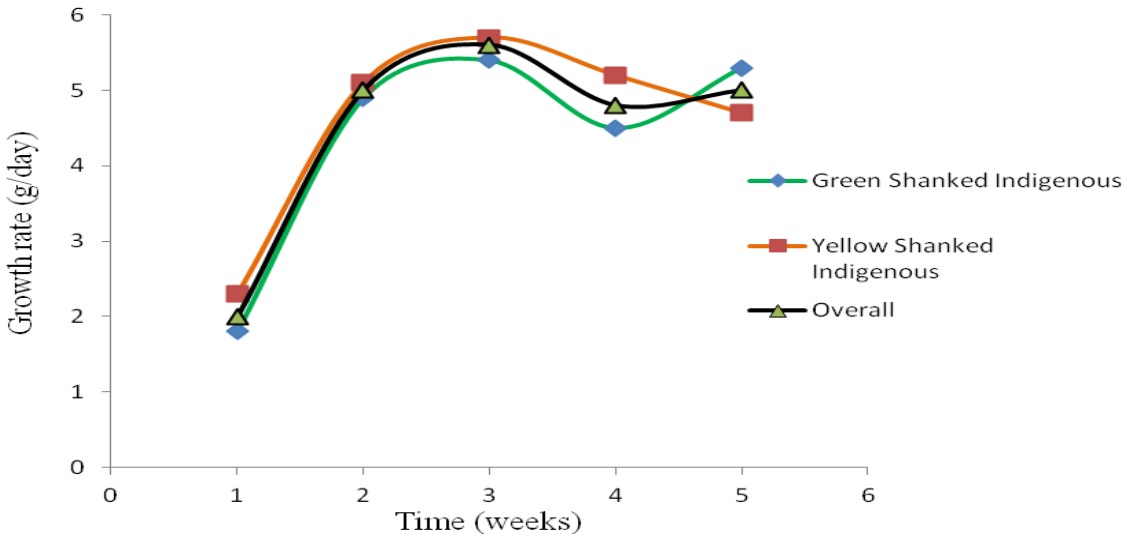

Figure 1: Growth rate for GSI and YSI genetic groups

Table 3:Mean body weight gain measurements up to 5th week for Indigenous chicken genetic groups

Genetic group	Growth rate (g/day)					Overall
	Week 1	Week 2	Week 3	Week 4	Week 5	
GSI	1.85 ± 0.14	4.87 ± 0.24	5.68 ± 0.27	4.98 ± 0.32	6.50 ± 0.74	4.78 ± 0.23
YSI	2.46 ± 0.16	5.32 ± 0.26	5.80 ± 0.29	5.20 ± 35	5.67 ± 0.81	4.89 ± 0.24
Overall	2.12 ± 0.11	5.07 ± 0.18	5.74 ± 0.19	5.08 ± 0.23	6.12 ± 0.54	4.83 ±0.17

4.2.2 Egg production traits

The study revealed a significant difference (P≤0.05) in egg production traits between RIR and the indigenous genetic groups. RIR produced 27 more eggs than the indigenous ones in the first 90 days. However, there were no significant difference between GSI and YSI (P>0.05). Rhode Island Red chicken had the highest egg weight, egg number and egg mass and laying intensity in the first 90 days of laying while GSI had the lowest (Table 4). The Rhode Island Red differed significantly (P≤0.05) with both GSI and YSI genetic groups in egg weight, egg number, egg mass and laying intensity. The laying intensity for RIR was 29.9% higher than both indigenous genetic groups. However, GSI did not differ significantly (P>0.05) from YSI chickens in egg weight, egg number, egg mass and laying intensity in the first 90 days of laying.

Table 4: Least square means for productive traits in GSI, YSI and RIR chickens

Productive traits	**Genetic group**		
	GSI	YSI	RIR
BWSM, (g)	1457.1 ± 43.1 [a]	1440.3 ± 43.1 [a]	1440.3 ± 43.1 [a]
EW, (g)	42.4 ± 0.6[b]	42.3 ± 0.6[b]	52.4 ± 0.6[a]
EN90D, (egg)	42.0 ± 1.0[b]	42.1 ± 1.0[b]	69.1 ± 1.[a]
EM90D (g)	1780.4 ± 43.6[b]	1781.9 ± 43.6[b]	3618.9 ± 43.6[a]
LI90D (%)	46.7 ± 1.7[b]	46.8 ± 1.7[b]	76.7 ± 1.7[a]

[ab] means within rows with the same superscript are not significantly different (P>0.05)

BWSM, EW, EN90D, EM90D, LI90D = body weight at sexual maturity, egg weight, egg number at first 90-days, egg mass at first 90-days and laying intensity at first 90 days respectively.

4.2.3 Survival rate for chicks

The study revealed insignificance difference between the GSI and YSI genetic groups for survival rate as shown in Table 5. The survival rates in this study were 89.13 and 90.48% for GSI and YSI respectively.

4.3 Reproductive Performance Assessment

Both fertility and hatchability for GSI and YSI genetic groups of chickens were not significantly different as shown in Table 5 and Fig.2. The hatchability was 77.42 and 75.00% for GSI and YSI, respectively. Fertility was 93.55 and 93.33% for GSI and YSI, respectively.

Table 5: Reproductive performance and survival rate for GSI and YSI chickens

Genetic group	Fertility (%)	Hatchability (%)	Survival rate (%)
GSI	93.55	77.42	89.13
YSI	93.33	75.00	90.48
Chi-Square	0.9617	0.7536	0.8351

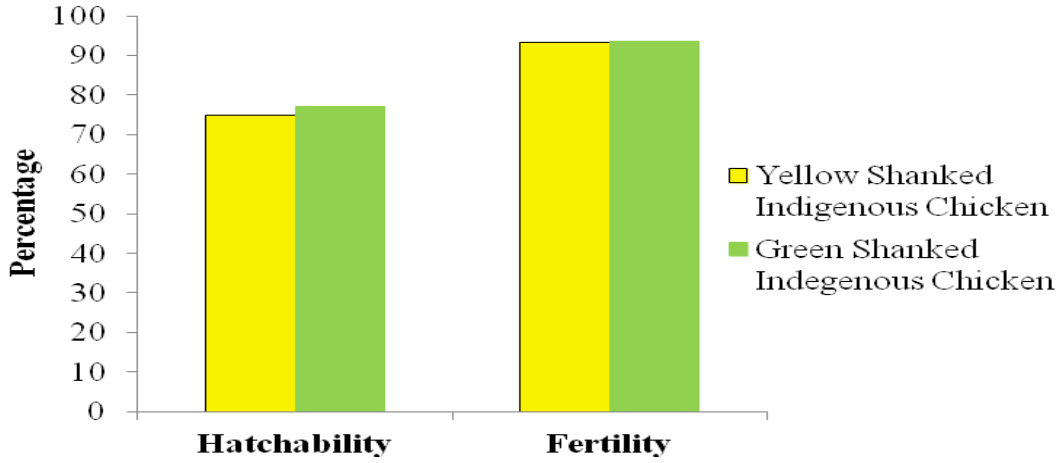

Figure 2: Reproductive performance

4.4 Egg Quality Traits Assessment

4.4.1 External egg quality traits

Results on external egg quality traits show that RIR differed significantly ($P \leq 0.05$) from both GSI and YSI genetic groups in gross egg weight (EW). The EW for RIR was 10.0 and 9.9 g higher than GSI and YSI respectively (Table 4). Other external egg quality traits also differed significantly between RIR and both indigenous genetic groups as indicated in Tab. 6. The RIR were found to have higher values than the Indigenous genetic groups in EW, L, W, V and SW but were lower in STH, and SR. Egg volume in RIR was higher than YSI and GSI genetic groups by 9.64 and 9.43 cm^3 respectively. On the other hand, there was no significant difference between GSI and YSI in all egg quality parameters for the indigenous genetic groups.

Table 6: Least squares means for external egg quality traits in GSI, YSI and RIR chickens

Genetic group	N	L (cm)	W (cm)	V (cm^3)	SW (g)	STH (mm)	SR (%)	ESI (%)
GSI	40	4.94 ± 0.03^{b}	3.63 ± 0.02^{b}	33.85 ± 0.56^{b}	4.27 ± 0.13^{b}	0.35 ± 0.01^{a}	10.07 ± 0.22^{a}	73.43 ± 0.63^{a}
YSI	40	4.91 ± 0.03^{b}	3.62 ± 0.02^{b}	33.64 ± 0.56^{b}	4.41 ± 0.13^{ab}	0.36 ±0.01^{a}	10.43 ± 0.22^{a}	73.78 ± 0.63^{a}
RIR	40	5.37 ± 0.03^{a}	3.93 ± 0.02^{a}	43.28 ± 0.56^{a}	4.68 ± 0.13^{a}	0.33 ± 0.01^{b}	8.9 ± 0.22^{b}	73.27 ±0.63^{a}

^{ab}means within column with the same superscript are not significantly different ($P>0.05$)

Where; N = Sample size, L = Egg length, W = Egg width, V = Egg volume, SW Egg shell weight, STH = Egg shell thickness, SR = Egg shell ratio, ESI = Egg shell index ratio.

