

EFFECT OF INDIGENOUS STORAGE MEDIA AND DURATION ON EGG QUALITY
PARAMETERS OF LOHMANN BROWN CHICKEN EGGS

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DECLARATION

I hereby declare that this work is the product of my research efforts under the supervision of Dr. S.K. INUSA and has not been presented anywhere for the award of a degree or certificate. All sources have been duly acknowledged.

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CERTIFICATION

This is to certify that the research work for this dissertation and the subsequent write-up (Ibrahim Garba, SPS/14/MAS/00003) were carried out under my supervision.

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DEDICATION

This dissertation is dedicated to my Father Alh Haruna Yusuf S.K and my Mother Furera, I also dedicated to my children Abdurrahman Ibrahim Haruna, Aishatu Ibrahim Haruna and lastly to Amina Ibrahim Haruna.

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ABSTRACT

This study was conducted to determine the effect of indigenous storage media and duration on egg quality parameters. A total of 200 freshly laid Lohmann Brown chicken eggs were obtained and stored in different storage media (jute bag, calabash, basket, earthen pot and egg crate) for a period 28 days. Chemical analysis was conducted at 7 and 28 days of storage at room temperature 20-22⁰C. The microbial load of the experimental eggs was similarly assessed. Data on egg quality parameters were also evaluated. The results revealed that storage duration and media had significant (P<0.05) effect on proximate compositions of the eggs. The highest mean value for moisture (25.90%) was recorded at 7 days whereas the lowest (17.33%) was at 28 days. Similarly, crude protein was highest (16.01%) and lowest (15.31%) at 7 and 28 days respectively. The highest values of moisture and crude protein (23.56 & 16.83%) were observed in eggs stored in jute bag while the least values (20.57 & 15.35%) were obtained in calabash and egg crate. Also the storage media were found to significantly (P<0.05) affect the minerals content. However, there were significant (P<0.05) differences in the egg quality parameters examined except egg length, egg diameter and shell weight for both storage duration and media. The Haugh Unit was observed to decrease as the storage duration increase while eggs kept in jute bags had better quality. The results of the microbiological load assessment revealed increase in TVC, TSC and TCC as the storage duration increased. However, no increase was observed with respect to TCC in eggs stored inside jute bag. It was concluded that storage media and duration can affect the quality of eggs. However, indigenous storage media especially jute bag are recommended for keeping eggs up to 28 days in the absence of modern facilities.

CHAPTER ONE

1.0 INTRODUCTION

1.1 BACKGROUND INFORMATION

Poultry egg is one of the cheapest most affordable nutrient-rich and widely acceptable animal products which contain highly digestible proteins, lipids, minerals, and vitamins. Eggs play an important role in human nutrition as they are consumed by people throughout the world. They are versatile and wholesome and have a natural balance of essential nutrients (Silverside & Scott, 2001). Egg is a complete protein food with excellent quality as one egg will give 6g of protein (FAO, 2005). The nutritional status of many Nigerians is characterized by low animal protein intake, the average daily intake still far less than the 35g per head per day recommended by FAO (2007). Egg has been and continuous to be a major agricultural product in many countries (USDA, 2000). Eggs provide means through which the animal protein requirements of the populace can be met (Silversides & Scott, 2001). Egg is the most nutritious and complete food known to man (Stadelman, 1994).

According to Campo and Ruano (1995), egg quality is composed of those characteristics that affect its acceptability to consumers. It is therefore important that attention is paid to the problems of preservation and marketing of eggs to ensure quality. The chicken egg contains high-quality proteins, carbohydrate, easily digestible fats and minerals, as well as valuable vitamins (Huopalahti, Lopez, Antom & Schate, 2007).

The quality of eggs is composed of those characteristics that affect its acceptability to consumers such as cleanliness, freshness, egg weight, shell quality, yolk index, albumen index, Haugh unit and chemical composition (Song, Choi & Oheye, 2002). Egg quality is influenced by management, climatic factors, nutrition, breed and post laying handling practices. Fresh eggs are

highly susceptible to internal quality deterioration during storage (Wong, Herald & Hachmeister, 1996). Eggs are laid by female animals of many different species including birds, reptiles, amphibian, mammals and fish, and have been eaten by humans for thousands of years. Bird and reptile eggs consist of a protective egg shell, albumen (egg white) and vitellus (egg yolk) within the thin membranes. The most popular animal products for consumption are chicken eggs (Kennet & Kiple, 2007).

Eggs contain significant amount of protein and are widely used in cookery (USAD, 2000). Egg consumption is not affected by any religions and cultures and thus egg products contribute in solving nutritional problems in the world. Presently the consumption of egg is rapidly increasing (FAO, 2007). Apart from consumption, eggs are valuable raw materials for the pharmaceutical and cosmetic industries due to their multifunctional properties like foaming, gelling, and emulsifying (Matt, Veromann & Luik, 2009). It was similarly reported that quality of egg is highly dependent on the interior and exterior characteristics reflected both in the shell quality and size.

Egg handling and storage practices have significant impact on the quality of eggs reaching consumers. Eggs produced in farms could have good quality (more than 75 Haugh units) but because of poor handling and storage conditions in farms and markets there could be significant losses in quality. Improper storage is reported to produce some changes such as reduction in the viscosity of the albumen, enlargement of yolk and enlargement of the air cell (Nadia, 2012).

1.2 PROBLEM STATEMENT

Egg gluts occur from time to time, during which many poultry farmers may incur enormous economic losses including those attributable to spoilage of unsold eggs. Similarly, eggs also spoil in homes due to inability to refrigerate the eggs as a result of electricity failure which is

common in Nigeria (Buba, Dafwang, Olugbemi, Spoola, Tunji & Okofor, 2013). Deterioration in egg quality is attributed to moisture loss and a decline in interior quality during extended storage (Wong *et al.*, 1996). The shelf life of shell eggs, during which they are of good quality and safe to consume, is a function of carbon dioxide content (Keener *et al.*, 2001). Factors associated with decline in quality are storage time, temperature, humidity and handling (Samli, Agna & Senkoylu, 2005).

Poor quality of shell, albumen and yolk result in egg deterioration. Maintaining egg quality from producer to consumer is one of the major problems facing those engaged in marketing eggs. Proper attention to production, distribution and point of sale phases are of vital importance in maintaining egg quality. Temperature, humidity, storage method and storage time can have adverse effects on interior egg quality (Samli, Agna & Senkoylu, 2005).

Egg production is on the increase in Nigeria and poor storage conditions results in quality deterioration and consequently waste of eggs. Moreover, the economic success of a laying flock depends on the number of quality eggs produced. Egg quality comprises a number of aspects related to the shell, albumen and yolk and may be divided into external and internal quality (Raji, *et al.*, 2009). Eggs are highly susceptible to the growth of microorganisms which may cause poisoning (Mohammed *et al.*, 2013).

Egg deteriorates in internal quality with time and this depends on the shell condition and internal contents of the egg. Poor storage condition of the eggs may result in egg deterioration and loss of egg value or quality (Adeogun & Amole, 2004). Since the storage environment influence egg value, some methods like lower temperature and modified atmosphere packaging such as refrigeration have been recommended (Chang & Chen, 2000).

All foods have limited shelf lives which vary on the type of food and storage conditions. Egg deteriorates rapidly between the period of storage and consumption. Egg quality can be affected by the environmental conditions such as temperature, relative humidity of the storage as well as gaseous environment and storage time. Storage can modify some characteristics of eggs including loss of water, carbon dioxide and subsequent increase in the pH of the albumen (Ducuyperre, 2001). Cold storage is one of the methods widely adopted in the preservation of eggs from different species globally (Adegun & Amole, 2004).

Egg is also an ideal source of nutrients for proliferation of both spoilage and pathogenic contaminating microorganisms. The rate of spoilage of egg depends on nutrient availability, temperature, storage and handling (Al-Bahry *et al.*, 2014). Eggs can be contaminated with microorganisms such as bacteria and fungi. These microorganisms can evade the defense mechanism of eggs and penetrate inside, thus increasing the risk of food-borne illnesses or product spoilage (Osei, Otsyina, Arthur, Nortey, & Hammond, 2003). Microbial contamination of egg has significant impact on the poultry industry.

1.3 JUSTIFICATION FOR THE STUDY

Chicken eggs are the most common for both domestic and commercialized uses. Chicken eggs are available and consumed almost everywhere and therefore production increases rapidly due to high demand by consumers (Ducuyperre, 2001). In the tropics eggs deteriorate very rapidly and this make producers to store them at lower temperature so as to maintain quality. The degree of deterioration may vary depending on the storage method and duration (FAO, 2007).

Since Nigeria is a country with huge population of about 160 million(NPC, 2009) and the population is continuously on the rise, there is high demand for animal protein sources in all parts of the country. Egg is among the cheapest and highly affordable animal protein source

(Kuramvel, *et al.*, 2012). Egg is a very perishable food product, which could lose its quality rapidly during the period between laying and consumption. Egg provides unique and well balanced sources of protein which contain all the essential amino acids in sufficient amounts and proportions to maintain life and support growth even when used as a sole source of food protein (Ricketts, 1981).

Appropriate storage method for eggs is very important to preserve its quality. Poor storage condition can reduce egg grade within a few days. The value of egg is determined by standards based on the interior and exterior characteristics of individual eggs to reflect both the quality and size of the eggs (Jones & Musgrove 2005). Refrigeration and freezing of egg and egg products are widely practiced. However, these methods are expensive and require constant electric power supply, hence are often not suitable in developing countries, particularly in rural areas (Samli, Agna & Senkoylu, 2005). Egg spoils in homes due to inability to refrigerate the eggs as a result of electricity failure which is common in Nigeria. Deterioration in egg quality is attributed to moisture loss and a decline in interior quality during extended period of storage (Wong *et al.*, 1996).

To retard the deteriorative changes in the internal qualities of eggs, various storage methods are employed and shell treatments such as coating with vegetable and mineral oils, water glass and lime sealing have been suggested. Oil coating of the shell has been documented as a method of preserving quality and is an accepted practice. In coating, the shell pores are sealed reducing evaporation and carbon dioxide escape, thus much of the original carbon dioxide is retained and albumen pH increases less rapidly. (Obanu & Mpieri, 1984). However, the storage of eggs under good condition maintains its internal quality up to 28 days (Samli, Agna & Senkoylu 2005).

There is marked increase in poultry production in Nigeria as a result of the steady and substantial income actualized from its production particularly in layer production as eggs are obtained almost every day under proper management (FAO, 2003). This increase in productivity necessitates the need to effectively store and preserve poultry eggs. Eggs spoil in homes due to improper storage leading to deterioration in egg quality both physically and chemically (FAO, 2003). Observed changes include watery albumen, enlargement and flattening of egg yolk and air cells and absorption of off-flavours and odours (Mohammed, 2011; Scott & Silversides, 2001). This study aims at identifying a suitable storage method that will significantly reduce the rate at which biological and physico-chemical changes occur within the egg.

1.4 OBJECTIVES OF THE STUDY

The broad objective of the study is to determine the effects indigenous storage media and duration on egg quality parameters of Lohmann Brown chicken eggs. The specific objectives were:

- i. To determine the effect of indigenous storage media and duration on chemical properties of eggs.
- ii. To examine the effect of indigenous storage media and duration on egg quality parameters such as haugh unit, yolk index, yolk height and weight, albumen height and weight.
- iii. To assess microbiological quality of chicken eggs as affected by indigenous storage media and duration.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 ORIGIN AND DOMESTICATION OF CHICKEN

The origin of domestic chickens (*Gallus gallus domesticus*) has been debated ever since the time of Darwin (Darwin, 1988). Archeological remains of domestic chickens were found in 16 Neolithic sites along the Yellow River in Northeast China as well as in the Indus Valley because some of these remains date back to 8,000 years ago (West & Zhou, 1988) domestication must have been undertaken at least since that time.

