EFFECT OF POSITIONING AND DURATION OF STORAGE ON THE EGG QUALITY OF ISA BROWN CHICKENS

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CHAPTER ONE

1.0 Introduction

1.1 Background of the study

The chicken egg is a complex biological structure designed by nature to support reproduction and provide complete nutrition for the developing embryo (Jacob *et al.*, 2000). It stands as a vital source of animal protein, offering advantages over other sources due to its ease of digestion, transportation, storage, and marketing (Bayer, 2000). Eggs are highly digestible and supply essential nutrients necessary for the growth and maintenance of body tissues. According to Belitz *et al.* (2013), chicken eggs hold greater importance compared to eggs from other bird species, serving diverse roles both in the food industry and domestic consumption.

Egg quality encompasses multiple criteria defining both internal and external attributes. The external quality focuses on shell cleanliness, texture, and shape, while internal quality involves parameters such as the cleanliness and viscosity of the albumen, the size of the air cell, yolk shape, and yolk firmness (Silversides and Scott, 2001). Additionally, egg quality is made up of features that influence consumer acceptance (Song *et al.,* 2000; Dudusola, 2010). Consumers often base their confidence in egg products on the physical appearance of the egg, with diminished trust when quality falls below their expectations. Furthermore, egg quality significantly impacts pricing for both table eggs and hatching eggs (Altan *et al.,* 1998).

Egg quality is a critical attribute influencing both consumer satisfaction and economic value in the poultry industry. Among commercial layers, Isa Brown chickens are widely used for their high productivity and egg quality. However, egg quality deteriorates over time, particularly during storage, which is an inevitable practice in the supply chain from farm to consumer. Studies have documented that both the duration of storage and the positioning of eggs during storage affect critical quality parameters such as albumen height, yolk integrity, shell strength, and freshness (Scott and Silversides, 2000; Adeoye *et al.,* 2020).

Eggs stored for prolonged periods at ambient temperatures tend to lose moisture through the shell, resulting in increased albumen pH and a decline in the Haugh unit, which measures the protein quality of the egg (Adeoye *et al.,* 2020). This degradation diminishes the nutritional and market value of the eggs. Moreover, the positioning of eggs during storage has been shown to influence the air cell stability and internal damage, with broad end up positioning generally preserving better freshness compared to narrow end up orientation (Ibrahim *et al.,* 2020).

Isa Brown eggs, in particular, have demonstrated variability in albumen height and weight with storage, which requires optimized handling to reduce quality losses (Scott and Silversides, 2000). Understanding the combined effects of storage duration and egg positioning is therefore essential for maximizing the shelf life and quality of Isa Brown eggs, which are a fundamental protein source in many diets worldwide.

1.2 Justification of the Study

Eggs are a vital source of protein and nutrients in many diets worldwide, with Isa Brown chickens being a prolific layer breed contributing significantly to poultry production. Maintaining the quality of eggs from farm to consumer is essential for food safety, economic value, and nutritional benefits. However, egg quality tends to deteriorate during storage due to factors such as moisture loss, changes in albumen consistency, and yolk degradation, which are further influenced by how long eggs are stored and how they are positioned (Grashorn, 2020).

In commercial and small-scale poultry operations, eggs are often stored for variable durations under ambient conditions, making it necessary to understand how storage affects egg freshness and consumer acceptability. Moreover, egg positioning during storage whether broad end up or narrow end up has been shown to impact internal qualities such as air cell size and albumen integrity, which are critical to egg longevity and hatchability (de Lima *et al.,* 2012). Positioning eggs with the small end up reduces weight loss and maintains embryonic viability in fertilized eggs, highlighting the practical significance of storage orientation (de Lima *et al.,* 2012; Gogo *et al.,* 2021).

1.3 Objectives of the Study

The objectives of this study are to:

i. to determine the effect of egg positioning on internal and external egg quality parameters.

ii. assess the effect of egg positioning (broad end up versus narrow end up) in an open crate on the retention of internal and external quality traits during the storage period.

iii. evaluate the impact of storage duration on key quality parameters such as albumen height, yolk , shell thickness, and Haugh unit of Isa Brown chicken eggs stored at room temperature

iv. develop practical recommendations for producers and retailers on optimal storage conditions to preserve egg quality and reduce economic losses in Isa Brown egg supply chains.

CHAPTER TWO

2.0 Literature Review

2.1 Egg Quality in Poultry Production

Egg quality refers to all the traits that make eggs acceptable to consumers and suitable for processing. It includes both external qualities such as shell thickness, shape, cleanliness, and egg weight, as well as internal qualities like albumen height, yolk firmness, and overall freshness (Haugh, 1937; Raji *et al.,* 2014).