4.4.2 Internal egg quality traits

Internal egg quality traits assessed were yolk weight (YW), albumin weight (AW), yolk albumin ratio (YAR), yolk ratio (YR) and albumin ratio (AR) as presented in Table 7. The study revealed that the gross YW did not differ significantly among the genetic groups of chickens (P>0.05) though the trend showed a significant difference (P≤0.05) in YR where by indigenous genetic groups had higher YR than RIR by 7.22 and 7.26%. But when AW and AR were compared across GSI, YSI and RIR chickens, RIR had the highest values for the traits and differed significantly (P≤0.05) from both GSI and YSI genetic groups. The RIR was higher by 8.44% than GSI in AR. To the contrary RIR had significantly (P≤0.05) lower values for YR and YAR, whilst GSI did not differ significantly from YSI.

Table 7: Least squares means for internal egg quality traits in GSI, YSI and RIR genetic groups

Genetic group	YW (g)	AW (g)	YAR	AR (%)	YR (%)
GSI	14.93±0.23[a]	23.18±0.45[a]	0.65±0.01[b]	54.61±0.48[a]	35.31±0.41[b]
YSI	14.93±0.23[a]	22.97±0.45[a]	0.65±0.01[b]	54.31±0.48[a]	35.27±0.41[b]
RIR	14.65±0.23[a]	33.07±0.45[b]	0.45±0.01[a]	63.05±0.48[b]	28.05±0.41[a]

[ab] Least square means within column with the same superscript are not significantly different (P>0.05)

Where YW, AW, YAR, AR and YR refers to yolk weight, albumin weight, yolk albumin ratio, albumin ratio and yolk ratio respectively.

4.5 Cholesterol Assessment

4.5.1 Egg yolk cholesterol content

The results did not show a clear trend in the means egg yolk cholesterol concentration for the three genetic groups of chickens. Egg yolk cholesterol

concentration of the three genetic groups of chickens in the 1st and 2nd period of the experiment was in the order: GSI< RIR<YSI and there were significant differences (P≤0.05) among the three genetic groups (Table 8). In period 1 and 2, egg yolk cholesterol content was higher in YSI than GSI by 55.29 and 23.82 gm/dl respectively. However, there were no significant differences (P>0.05) among all three genetic groups in cholesterol concentration for the 3rd, 4th and 5th periods of the experiment. The overall average of yolk cholesterol at the end of experiment revealed no significant difference (P>0.05) though the YSI was slightly higher(210.11 gm/dl) than GSI (196.16 gm/dl). In general, the study revealed no significant difference (P>0.05) between the genetic groups in mean egg yolk cholesterol content, however an increase in egg yolk cholesterol concentration with age was revealed in all the three genetic groups (Fig. 3).

Table 8: Least square means for egg yolk cholesterol in GSI, YSI and RIR genetic groups

Genetic group	Egg Yolk cholesterol (mg/dl)					
	Period1	Period 2	Period 3	Period 4	Period 5	Average
GSI	86.30± 7.29 [c]	164.53± 7.12 [b]	194.53± 8.87 [a]	259.16± 16.92 [a]	276.22± 23.72 [a]	196.16± 7.15 [a]
YSI	141.59± 7.29 [a]	188.35± 7.12 [a]	197.72± 8.87 [a]	260.90± 16.92 [a]	262.06± 23.72 [a]	210.11± 7.15 [a]
RIR	109.63± 7.29 [b]	181.10± 7.12 [a b]	191.68± 8.87 [a]	267.53± 16.92 [a]	259.11± 23.72 [a]	201.83± 7.15 [a]

[abc]Least square means within column with the same superscript are not significantly different (P>0.05)

4.5.2 Blood plasma cholesterol assessment

The study revealed a significant difference ($P \leq 0.05$) in mean blood cholesterol concentration between RIR and the indigenous genetic groups, but there were no statistical differences ($P > 0.05$) in period 1, 3 and 4 between GSI and YSI (Table 9). However, the significance differences was expressed in period 2 and 5 where the blood plasma cholesterol content for GSI was higher than YSI by 37.57 and 62.18 gm/dl respectively. The means for blood plasma cholesterol of the three genetic groups of chickens were in the order: GSI>YSI>RIR, though there were some fluctuations with age as illustrated in Fig.4. However, the results show a general trend of decreasing of the plasma cholesterol with age. The overall average of plasma indicated that, RIR had the lowest content (152.09 mg/dl while GSI had the highest level (210.37 mg/dl).

Table 9: Least squares means ± SE for blood plasma cholesterol in GSI, YSI and RIR genetic groups

Genetic group	Blood plasma cholesterol (mg/dl)					
	Period1	Period 2	Period 3	Period 4	Period 5	Average
GSI	251.95	204.52	173.47	201.26	220.66	210.37
	±18.18^{ab}	±12.18^{a}	±14.37^{a}	±10.74^{a}	±13.04^{a}	±7.49^{a}
YSI	282.89	166.95	195.32	178.68	158.48	196.47
	±18.18^{a}	±12.18^{b}	±14.37^{a}	±10.74^{a}	±13.04^{b}	±7.49^{a}
RIR	202.57	176.77	128.45	123.08	129.60	152.09
	±18.18^{b}	±14.37^{a}	±12.18^{b}	±10.74^{b}	±13.04^{b}	±7.49^{b}

^{ab}Least square means within column with the same superscript are not significantly different (P>0.05