It is suggested that domestic chickens originated from jungle fowls in Southeast Asia. Four species of genus *Gallus* inhabit Southeast Asia: red jungle fowl (*Gallus gallus gallus*), La Fayette's jungle fowl (*G. lafayettei*), gray jungle fowl (*G. sonnerati*), and green jungle fowl (*G. varius*). Red jungle fowl has a strong sexual dimorphism with males having red fleshy wattles, and it is most widely distributed over the area. La Fayette's jungle fowl morphologically resembles red jungle fowl, but it inhabits only in Sri Lanka. Gray jungle fowl has body plumage on a gray background color and is distributed from southwest to central India. (Liu, Yao, Miao & Luikart, 2006).

Morphologically distinct green jungle fowl is limited to Java and its immediate vicinity, Bali and Lombok. It has been debated whether any single species of the four, especially red jungle fowl, predominantly contributed to the genome of domestic chickens (a single-origin hypothesis) or whether multiple species of the four made a substantial genetic contribution to domestic chickens (a multiple-origin hypothesis). Poultry, particularly chickens are very important and were recognized as important genetic resource among the avian species (Oluwofeso, 2005). Genetic evidence confirms that chickens are derived from multiple origins in

Asia (Liu *et al.*, 2006). Chickens are the most widely distributed of all livestock species in Nigeria with a population of 180 million birds (NVRI, 2015). Chickens play very significant socio-cultural and economic roles in most African societies. Quantifying the structure of genetic diversity in different African chicken populations is of significance in optimizing conservation and utilization strategies.

2.2 IMPORTANCE OF EGG

Eggs are a major source of dietary cholesterol, but they are not high in saturated fat or calories. They can easily be included in a diet that meets current dietary guidelines for the prevention of heart disease (Song & kerver, 2000). There is no longer any specific limit on the number of eggs or egg yolks that can be eaten each week, but the recommendation to limit dietary cholesterol intake to an average of 300 mg/day still stands (Appelegate, 2000). Eggs are a highly nutritious food. They are an excellent source of high-quality protein and are far less expensive than most other animal-protein foods. Eggs also provide significant amounts of several vitamins and minerals (Song & kerver, 2000). Both the white and yolk of an egg are rich in nutrients - proteins, vitamins and minerals with the yolk also containing cholesterol, fat soluble vitamins and essential fatty acid.

Eggs are among the highest quality human foods. Eggs have been making substantial contribution in reducing the protein insufficiency in many African countries (MAFF, 2006). Egg is a complete protein with excellent quality; one egg will give 6g of protein. Egg white protein has a biological value of 100g, the highest biological value of any single protein (FAO, 2005). Eggs have a number of uses apart from domestic consumption in households. They are used in confectionary (Tijani *et al.*, 2006), bakery products (Ali & Mudassar, 2012), Ice cream and cosmetics (Mine & Kovacs-Nolan, 2004). Animal products such as egg protein are of high

biological value (Jay & Michael, 2004). Eggs are amongst the most nutritious foods. Eggs are rated with milk as the best protein foods rich in iron and vitamins (Oluyemi & Roberts, 2000).

There is scientific evidence that eggs contain other biologically active compounds that may have a role in the therapy and prevention of chronic and infectious diseases. The presence of compounds with antimicrobial, immunomodulator of antioxidant, anti-cancer or anti-hypertensive properties has been reported in eggs (Abeyrathne, Lee, & Ahn, 2013). Lysozyme, ovomucoid, ovalbumin and cystatin are biologically active proteins in egg albumen, and their activity prolongs the shelf life of table eggs (Rakonjac *et al.*, 2014). In addition, lecithin increases the secretion of bile, preventing stagnation in the bladder and, consequently, decreases the lithogenicity (Herron & Fernandez, 2004).

Another important nutritional component found in eggs is phosvitin, a phosphoglycoprotein present in egg yolk and represents about 7% of yolk proteins. It has a specific amino-acid composition, comprising of 50% serine, 90% of which are phosphorylated. This specific structure makes phosvitin a strong metal chelator and, by this mechanism it acts as an important melanogenesis inhibitor to control excessive melanin synthesis in the melanocytes of animal and human skin (Jung, Kim, Son, Nam, & Dong, 2012).

2.3 STRUCTURE OF THE EGG

The egg is a complex entity having four main parts; these are the shell, shell membranes albumen and yolk. The dry matter of a chicken's egg contains approximately 64% albumen, 27% yolk, 9% chalazae and 0.75% shell membrane (Rose, 1997).

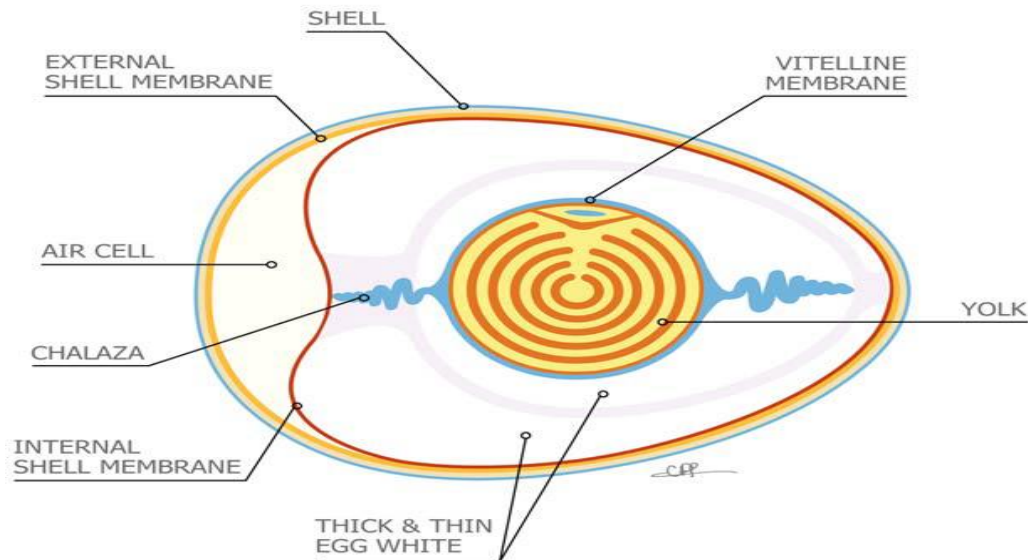


Fig 1: Anatomical Structure of an Egg. (Mine, 2000)

2.3.1 The Egg Shell

The egg has an outer hard covering referred to as the shell. This accounts for about 11% of the total egg weight. It functions as a physical barrier to protect the contents of the egg, and also mediates gaseous exchange of the developing embryo through small pores present throughout the shell (Oluyemi & Roberts, 1992). The shell is also covered with a waxy cuticle which partially blocks the pores to prevent excessive evaporation of moisture from the egg and also physically blocks the entrance of microorganisms into the egg. The cuticle is bacteriostatic in nature (Juliet, 2004). The cuticle is the outermost part of the shell and aside its bacteriostatic nature, it also gives the egg its characteristic bloom or shine (MAFF, 2006). Shell colour comes from pigment in the outer layer of the shell. The shell colour is primarily a breed characteristic, although there is often a difference among individual hens even when all are of the same breed and variety (Jacob *et al.*, 2000). In general, chicken breeds with white ear lobes lay white eggs, while breeds with red ear lobes lay brown eggs. The local chicken has both white and brown eggers (Pousga, Boly & Ogle, 2005). Egg shell texture can be assessed as either rough or smooth

(Ikeobi *et al.*, 1996). An egg shell that is smooth is preferred, since rough shelled eggs fracture more easily and have poor appearance (Jacob *et al.*, 2000).

Some eggs may have rough, pimples appearance. The pimples which are calcium deposit cause the shell to be distorted in appearance, this defect may be partly hereditary. Shell texture deteriorates as the bird gets older. Mineral content of diet also plays a vital role in determining the egg texture. High phosphorous and low calcium levels in the diet causes ridging and distortion of the shell (Jacob *et al.*, 2000).

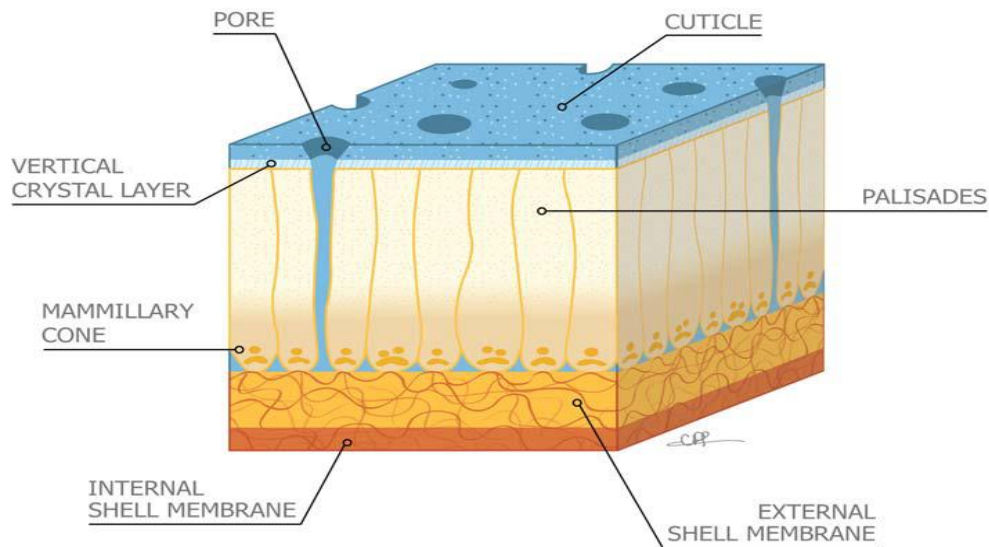


Fig 2.A Cross Section of Egg Shell (Jacob, 2000).

2.3.2 Shell Membrane

Within the shell there is inner and outer membrane that protect the quality of egg both the membrane are porous and composed of fibre. The outer membrane which is thicker (48 μm) than the inner membrane of (22 μm) is firmly attached to the shell, the membrane has six layers while inner membrane is attached to one place usually at the broad end of the egg (Peerzano, 2015). The egg contain little or no air cell when they are laid, after being laid because of the lower

temperature of the outer membrane of the egg than when it was in the hens body, there is contraction inner contents of the egg, this result in air being drawn in to the shell resulting in a small air cell formation between the shell membrane usually at broad end of the egg. The condition of shell and shell membrane influence the moisture and carbon dioxide, breaking strength and susceptibility to microbial inversion (Ukoba & Augustine, 2007).

2.3.3 The Egg White (Albumen)

The albumen surrounds the yolk and act as a shock absorber (Rose, 1997). It is rich in protein and vitamins and contains substances that protect the egg from microorganisms which may have entered through the shell. In a freshly laid, good quality egg, alternating layers of thick and thin albumen are clearly visible. The innermost layer of thick albumen (the chalaziferous layer) is extended at two opposite points, forming the white, fibrous chalazae which are anchored in the outer thick albumen. The structure of the albumen is designed to provide support and protection to the yolk, holding it centrally inside the egg (MAFF, 2006). Different species of poultry and strains within species all have their characteristic egg weight (Rose, 1997).