Egg freshness naturally begins to decline as soon as the egg is laid because of moisture and carbon dioxide escaping through the porous shell (Ashraf *et al.,* 2020). As freshness reduces, consumers and markets tend to reject the eggs, making quality preservation very important in poultry production.

2.2 Egg Quality Parameters and Measurement

Egg quality parameters are critical indicators used to evaluate the freshness, nutritional value, and consumer acceptability of eggs. These parameters are typically divided into external and internal quality traits and are commonly measured using standardized approaches in poultry science research.

Measurements are often performed using instruments like the Vernier calipers for internal assessments. Statistical analysis is commonly applied (e.g., ANOVA, GLM) to detect significant differences among treatment groups or storage conditions (Phitsane, 2006; Kumar *et al*., 2021; Dilawar *et al.,* 2021).

These egg quality traits are crucial for grading, pricing, hatchability, and consumer purchasing decisions, making their precise measurement essential for both research and commercial purposes.

2.2.1 External Quality Parameters

External egg quality parameters include egg weight, egg length, egg width, shell thickness, and shell weight. These can be measured using electronic scales and calipers to ensure accuracy (Kumar *et al.,* 2021; Moreki, 2005). For example, egg length and egg width are measured to determine the size and geometric characteristics of the egg (Phitsane, 2006). These characteristics are critical as they directly influence packaging, storage, and consumer preference (Stadelman, 2002). Shell thickness and strength are assessed to determine the egg's resistance to cracking during handling and storage (Dilawar *et al.,* 2021).

2.2.2 Internal Quality Parameters

Internal quality parameters focus on the albumen (egg white) and yolk characteristics, including albumen height, albumen index, yolk height, yolk index, yolk color, and the Haugh unit, which is a widely used measure combining albumen height and egg weight to assess protein quality and freshness. The Haugh unit decreases as storage time increases due to albumen thinning (Duman *et al.,* 2021; Kumar *et al.,* 2021). Biochemical analyses, such as yolk cholesterol, HDL, LDL, and triacylglycerol contents, are sometimes included for nutritional quality assessment (Kumar *et al.,* 2021).

Haugh Unit (HU)

The Haugh Unit is a critical metric for assessing albumen quality and overall egg freshness. Introduced by Haugh (1937), it is calculated using the formula:

$HU=100\times\log(h+1.7W^{0.37})$

where h is the albumen height in millimeters and w is the egg weight in grams. Higher Haugh scores indicate better albumen quality (>72) which are considered of superior quality (Silversides & Scott, 2001; Eisen, 1962).

Albumen pH and Height

Albumen height is a direct indicator of freshness; fresh eggs typically have heights around 6–8 mm. Over storage, albumen height decreases due to water evaporation and pH increase from around 7.6 initially to over 9.0 after prolonged storage, correlating with declining freshness and quality (Davis & Stephenson, 1991; Silva *et al.,* 2012).

Yolk Index (YI)

Yolk quality is assessed by the yolk index, which is the ratio of yolk height to yolk diameter typically around 0.4 to 0.5 in fresh eggs. A higher YI indicates a firm, fresh yolk while a decreasing YI signifies deterioration and aging (Adhikari *et al.,* 2022).

Measurement Techniques

Haugh Units are measured using a precision caliper for albumen height and a scale for egg weight, then calculated with the formula.

Yolk index is measured through calipers in the laboratory following eggs breaking, calculating the ratio of yolk height to diameter.

2.3 Factors Affecting Egg Quality

Several factors influence egg quality, including breed, nutrition, environmental conditions, and the age of the hen (Roberts, 2004). For instance, older ISA Brown hens produce larger eggs, but their shells are usually thinner and more prone to cracks (Abdulrahman, 2020). High temperature especially in the tropics also causes albumen breakdown and faster deterioration of freshness (Samli *et al.,* 2005).

Therefore, egg producers must pay attention to proper egg handling and post-lay storage to reduce quality loss (Ayorinde, 2011).

2.4 Influence of Storage Duration on Egg Quality

As storage time increases, a number of physical and chemical changes occur. Some of these changes include:

1. Increase in air cell size
2. Reduction in albumen height and Haugh unit
3. Flattening and weakening of the yolk structure
4. Gradual decline in weight due to evaporation

(Silversides & Scott, 2001; Tarongoy *et al.,* 2022)

Research has shown that leaving eggs at room temperature especially for more than two weeks can lead to significant deterioration in their interior quality (Okeudo *et al.,* 2021). Refrigeration slows down the changes but does not prevent them completely (Fawole *et al.,* 2016).

2.5 Effect of Temperature During Storage

Temperature plays a critical role in preserving egg freshness. In regions with high ambient temperatures such as tropical environments, eggs spoil faster when kept outside refrigeration because the shell allows moisture and gas to escape quicker (Olalekan, 2014).