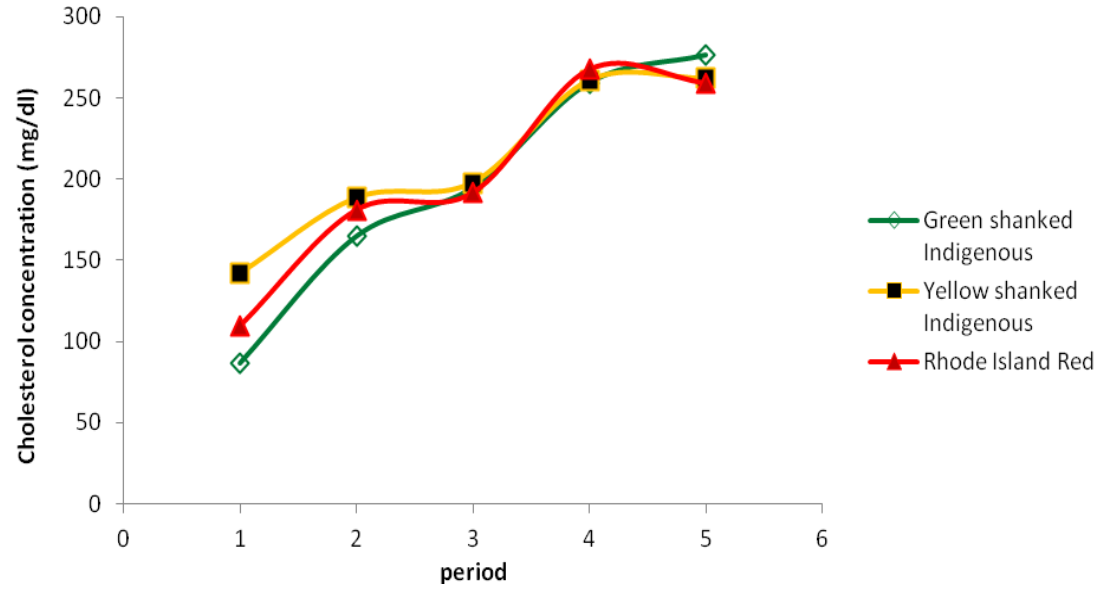

Figure 3: **Variation in yolk cholesterol concentration with age.**

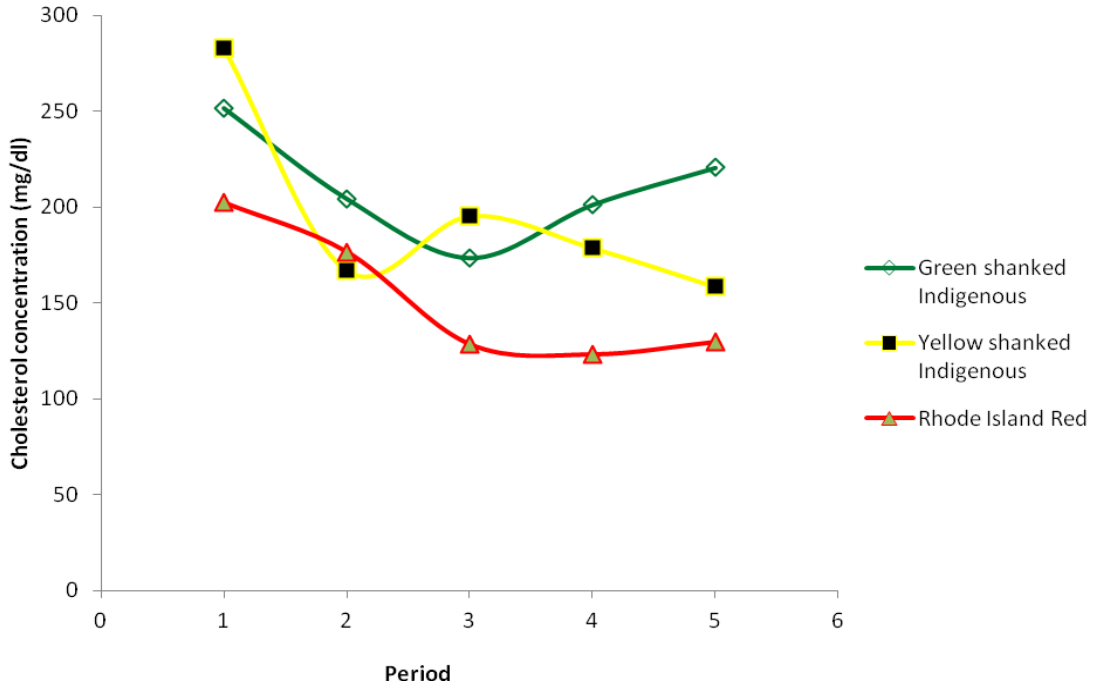

Figure 4: Variation in plasma cholesterol concentration with age

4.6 Correlation with Internal Egg Quality Traits

The study revealed a significant weak negative correlation between egg yolk cholesterol and blood plasma cholesterol for all genetic groups of the study being

-0.32, -0.34 and -0.31 for GSI, YSI and RIR, respectively. On the other hand the study revealed weak positive correlation between yolk cholesterol and yolk weight with egg weight (Table 13). The results indicate that, the correlation values were statistically not significant ($p>0.05$) for all genetic groups except for RIR where the correlation between yolk cholesterol and yolk weight was significant ($P\leq0.05$). However, the correlation was weak (0.32610).

Table 10: Correlation between egg yolk cholesterol with plasma cholesterol, egg weight and yolk weight

Genetic groups	**YC *vs.* PC**	**YC *vs.* EW**	**YC *vs.* YW**
GSI	-0.31952*	0.20986ns	0.12375ns
YSI	-0.34417*	0.11650ns	0.20687ns
RIR	-0.31303*	0.09118ns	0.32610*
Local	-0.30630**	0.16793ns	0.15826ns
All genetic groups	-0.28477**	0.07801ns	0.21238*

YC, PC, EW, YW and *vs*. = Yolk Cholesterol, Plasma Cholesterol, Egg Weight, Yolk Weight and versus respectively.

** Correlation is significant at $P\leq 0.01$ Probability Level

* Correlation is significant at $P\leq 0.05$ Probability Level

ns Not significant at $P>0.05$

CHAPTER FIVE

5.0 DISCUSSION

5.1 Productive Performance

5.1.1 Growth rate

The results show that shank colour had no effect on hatch weight and growth performance. The study revealed no significant difference in body weight between GSI and YSI up to the 5th week of age. The observed hatch weight of 30.2 and 30.0 g for GSI and YSI, respectively, are comparable with *N'zenzegere, Tanga* and *Unguja* chicken ecotypes as reported by Msoffe *et al*., (2004) for indigenous chicken of Tanzania.

The average body weight of 151.48 g and 161.38 g for GSI and YSI respectively at 4th weeks of age in this study are comparable with that of *Tanga, Pemba* and *Morogoro-medium* ecotypes reported by Msoffe *et al*., (2004) for Indigenous chicken of Tanzania. However, the body weight in the 4th week in this study was lower than that of *Mbeya* ecotype, but higher than *Ching'wekwe* and *N'zenzegere* as documented by Msoffe *et al*., (2004). The differences are possibly due to genetic variations between the different genetic groups. Whilst the non significant difference in terms of body weight from the 2nd week to 5th week indicate that GSI and YSI chickens have the same genetic potential for growth, the difference being at the shank colour loci. Nonetheless YSI chickens tended to have slightly higher weight and growth rate than GSI.

5.1.2 Body weight at sexual maturity

There were no significant differences in terms of body weight at first egg lay (BWFE) among the two indigenous genetic groups of experimental chicken. The values for GSI and YSI chickens of 1457.1 and 1440.3 g respectively are lower than the value (1647 g) obtained by Lwelamira *et al*., (2008a) for medium ecotype of Tanzania under intensive management. The weights are also lower than the range of 1600 – 2000 g obtained for South African local chickens (ARC, 2005). However, the values observed are in agreement with the range of 1136 -1520 g reported by Theerachai *et al*., (2003) for local chickens of Thailand and Malaysia. On the other hand the weights are higher than the value of 1300 g obtained by Demeke (2003) for Ethiopian local chickens.

The results also show significant difference in BWFE between the RIR and the other two indigenous genetic groups. The mean BWFE for RIR is higher than that (1394 g) reported by Hassen *et al*., (2006). The variation in body weight at sexual maturity between this study and others is probably due to differences in genetic makeup as well as environmental factors including nutrition and management systems.

5.1.3 Egg number

In the current study, average egg number for the first 90 days of laying was significantly higher in RIR genetic group than in the two Indigenous genetic groups. The value of 42.0 and 42.1 eggs for GSI and YSI respectively observed in the present study are lower than the value (48.9 eggs) reported by Lwelamila *et al.*, (2008) for medium ecotype of Tanzania under intensive management. These values correspond

to laying intensities of 46.7% and 46.8% for GSI and YSI chickens respectively. The laying intensity in the current study in both GSI and YSI genetic groups are within the range of 40 to 55% as documented for local chickens of Sudan (Mohammed *et al*., 2005), but lower than the 54% for medium ecotype of Tanzania reported by Lwelamila *et al.,* (2008). The laying intensity of 76.7% for the RIR is expected, despite being lower compared with the results obtained by by Lalev *et al.,* (2012). Higher laying intensity in RIR is due to the fact that this breed has been selected for higher egg number, since the breed is a commercial egg type.

5.1.4 Egg weight

The mean egg weight for all three genetic groups of chicken in the current study are consistent to the values observed in Tanzania indigenous chickens, within the range of 37.7 to 45.6 g reported by Msoffe *et al*., (2001). In this study egg weight differed significantly between RIR and the Indigenous chicken. The value of 42.4 g and 42.3 g for egg weight (EW) obtained in GSI and YSI chicken genetic groups, respectively, are higher than the value (37.7 g) reported by Msoffe *et al*., (2004) for *Ching'wekwe* indigenous ecotype chicken of *Morogoro*-Tanzania, and the value of 37.3 g in Nigeria local chickens (Adedokun and Sonaiya 2001; Momoh,2008;). However, both GSI and YSI values are lower than that of *Mbeya* indigenous ecotype chicken (49.3 g) reported by Msoffe *et al*., *(*2004). Moreover, the results for both GSI and YSI chickens agree closely to the values of about 40 g given by Pedersen (2002), Fayeye *et al*., (2005), and Momoh (2008) for local chickens of Zimbabwe, Nigeria, and heavy local chicken of Nigeria respectively. The values also agree with the value 42.4 g documented by Lwelamira and Kifaro (2010) for medium ecotypes of

Tanzania under intensive management and the value (42.47 g) of Faruque *et al*., (2010) in Bangladesh. Moreover, the difference between the EW in two indigenous genetic groups in this study was not significant implying that shank colour does not affect egg weight.

On the other hand the results for EW of 52.0 g for RIR were lower than the values of 60.58, 59.40 and 55.95 g reported by Malago and Baitilwake (2009), Wardęcka *et al*., (2003) and Monira *et al*., (2003) respectively. As expected, there was a significant difference between RIR and the Indigenous ecotypes on egg weight. Higher egg weight of RIR birds is due to their superior genetic potential for the production of large sized eggs due to continuous selective breeding for better egg size which have been done for many generations**.**

5.1.5 Egg mass

The similarity of the egg mass of GSI and YSI genetic group is unquestionable because egg mass represents the product of egg number and egg weight. The RIR genetic group recorded higher number of eggs with higher weight. Egg mass reflects egg off take in metric kilograms/grams. The egg mass in RIR was twice as much compared with Indigenous ecotypes (3618.9 versus 1781.2 g).

5.1.6 Survival rate for chicks

The study revealed a non significant difference in survival rate between the two indigenous genetic groups of chickens. The observed results in this study show a slightly lower survival rate than the rate reported by Malago and Baitilwake (2009)

for indigenous chicken of Tanzania. However, other studies (Permin and Pedersen, 2000; Mwalusanya *et al.,* 2002; Abdelqader *et al.,* 2007) have shown high mortalities of up to 50% in local chickens even after vaccination against Newcastle disease. Most of death in indigenous chicks for their studies were tied to mishandling and improper rearing conditions at an early age, Newcastle disease outbreaks, predation and cold weather. The high survival rate in this study was attributed by improved handling and proper rearing management during the first month of growth.