Egg weight is determined by the breed or strain, the age of the hen, body weight, and composition of the feed (particularly the energy and crude protein content), the ambient temperature and lighting schedule (Ketelars & Saxena, 1992). Eggs are graded according to shell colour and texture, size, shape, cleanliness and freedom from cracks and other defects (Aduku, 1993). The chief constituents of egg white besides water are proteins: The egg albumen is made up of four structures namely:

Chalazae: The *chalazae* are two spiral bands of tissue that suspend the yolk in the center of the white (the albumen) and form about 3% of egg white. The function of the *chalazae* is to hold the

yolk in place, (USDA, 2000). *Chalazae* layer covers the egg yolk and has a thickness of 40 μm . It is therefore in close contact with the vitelline membrane of the yolk.

Inner thin layer: This surrounds the chalazae and makes up about 17% of the albumen (USDA, 2000)

Thick layer: This is an envelope that surrounds the inner thin white layer and the yolk. It is attached to the shell membrane at each end of the egg and constitutes about 57% of the egg albumen (USDA, 2000)

The outer thin layer: This is found just inside the shell membrane. It constitutes about 23% of the albumen (USDA, 2000)

Table 1: Major Proteins in Egg white (Albumen)

Protein	Amount%
Ovalbumin	54
Canalbumin	12
Ovomucoid	11
Lysozyme	3.4
Ovo inhibitor	3.5
Ovo flavor protein	1.4

Source: Mine, (2000).

Ovalbumin

This constitutes of 54% of the protein of egg white. This is phosphor glycoprotein and is composed of three components A_1 , A_2 , and A_3 , which differ only in phosphorus content. The most abundant and central protein to egg white's functional properties in food is ovalbumin. Ovalbumin has a molecular weight of 44.5 Kilodalton (kcal) and is monomeric phosphoglycoprotein with a known complete amino acid sequence of 385 residue (Doi &

Kitabatake, 1997). It is a storage protein and major source of amino acid for the developing embryo (Mine & Yang, 2008). Ovalbumin is a heterogeneous molecule with variation in its composition, which include the degree of phosphorylation, glycosylation and genetic variance. S-ovalbumin is found naturally in egg white and contributes to ovalbumin heterogeneity. It is an alternative form of ovalbumin with greater heat stability and is known as “stable” ovalbumin.

The presence of S-ovalbumin is confirmed by the difference in denaturation temperature of 92.5°C compared to 84.0°C for ovalbumin. Other properties of S-ovalbumin such as molecular weight, sulfhydryl content, crystal formation and electrophoretic separation are indistinguishable from ovalbumin. S-ovalbumin has also been found to have increased surface hydrophobicity (Kilara & Harwalker, 1996). The mechanism for conversion of ovalbumin to S-ovalbumin has not been confirmed but may be a result of deamination or partial reactive loop insertion (Huntington & Stein, 2003). The crystal structure of S-ovalbumin has been determined and shows no difference in secondary structure with ovalbumin.

Ovatransferrin (Canalbumin)

This constitutes about 12% of protein in egg albumin. It consists of two forms neither of which contains phosphorus nor sulphur. It has a molecular weight of 77.7 kDa and is a glycoprotein consisting of 686 amino acid residues (Mine, 1995). Ovatransferrin is a member of iron binding protein group known as transferrins. Its iron-binding activity, $K_D=10^{-29}$ M, is thought to be responsible for the antimicrobial properties of protein. The metal-binding action helps to stabilize the protein raising the denaturation temperature from 61°C to around 72°C when iron is bound (Kilara & Harwalker, 1996).

Ovomucoid

It is a glycoprotein. This constitutes about 10% of the egg white proteins. Ovomuroid is a glycoprotein with a molecular weight of 28.0 kDa. About 25% of the protein has its carbohydrates attached via Aspartate (Asp) residues. Ovomuroid is a well known trypsin inhibitor. Ovomuroid is very stable due to its multiple disulfide bridges and is physicochemically unchanged under acidic conditions at 100°C for long period of time (Kilara & Harwalker, 1996). However, with extreme heat, trypsin inhibitory activity and immunoactivity with some antibodies is lost due to the reduction and alkylation of disulfide bonds (Nakamura & Doi, 2000).

Ovomucin

Ovomucin is a viscous glycoprotein that composes 1.5-3.5% of protein in egg white. Its molecular weight ranges between 5.5 to 5.8 x 10³kDa (Mine, 1995). Ovomucin is insoluble in water unless in the presence of salt or at >pH 9 (Nakurama & Doi, 2000). Ovomucin is an inhibitor of virus hemagglutination and is an important determinant for egg quality (Kilara & Harwalker, 1996) as the thinning of egg white is thought to be caused by disassociation of α -ovomucin from soluble ovomucin (Nakurama & Doi, 2000).

Lysozyme

The lysozyme contents of egg white are about 3.4%. This is an enzyme capable of lysing or dissolving the cell wall of bacteria. It is composed of 3 components A, B and C. It binds biotin and makes the vitamin unavailable. Lysozyme was the first protein to be sequenced and is one of the most studied egg white protein. It is a small protein consisting of 129 amino acids with a molecular weight of 14.3 kDa (Lesnierowski & Kijowski, 2007).

Lysozymes are group of enzymes with antimicrobial function. The reduction of more than 2 of the disulfide bonds results in a loss of bioactivity (Lesnierowski & Kijowski, 2007). However, reduction in disulfide linkages significantly improves functional properties including

gelation and foaming (Doi & Kitabate, 1997). Along with its role in interaction with other proteins during foaming and gelation, lysozyme may play a role in thinning of egg white during storage through electrostatic interaction with ovomucin (Mine, 1995).

2.3.4. The Egg Yolk

The yolk is the yellowish spherical structure enveloped in the albumen (Jones, 2005). The yolk is easily identified by its bright, yellow color both when cooked and raw. It is spherical, although when the egg is broken out raw it tends to flatten out (Oluyemi & Roberts, 1992). The yolk consists of fats, vitamins and minerals together with about half of the egg's total protein content. A transparent barrier called the vitalline membrane surrounds the yolk and prevents the yolk content leaking into the albumen. On the surface of the yolk, under the vitalline membrane is the germ cell (or germinal disc), which is the site of cell division if the egg is fertile (MAFF, 2006). Furthermore the colour of the yolk varies and this is influenced by the laying hen diet but the colour of the yolk has no connection with food value. The egg yolk comprises of 48% water, 16-17% protein, 32.5%, and 2.0% for fat, minerals respectively while the egg white consist of 88% water, 10-11% protein and 0.8% minerals, fat in the egg white is negligible 0.1-0.2% compared with the amount present in egg yolk. Refer to table 4. The gross composition of the egg quality involves functional, aesthetic and microbiological properties of the egg yolk and albumen. The proportions of components for fresh egg are 32% yolk, 58% albumen and 10% shell (Leeson, 2006).

Table 2: Gross Composition (%) of an Egg

Part	Percentage %
Albumen	58
Yolk	32
Shell	10

Source: Leeson, (2006).

Table 3: Chemical Composition (%) of Egg White and Egg yolk

Nutrients	Egg white	Egg yolk
Water	88.0	48.0
Protein	11.0	17.5
Fat	0.2	32.5
Minerals	0.8	2.0

Source: Li-chan *et al.* (2012)

2.4 EGG QUALITY CHARACTERISTICS

Egg equality is a term that explains the standards which defines both the internal and external characteristics of the egg. The external quality of egg encompasses thickness, texture, shape, colour and cleanliness of the shell. The internal quality focuses on size of air cell, yolk shape, yolk height, albumen viscosity, strength and blastoderm diameter (De Ketelaere *et al.*, 2004). Egg quality is the sum total of the characteristics of an egg which appeal to the consumer. Measurement of these characteristics is a prerequisite for their improvement through research. Some important egg quality characteristics include colour of shell, shell porosity, shell strength, albumen conditions, yolk shape and colour, flavour, cleanliness, presence of meat and blood spots (Rose, 1997). The quality of an egg is influenced by many factors which can be divided into two broad categories; those that come into play before the egg is laid and those that take effect thereafter (Oluyemi & Roberts, 1992).

Mertens (2009) has reported that external quality of an egg may be assessed by size, shape, shell colour and texture, cleanliness and uniformity of eggs within a given sample.

2.5 METHODS OF EGG QUALITY DETERMINATION

The quality of egg can be determine through the following methods

- i. Internal method of egg quality determination.
- ii. External method of egg quality determination.

2.5.1 Internal Egg Quality Properties

Internal egg quality entails structural properties, and microbial population of the egg yolk and albumen. The proportions of components for fresh eggs are 32% yolk, 58% albumen and 10% shell (Leeson, 2006)

Egg yolk from a freshly laid egg is round and firm. As the egg stay longer, the yolk absorbs water from the egg white, increasing its size; this stretches and weakens. The vitelline membrane makes the yolk flatter. As soon as the egg is laid, its internal quality starts to decrease: the longer the storage time, the more the internal quality deteriorates. In a newly laid egg, the albumen pH lies between 7.6 and 8.5. During storage, the albumen pH increases. After 2 days of storage Jin *et al.* (2011) found an increase in albumen pH regardless of the storage temperature. Li-Chan *et al.* (1995) observed that when carbon dioxide (CO₂) loss was prevented by the oiling of the shell, the albumen pH of 8.3 did not change over a 7-day period of storage at 22 °C. In oiled eggs stored at 7 °C, albumen pH dropped from 8.3 to 8.1 in seven days (Li-Chan *et al.*, 1995).

Increase in albumen pH is due to CO₂ loss through the shell pores, and depend on dissolved CO₂, bicarbonate ions, carbonate ions and protein equilibrium. Bicarbonate and carbonate ion concentration is affected by the partial CO₂ pressure in the external environment. In freshly laid eggs, the yolk pH is in general is close to 6.0; however, during storage it gradually increases to reach 6.4 to 6.9. Egg quality preservation throughout the period of storage, handling

and distribution is dependent on constant care from all personnel involved in these activities. The quality of the egg once it is laid cannot be improved, so efforts to maintain its quality must start right at the time it was laid (Scott & Silversides, 2000).

The decrease in internal egg quality once the egg is laid is largely due to the loss of water and CO₂. In consequence, the egg pH is altered, resulting in watery albumen due to changes in the thick albumen protein structure. The cloudy appearance of the albumen with age is also due to the loss in CO₂ (Jin *et al.*, 2011).

Yolk colour

Although, yolk colour is a key factor in any consumer survey relating to egg quality consumer preferences for yolk colour are highly subjective and vary widely from country to country (Okeudo *et al.*, 2003). It is possible to manipulate the yolk colour of eggs by the addition of natural or synthetic xanthophyll to layer hen feeds. This ability to readily manipulate egg yolk colour can be an advantage in meeting market demands. However, the ease with which yolk colour can be manipulated can lead to unwanted colour changes. For example, the inclusion of higher than recommended levels or incorrect ratios of pigments can lead to orange-red yolks (Okeudo *et al.*, 2003).

Yolk firmness

The yolk of a freshly laid egg is round and firm (Lee, 2000). However, as the egg ages and the vitelline membrane degenerates, water from the albumen moves into the yolk and gives the yolk a flattened shape.

Yolk texture

Rubbery yolks may be caused by severe chilling or freezing of intact eggs, the consumption of crude cottonseed cake or the seeds of some weeds (Jacob *et al.*, 2000).

Albumen consistency

Albumen quality is measured in terms of Haugh units (HU) calculated from the height of the albumen and the weight of the egg (Haugh, 1993). Normal albumen is transparent, with a slightly yellow green colour. Cyclo-propene fatty acids from cottonseed meal and the certain weed seeds (Sell *et al.*, 1986) may cause albumen to turn pink after storage. Green whites are caused by excesses of riboflavin (vitamin B2) in the diet. Cloudy whites may be caused by the oiling of eggs within 6 hours of lay (Sell *et al.*, 1986).