On the other hand, refrigeration maintains albumen firmness and reduces microbial activity, helping the eggs keep their freshness for a longer period (Ayeni *et al.,* 2018). However, even under cold storage, the changes become noticeable after about 3–4 weeks (Azeem *et al.,* 2020).

2.6 Effect of Egg Positioning During Storage

Egg orientation also influences how quickly the internal quality reduces. Eggs are commonly stored:

1. Broad end up (air cell on top)
2. Narrow (pointed) end up

Egg positioning during storage has been identified as an important factor that affects internal egg quality deterioration over time. Eggs naturally contain an air cell located at the broad end, formed when the contents contract after laying. When stored broad end up, the air cell remains in its natural position, helping the yolk stay centered and delaying internal spoilage (Hassan *et al.,* 2019).

However, if eggs are stored narrow end up, especially in open crates under room temperature conditions, the yolk tends to float upwards and may come into closer contact with the inner shell membranes. This accelerates the breakdown of albumen quality, increases air cell expansion, and increases the risk of microbial penetration through the shell pores (Ayorinde & Egharevba, 2021; Bawa *et al.,* 2018).

Several studies have reported that eggs kept pointed end up lose quality faster due to enhanced moisture and carbon dioxide escape through the shell (Alabi *et al.,* 2022). The problem is more pronounced when stored in open crates and ambient tropical temperatures, where there is unrestricted air circulation and higher heat exposure (Okeudo *et al.,* 2021). Under such conditions, deterioration becomes visible within 7–14 days.

Therefore, based on reviewed findings, it is recommended that eggs be stored broad end up in open crates at room temperature to minimize early quality loss and maintain egg freshness for a longer period (Ayorinde, 2011; Hassan *et al.,* 2019).

2.7 Microbial Quality of Stored Eggs

As eggs age and internal membranes weaken, bacteria can easily penetrate the shell and invade the egg content (Adesokan, 2020). Storage orientation also affects microbial risk because yolk contact with shell membranes creates a favorable point of entry (Afolabi, 2022). Studies have confirmed that eggs stored too long under poor conditions have higher chances of contamination and spoilage (Mensah et al., 2021).

2.8 Economic and Consumer Implications

Consumers generally cannot detect quality deterioration from just looking at the shell, which means poorly stored eggs may still enter the market and reduce trust in egg products (Ekunseitan *et al.,* 2017). Once freshness is lost, the eggs decline in value, nutrition, and performance in cooking (Olawumi & Ogunlade, 2019). Therefore, maintaining egg quality benefits not only public health but also poultry business profitability.

CHAPTER THREE

3.0 Materials and Methods

3.1 Experimental Site and Duration of the Study

The research was conducted at the Main Laboratory of the Food Science and Nutrition, Faculty of Agriculture located on the Ugbowo Campus of the University of Benin, Ovia North East Local Government Area, Benin City, Edo State, Nigeria.

3.2 Experimental Period and Design

The experiment was carried out for five (5) weeks from August to September 2025, using Completely Randomized Design (CRD).

3.3 Experimental Materials

The key materials and equipment used include:

Materials

- 30 fresh ISA Brown eggs
- Plastic open crate
- Permanent marker (for coding)
- Clean collection trays
- Gloves and tissue paper

Equipment

- Digital weighing scale (0.01g sensitivity)
- Vernier caliper
- Sample recording sheets

All measuring equipment were checked for proper calibration prior to use to ensure accuracy and reliability of data.

3.4 Egg Collection and Selection Criteria

For this research 30 freshly laid ISA Brown eggs was purchased from the University of Benin farm project poultry farm on August 8th, 2025 (Week 0). To remove variability, eggs where selected:

- With intact shells
- Without cracks or deformities
- Similar in size and weight
- Fresh (≤24 hours after lay)

Each egg was gently cleaned with sterilized dry tissue to remove visible dirt without washing, since washing can damage the cuticle and lead to increased moisture loss and spoilage.

3.5 Experimental Layout and Treatments

The eggs were randomly divided into two treatments with 15 eggs:

Treatment Code	Positioning	Description
BEU	Broad End Up	Air cell at top (recommended storage method)
NEU	Narrow End Up	Air cell downward (irregular storage method)

Table 1

Eggs were stored in an open plastic crate at room temperature to simulate traditional household storage practices in Nigeria

3.6 Storage Duration and Observation Schedule

Eggs were observed for four weeks as follows:

Week	Date	Duration	Activity
Week 0	Aug. 8th	Initial Day	Baseline Quality Evaluation
Week 1	Aug. 15th	7 Days	Repeat Measurements
Week 2	Aug. 22nd	14 Days	Repeat Measurements
Week 3	Aug. 29th	21 Days	Repeat Measurements
Week 4	Sept. 5th	28 Days	Repeat Measurements

This schedule allowed tracking of progressive egg quality changes due to time and gravity effects.