5.2 Reproductive Performance.

The study revealed a non significant difference in both fertility and hatchability between the two indigenous genetic groups of chickens. The observed values for both fertility and hatchability in GSI and YSI genetic groups in this study are comparable to the value reported by Malago and Baitilwake (2009) for indigenous chicken of Tanzania. The results of the present study indicate that GSI are potentially as fertile as YSI genetic group of chickens.

5.3 Egg Quality Traits

5.3.1 External egg quality traits

The study revealed no statistical difference among the genetic groups of indigenous chickens for egg length. However, there was statistical difference between Indigenous and RIR where RIR eggs were longer than those of GSI and YSI.

The value of 4.94 cm for GSI and YSI chickens is closer to the value (4.83 cm) documented by Islam and Data, (2010) in indigenous chickens of Bangladesh, but higher than the value documented by Fayeye (2005) for Fulani ecotype, the native

chicken of Nigeria. Moreover, the value is lower than the value of 5.14 cm observed by Malago and Baitilwake (2009) for indigenous chicken of Morogoro, Tanzania. On the other hand, the value (5.37 cm) obtained for RIR is close to 5.66 and 5.71 cm documented by Malago and Baitilwake (2009) and Monira *et al*., (2003), respectively.

As for egg length, the difference in egg volume between GSI and YSI was not significant while the egg value of RIR differed significantly from that of indigenous genetic groups. The present results of 33.85 and 33.64 cm^3 egg volume in GSI and YSI, respectively, are lower than the value of 34.99 cm^3 reported in indigenous chicken of Bangladesh (Islam and Dutta, 2010), and the value of 38.43 cm^3 for indigenous chicken of Morogoro (Malago and Baitilwake, 2009). On the other hand the observed value (43.28 cm^3) for RIR in the present study is lower than the value of 59.52 cm^3 for RIR obtained by Islam and Dutta (2010) and 54.88 cm^3 reported by Malago and Baitilwake (2009).

Similarly, the egg width values of GSI and YSI were not deferent but differed significantly from those of RIR. The obtained values of 3.63 cm and 3.62 cm for GSI and YSI respectively were closer to 3.71 cm reported by Islam and Dutta (2010) for indigenous chicken of Bangladesh, but higher than the value (2.36 cm) documented by Fayeye (2005) for Fulani ecotype, the native chicken of Nigeria. Likewise, the value (3.93 cm) for RIR in the current study is lower than the value (4.43 cm) obtained by Islam and Dutta (2010) as well as the value (4.13 cm) found by of Monira *et al*., (2003).

The egg shape index (egg shape percentage) is an important attribute in packaging and transportation of eggs. The results of the study clearly demonstrate that the egg shape indexes of the three genetic groups of chicken were not significantly different (P>0.05). The observed values of 73.43, and 73.78% for GSI and YSI genetic groups respectively are slightly lower than the value (74.10%) observed by Lwelamila *et al.*, (2008) for medium indigenous ecotype of Tanzania and the value (73.93%) for indigenous Kadaknath breed of India (Parmar *et al*., 2006). But the value (73.27%) observed in RIR is higher than the value (72.32%) observed by Monira *et al*., (2003). However, the results are contrary to findings of Anderson *et al.*, (2004) who reported a genetic difference in egg shell formation characteristics between genetic groups.

Similarly, the mean shell weight values (4.27 and 4.41 g) obtained in the present study for GSI and YSI were not significantly different. However, there was significant difference in shell weight between GSI and RIR chickens where the former had a lower value than the later. The mean value for the shell weight observed in the present study are comparable to the value (4.89 g) reported by Nonga *et al.,* (2010) for Morogoro medium ecotype in Tanzania, but lower than the value (6.41 g) reported by Islam and Dutta (2010) for Bangladesh indigenous chicken and the value (5.12g) reported by Fayeye *et al*., (2005) for Fulani ecotype, the native chicken of Nigeria. The observed shell weight value (4.68 g) for RIR in the study is lower than the value (9.10 g) observed by Islam and Dutta (2010). These variations in egg shell weight are possibly due to the differences in rearing systems as suggested by Nonga *et al*., (2010) as this may affect the uptake of calcium. Another

cause of the variation is the differences in egg weight, RIR eggs being bigger they are also expected to have heavy shell weight.

Likewise there was no significant difference in shell thickness between Indigenous ecotypes. The observed mean values (0.35 and 0.36 mm) for GSI and YSI are comparable to the value of 0.36 mm documented by Nonga *et al*., (2010) for Morogoro medium ecotype in Tanzania, but higher than the value (0.31 mm) reported by Parmar *et al*., (2006) for indigenous Kadaknath breed of India. Shell thickness is a function of dietary calcium intake. Given that all genetic groups were fed standard diet, it implies that GSI and YSI may be exploited in reducing losses due to cracked eggs. However, North and Bell (1990) observed that as egg gets larger, the shell becomes thinner to cover the larger contents.

Moreover, the study revealed a significant difference between RIR and both GSI and YSI for egg shell ratio. However, there was no significant difference between GSI and YSI genetic groups. The results for GSI show a value of 10.07% while that of YSI and RIR were 10.43 and 8.90%, respectively. High values of shell ratio connote natural selection for heavy and thick egg shells. However, the values for RIR and Indigenous genetic groups are lower than the value (16.13%) observed by Islam and Dutta (2010) for indigenous chicken of Bangladesh. Nonetheless Hatice and Ergul (2005) reported insignificant effect of genotype on egg shell ratio.

5.3.2 Internal egg quality traits

Among the internal egg quality parameters, yolk weight (YW), yolk ratio (YR), albumin weight (AW) and albumin ratio (AR) have been reported by Bain (2005) to be important from nutritional point of view while Abdullahi *et al*., (2003) and Sparks (2006) reported that the egg yolk is important in relation to cholesterol content.

The value of 14.93 g obtained for YW for both GSI and YSI is comparable to the value (14.65 g) documented by Islam and Dutta (2010) for indigenous chicken of Bangladesh, and the value of 14.77 g reported by Parmar *et al*., (2006) for indigenous Kadaknath breed of India. But, the values in this study are higher than the value (13.03 g) reported by Fayeye (2005) for Fulani ecotype native chicken of Nigeria.

RIR did not differ significantly in YW from indigenous genetic groups. However, there was a significant difference in AW between the RIR and the indigenous genetic groups of chicken, RIR having higher value (43% higher). No statistical difference was revealed in AW between GSI and YSI. The RIR are improved chicken specifically for egg production, and they produce large eggs and this might be the reason for higher AW observed in the present result. The value obtained for GSI (23.18 g) and YSI (22.97 g) are higher than the value (18.92 g) observed by Islam and Dutta (2010) for indigenous chicken of Bangladesh, and 20.25 g observed by Fayeye *et al*., (2005) and 20.74 g by Parmar *et al*., (2006) for Fulani-ecotype native chicken of Nigeria and indigenous Kadaknath breed of India, respectively. On the other hand the observed value AW (33.07 g) in this study for RIR is lower than the

value (36.10 g) documented by Islam and Dutta (2010). Differences in values obtained from this study with other studies are probably due to genetical differences between the Indigenous on one hand and exotic egg types on the other hand. With regard to content of albumen, there was also a significant difference between RIR and indigenous genetic groups in AR whereby RIR had the highest value compared to YSI and GSI mainly due to genetical differences between exotic and indigenous type. Like in the other egg traits, the difference in AR between GSI and YSI was not significant suggesting their similarity in genetic group.

5.4 Cholesterol Content

5.4.1 Egg yolk cholesterol

The study showed significant difference between GSI and YSI genetic groups for the first two periods of experiment. Likewise, RIR differed significantly from GSI and YSI. The difference is likely to be due to the carry over effect of the differences in management systems. Both GSI and YSI chickens were under scavenging while the RIR chickens were under confinement prior to the start of experiment. Sanjeewa *et al.,* (2011) have reported that the egg yolk of normal village chicken ecotypes have a higher fat content than the commercial chicken egg yolk. Fat content is positively correlated with cholesterol concentration (Hassan *et al*., 2007), it is likely that during the first periods of experiment eggs of both yellow and green shanked indigenous chicken exhibited more the quality of a normal village scavenging chicken. Confinement and the use of commercial feeds was probably the cause of changes in yolk cholesterol concentration for indigenous chickens.

Results also indicate a gradual increase of egg yolk cholesterol concentration with age in all three genetic groups of chicken. As laying stage advanced there was no significant difference between genetic groups in cholesterol concentration. Since the yolk weights were similar in all genetic groups, it is assumed that under similar management, there will be no any significant difference in cholesterol content. Moreover, the results in this study have demonstrated that eggs produced by older hens have on average a heavier yolk, higher yolk cholesterol concentration and hence higher egg cholesterol. This pattern corresponds to the findings of Shafey *et al*., (1998). In contrast, Hatice and Ergul (2005) reported that the egg cholesterol content is contributed by genotype and other environmental factors including rearing system. They reported that egg yolk and serum cholesterol contents in brown layers (IsaBrown) are higher than in white layers (Babcock-300). Basmacioúlu and Ergul (2005) reported that egg yolk cholesterol content and egg production are negatively correlated. Abdullahi *et al*., (2003) revealed that cholesterol level increases as yolk and yolk albumin ratio increases implying that the egg with largest yolk and yolk:albumin ratio might be expected to contain the highest amount of cholesterol.