2.5.2 External Egg Quality Properties

External quality characteristics of an egg are basically those of the eggshell. A good quality shell must be without cracks, clean, smooth with uniform colour, shape and size. Kouszek *et al.* (2009) reported that, eggs with dark colour eggshells stored for a period of 0 to 10 days, in comparison with their light colour counterparts were characterized by higher numbers of blastodermal cells already on the day of laying. One factor associated with the egg shell quality is the thickness of the egg shell. It is an important trait which affects egg quality. According to Khan *et al.* (2004), shell thickness and thinness has effect external egg quality. The number of pores concentrated on a shell also affects gaseous exchange of the embryo. Too much or less pores on the shell can be detrimental to the development of embryo (Narushin & Romanov, 2002).

Egg Size and egg weight

Body weight appeared to be the main factor influencing early egg size. There is general and direct relationship between body size of birds and the size and weight of eggs laid. Birds with large body size lay large eggs and vice-versa (Singh *et al.* 1992).

Dietary protein increase and methionine level had little or no effect on egg size and weight for the first 12 weeks of production, linoleic acid levels also fail to show any influence on egg size during the same period (Summer & Leeson, 1990). Egg size and weight are also influenced by age and season of laying (Sing *et al.*, 1992).

Egg shape

There are great variations in shape of avian eggs. Eggs laid by chicken may be similar however not identical. Some eggs are truly oval; others may be spherical or elongated or equally pointed on either side (Rose, 1997). Breed factors are generally responsible for the diversities in the shape of normal eggs. Shape can also be influenced by diseases. The normal poultry egg is elliptical in shape (Jacob *et al.*, 2000). Thin, miss shaped, rough, ridged or soft shelled eggs could be caused by constantly high temperatures, low calcium intake, sulfa drugs, respiratory disease (e.g. Newcastle), bronchitis and high salt (NaCl) content in feed, fright and poisonous drugs (Beyer, 2005).

Egg shell colour

Egg shell colour often has economic importance as there are local prejudices in favor or against certain traits. It may be white, yellow or different shades of brown in eggs of domestic chickens (Singh *et al.*, 1993). The colour of the egg is determined by genetic factor. Egg shell colour has no effect on internal egg quality involving structural properties, and microbial population of the egg yolk and albumen. The proportions of components for eggs are 32% yolk, 58% albumen and 10% shell (Leeson, 2006).

2.6 FACTORS AFFECTING EGG QUALITY

Egg quality is one of the most important factor which would consider, Egg quality is the sum total characteristics of an egg which appeal to the consumer, The quality of an egg can be influenced by storage, age of the hen, nutrition, strain, disease, heat stress and contamination

2.6.1 Age of the Hen

Haugh unit (HU) this will decrease with increasing bird age, with HU decreasing by around 1.5 to 2 units (Awosanya *et al.*, 1998) for each month in lay. Doyon *et al.* (1986) stated that HU decreases at a fairly constant rate of 0.0458 units per day of lay as the hen ages. The author further noted that under ideal situation, HU should be on an average of 74 HU by 78 weeks of age, the egg size increase with the increasing of hen age.

2.6.2 Storage Time and Temperature

As the egg stay longer, carbon dioxide (CO₂) is lost through the shell, the contents of the egg becomes more alkaline, causing the albumen to become transparent and increasingly watery (Okeudo *et al.*, 2003). At higher temperatures, loss of CO₂ is faster and the albumen quality deteriorates faster. Decreasing shed temperatures in the hotter months, combined with regular collection of eggs will help to reduce deterioration of the albumen before collection.

Eggs stored at ambient temperatures and humidity lower than 70% will lose 10-15 HU in a few days from point of lay. By 35 days, these eggs will lose up to 30 HU (Okeudo *et al.*, 2003). Storage of eggs at temperatures of 7-13°C and a humidity of 50-60% may reduce the rate of degeneration of thick albumen proteins and, consequently, egg albumen quality will be maintained for longer (Jones, 2006). Oiling of eggs could also help to reduce CO₂ losses and thus help maintain internal egg quality (Okeudo, *et al.*, 2003) but is not a substitute for cool storage.

Kirunda and Mckee (2000). Stated that as the internal temperature of egg increase above 7⁰C, the protein structure of the thick albumen and vitalline membrane break faster.

2.6.3 Nutrition and Water Quality

Egg shell contain up to 3g of calcium, therefore the diet of the hen must contain adequate calcium in a form that can be utilized efficiently (Nays, 1999). It was further stated that the provision of adequate dietary minerals and vitamins is essential for good egg shell quality; similarly the drinking water supplied to birds must be hygienic to ensure that disease is not transmitted by this route. The temperature of the water provide to laying hens is also important, especially during hot weather. Hens reduce water intake or may even cease to drink, if the water get too hot. Studies have shown that provision of cool drinking water can improve egg shell quality in heat stress hens (Balnavel, Yoselewitz & Dixon, 1987).

2.6.4 Heat Stress

The high temperature above 25⁰C results in smaller eggs and reduced shell quality via a number of physiological processes occurring within the bird (Hughes & Black, 1996). Heat stress reduced feed intake and limit the availability of calcium for egg shell formation, it also may reduced the activity of carbonic anhydrase, an enzymes which result in formation of bicarbonate which contribute to egg shell carbonate (Solomon, Hughes & Gilbert, 1987).

2.6.5 Egg Contamination

Poultry manure contains a variety of pathogens, some are host adapted and therefore not a health risk for humans. Others can produce infection in humans. The more common zoonotic pathogens in poultry manure includes; *Escherichia coli*, *Campylobacter*, *Salmonella*, *Cryptosporidium parvum*, and *Giardia lambia* (Kinde *et al.*, 1996). The egg products inspection Act of the early 1970s (USDA, 2000) essentially brought an end to egg associated *Salmonella*

infections, in humans at least for a short time. Intact shelled eggs were considered safe, essentially sterile food product until a study published by Louis *et al.* (1988) linked the increasing number of food borne *Salmonella enteridis* outbreaks.

The production of *Salmonella enteridis* contaminated eggs in an infected flock is sporadic and reported incidence is low (Kinde *et al.*, 1996). *Salmonella enteridis* remains the principal *Salmonella serovar* for egg contamination, but it is not the sole agent in this problem. *Salmonella heidelberg* have also been implicated in egg borne human *Salmonella* outbreaks and must be considered in overall problem, Phage typing and plasmid profiles of the environmental isolates were identical to those recovered from the hen (Hennesy *et al.*, 2004). This indicates that the environmental *Salmonella enteridis* originated from the birds (Mutallib *et al.*, 1992) and demonstrated that although only a proportion of the birds may be infected at any time, the bird's continual excretion of pathogens will progressively increase the pathogen levels in the surrounding environment (Mutallib *et al.*, 1992). This statement was made based on the findings of Kinde *et al.* (1996).

Mutallib *et al.* (1992) reported that some routine monitoring for *Salmonella* was carried out in breeding flocks, bacteriological techniques based on sample taken from individual birds and pooling samples had shown low sensitivity compared with indirect environmental monitoring.

Bacterial contamination

Solomon (1999) suggested that while pores on the surface of the egg do represent possible ports of entry for bacteria, particularly as the cuticle hardens just after oviposition, these are of secondary importance to the structural defects that may occur. Structural defects, because of their magnitude, offer a much more likely route for bacteria to enter the egg contents. Bacterial and fungal contamination of eggs usually results in black, red or green rot. The egg looks and smells putrid when broken out of the shell.

Bacterial and fungal contamination of eggs, resulting from faecal contamination of the egg, can be prevented by good management practices, including regular replacement of nesting materials or good cage maintenance as appropriate (Bacterial contamination of the egg contents may also occur as a result of an infection in the oviduct of the hen and any affected hens should be culled (Etuk *et al*, 2005).

Proper handling and storage of eggs following collection will minimize the opportunity for bacterial or fungal contamination. However, improper washing procedures, high storage temperatures and humidity will increase the incidence of bacterial or fungal contamination (Etuk *et al.*, 2005). Careful attention should be paid to feed source, as *Salmonella* sp. can be transmitted through the feed.

Roundworms in eggs

Burley and Vadehra, (1989) reported that where roundworm infestation of the intestinal tract occurs, worms may migrate from the cloaca into the oviduct and become enclosed in the egg. This can be prevented by good flock management.

Off odours/flavours

Although, off odours and flavours are rare if eggs are stored correctly (Okoli & Udedibie, 2000), eggs readily absorb strong odours or flavours. Storage of eggs in close proximity to fish oils and meals, sour milk, strongly scented or decaying fruit and vegetables, mould, disinfectants and kerosene is likely to result in the development of off odours or flavours (Okeudo *et al.*, 2003). However, eggs that have been oiled are less likely to absorb foreign odours. Old eggs and eggs stored at **high temperatures** are more likely to exhibit off odours or flavours (Okoli & Udedibie, 2000). Other causes of off odours or flavours include strongly flavoured feed ingredients such as fish meal or fish oil, some vegetables (including onions, turnips and excessive amounts of cabbage) and rapeseed or canola.

2.6.6 Diseases of the Laying Hens

The main disease of laying hens that have been reported to affect albumen quality is infectious bronchitis which may cause a decrease in quality and more variable albumen quality (Nays, 1995). Infectious bronchitis impairs the synthesis of albumen protein in the magnum of the oviduct and associated with histological changes in the epithelium of the magnum (Butler, Curtis, Pearson & McDougall, 1972). Diseases such as Newcastle disease may also cause a decrease in albumen consistency (Jacob *et al.*, 2000). The diseases that can affect egg quality are as follows:

Newcastle diseases

This is a viral infection that can result in a mortality rate of 100 % in chickens. It also leads to a drop in egg production and quality. Newcastle disease virus was found to decrease the albumen score, weight of eggs and increase mortality (Butcher & Miles, 2003).

Infectious brochities

This is a rapidly-spreading viral infection of chicken characterized by respiratory signs. It also causes drop in egg production (up to 50 %) and egg quality. Egg shells are deformed, infectious bronchitis produce watery albumen, and this condition may persist for long periods after the disease outbreak has been controlled (Butcher, 2003). Every portion of the reproductive tract can be affected, a decline in egg shell quality occurs when the uterus is affected. This decline is reflected as poor egg specific gravity caused by a decline in shell thickness, and misshapen eggs caused by degeneration and distortion of the shell gland cells (Butcher, 2003).

Mycotoxin

Aflatoxin B₁ and cyclopiazonic acid are the most common mycotoxins affecting eggshell quality, a clear positive correlation between aflatoxin B₁ and cyclopiazonic acid contamination of feed and poor shell quality. Dietary aflatoxin B₁ causes reduction in eggshell weight of laying

hens (Zaghini *et al.*, 2005). Furthermore a reduction in the eggshell weight of laying hens exposed to 2.5 mg/kg of dietary aflatoxin B₁.

2.7 NUTRITIVE VALUE OF EGG

Eggs are valuable source of food used throughout the world to feed the ever growing world population. Eggs are source of nutrients such as protein, lipid, and minerals. The yolk is particularly rich in nutrients. Yolk supplies approximately 50% of the protein in the egg and nearly all the fat (Singh *et al.*, 1992).The egg has long been known for its exceptional nutritional value. It consists of a porous carbonate shell. The yolk makes up 1/3 of the egg and contains most of the vitamins including A, D, E, K and B-complex vitamins.