3.7 Data Collection

3.7.1 External Egg Quality Measurements

External egg quality traits were measured at storage interval for both positioning treatments.

Egg Weight (g):

Each egg was weighed using a digital scale with a sensitivity of ±0.01 g before and after each storage period. Weight loss (%) was determined using the formula

Shell Thickness (mm):

After breaking the eggs, the shell membranes were carefully removed, and the shell thickness was measured using a vernier caliper at three points (broad end, equator, and narrow end). The average of these three readings was recorded as shell thickness.

Egg Length (mm):

It is the measurement of an egg from its broad end to its narrow end (the longest axis).

It's usually measured in millimeters (mm) using a vernier caliper.

Egg Width (mm):

It is the measurement of an egg at its widest point, which is across the broadest diameter of the egg. It's usually measured in millimeters (mm) using a vernier caliper

3.7.2 Internal Egg Quality Measurements

Eggs were broken individually onto a clean, flat glass surface to measure the following internal quality parameters:

Albumen Height (mm):

Measured at three points around the yolk using a vernier caliper

Yolk Height (mm) and Yolk Diameter (mm):

Measured using a digital vernier caliper.

The Yolk Index (YI) was then computed as:

Yolk Index = Yolk Height (mm)/Yolk Diameter (mm)

Haugh Unit (HU):

A key indicator of albumen quality, calculated using the formula proposed by Haugh (1937):

$HU = 100 \log (H + 7.57 - 1.7W^{0.37})$

Where H = albumen height (mm) and W = egg weight (g).

Albumen Weight (g):

It is the weight of the egg white after removing the yolk and shell.

Formula:

Albumen weight = Yolk-Albumin − Yolk weight

Shell Weight and Yolk Weight (g):

After contents were separated, shell and yolk were weighed individually using a digital scale

3.8 Method of Data Collection

Data collection was carried out at weekly intervals from Week 0 (August 8th) to Week 4 (September 5th). At each interval, eggs from both treatment groups — Broad End Up (BEU) and Narrow End Up (NEU) — were randomly selected for observation to avoid selection bias. The eggs remained in their original positions throughout the study to prevent disturbance of internal structures.

Physical examination were carried out to assess:

- Albumen quality (watery or firm)
- Yolk stability (central or displaced)
- Shell condition (cracks, stains, moisture)
- Presence of blood/meat spots or other defects

All results were recorded immediately using a standardized data sheet.

3.9 Method of Data Analysis

Data obtained from the weekly observations were categorized according to storage orientation (BEU and NEU). Descriptive statistical methods were applied including:

- Mean calculations
- Percent change comparisons
- Tabular and graphical presentation for better interpretation of trends

Comparative analysis focused on determining:

1. The rate of internal quality deterioration during storage
2. The influence of egg positioning on air cell size and egg freshness over time

Interpretation of findings was supported by existing scientific knowledge on egg physiology and storage behavior.

3.10 EXPECTED FINDINGS

Based on established egg storage principles, eggs were expected to deteriorate progressively with increased duration of storage especially under room temperature (28–32°C) and open-crate storage conditions.

It was also expected that:

This expectation is based on the natural location of the air cell at the broad end, which helps maintain yolk centrality and reduces albumen thinning. Narrow-end positioning tends to disrupt this balance, resulting in:

- Faster enlargement of the air cell
- Increased yolk movement toward the shell
- Higher risk of internal contamination and spoilage

Significant quality loss was anticipated by Week 2 to Week 3, consistent with reported trends in tropical climates.

3.11 Ethical Considerations

The study involved food-based eggs only; therefore, no live animals were directly handled. The following ethical procedures were implemented:

- Eggs were sourced from a certified ISA Brown layer unit
- Proper sanitation was maintained to minimize contamination
- Observations were made without destructive testing to reduce wastage
- Research integrity was upheld; no manipulation or falsification of data occurred
- All scientific sources were properly cited to acknowledge intellectual contribution

The study complied with general laboratory safety and ethical standards for food-quality assessment research.

3.12 Statistical Analysis

All data collected were subjected to Analysis of Variance (ANOVA) using the General Linear Model (GLM) procedure in SAS (Statistical Analysis System, Version 9.4). Significant differences among treatment means were separated using Duncan's Multiple Range Test (DMRT) at a 5% level of significance ($p < 0.05$).

3.13 Experimental Validity and Replication

All measurements were performed in triplicate to ensure precision and repeatability. Instruments were calibrated before use, and eggs were handled gently to avoid mechanical stress. The experiment was replicated to enhance statistical reliability, and results were expressed as means ± standard error.