5.4.2 Blood plasma cholesterol

The result from period 1 to 3 shows a steady decline in plasma cholesterol in RIR genetic group and levelling off thereafter. In GSI and YSI, the cholesterol levels also declined but started to increase in yellow and green shanked birds after period 2 and 3, respectively. The steady decline of serum cholesterol in RIR is understandable as RIR lays eggs continually. However, in Indigenous types the fluctuations are likely to be due to reduction in egg production especially when local chickens started

expressing broodiness. The fluctuation in plasma cholesterol level particularly in Indigenous type implies that, when hens start brooding, more cholesterol is retained in the blood, hence an increase in total plasma cholesterol. Thus the more the eggs produced the more the cholesterol secreted out from the body as eggs are the major route for cholesterol excretion (Sim *et al*., 1980; Burczak *et al*., 1980; Naber, 1983; Cho *et al*., 1987 and Elkin *et al*., 2003).

Turk and Barnett (1971) reported the environmental factors as one of the sources for variation in cholesterol concentration in blood. The author pointed out that stress plays a major role in increasing blood cholesterol. Thus, the raise of cholesterol concentration in blood plasma during brooding period is likely to be contributed by the stress due to brooding.

5.5 Correlation Among Traits

5.5.1 Correlation among egg quality traits

The study revealed a significant positive correlation between egg yolk cholesterol, egg weight and yolk weight. This was observed in all the genetic groups, though the correlation was statistically not significant ($P>0.05$) except for RIR and the overall yolk weight. The finding of this study is similar to that of Marks and Washburn (1977), Becker *et al.*, (1977), Beyer and Jensen (1989) and Shafey (1998), but contrary to the study of other researchers (Bartov *et al*., 1971 and Ansah *et al*., 1985). These findings imply that breeders should focus on producing eggs with light yolk for less egg cholesterol level.

5.5.2 Correlation between plasma and yolk cholesterol

In the present study, a negative correlation between egg yolk cholesterol and plasma cholesterol was observed in each genetic group. Whilst the cholesterol concentration was increasing with age in egg yolk, it was decreasing in blood plasma. This indicates the possibility of reducing egg yolk cholesterol through selection of birds that produces more eggs in their younger age.

Furthermore egg yolk cholesterol was shown to be positively correlated with egg weight for all genetic groups, though the correlation coefficient was not statistically different. Similarly, yolk weight was positively correlated to yolk cholesterol concentration, though the relation was weak except in RIR. This implies that larger yolk in RIR contain high level of cholesterol than smaller ones.

CHAPTER SIX

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

i. The study demonstrated that both the GSI and YSI dot not differ significantly in most of the traits studied, i.e. egg yolk and plasma cholesterol, production and reproductive efficiency, external and internal egg quality traits. This implies that the shank colour has no influence on the studied traits and this suggests that the GSI is not a distinct strain from the YSI genetic group.

ii. Both GSI and YSI genetic groups differed with RIR in most of the assessed traits. Egg production (egg number) and the related egg quality traits such as egg weight and egg volume, were higher in RIR suggesting the need of mere efforts on improving the productivity of indigenous chickens through crossbreeding with exotic breeds.

6.2 Recommendations

i. Father study is recommended with pure green shanked chickens so as to establish the inheritance pattern of green shank gene because the current study used the chicken from the field whereby yellow and green shanked chickens mate randomly.

ii. The magnitude of Genetics x Environment interaction also needs to be quantified to determine whether it would have a significant effect on the performance of various shank colours and hence the biological importance of shank gene colour.

iii. Further studies are also recommended using shank colour of specified indigenous scavenging chicken eco-types from different ecological zones. Likewise, more studies are needed to explore other factors like growth performance to maturity (in terms of carcass quality), disease resistance and adaptability to harsh environment of the YSI and GSI genetic groups compared to exotic egg types.

REFERENCES

Abdelqader, A., Wollny, C.B.A. and Gauly, M. (2007). Characterization of local chicken production systems and their potential under different levels of management practice in Jordan. *Tropical Animal Health and Production* 39: 155–164pp.

Abdullahi, A.R., Ojedapo, L.O., Adedeji, T.A., Olayemi, T.B. and Adedeji, O.S, (2003). Influence of Hen's age on egg quality parameters in Bovans near black layer strain. In: *Proceedings of the 28th Annual Conferences of the Nigerian Society for Animal Producton, March 18-22, University of Calabar, Cross Rivers State,*103-103pp.

Adedeji, T.A., Ojedapo, A.O., Ige, S.A., Akinwunmi, A.O and Amao, S.R. (2008). Genetic evaluation of growth performance of pure and crossbred chicken progenies in a derived savannah environment. In: *Proceedings of the 13th Annual Conference of the Animal Science Association of Nigeria* (ASAN), 15th -19th September 2008. ABU Zaria. 8-12pp.

Adedokun, S.A. and Sonaiya, E.B. (2001). Comparison of the performance of Nigerian indigenous chickens from three agro-ecological zones. *Livestock Research for Rural Development 1*3(2) [http://www.lrrd.org/lrrd13/2/ aded132.htm]. Site visited on 20th July 2012.

Ajayi, F.O. (2010). Nigerian Indigenous Chicken: A Valuable Genetic Resource for Meat and Egg Production. *Asian Journal of Poultry Science* 4: 164-172pp.

Alabi, R.A., Esobhawan, A.O. and Aruna, M.B. (2006). conometric determination of contribution of family poultry to women's income in Niger-delta, Nigeria. *Journal of Central Europe Agriculture* 7: 753-760pp.

Anderson, K.E., Tharrington, J.B., Curtis, P.A. and Jones, F.T. (2004). Shell characteristics of eggs from historic strains of single comb white leghorn chickens and the relationship of egg shape to shell strength. *Journal of Poultry Science* 1: 17-19pp.

Andrews, J.W., Wagstaff, R.K. and Edwards, H.M. (1968). Cholesterol metabolism in the laying fowl. *American Journal of Physiology* 214: 1078-1083pp.

Ansah, G.A., Chan, C.W., Touchburn, S.P.and Buckland, R.B. (1985). Selection for low yolk cholesterol in Leghorn-type chickens. *Journal of Poultry Science* 64: 1-5pp.

Apuno,A.A., Mbap,S.T. and Ibrahim, T. (2011). Characterization of local chickens (*Gallus gallus domesticus*) in Shelleng and Song Local Government Areas of Adamawa State, Nigeria. *Agriculture and Biology Journal of North America* 2(1): 6-14pp.

ARC. (2005). Agricultural Resource Council-South Africa Fowl for Africa. [http://www.arc.agric.za/institute/aii/main/division/animbreedgen/resourcepo/fowlsfa.htm].Site visited on 30th Aug. 2011.

Bain, M.M. (2005). Recent advances in the assessment of eggshell quality and their future application. *World's Poultry Science Journal* 61: 268-277pp.

Bartov, I., Bornstein, S. and Budowski, P. (1971). Variability of cholesterol concentration in plasma and egg yolk of hens and evaluation of the effects of some dietary oils. *Journal of Poultry Science* 50:1357-1364pp.

Basmacioúlu, H. and Ergul, M. (2005). Research on the Factors Affecting Cholesterol Content and Some Other Characteristics of Eggs in Laying Hens, The effects of genotype and rearing system. *Turkey Journal of Veterinary Animal Science* 29: 157-164pp.

Baumgartner, J., Končekova, Z., Benkova, J., Peškovičova, D., Simenovova, J. and Csuka, J. (2008). Changes in egg quality traits associated with long-term selection for lower yolk cholesterol content in Japanese quail. *Czech Journal of Animal Science* 53(3): 119–127pp.

Becker, W.A., Spencer, J.V., Verstrate, J.H. and Mirosh, L.W. (1977). Genetic analysis of chicken egg yolk cholesterol. *Journal of Poultry Science* 56: 895-901pp.

Beyer, R.S. and Jensen, L.S.(1989). Cholesterol content of commercially produced eggs in Georgia. *Journal of Poultry Science* 68(12): 1703-1706pp.

Bonekamp, R.P.R.T., Lemme, A., Wijtten, P.J.A. and Sparla, J.K.W.M. (2010). Effects of amino acids on egg number and egg mass of brown (heavy breed) and white (light breed) laying hens. *Journal of Poultry Science* 89: 522-529pp.

Burczak, J.D., Mcnaughton, J.L. and Kellogg, T.F. (1980). Cholesterol metabolism in poultry (*Gallus domesticus),* Faecal neutral sterol and bile acid excretion. Comparative Biochemistry and Physiology, Part B 66: 385-389pp.

Chen, Y. C., Nakthon, C. and Chen, T. C. (2005). Effects of Chicory Fructans on Egg Cholesterol in Commercial Laying Hen. *International Journal of Poultry Science* 4(2): 109-114pp.