The yolk also contains most of the lipids about 3/4 and is a good source of antioxidant carotenoids. In contrast, egg white contains over half of the egg proteins and is a source of the vitamin riboflavin (Mine, 2002). Egg whites contains very low amount of lipids (0.01%) as reported by Mine (1995).This make egg white a healthy sources of food. Eggs contain considerable quantity of minerals and vitamins with exception of vitamin C (AEB, 1999). Eggs are also excellent source of choline, folate and selenium, nutrients which are required for normal development of the brain (Herron & Fernandez, 2004).

The egg white and the egg yolk contribute essential nutrients to the human body. An average large egg contributes 6.25 g of high-quality protein based on 10-12% of the Daily Reference value for protein. One egg also contributes around 200 milligrams of cholesterol (Ali & Mudassar, 2012), which nearly meet the dietary cholesterol intake limit as established by the American Heart Association at ≤ 300 mg/d (AEB, 1999).

2.7.1 Protein Value of the Egg.

Egg protein is of high quality and easily digestible. The levels of amino acids are similar to the balance of amino acid needed by humans. The fat within egg is emulsified and highly digestible (Rose, 1997). Eggs contain high levels of unsaturated fatty acids although this may be affected by the diet of the birds (Oluyemi & Roberts, 1992). The mineral compositions of the edible parts of eggs are relatively high. Eggs are particularly rich in iron and phosphorous. Diets of the laying birds can also alter the mineral composition of eggs (MAFF, 2006). The average egg provides approximately 647 kilojoules of energy, of which 80% comes from the yolk (USDA, 2000). Consumption of one egg daily will contribute to an average of 3% of the energy requirement of an adult (FAO, 2007). Egg has significant amount of protein, vitamins and minerals with relatively low saturated fat content. Egg has very low energy density (FAO, 2007).

2.7.2 Protein Content of the Egg

Eggs are important sources of protein as they rank consistently high in protein compared to other sources of protein such as beef and cow milk (Lyman & Rodriguez, 2009). About 12.6% of edible portion of egg is protein and is found in the yolk and albumen. According to Praba and Karan (2009), egg contains 12-14% proteins which are well balance with respect to essential amino acid; egg protein has an excellent value over all other plant protein foods. The average egg provides approximately 647 kilojoules of energy, of which 80% comes from the yolk (USDA, 2000).

2.7.3 Vitamins in Egg

Eggs are an important vehicle to complement the essential vitamin supply to the human population. Eggs contains all vitamins except vitamin C, they are particularly rich in the fat soluble vitamins i.e. Vitamin A, D, E and K (Rose, 1997).

2.7.4 Mineral Content of the Egg

Eggs are a good source of iron and phosphorus and also supply calcium, copper, iodine, magnesium, potassium, sodium, zinc, chloride and sulphur. All these minerals are present as organic chelates and are highly bioavailable (USDA, 2000).

2.7.5 Fat Content of the Egg

About 11.2% of an egg is fat. The fat of an egg is found almost entirely in the yolk as there is less than 0.05% in the albumen. Approximately 17% of an egg's fatty acids are polyunsaturated, 44% monounsaturated and 32% saturated (Royal, 2002). Fat is one of the richest sources of lecithin, a phospholipid which forms a part of the structure of every cell wall in the body besides contributing to energy, it is a source of essential fatty acids (FAO, 2007).

Table 3: Nutritional Value of Egg /100g

Nutrient/Unit	Amount
Energy kcal	173.0
Protein (g)	13.3
Fat (g)	13.3
Calcium (mg)	60.0
Phosphorus (mg)	220.0
Iron (mg)	2.1
Carotene	600
Thiamin (mg)	0.1
Riboflavin (mg)	0.4
Niacin (mg)	0.1
Folic acid (ug)	78.3
Vitamin B ₁₂	0.2

2.8 EVALUATION OF EGG QUALITY

Quality of egg is very important for marketing and hatchability. Eggs are normally sorted by packing plants based on their quality. Eggs with dirt, cracks, meat spots and blood spots are not classified as quality eggs. However, classification or sorting of eggs is subjective to human error. There are two main methods to determine egg quality which includes destructive and non-destructive methods (Nesheim, *et al.*, 1979)

The deformation, also known as non - destructive which can be defined as the amount an eggshell bends or deflects under an applied force, can be used to estimate the force required to fracture the eggshell (Hamilton, 1982) and measures a structural property of the egg while destructive method It is based on the relationship between the weight of the whole egg and its albumen height when the egg is broken out. Fresh egg has its yolk centrally placed,

2.8.1 Destructive Method

The Haugh Unit is the most widely used method and the most accepted method of determining albumen quality. It is based on the relationship between the weight of the whole egg and its albumen height when the egg is broken out. Fresh egg has its yolk centrally placed, surrounded by thick albumen when the egg is broken out onto a flat surface. However, egg stored for long period of time may have the yolk displaced at one side with thin albumen surrounding the yolk. This results in a decrease in albumen height which causes the Haugh unit to decrease (Kemps *et al.*, 2006).

2.8.2 Non-Destructive Methods

The most common nondestructive method used to determine egg quality is candling. This is a simple and fast way of assessing egg quality. Candling devices ranges from simple unit to

more sophisticated unit. However, whether simple or sophisticated, the principle technique of candling is to pass a white light through the egg. This is more accurate when the candling is done in the darkroom. During candling the yolk of a freshly laid egg is seen as a faint shadow. As the storage period increases and albumen quality decreases causing the yolk to be closer to the shell, the shadow of the yolk appears darker. Darker shadow can also result when the yolk enlarges or when the vitelline membrane becomes weak (Jacob *et al.*, 2000).

External appearance is not an accurate indication of what is to be found inside the shell, and it is therefore customary to make use of candling in order to measure internal quality (Nesheim *et al.*, 1979). The characteristics used in measuring quality during candling are appearance of the shell, air cell, yolk, albumen and germ (Rose, 1997). Eggs that have thin, porous or cracked shells could easily be detected. The air space or air cell is usually at the large end of the egg and can be plainly seen when the egg is candled (Singh *et al.*, 1992). The air cell develops between the two membranes that line the shell and increase in size according to the amount of moisture lost from the egg.

A motile air cell that moves freely to any part of the egg indicates staleness and damaged shell membrane, probably resulting from rough handling (Oluyemi & Roberts, 1992). In an egg of lower quality the yolk moves more freely and casts a darker shadow because it floats nearer to the shell (Abdel-nour, 2008). Most of the differences in appearance have been observed to be due to changes in the white or albumen rather than change in the yolk.

2.8.3Yolk Colour

Although yolk colour is a key factor in any consumer survey relating to egg quality consumer preferences for yolk colour are highly subjective and vary widely from country to country (Okeudo *et al.*, 2003). The primary determinant of yolk colour is the xanthophyll (plant

pigment) content of the diet consumed (Silversides *et al.*, 2006). It is possible to manipulate the yolk colour of eggs by the addition of natural or synthetic xanthophylls to layer hen feeds. This ability to readily manipulate egg yolk colour can be an advantage in meeting market demands. However, the ease with which yolk colour can be manipulated can lead to unwanted colour changes. For example, the inclusion of higher than recommended levels or incorrect ratios of pigments can lead to orange-red yolks (Silversides *et al.*, 2006).

2.8.4 Yolk Firmness

Yolk of a freshly laid egg is round and firm (Okoli & Udedibie, 2000). However, as the egg ages and the vitelline membrane degenerates, water from the albumen moves into the yolk and gives the yolk a flattened shape.

2.8.5 Yolk Texture

Rubbery yolks may be caused by severe chilling or freezing of intact eggs, the consumption of crude cottonseed oil or the seeds of some weeds (Jacob *et al.*, 2000).

2.8.6 Albumen Consistency

Albumen quality is measured in terms of Haugh units (HU) calculated from the height of the albumen and the weight of the egg (Haugh, 1993). A minimum HU score for eggs reaching the consumer is 60. However, most eggs leaving the farm should be between 75 and 85 HU (Zaman *et al.*, 2005).

2.9 PRESERVATION OF EGGS

Liquid eggs are normally frozen and held in this form until used. Liquid eggs are shipped in bulk to drying and processing plants in refrigerated trucks (Nesheim *et al.*, 1979). Eggs may

also be prepared and kept dry. The evaporation process usually involves the use of high pressure steam at 250-350°F in which 60-65% moisture content of the egg escapes (Nesheim *et al.*, 1979).

2.9.1 The Water Glass Method

Water glass (sodium silicate) has been used for the home preservation of eggs for many years. The usual recommendations have been to make a 10% solution by using 1/4 of commercial water glass to boiled water. It was suggested that the solution be placed in an earthenware crock and that only clean, sound fresh eggs be used for preservation. It was further suggested that the crock be kept covered and that it be stored in as cool a place as possible (Benerjee, 2001). This method safely stored eggs as long as six months, when eggs are surplus, carefully select only clean, sound. Sodium silicate is formed over the shell and their pores are completely closed.

2.9.2 The Lime Water Method

Slaked lime is calcium hydroxide, an inorganic compound with the chemical formula $\text{Ca}(\text{OH})_2$. It is obtained when calcium oxide (called lime or quicklime) is mixed, or “slaked” with water. It has many names including, caustic lime, builders’ lime, slack lime, cal, or pickling lime. Calcium hydroxide is used in many applications, including food preparation. Limewater is the common name for a saturated solution of calcium hydroxide (Benerjee, 2001). According to FAO (2005), eggs can be preserved for nearly six months. Limewater has also been discovered to be an effective egg preservation method (Keener *et al.*, 2001). Eggs preservation using limewater involves the following steps:

1. To prepare limewater for preservation of egg, dissolve 1 pound of salt and 1 quart of finely slake lime in 3 gallons of water, stir solution at frequent interval for a day and then allow the liquid to settle.

2. Place the eggs in crock or keg with their pointed end turned down, fill the receptacles to within a few inches of the top
3. Pour the clear limewater over the eggs so arranged, allowing it to rise an inch or two above the top layer
4. Then stand the vessel in a cool place where the temperature will not exceed 50 degree Fahrenheit.
5. Eggs so treated could be kept for at least 6 or 8 months.
6. The only objection to this method is that, the egg preserved by it sometimes a slight lime taste.(Warren & Scott, 1990)

2.9.3 Oiling or Shell Coating Method

Eggs are dipped in warm oil generally in coconut oil or groundnut oil. Oiling should be made as soon as possible after the eggs are laid. In this way the pores of the shell are sealed or blocked which prevent carbon dioxide loss, thus maintaining good internal egg quality and prevent weight loss of egg, especially where eggs are in cool storage for several months or are held at temperature of 21⁰C (FAO, 2005). If eggs are to be stored at temperature of 0⁰C they should be oiled 18 – 24 hours after laid. Eggs can be oiled by hand dipping wire basket. The temperature of oil should be at least 11⁰C (Benerjee, 2001). Oiling has also been reported as an effective method in egg preservation (Semih & Yasar, 2004). The coating method of the egg shell with oil was first used by Dutch farmers as early as 1807, and it was reported that coating the egg with mineral oil greatly improved its shelf-life (Lee, 2000). Raji *et al.* (2009) suggested that coating the eggs several hours after lying is most effective.

Oiling slowed down the decline of Haugh units and increase in albumen pH in eggs stored at 28⁰C and 12⁰C (Jin *et al.*, 2011). Oil coating checks the loss of moisture and carbon

dioxide during storage and minimizes the risk of uptake of odour and penetration of microorganisms and also inhibits mould growth.