Cho, B.H.S., Hassan, A.S., Egwim, P.O. and Park, J.R. (1987). Faecal steroid excretion in chickens with hereditary hyperlipidemia. In: *Proceedings of the Society for Experimental Biology and Medicine* 186: 84- 89pp.

Chowdhury, S. R., Chowdhury, S. D. and Smith, T. K. (2002). Effects of dietary garlic on cholesterol metabolism in laying hens. *Journal of Poultry Science* 81: 1856-1861pp.

Chowdhury, S. R., Sarker, D. K., Chowdhury, S. D., Smith, T. K., Roy, P. K. and Wahid, M. A. (2005). Effects of Dietary Tamarind on Cholesterol Metabolism in Laying Hens. *Journal of Poultry Science* 84 (1):56–60pp.

Connor, W.E., Osborne, W.J. and Marion, W.L. (1965). Incorporation of plasma cholesterol-4-C14 into egg yolk cholesterol. In: *Proceedings of the Society for Experimental Biology and Medicine* 118: 710-713pp.

Demeke, S. (2003). Growth performance and survival of Local and White Leghorn chickens under scavenging and intensive systems of management in Ethiopia. *Livestock Research for Rural Development.* 15(11): [http://www.lrrd.org/lrrd15/11/deme 1511.htm]. Site visited on 20th May 2012.

Dessie, T. and B. Ogle, (2001). Village poultry production system in the central highlands of Ethiopia. *Journal of Tropical Animal Health and Production* 33: 521-537pp.

Ekue, F.N., Pone, K.D., Mafeni, M.J., Nfi A.N. and Njoya, J. (2002). Survey of the Traditional Poultry Production System in the Bamenda Area, Cameroon. In: *Characteristics and Parameters of Family Poultry Production in Africa*, FAO/ IAEA, 15-24pp.

Elkin, R. G. (2006). Reducing shell egg cholesterol content. I. Overview, genetic approaches, and nutritional strategies. *Journal Worlds Poultry Science* 62: 665–687pp.

Elkin, R.G., Zhong, Y., Porter, R.E. and Walzem, R.L. (2003). Validation of a modified PCRbased method for identifying mutant restricted ovulator chickens: Substantiation of genotypic classification by phenotypic traits. *Journal of Poultry Science* 82: 517-525pp.

Farooq, M. Mian, M.A., Ali, M., Durranim, F.R., Asquar, A. and Muqarrab, A.K. (2001). Egg traits of Fayoumi bird under subtropical conditions. *Sarad. Journal of Agriculture* 17: 141-145pp.

Faruque,S. Siddiquee, N.U., Afroz, M.A. and Islam, M.S. (2010) Phenotypic characterization of Native Chicken reared under intensive management system *Journal of the Bangladesh Agricultural University* 8(1): 79–82pp.

Fayeye, T.R., Adeshiyan, A.B., Olugbami, A.A., (2005). Egg trait, hatchability and early growth performance of the Fulani-ecotype chicken. *Livestock Research for Rural Development*, 17 (8) [http://www.unilorin.edu.ng/ publications/fayeyetr/pdf].Site visited on 17 July 2012.

Garcaoa-Lapez, J.C., Suarez-Oporta, M.E., Pinos-Rodraoguez, J.M. and Aolvarez-Fuentes G.A. (2007). Egg components, lipid fraction and fatty acid composition of Creole and Plymouth Rock-Rhode Island Red cross hens fed with three diets. *World's Poultry Science Journal* 63: 473-479pp.

Griffin, H. D. (1992). Manipulation of egg yolk cholesterol: a physiologist's view. *World Poultry Science Journal* 48: 101-112pp.

Gueye, E.F. (2003). Production and consumption trend in Africa. *World Poultry* 19(11): 12-14pp.

Han, C. K. and Lee, N.H. (1992). Yolk cholesterol content in eggs from the major domestic strains of breeding hen. *Asian Australian Journal of Animal Science* 5:461–464pp.

Hassan H. M., Guo, H. C., Jin, H. C. and Galal. M. Y. (2007). Relation between Abdominal Fat and Serum Cholesterol, Triglycerides, and Lipoprotein Concentrations in Chicken Breeds. *Turkey Journal of Veterinary Animal Science*. 31(6): 375-379pp.

Hassen, H., Neser, F.W.C., Dessie, T., Kock, A. and Marle-Koster, V.E. (2006). Studies on the growth performance of native chicken ecotypes and RIR chicken under improved management system in Northwest Ethiopia. *Livestock Research for Rural Development*, 18 (6), [http://www.lrrd.org/lrrd18/6/hass18076.htm]. Site visited on 17th May 2012.

Hatice, B. and Ergul, M. (2005). Research on factors affecting cholesterol content and some other characteristics of eggs in laying hens. *Turkey Journal of Veterinary Animal Science* 29: 157-164pp.

Herron, K.I. and Fernadez, M.L. (2004): Are the current dietary guided lines regarding egg consumption appropriate. *Journal of Nutrition* 134: 187–190pp.

Hunton, P. (1987) Laboratory Evaluation of egg quality. Current Problems and Recent Advances. *Poultry Science Symposium No. 20.* (Edited by Wells, R.G. and Belyavin, C.G.), Butterworths Publishers, London, 87-102pp.

Illango, J., Olaho-Mukani, W., Mukiibi-Muka, G., Abila P.P. and Etoori, A. (2005). Immunogenecity of a locally produced Newcastle disease I-2 thermostable agrovaccine in chickens in Uganda. *Tropical Animal Health and Production Journal* 37: 25-31pp.

Islam M. S. and Dutta K.R. (2010). Egg Quality Traits of Indigenous, Exotic And Crossbred Chickens (*Gallus Domesticus* L.) *Journal of Life Earth Science* 5: 63-67pp.

Islam, M.A., Bulbul, S.M., Seeland, G. and Islam, A.B. (2001). Egg quality of different chicken genotypes in summer and winter. *Pakistan. Journal of Biology Science* 4: 1411-1414pp.

Jones, D.R, Musgrove, M.T., Anderson, K.E. and Thesmar, H.S. (2010). Physical quality and composition of retail shell eggs. *Journal of Poultry Science* 89: 582-587pp.

Kritchevsky, S. B. (2004). A review of scientific research and recommendation regarding eggs. *Journal of American College Nutrition* 23: 596–600pp.

Kritchevsky, S. B. and Kritchevsky, D. (2000). Egg consumption and coronary heart disease: An epidemiological overview. *Journal of American College Nutrition* 19: 549–555pp.

Kuksis, A. (1992) Yolk lipids. Biochimica Biophysica Acta, 1124: 205-222pp.

Lalev, M., Oblakova,M., Hristakieva, P., Mincheva, N. and Ivanova, I. (2012). Development of new laying hen lines. I. Growth potential and egg production rate, *Trakia Journal of Sciences* 10: 43-47pp.

Lwelamira, J. and Kifaro, G. C. (2010). Desired-gain selection indices for improving performance of two Tanzania local chicken ecotypes under intensive management. *African Journal of Agricultural Research* Vol. 5 (2), pp. 133-141.

Lwelamira, J., Kifaro, G. C. and Gwakisa, P. (2008a). On station and on-farm evaluation of two Tanzania chicken ecotypes for body weights at different ages and for egg production. *African Journal of Agricultural Research* 3 (12): 843-851pp.

Lwelamira, J., Kifaro, G. C. and Gwakisa, P. (2008b). Breeding strategies for improving performance of Kuchi chicken ecotype of Tanzania for production under village conditions. *Livestock Research for Rural Development* 20 (11) [www.lrrd.org/lrrd20 /11/lwel20171.htm] site visited on13/08/2011.

Malago, J.J. and Baitilwake, M.A. (2009). Egg traits, fertility, hatchability and chick survivability *of* Rhode Island Red, local and crossbred chickens. *Tanzania Veterinary Journal* 26: 24-36pp.

Marks, H.L. and Washburn, K.W.(1977) Divergent selection for yolk cholesterol in laying hens. *Britain Poultry Science Journal* 18: 179-188pp.

McDonald, P., Edwards, R.A., Greenhalg, J.F.D. and Morgan C.A. (1996). Animal Nutrition (5^{th} Edition), Longman Singapore Publishers (Pte) Ltd. 607pp.

MLDF (2009). Ministry of Livestock Development and Fisheries-Budget speech 2009/2010, Government Printer, Dar-es-Salaam, Tanzania.

Mlozi, M. R. S., Kakengi, A. V. M., Minga, U. M, Mtambo, A. M. and Olsen, J. E. (2003) Marketing of free - range local chickens in Morogoro and Kilosa urban markets, Tanzania. *Livestock Research for Rural Development*, 15(2).

Mohammed, M. D., Abdalsalam, Y. I., Kheir, A. M., Jin-yu, W. and Hussein, M. H. (2005). Comparison of egg characteristics of different Sudanese Indigenous chicken types. *International Journal of Poultry Science* 4(7): 455-457pp.