2.9.4 Thermostabilisation

According to Ashagidibi and Sulaiman (2011) eggs may be thermostabilised by immersing the shell eggs for 15minutes in water at 54.4⁰C (130⁰F) or 60⁰C (140⁰F) for 3-5minutes in water and kept stirred. This process kills bacteria on the egg shell (pasteurization) and kills the embryo (defertilises egg).

Commercial preservation of eggs

This is the method of preserving eggs in large quantity. The eggs are distributed in the form of whole sale to both retailers and consumers.

2.9.5 Cold storage (5 – 8 months)

The temperature of eggs storage room should be maintained at +0.5⁰C to -0.5⁰C (31 - 33⁰F) being the temperature usually preferred. A relative humidity of 75 – 95% is necessary; too much humidity favors the formation of mould (Praba & karam, 2009). Chilling using a refrigerator or cooling in clay pots is one of the most common methods of preservation of eggs. Eggs should be cooled as promptly as possible after production and held at a temperature and a relative humidity that depends upon the anticipated duration of storage (Keener *et al.*, 2005).

2.9.6 Frozen eggs

Freezing of internal egg contents is now a method of preservation of eggs, especially in developed countries. The eggs are candled and when they are broken out, the smell and appearance of the contents are noted for any possible defect. The yolk and albumen may freeze separately with addition of 5% glycerin (Praba & karam, 2009).

2.9.7 Dried eggs

Egg drying is now largely practiced in place of freezing. Although the process is more expensive but there is considerable saving in transport and less need for cold storage. The egg content are dried at a temperature of 160⁰F and stored under 50⁰F to convert white, yolk or whole egg into fine powder. The whole egg is of use for bakery products, the yolk for flour and albumen for confectionary (Praba & karam, 2009).

2.9.8 Pasteurization of eggs

Pasteurization of eggs is a process which is intended to destroy harmful microorganisms, specifically *Salmonella enteritidis* that may be present on or in the egg (USDA, 2000). Pasteurization is done by immersing eggs in hot water. The optimum time and temperature is 62.5°C for 2 minutes (Singh *et al.*, 1992). The keeping quality of thick albumen has been found to improve with heat treatment of between 60-65°C, egg yolk 65-70°C and beaten whole egg 68°C for 5 minutes.

2.10 EGG HANDLING

On farm eggs should be collected regularly and kept in cool and ventilated stores. Dirty eggs (as a result of litter or collection) should be cleaned with abrasive materials in preference to washing. If it is necessary to wash, the water temperature should be 38 to 43°C and changed every few minutes. Washed eggs should not be stored for a very long time because as eggs ages it loses carbon dioxide and moisture through the shell pores and the cuticle covering the shell is washed away which prevents escape, this cause the air cell within the egg to become large. With these losses of carbon dioxide, the egg pH becomes more basic and structural changes takes place in the albumen which leads to the thinning of the albumen (Oluyemi&Roberts, 1992).

2.11 CLEANING OF EGGS

Dirty eggs are covered with bacteria that will cause spoilage if they penetrate the egg shell (Singh *et al.*, 1993). Dirty eggs could be dry cleaned easily with the help of cloth or fine sand paper which may be used to scratch out dirty spots or stains (Semih &Yassar, 2004). Wet washing of dirty eggs may also be carried out, and is the most effective and simplest way to provide shell eggs with the appearance preferred by consumers (Oluyemi & Roberts, 1992). Most eggs are clean when they are laid but could become contaminated with manure or other foreign materials. Egg with manure or adhering material is unattractive in appearance and may cause the egg to be downgraded (Jacob *et al.*, 2000). Every effort should be made to produce clean eggs by maintaining a high standard of management (Thear, 1990).

2.12 EGG QUALITY CONTROL

Quality control involved the segregation of eggs with obvious defects. The major technique used in subsequent quality tests on the rest of the eggs is candling. In this process, all eggs are passed over a bright light which shows up internal defects and previously undetected cracked or weak shells. The internal defects often detectable by candling include blood and meat spots, enlarged air cells and very thin whites (MAFF, 2006).

The application of the knowledge of the manufacturing, marketing and distribution of products (egg) with the optimum quality is referred to as quality control (QC). It assures product conformity, wholesomeness, reliability and quality assurance. Quality assurance itself is a design, a plan established in order to ensure that quality, as defined, is maintained within specific limits (MAFF, 2006).

How to control egg quality

Samples of eggs are also taken to assess egg freshness and yolk colour. These eggs are broken out onto a level surface and the height of the thick albumen is measured with a micrometer. From this measurement and the weight, the Haugh unit value of an egg can be calculated. The fresher the egg, the higher its Haugh unit value (USDA, 2000).Yolk colour is checked against a required colour standard, the DSM Yolk Colour Fan (formerly known as the Roche Yolk Colour Fan).

2.13 EGG GRADING

Grading is a form of quality control used to categorize a variable commodity or product into a number of classes. The United States Department of Agriculture (USDA) standards for quality of individual shell eggs were developed on the basis of both interior and exterior quality factors. Commercially, eggs are graded simultaneously for exterior and interior quality (USDA, 2000).

Eggs which do not meet certain minimum requirements may only be sold for human consumption if they have been pasteurized (or undergone an equivalent process) and meet specific microbiological criteria. Grading systems for shell eggs may vary from country to country or region to region, however, regardless of the grading or classification system used, shell egg quality and interior quality are important factors in determining egg quality (Chukwuka *et al.*, 2011).

The United States Department of Agriculture USDA (2000) has developed a system which has three grades of eggs based on the interior quality of the egg, the appearance and condition of the egg shell. The USDA egg grading specifications are Grade AA eggs have whites that are thick and firm; yolks that are high, round, and practically free from defects, clean, and shells that are free of cracks. Grade AA and Grade A eggs are best for frying and poaching

where appearance is important, and for any other purpose. Grade A eggs have characteristics of Grade AA eggs except that the whites are "reasonably" firm. This is the quality most often found in stores. Grade B eggs have whites that may be thinner and yolks that may be wider and flatter than eggs of higher grades. The shells must be without cracks, but may show slight stains. This quality is seldom found in retail stores because they are usually used to make liquid, frozen, and dried egg products.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 STUDY AREA

The experiment was conducted at the Teaching and Research Laboratory of the Department of Animal Science, Faculty of Agriculture, Bayero University Kano. Microbiological study was conducted at the microbiology laboratory, Infectious Disease Hospital (IDH) Kano. Kano is located in the semi-arid zone of Nigeria (latitude $9^{\circ} 12' 3''$ N and longitude $8^{\circ} 30'$ to $9^{\circ} 42'$ E). The area is characterized by tropical wet (May - September) and dry season (October - April) (Olofin, 2007). Mean annual rainfall ranges between 888.6mm- 960mm while temperature vary from 21°C and 46°C humidity ranges between 20 to 40 % (dry season) and 60 to 80% (wet season) KNARDA (2006). The State has a total land area of 42,592.8 square km, with a population of 9,383,682 people (NPC, 2006). The pattern of animal rearing in the study area includes keeping of both ruminant and non-ruminant animals. Poultry are commonly kept at small, medium and large scale levels. The consumption of egg increases especially during the cold season of the year and egg gluts occur mostly during hot season when egg spoilage also increased. Eggs are normally sold raw to consumers.

3.2 EGG COLLECTION

A total of two hundred (200) freshly laid Table eggs by Lohmann Brown hens were procured and used for the experiment. The eggs were purchased from the Poultry Unit of the Centre for Dry Land Agriculture (CDA), Faculty of Agriculture Bayero University, Kano.

3.3 EXPERIMENTAL DESIGN

The experiment was laid in 5x4 factorial arrangements of a completely randomized design (CRD) comprising five (5) storage methods and four (4) storage duration 7, 14, 21 and 28 days. The treatments were replicated 4 times.

3.4 EXPERIMENTAL TREATMENTS

A total of two hundred eggs (200) were stored in five storage media. Each contained 40 eggs.

The storage methods were:

- i. Crate storage (control): Eggs was leveled placed on the disposable egg crates and left at normal room temperature.
- ii. Earthen pot storage: Eggs was leveled and arranged inside the earth pot, covered and left at normal room temperature.
- iii. Jute bag storage: Eggs was leveled and placed inside the jute bag, with its mouth tied and stored at room temperature.
- iv. Basket storage: Eggs was leveled and arranged inside the woven basket and covered and left at normal room temperature.
- v. Calabash storage: Eggs was leveled arrange inside the calabash, covered left at normal room temperature.

3.5 EXPERIMENTAL PROCEDURE

Fresh eggs laid by Lohmann Brown chickens were used for the experiment. A total of four eggs were taken at random from each storage method to determine the external and internal quality parameters, after taken the egg length and egg diameter. Eggs were broken on a flat transparent glass (Petri-dish) to assess the internal quality parameters such as yolk height, albumen height, yolk index, yolk diameter all were determined using digital Vanier caliper.

Haugh unit was also calculated at duration of 7, 14, 21 and 28 days respectively. The experiment was conducted during (March - April), 2018. (March, 36.9⁰C- 19⁰C and April, 38.2⁰C- 23.6⁰C) The relative humidity is March, 11% and April, 14%.

3.5.1 Determination of Proximate Composition.

The AOAC (2012) procedure was used to determine the chemical properties of eggs as affected by different storage methods. The crude protein was determined using Kjeldahl method. The fat content was determined using reflux soxhlet method. The ash content was determined by igniting 2 g of sample in a furnace. The moisture content of the sample was determined by Oven drying.

3.5.2 Determination of Minerals.

Two 2gram from each egg sample were taken to the soil Science laboratory Bayero university Kano, for minerals analysis after Oven drying. The minerals determined were calcium, (Ca), magnesium (Mg), Copper (Cu), Iron (Fe), Zinc (Zn) and Phosporous (P) using Atomic Absorption Spectrophotometer and Potasium (K) using Flame Photometer.

3.5.3Determination of Microbial Load.

Samples were analyzed for Total Viable Count (TVC), Total Coliform Count (TCC) and Total Staphylococcal Count (TSC), using Nutrient, Mackonky and Manitol agars which were prepared as described by the manufacturer. The reagents used were Lactose broth, peptone water and 0.85% normal saline.

Procedure

- i. Eight test tubes were arranged on a tube rack and leveled,
- ii. 9mls of peptone water was dispensed in each of the test tube

- iii. 1ml of the egg sample homogenate was aseptically added to the first test tube which resulted in a dilution of 1:10
- iv. From the first dilution 1ml of egg sample was transferred to the second dilution tube containing 9mls of peptone water which resulted in 1:100
- v. This was repeated using the third, fourth to eight tube making 1:1000, 1:10000, 1:100000, 1:1000000, 1:10000000 dilution respectively.
- vi. Counting of colonies. Following inoculation, all colonies on petri dishes containing 30 – 300 colonies were counted and recorded using formula bellow:

$$N = \frac{\sum C \times \text{Dilution factor}}{\text{Volume inoculation}}$$

Where N = actual number of colonies

$\sum C$ = Sum of colonies counted

If plates from all dilution have no colonies, the result is expressed as less than 1×10^1 cfu/g and interpreted as no growth detected.