Momoh, O.M., Ani, A.O. and Ugwuowo, L.C. (2010). Part-period egg production and egg quality characteristics of two ecotypes of Nigerian local chicken and their F1 crosses. *Journal of Poultry Science* 9(8): 744-748pp.

Momoh, O.M., Nwosu, C.C. and Adeyinka, I.A. (2008). Egg Production of Two Nigerian Local Chicken Ecotypes Under Improved Management *ASSET International Journal A* 8 (2): 151-158pp.

Monira,K.N., Salahuddin, M. and Miah, G. (2003). Effect of Breed and Holding Period on Egg Quality Characteristics of Chicken. *International Journal of Poultry Science* 2(4): 261-263pp.

Msoffe P.L., Minga, U.M., Olsen, J.E., Yongolo, M.G., Juul-Madsen, H.R., Gwakisa, P.S., Mtambo, M.M. (2001). Phenotypes including immunocompetence in scavenging local chicken ecotypes inTanzania. *Tropical Animal Health and Production Journal* 33: 341- 354pp.

Msoffe, P. L., Mtambo, M. M. A., Minga, U. M., Olsen, J. E., Juul-Madsen, H. R., Gwakisa, P. S., Mutayoba, S. K. and Katule, A. M. (2004). Productivity and reproductive performance of the free-range local domestic fowl ecotypes in Tanzania. *Livestock Research for Rural Development* 16 (9) [http://www.lrrd.org/lrrd16/9/msof16067. htm]. Site visited on 10th January 2012.

Msoffe, P.M.M. (2003). Diversity among local chicken ecotypes in Tanzania. Dissertation for Award of PhD Degree at Sokoine University of Agriculture, Morogoro, Tanzania, 223pp.

Muchadeyi, F.C., Sibanda, S., Kusina, N.T., Kusina, J.F. and Makuza, S.M. (2005). Village chicken flock dynamics and contribution of chickens to household livelihoods in smallholder farming area in 108. Zimbabwe. *Tropical Animal Health and Production Journal* 37: 333-344pp.

Mukherjee, T. K., Jerome, F. N. and Reinhart B. S. (1965). The Inhibition of Dermal Melanin in the Shanks of the Domestic Fowl. *Journal of Poultry Science* 48: 2137-2142pp.

Mwalusanya, N.A., Katule, A.M., S.K., Mtambo, M.M.A., Olsen, J.E., Minga, U.M. (2002). Reproductivity of Local Chickens under Village Management Conditions. *Tropical Animal Health and Production Journal* 34(5): 405-416 pp.

Naber, E. C. (1976). The cholesterol problem, the egg and lipid metabolism in the laying hen. *Journal of Poultry Science* 55: 14-30pp.

Naber, E.C. (1983). Nutrient and drug effects on cholesterol metabolism in the laying hen. *Federation Proceedings*, 42(8): 2486-2493pp.

Nahar, K., Ahmed, S., Monir, M.M. and Rahman, M.S. (2007). Comparative evaluation of egg quality characteristics of broiler parent stock and synthetic broiler. *Bangladesh Journal of Animal Science* 36 (1 and 2): 82-87pp.

NBS (2012). National Bureau of Statistics-National sample census of agriculture 2007/2008 report. [http://www.agriculture.go.tz]. Site visited on 20th August 2013.

Niranjan, M., Sharma, R.P., Rajkumar, U., Chatterjee, R.N., Reddy, B.L.N. and Battacharya, T.K. (2008). Egg quality traits in chicken varieties developed for backyard poultry farming in India. *Livestock Research for Rural Development* 20 (12) [http://www.lrrd.org/lrrd20/12/nira20189.htm]. Site visited on 23th August 2012.

Nonga, H.E., Kajuna, F.F., Ngowi, H.A. and Karimuribo, E.D. (2010). Physical egg quality characteristics of free-range local chickens in Morogoro municipality, Tanzania. *Livestock Research for Rural Development* (22) 12 [http://www.lrrd.org/lrrd22/12/nong22218.htm]. Site visited on 12th Nov. 2011.

North, M.O.D.D. and Bell (1990). Commercial chicken production manual van Nastrand Reinhold. New York, 689pp.

Green Legged Partridge. *Electronic Journal of Polish Agricultural Universities,* Veterinary Medicine, Volume 10, Issue 2.

Olawumi, S.O. and Ogunlade, J.T. (2008). Phenotypic Correlations Between Some External and Internal Egg Quality Traits in the Exotic Isa Brown Layer Breeders. *Asian Journal of Poultry Science* 2(1): 30-35pp.

Olugbemi, T. S., Mutayoba, S. K. and Lekule, F.P. (2010). Moringa oleifera leaf meal as a hypocholesterolemic agent in laying hen diets. *Livestock Research for Rural Development* 22 (4) [http://www.lrrd.org/lrrd22/4/olug22084.htm] site visited on 20/07/2011.

Onagbesan, O., Bruggeman, V., Desmit, L., Debonne, M., Witters, A., Tona, K., Everaert, N. and Decuypere, E. (2007). Gas exchange during storage and incubation of Avian eggs: effects on embryogenesis, hatchability, chick quality and post-hatch growth. *World's Poultry Science Journal* 63: 557-573pp.

Pandey, H.S., Katpatal, B.G., Bisht, G.S. and Kumar, M. (1986). Factors affecting milk constituents in Murrah buffaloes. *Indian Journal of Animal Science* 56:425-429.

Parmar, S. N. S., Thakur, M.S., Tomar, S.S, and Pillai P.V.A. (2006). Evaluation of egg quality traits in indigenous Kadaknath breed of poultry. *Livestock Research for Rural Development* 18 (9) [http://www.lrrd.org/lrrd18/9/ parm18132.htm].Site visited on 23th March 2012.

Partyka A., Jerysz, A., Pokorny, P. (2007). Lipid peroxidation in fresh and stored semen.

Pedersen, C.V. (2002). Productivity of semi-scavenging chickens in Zimbabwe. Ph.D Thesis. The Royal Veterinary and Agricultural University (RVAU), Copenhagen, Denmark, 133pp.

Permin, A. and Pedersen, G. (2000). Problems Related to Poultry Production at Village Level. In: *Possibilities for Smallholder Poultry Projects in Eastern and Southern Africa,* (Edited by Pedersen, G., A. Permin and U.M. Minga). The Royal Veterinary and Agricultural University, Copenhagen, Denmark).

Pištěkova, V., Hovorka, M., Večerek, V., Strakova, E. and Suchy, P. (2006). The quality comparison of eggs laid by laying hens kept in battery cages and in a deep litter system. *Czech Journal of Animal Science* 51: 318–325pp.

Proudfoot, G.F.G. and Hulan, H.W. (1981). The influence of hatching egg size on the subsequent performance of broiler chickens. *Journal of Poultry Science* 60(10):2167-2170pp.

Rajkumar,U., Sharma, R.P., Rajaravindra, K.S., Niranjan, M., Reddy, B.L.N., Bhattacharya T.K. and Chatterjee, R.N. (2009). Effect of Genotype and Age on Egg Quality Traits in Naked Neck Chicken under Tropical Climate from India. *International Journal of Poultry Science* 8: 1151-1155pp.

Ramesh, A., Manegar, A., Shambulingappa, B. E. and Ananda, K. J. (2009). Study of Lipid Profile and Production Performance in Layers as Influenced by Herbal Preperations Abana™ and Garlic Paste. *Journal of Veterinary World* 2(11):426-428pp.

Robinson, D.S. (1987) The chemical basis of albumen quality. In: *Egg Quality*, (Edited by Wells, R.G and Belyavin, C.G). Current Problems and Recent Advances Butterworths Publishers, London, UK., 171-191pp.

Rosegrant, M.W., Paisner, M.S., Meijer, S. and Witcover, J. (2001). 2020 Global food outlook trends, alternatives and choices. International Food Policy Research Institute, Washington, DC., USA, [http://www.fcrn.org.uk/research-library/ agriculture/ projections/2020-global-food-outlook-trends-alternatives-and-choices] Site visited 0n 10th September 2012.

Sanjeewa, M.N., Liyanage, R.P., Vidanarachchi, J.K. and Silva, G.L.L.P. (2011). Association between Egg Production and Body Morphology of Some Village Chicken Ecotypes in Sri Lanka. In *Proceedings of The Peradeniya University Research Sessions*. (edited by Silva I.D., Weerakkody W.A.P., Herath, H.M.T.U., Jayaratne, D.K., Rajapakshe, P.S., Wijetunge, J.J., Rosairo, S., Yakandawala, D.M.D. and Ariyaratne. H.B.S). The University of Peradeniya, Peradeniya, Sri Lanka, 44pp.

Sarkar, P.K., Chowdhury, S.D., Kabir, M.H., Sarker, P.K. (2008). Comparative Study On The Productivity And Profitability Of Commercial Broiler, Cockerel Of A Layer Strain And Cross-Bred (Rir × Fayoumi) ChicksBangladesh. *Journal of Animal Science* 37(2): 89-98pp.

SAS (2004). Statistical Analysis system. Statistics Software. Release 9.1, SAS Institute Inc., Cary, NC, USA.