The internal egg quality parameters were measured from each indigenous storage media and duration as follows:

- i. Yolk diameter (mm): this was measured as the widest horizontal circumference of the egg with a digital vernier caliper.
- ii. Yolk height (mm): this was measured by immersing Tip of digital varnier caliper to the highest point of the yolk.
- iii. Albumen height (mm): this was measured by immersing tip of digital caliper to the highest point of the albumen.
- iv. Egg weight loss: This was calculated as the difference between initial egg weight and the weight of egg after storage: Total weight loss (g) = Initial weight – Final weight

- v. Yolk index: this was calculated by dividing yolk height by its diameter as prescribed by (Stadelman, 1986).

$$YI = \frac{\text{yolk height}}{\text{yolk diameter}}$$

- vi. Haugh unit: this was determined by using the formula proposed by Haugh (1937).

$$HU = 100 \log (H + 7.5 - 1.7W^{0.37})$$

Where:

HU=Haugh unit

H=height of albumen (mm)

W=egg weight (grams)

The external quality parameters of the eggs were determined as follows.

- i. Egg diameter (mm).this was measured along the equatorial axis of the egg using digital vanner caliper to the nearest 0.01mm.
- ii. . Egg length (mm).This was measured along the longitudinal axis of the egg using digital Vanier caliper to the nearest 0.01mm.
- iii. . Shell weight (g): this was determined after emptying the egg contents then the shell was allowed to dry for 24hours before taken the weight using electronic weighing scale to the nearest 0.01g.

3.6 DATA ANALYSIS.

The data obtained from chemical analysis, internal and external egg quality parameter assessment from each storage method and duration were subjected to analysis of variance (ANOVA), using SPSS (2007). Significantly different means was separated using least significant different (LSD) at 5% levels of probability.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 RESULTS

4.1.1 Chemical Properties

Effects of storage duration on chemical properties of Lohmann Brown chicken eggs

The effect of storage duration on Lohmann Brown egg on chemical properties is presented on Table 1. The duration of storage had significant ($P < 0.05$) effect in all parameters examined except ash. The maximum duration of storage (28 days) significantly ($P < 0.05$) affected fat content. However, the first (7 days) of storage was found to have significant ($P < 0.05$) influence on moisture and crude protein. The value of moisture and crude protein recorded in this study indicates decrease as the duration of storage increased. There was no significant ($P > 0.05$) difference in the ash content of the egg.

Table 4: Effect of Storage Duration on Chemical Properties (%) of Lohmann Brown chicken Eggs

Parameters (%)	Storage Duration (days)		SE
	7	28	
Moisture	25.90 ^a	17.33 ^b	0.38
Crude Protein	16.01 ^a	15.31 ^b	0.49
Fat	9.02 ^b	10.05 ^a	0.23
Ash	1.12	1.06	0.06

^{a-b}Means in the same row with different superscripts differed significantly ($p < 0.05$), SE= standard error

Effect of indigenous storage media on chemical properties of Lohmann Brown chicken eggs

The effects of indigenous storage media on chemical properties of Lohmann Brown chicken eggs is presented in Table 2. The storage media had significant ($P < 0.05$) influence in all parameters examined except ash. The jute bag storage media significantly ($P < 0.05$) affected the moisture and crude protein. However, calabash storage media was significantly ($P < 0.05$)

influence fat content. Significant ($P<0.05$) difference was also observed in earthen pot storage media for crude protein.

Table 5: Effect of Indigenous Storage Media on Chemical Property (%) of Lohmann Brown Chicken Eggs

Storage Media Parameters (%)	Earthen pot	Basket	Calabash	Jute bag	Crate	SE
Moisture	22.61 ^b	22.01 ^c	20.57 ^b	23.56 ^a	21.57 ^d	0.60
Crude Protein	16.59 ^a	15.86 ^c	15.56 ^c	16.83 ^a	15.35 ^c	0.77
Ash	1.12	1.08	1.05	1.25	1.01	0.09
Fat	9.38 ^c	10.21 ^b	10.84 ^a	9.33 ^c	10.18 ^b	0.36

Means in the same row with different superscripts differed significantly ($p<0.05$), SE= standard error

Interaction effects of indigenous storage media and duration on chemical properties of Lohmann Brown eggs

The result of the interaction of indigenous storage media and duration are presented in Table 3 it was observed that the media and duration of storage had significant effects on the nutritional parameters examined with the exception of the ash content. The moisture content of the egg was found to decrease during the storage period. The moisture contents of eggs kept in calabash and jute bag were significantly ($P<0.05$) higher. The crude protein content of the experimental eggs did not show clear trend as a result of storing them in the indigenous media. The highest content of crude protein was observed in eggs stored in basket after 28 days. The crude protein contents of eggs kept in earthen pot, jute bag and crate were not significantly ($P>0.05$) affected by the duration of storage. The results further indicated that moisture content decrease with increase in storage duration.

Table 6: Interaction Effects of Indigenous Storage Media and Duration on Chemical Properties of Lohmann Brown Chicken Eggs

Media / Duration (days)	Nutritional Properties%			
	Moisture	Crude Protein	Ash	Fat
Seven days				
Earthen pot	25.42 ^b	17.88 ^b	1.20	9.68 ^c
Basket	25.59 ^b	15.63 ^d	1.01	9.86 ^c
Calabash	26.78 ^a	14.65 ^c	1.06	10.57 ^b
Jute bag	26.31 ^a	14.89 ^c	1.10	9.19 ^c
Egg crate	25.87 ^b	15.41 ^d	1.14	10.31 ^b
Twenty eight days				
Earthen pot	21.79 ^c	15.36 ^d	1.01	9.08 ^c
Basket	18.44 ^d	18.09 ^a	1.89	10.56 ^b
Calabash	18.36 ^d	16.47 ^c	1.01	11.10 ^a
Jute bag	14.80 ^e	15.16 ^d	1.06	9.46 ^c
Egg crate	18.27 ^d	15.30 ^d	1.13	10.04 ^b
SE	0.85	1.08	0.13	0.51

Means different superscripts in the same row are significantly different at (p<0.05)
SE= Standard error

4.1.2 Mineral Content

Effect of indigenous storage medium on minerals contents of Lohmann Brown chicken egg

The result of the analysis of the effect of indigenous storage media on the mineral composition of Lohmann Brown chicken eggs is shown in table 4. The K contents of the eggs kept in basket and jute bag were significantly (P>0.05) higher while those stored in earthen pot had the least value. Eggs kept in jute bag recorded significantly (P>0.05) higher levels of P, Cu and iron while those stored in earthen pot contained significant (P>0.05) levels of Ca and Zn. The Mg content of eggs kept in calabash was significantly (P>0.05) higher. The K, Mg and Fe contents of

eggs kept in earthen pot were significantly ($P>0.05$) lower. The lowest level of Ca was found in eggs kept in crate while those stored in calabash had the least content of P.

Table 7: Effects of Indigenous Storage Medium on Minerals Contents of Lohmann Brown Chicken Eggs

Parameters (mg/kg)	Storage Medium					SE
	Earthen Pot	Basket	Calabash	Jute Bag	Crate	
Potassium	16.19 ^c	18.21 ^a	17.32 ^b	18.81 ^a	17.32 ^b	1.61
Phosphorus	156.65 ^b	93.47 ^d	123.76 ^c	181.87 ^a	158.99 ^b	12.66
Calcium	366.73 ^a	211.13 ^d	333.07 ^b	261.13 ^c	127.80 ^e	84.40
Magnesium	31.01 ^c	41.33 ^a	41.66 ^a	27.33 ^d	39.66 ^b	6.37
Zinc	19.39 ^a	9.09 ^d	15.65 ^c	15.38 ^c	16.95 ^b	3.44
Copper	4.27 ^c	3.72 ^d	1.92 ^e	6.43 ^a	5.07 ^b	0.41
Iron	32.63 ^e	42.84 ^c	45.68 ^b	48.18 ^a	36.36 ^d	5.97

^{a-e}Means different superscripts in the same row are significantly different at ($P<0.05$)
SE= Standard error

4.1.3 Microbiological Properties of Lohmann Brown Chicken Eggs Under Different Storage Media and Duration.

Effect of indigenous storage media on microbial properties of Lohmann Brown chicken eggs stored for 7 days

Table 5 shows the effects of indigenous storage media on microbial properties of Lohmann Brown chicken eggs stored for 7 days. It was observed that, the total viable count was highest for eggs kept in earthen pot storage media, followed by basket and calabash respectively while the least value was observed in egg crate media. The total Staphylococcus count was highest for eggs stored in basket, earthen pot and calabash respectively. The lowest growth of TSC was observed for egg kept in jute bag and egg crate. The result further indicated decreasing trends with highest growth of total coliform count for eggs kept in earthen pot, basket, egg crate, jute bag, and calabash storage medium respectively.

Table 8: Microbial Properties of Lohmann Brown Chicken Eggs Stored in Indigenous Storage Media for 7 days

Parameters	StorageMedia				
	Earthen Pot	Basket	Calabash	Jute Bag	Crate
TVC cfu/g	4.0×10^4	3.3×10^4	2.1×10^4	5.3×10^3	3.4×10^3
TSC cfu/g	1.9×10^1	4.1×10^1	0.8×10^1	0.0×10^1	0.0×10^1
TCC cfu/g	5.0×10^2	4.0×10^1	1.3×10^1	2.5×10^1	2.5×10^1

TVC= Total Viable Count, TSC= Total Staphylococcus Count and TCC =Total Coliform Count.

Microbial properties of Lohmann Brown chicken eggs stored in indigenous storage media for 28 days

Table 6 present microbial properties of Lohmann Brown chicken eggs stored in indigenous storage media for 28 days. It was observed that the total viable count was highest for eggs kept in earthen pot, followed by calabash, basket and egg crate, the least value was observed from those kept in jute bag. The total staphylococcus count was highest for eggs kept in calabash and jute bag while the lowest staphylococcal contamination was observed in egg crate, basket and earthen pot respectively. The total coliform count was highest in egg crate, earthen pot, basket and jute bag while the least growth of TCC was observed in egg kept in the calabash

Table 9: Microbial Properties of Lohmann Brown Chicken Eggs Stored in Indigenous Storage Media for 28 days

Parameters	Earthen pot	Storage Media			
		Basket	Calabash	Jute bag	Egg Crate
TVC cfu/g	6.4×10^5	2.3×10^4	4.3×10^4	2.4×10^3	2.3×10^4
TSC cfu/g	0.6×10^1	1.4×10^1	1.9×10^2	1.6×10^2	2.0×10^1
TCC cfu/g	3.5×10^3	3.8×10^2	0.6×10^1	2.5×10^2	4.5×10^3

TVC= Total Viable Count, TSC= Total Staphylococcus Count and TCC= Total Coliform Count.

Effect of indigenous storage media and duration on the microbial properties of Lohmann Brown chicken eggs

Table 7 indicates the effects of indigenous storage media and duration on microbial properties of Lohmann Brown chicken eggs. The result revealed that total viable count increased with increase in storage duration for all the indigenous storage media. Similar pattern was observed for total staphylococcus count. The results also revealed an increase of total coliform count with the increase of storage duration for eggs kept in egg crate, calabash, basket and earthen pot while no increase was observed for egg kept in jute bag.

Table 10: Effects of Indigenous Storage Media and Duration on the Microbial Properties of Lohmann Brown Chicken Eggs

Parameters	Duration (days)	Storage Media				
		EC	A	B	C	D
TVC cfu/g	7	3.4x10 ³	4.0x10 ³	3.3x10 ⁴	2.1x10 ⁴	5.3x10 ³
	28	2.5x10 ⁴	6.4x10 ⁴	2.3x10 ⁵	4.3x10 ⁶	2.4x10 ⁵
TSC cfu/g	7	0.0x10 ¹	1.9x10 ¹	4.1x10 ¹	0.8x10 ²	0.0x10 ¹
	28	2.6x10 ²	0.6x10 ³	1.4x10 ²	1.9x10 ⁴	1.6x10 ³
TCC cfu/g	7	2.9x10 ¹	5.0x10 ²	4.0x10 ²	1.3x10 ¹	2.5x10 ¹
	28	4.5x10 ²	3.5x10 ³	3.8x10 ³	2.6x10 ³	2.5x10 ¹

A= Earthen pot, B= Basket C: Calabash D= Jute Bag EC= Egg Crate TVC= Total Viable Count, TSC= Total Staphylococcus Count and TCC= Total Coliform Count.

4.1.4 Egg Quality Parameters as Affected by Storage Media and Duration

Effect of storage duration on egg quality parameters

The effect of storage duration on Lohmann Brown egg quality parameters is presented in Table 8. The duration of storage had significant (P<0.05) impacts on the quality parameters examined except shell weight and egg diameter. The maximum duration of storage (28

days) significantly ($P < 0.05$) affected egg weight loss, yolk weight and yolk diameter. However, the first 7 days of storage duration was found to have significant ($P < 0.05$) influence on quality parameters of the eggs such as yolk height, albumen weight, albumen height, yolk index and Haugh unit. The value of Haugh unit, yolk index, albumen height, albumen weight and yolk height recorded in this study indicates decrease in the quality of the eggs as the duration of storage increased.

Table 11: Effect of Storage Duration on Lohmann Brown Egg Quality Parameters

Parameters	Duration (Days)				SE
	7	14	21	28	
Egg weight loss (g)	2.41 ^d	4.86 ^c	6.39 ^b	8.39 ^a	0.41
Shell weight (g)	4.83	4.90	4.22	4.90	0.14
Egg Diameter (mm)	42.40	42.97	42.41	42.80	0.30
Yolk Weight (g)	13.55 ^d	16.76 ^c	17.33 ^b	18.37 ^a	0.58
Yolk height (mm)	7.02 ^a	6.04 ^b	4.86 ^c	3.81 ^d	0.30
Albumen weight (g)	23.52 ^a	22.80 ^b	20.06 ^c	19.23 ^d	0.53
Albumen height (mm)	6.58 ^a	5.18 ^b	4.21 ^c	3.01 ^d	0.16
Yolk index (mm)	0.13 ^a	0.11 ^b	0.09 ^c	0.08 ^d	0.01
Yolk Diameter (mm)	55.79 ^d	57.99 ^c	58.30 ^b	62.29 ^a	2.93
Haugh unit %	68.25 ^a	63.35 ^b	57.11 ^c	53.01 ^d	0.31

Means different superscripts in the same row are significantly different at ($P < 0.05$) SE= Standard error

Effect of indigenous storage media on egg quality parameters.

The effect of indigenous storage media on quality parameters of Lohmann Brown chicken eggs is presented on Table 9. The earthen pot storage media significantly ($P < 0.05$) affected yolk

height, albumen height, yolk index and Haugh unit, the basket storage media significantly ($P<0.05$) influence the albumen weight, the jute bag storage media had significant ($P<0.05$) impact on yolk height and albumen weight, However egg crate storage media significantly ($P<0.05$) influence egg weight loss, yolk weight and yolk diameter.

Table 12: Effect of Indigenous Storage Media on Egg Quality Parameters

Parameters	Storage Methods					SE
	Earthen Pot	Basket	Calabash	Jute Bag	Crate	
Egg weight loss (g)	4.28 ^e	5.59 ^c	6.75 ^b	5.02 ^d	5.87 ^a	0.46
Egg length (mm)	53.87	53.89	54.19	54.54	54.80	0.61
Egg diameter (mm)	42.43	42.86	42.79	42.46	42.81	0.34
Yolk Weight (g)	14.67 ^e	15.96 ^c	16.95 ^b	15.00 ^d	15.18 ^a	0.65
Yolk height (mm)	6.09 ^a	5.14 ^c	5.91 ^d	6.08 ^a	3.91 ^b	0.34
Albumen weight (g)	24.72 ^c	25.52 ^a	24.10 ^d	25.19 ^a	24.98 ^b	0.59
Albumen height (m)	5.93 ^a	4.39 ^d	4.76 ^c	5.09 ^b	4.01 ^d	0.18
Yolk index (mm)	0.14 ^a	0.09 ^c	0.08 ^d	0.11 ^b	0.08 ^d	0.01
Shell weight (g)	4.76	4.96	4.73	4.69	4.44	0.15
Haugh unit %	58.63 ^b	54.75 ^c	51.85 ^d	62.96 ^a	50.13 ^e	0.35
Yolk diameter (mm)	48.07 ^e	52.37 ^d	67.07 ^b	57.97 ^c	68.62 ^a	3.27

^{a-e} Means different superscripts in the same row are significantly different at ($P<0.05$)
SE= Standard error

4.2 DISCUSSION

The effect of storage duration on Lohmann Brown egg on chemical properties in this study shows that. The duration of storage had significant ($P < 0.05$) effect in all parameters examined except ash. The result is in agreement with the finding of Dudusola (2009) who reported significant ($P < 0.05$) difference in moisture, crude protein and ether extract, also reported significant ($P < 0.05$) differences in ash content in quails egg, which disagree with the finding of the current study, this may be due to breed differences. Gradual decrease in moisture and crude protein reported by Dudusola (2009) is in line with the result of this study.

The effect of storage media on Lohmann Brown egg on chemical properties in this study shows that, the storage media had significant ($P < 0.05$) impact in all parameters examined except ash. The result is in agreement with the finding of Dudusola (2009) who reported that storage methods had significant ($P < 0.05$) influence on egg chemical composition. Refrigeration and oiling had highest values for moisture, crude protein and ether extract, therefore storage condition is chosen with regard of quality trait. Temperature, relative humidity and flow of air are considered as main factors of storage condition of eggs. The insignificant ($P > 0.05$) difference in ash content in this study disagree with the finding of Dudusola (2009) who reported significant ($P < 0.05$) difference in ash among the storage methods.

The effect of indigenous storage medium on minerals contents of Lohmann Brown chicken egg, the storage medium had significant ($P < 0.05$) impacts in all the parameters examined. The result of this study is in agreement with the finding of Eniola, Babatunde and Oyelami (2017) who reported significant ($P < 0.05$) differences in Ca and Fe between treatments. Calcium helps in the regulation of muscle contraction required by children, infants and fetuses for bones and teeth development. The recommended dietary allowance value of calcium is 600-1400mg/kg. The

result in this study for calcium is within the recommended daily allowances for all the storage methods. The values of calcium 366.73, 211.13, 333.07, 261.13, 127.80 for all the storage media were higher than the value of 38.2 reported for whole chicken egg. The enrichment of iron in eggs would provide and improving the nutritional status of people especially in risk of iron deficiency. The daily requirement of iron is 6 – 40 mg/kg, the result of this study for the eggs kept in earthen pot and egg crate storage media are within the range while the values for eggs kept in basket, calabash and jute bag were higher 48.18mg/kg, 45.68mg/kg and 42.84mg/kg respectively in decreasing trend.

The results of effect of indigenous storage media on microbial properties of Lohmann Brown chicken eggs stored for 7days indicate that the microbial load in the stored eggs for 7 days were within the range of 10^7 cfu/g as specified by the International Commission on Microbial Specification for Food (ICMSF, 1998). The result microbial properties of Lohmann Brown chicken eggs stored in indigenous storage media for 28days showed the highest value of microbial load in the earthen pot (6.4×10^5) which is within the normal range as specified by (ICMSF,1998). The result of this study is in agreements with the finding of (Abdullahi, 2010), who reported that warm, moist litter, poor condition in farms houses were reported to be the sources of microbial growth. The result in this study observed no growth of total staphylococcus count for eggs kept in earthen pot (0.6×10^1) and total colliform count for egg stored in calabash (0.6×10^1), the result in this study is in line with finding of Radkowski (2001) who reported that no yeast or mold were found in the internal egg contents in any samples. However the result of this study disagree with the report of (USDA, 2011) who reported that micro organism can be found inside the eggs, further more the results of this study disagree with report of (Ansa *et al.*,

2009), who reported that as egg stay longer their resistance reduce which enables micro organism to penetrate in to the egg contents.

The effect of indigenous storage media and duration on the microbial properties in Lohmann Brown chicken eggs.

The result revealed that the total viable count increase with increase of storage duration for all the storage media, the result of this study is in agreement with the findings of Ansah *et al*, (2009), who reported that as egg stay longer, their resistance reduce enabling organism to penetrate in to the egg contents. The result of this study is in line with finding of (Humphrey, 1994) who reported that microbial load of egg content depending on the temperature and length of storage.

The effect of storage duration on egg quality parameters

The results of storage duration on egg quality parameters shows that duration of storage had significant ($P < 0.05$) impacts on the quality parameters examined except egg length, egg diameter and shell weight. The results of this study is in line with the finding of Abiona *et al*. (2010) who reported no significant ($P > 0.05$) differences in egg length, egg diameter and shell weight. The significant ($P < 0.05$) differences in this study is in agreement with the findings of (Tabidi, 2011 & Raji *et al.*, 2009) who reported a decrease in albumen height, yolk height, yolk index and haugh unit with the increase in storage duration.

The effect of indigenous storage media on egg quality parameters of Lohmann Brown chicken eggs.

The storage media had significant ($P < 0.05$) influence on the quality parameters examined except shell weight, egg length and egg diameter. The result in this study is in line with the finding of Raji *et al*. (2009) who reported significant ($P < 0.05$) impacts on internal egg quality

trait. The decreases of Haugh unit, albumen height and yolk height in this study agreed with the finding of Buba and Dafwan (2013), who reported significant ($P<0.05$) decreased in Haugh unit, albumen height and yolk height in chicken egg among the storage methods. The observed egg weight loss in this study is in agreement with the finding of Dudusola (2009) who found significant ($P<0.05$) influence on egg weight loss among the storage methods in quails eggs. The increase of yolk index observed in this study is in line with the finding of Mohammed (2011) who reported significant ($P<0.05$) impacts on the eggs kept in refrigeration and room temperature.

CHAPTER FIVE

5.0 SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 SUMMARY

A study was carried out to determine the effects of indigenous storage media and duration on the quality parameters of Lohmann Brown chicken eggs. The experiment was laid in 4x5 factorial arrangements in a completely randomized design that involved 4 storage duration (7, 14, 21 and 28 days) and 5 storage media (earthen pot, basket, calabash, jute bag and egg crate). The storage duration and media had significant ($P<0.05$) effect in all chemical parameters examined except ash. The storage media had significant ($P<0.05$) impacts in minerals contents of the eggs assessed.

The result revealed that there was significant ($P<0.05$) differences in all the egg quality parameters considered except egg length, egg diameter and shell weight with respect to both the storage duration and storage media. The result of microbial quality assessment indicated that TVC was highest in earthen pot (4.0×10^4) and lowest in egg crate (3.0×10^3). The TSC and TVC were higher (4.1×10^1) and (5.0×10^2) in basket and earthen pot respectively. The lowest value recorded for TSC and TCC in basket and calabash (1.9×10^1 and 1.3×10^1). The results of the microbiological quality revealed increased in TVC, TSC and TCC as the storage duration increased. However, no increase was observed with respect to TCC for eggs stored inside jute bag. It was recommended that indigenous storage media especially jute bag can be used to store eggs up to 28 days in the absence of modern storage facilities.

5.2 CONCLUSION

Based on the results it was concluded that the quality of an egg is affected by storage media and duration.

5.3 RECOMMENDATIONS

1. It was recommended jute bag is the best storage material for chicken eggs within a period of 28 days.
2. Microbial loads were lower in eggs kept in jute bags.
3. Further studies should be carried out on the acceptability of indigenous storage media.

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