Shafey, T.M., Dingle, J.G. and McDonald M.W. (1998). The Relationships between Egg Yolk Cholesterol, Egg Production and Age of the Hen in Tree Australian Strains. *Journal of King Saud University* 10: 33-41pp.

Shrimpton, D.H. (1987) The nutritive value of eggs and their dietary significance. In Egg Quality in Individual Bird. (Edited by Belyavin, C.G; Boorman, K.N. and Volynchook, J.). Poultry Science Symposium No. 20. Butterworths Publishers, London, 11-22pp.

Sim, J.S., Kitts, W.D. and Bragg, D.B. (1980). Influence of dietary oil, cholesterol, and soysterols on the faecal neutral and acidic steroid excretion in laying hens. *Journal of Poultry Science* 59: 325-327pp.

Simopoulos, A.P. (2000). Symposium: Role of poultry products in enriching the human diet with N-3 PUFA. *Journal of Poultry Science* 79: 961-970pp.

Sola-Ojo, F.E., and Ayorinde, K.L. (2011). Evaluation of Reproductive Performance and Egg quality Traits in Progenies of Dominant Black Strain Crossed with Fulani Ecotype Chicken, *Journal of Agricultural Science* (3) 1, [www.ccsenet.org/jas]. Site visited on 11th July 2012.

Sparks, N.H.C. (2006). The hen's egg – is its role in human nutrition changing? *World's Journal of Poultry Science* 62: 308-315pp.

Stadelman, W.J. (1977). Quality identification of shell eggs. In *Egg Science and technology; 2nd Edn.* (Edited by Statesman, W.J. and Cotterill, O.J.). AVI Publishing Company Inc., Westport, Connecticut. 29-40 pp.

Tadelle, D.S. (2003). Phenotypic and genetic characterization of local chicken ecotypes in Ethiopia, Dessertation for Award of PhD degree at Humboldt-University, Berlin, Germany 209pp.

Theerachai, H., Ezzat, T., Michael, Z. (2003). Options for native Chicken (*Gallus domesticus*) production in Northeastern Thailand. In: *Proceedings of the conference on International Agricultural Research for Development*. Göttingen, Germany. [htt://www.tropentag.de /2003/abstract/full /166.pdf]. Site visited on 1st Aug. 2012.

Turk, D.E., Barnett, B.D. (1971). Cholesterol content of market eggs. *Journal of Poultry Science* 50: 1303-1306pp.

Wardęcka, B., Olszewski, R., Jaszczak, K., Zięba, G. and Pierzchała, M. (2003). Preliminary mapping of QTLs affecting egg quality on chromosomes 1–5 in chickens. *Czech Journal of Animal Science* 48 (3): 97–105pp.

Washburn, K.W. (1990). Genetic variation in egg composition: In *Poultry Breeding and Genetics,* (Edited by Rawford R.D). Elsevier Science Publisher, B. V, Amsterdam, Netherlands. 781-804pp.

Weggemans, R. M., Zock, P. L. and Katan, M. B. (2001). Dietary cholesterol from eggs increases the ratio of total cholesterol to high-density lipoprotein cholesterol in humans: a meta-analysis. *American Journal of Clinical Nutrition* 73(5): 885-891pp.

Weiss, J.F., Naber, E.C. and Johnson, R.M. (1967). Effect of dietary fat and D-thyroxine on the incorporation of acetate-1-14C into egg yolk lipids. *Journal of Nutrition* 93: 153-160pp.

Weiss, J.F., Naber, E.C. and Johnson, R.M. (1967b). Effect of dietary fat and cholesterol on the in vitro incorporation of acetate-14C into hen liver and ovarian lipids. *Journal of Nutrition* 93: 142-152pp.

Yildiz, G., Sacakli, P. and Gungor, T. (2006). The effect of dietary Jerusalem artichoke (*Helianthus tuberosus* L.) on performance, egg quality characteristics and egg cholesterol content in laying hens. *Czech Journal of Anima Science* 51: 349–354pp.

Zemkova, L., Simeonovova, J., Lichovnikova, M., Somerlikova, K. (2007). The effects of housing systems and age of hens on the weight and cholesterol concentration of the egg. *Czech Journal of Animal Science* 52: 110–115pp.

APPENDICES

Appendix 1: plasma and egg yolk cholesterol

Appendix 1a: ANOVA for dependent variable plasma cholesterol (PC)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Genetic group	2	29648.44669	14824.22335	16.50	<.0001
Error	45	40418.27853	898.18397		
Corrected Total	47	70066.72522			

R-Square	C.V	Root MSE	PC Mean
0.423146	16.08580	29.96972	186.3116

Appendix 1b: Dependent Variable: Egg Yolk cholesterol (YC)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Genetic group	2	787.597500	393.798750	0.96	0.3983
Error	21	8594.802500	409.276310		
Corrected Total	23	9382.400000			

R-Square	C.V	Root MSE	YC Mean
0.839440	9.980552	20.23058	202.7000

Appendix 2: Production traits

Appendix 2a: ANOVA for Dependent Variable: Egg Number in the first 90 days (EN90D)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Genetic group	2	7776.125000	3888.062500	254.51	<.0001
Error	45	687.437500	15.276389		
Corrected Total	47	8463.562500			

R-Square	C.V	Root MSE	EN90D Mean
0.918777	7.654349	3.908502	51.06250

Appendix 2b: ANOVA for Dependent Variable: Laying intensity (LI)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Genetic group	2	9600.96247	4800.48123	254.32	<.0001
Error	45	849.39540	18.87545		
Corrected Total	47	10450.35787			

R-Square	C.V	Root MSE	LI Mean
0.918721	7.657462	4.344589	56.73667

Appendix 2c: ANOVA for Dependent Variable: Egg Mass in the first 90 days (EM90D)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Genetic group	2	36024377.91	18012188.95	592.54	<.0001
Error	45	1367914.46	30398.10		
Corrected Total	47	37392292.37			

R-Square	C.V	Root MSE	EM90D Mean
0.963417	7.283676	174.3505	2393.716

Appendix 3: External egg quality traits

Appendix 3a: ANOVA for dependent variable egg weight (EWT)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Genetic group	2	538.7200000	269.3600000	127.17	<.0001
Error	21	44.4800000	2.1180952		
Corrected Total	23	583.2000000			

R-Square	C.V	Root MSE	EWT Mean
0.923731	3.184612	1.455368	45.70000

Appendix 3b: ANOVA for Dependent Variable egg length

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Genetic group	2	1.05583333	0.52791667	67.7	<.0001
Error	21	0.16375000	0.00779762		
Corrected Total	23	1.21958333			

R-Square	C.V	Root MSE	Egg length Mean
0.865733	1.738555	0.088304	5.079167

Appendix 3c: ANOVA for Dependent Variable egg weight (Ewt)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Genetic group	2	0.44083333	0.22041667	46.87	<.0001
Error	21	0.09875000	0.00470238		
Corrected Total	23				

R-Square	C.V	Root MSE	Ewt Mean
0.816988	1.842972	0.068574	3.720833

Appendix 3d: ANOVA for Dependent Variable: Egg volume (EV)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Genetic group	2	484.7449401	242.3724700	131.07	<.0001
Error	21	38.8320059	1.8491431		
Corrected Total	23	523.5769460			

R-Square	C V	Root MSE	EV
0.925833	3.682865	1.359832	36.92321

Appendix 3e: ANOVA for Dependent Variable: Shell thickness (STH)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Genetic group	2	0.01750000	0.00875000	4.74	0.0200
Error	21	0.03875000	0.00184524		
Corrected Total	23	0.05625000			

R-Square	C.V	Root MSE	STH Mean
0.311111	12.72777	0.042956	0.337500

Appendix 3f: ANOVA for Dependent Variable: Albumin weight (ALWT)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Genetic group	2	532.8475000	266.4237500	252.34	<.0001
Error	21	22.1725000	1.0558333		
Corrected Total	23	555.0200000			

R-Square	C.V	Root MSE	ALWT Mean
0.960051	3.892188	1.027538	26.40000

Appendix 3g: ANOVA Dependent Variable: shell weight (SW)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Genetic group	2	0.63583333	0.31791667	3.74	0.0407
Error	21	1.78375000	0.08494048		
Corrected Total	23	2.41958333			

R-Square	C.V	Root MSE	SW Mean
0.262786	6.543210	0.291445	4.454167

Appendix 3h: ANOVA Dependent Variable: Shell ratio (SR)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Genetic group	2	10.08583333	5.04291667	27.21	<.0001
Error	21	3.89250000	0.18535714		
Corrected Total	23	13.97833333			

R-Square	C.V	Root MSE	SR Mean
0.721533	4.389443	0.430531	9.808333

Appendix 3i: ANOVA Dependent Variable Albumin ratio (AR)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Genetic group	2	395.9033333	197.9516667	203.61	<.0001
Error	21	20.4162500	0.9722024		
Corrected Total	23	416.3195833			

R-Square	C.V	Root MSE	AR Mean
0.950960	1.720148	0.986003	57.32083