Shelf Life of Fowl Fresh Eggs Stored in Locally Fabricated Egg Pack Kept in Different Storage Conditions

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ABSTRACT

Background*: Poultry egg is an excellent source of high quality proteins, lipids, minerals, vitamins, water and carbohydrates. Unfortunately, it is perishable in nature hence the quest for storage conditions that will prolong the shelf life yet maintains the nutritional quality.*

Objective: *Although several techniques to store fresh eggs have been reported, little is known about using airtight packs. Therefore, this study evaluated the quality of fresh eggs kept in airtight packs stored at different environmental conditions.*

Methods: *Fabricated egg packs were used in storing 30 fowl fresh eggs each in the Freezer, Kitchen and Sales-outlet for 30 days. Data on temperature, egg weight and spoilage were collected and subjected to descriptive statistics and ANOVA at 0.05.*

Results: *Kitchen and Sales-outlet temperature varied from 32 – 41oC and 30 – 34oC, accordingly but that of Freezer was not determined. Eggs stored in the Freezer (14.58g) and Kitchen (13.92g) lost more weight, compared to 5.31g recorded in the Sales-outlet. Percentage egg weight loss was highest (23.65%) in the Freezer, followed by 22.6% (Kitchen) and 8.38% (Sales-outlet). Even when all (100%) the eggs in the Freezer cracked, they were observed to maintain normal albumen/yolk colour and viscosity without offensive smell. While all the eggs (100%) stored in the Kitchen spoilt, 20 eggs (66.7%) in the Sales-outlet had normal albumen/yolk colour and viscosity without rotten smell.*

Conclusion: *Consequently, use of airtight pack in storing fresh fowl eggs, maybe feasible in prolonging the shelf life.*

Keywords: Eggshell integrity, poultry eggs, spoilage microorganisms, storage medium

INTRODUCTION

Poultry eggs have been considered to be highly nutritious due to the high levels of proteins, lipids, minerals, vitamins, water and carbohydrates (1, 2). More significantly, it was reported that poultry eggs contribute 1.3% of the total calories in the diet with substantial amount of high quality protein, foliate, riboflavin and a number of other nutrients (1, 3). The biological value of poultry eggs was rated highest, among other foodstuffs of animal origin, even milk that is generally believed to be the best animal product in nature (4, 5). Idahor *et al* (6) described avian egg as "poor masses cheapest source of animal protein" because it is comparatively affordable, accessible and relished by many. Also, Idahor (7) stated that poultry birds' egg could best be defined as "an egg inside egg that gives and sustains life". The physical appearance of poultry egg creates first impression, that often influences the consumer's choice and if it does not meet the perceived expectations, the consumer sureness weakens resulting in rejection of the eggs. According to Nongtaodum *et al* (8) egg freshness is a major contribution to the quality however, the internal components begin to deteriorate after oviposition due to loss of moisture and carbon dioxide through the eggshell pores. It was stated that the eggshell is porous and as such allow in and out movement of air but, it is coated with a mucilaginous matter called cuticle that prevents

the entrance of microorganisms. However, when the cuticle is wet, softened by moisture or otherwise and as the egg ages, the cuticle becomes old and weak thus, the egg may be invaded by microorganisms resulting in deterioration. Therefore, to ensure eggs keeping quality, Wahba *et al* (3) speculated that eggs should not be washed, held in damp musty places or handled more than necessary and should be marketed or preserved as soon as possible. These conditions, possibly explained why many methods of avian eggs preservation, have not been fully successful. Consequently, it was suggested that egg preservation methods employed, should be based upon the idea of protecting and rendering more effective, the natural coating (cuticle) of the shell, so that spoilage microorganisms that cause egg deterioration may be averted.

Meanwhile, poultry eggs are highly perishable hence information on possible storage conditions that would ensure its keeping quality is requisite, to lessen its deterioration, spoilage, increase its shelf life and make way for its availability all year round at affordable rate. With this quest, many techniques of preservation of shelled eggs based on the principle of retarding the microbial growth such as sealing the pores of the shell to minimize loss of water has been propounded (3, 9). Besides, the principle of reducing physico-chemical changes in the egg contents for reasonable length of time and many other methods have been adopted (8, 10). Essentially, these principles were to reduce the harmful effects of spoilage microorganisms thereby, extending the shelf life of the eggs.

Some of the known methods of poultry eggs storage include refrigeration or cold, dry packaging, immersion in liquids, lime treatment, use of brine solution and sodium silicate also known as water glass technique. Others are use of oil coating, cellophane, polyethylene, polyvinylidene and other transparent materials (10 – 13). In all these, refrigeration or cold storage method was claimed to be the most effective way of storing poultry fresh eggs (10, 12, 13).

Irrespective of the poultry eggs storage methods adopted in these studies, the safe storage duration reported ranged between 3 and 28 days. For example, Dudusola (12) reported that eggs maintained desired internal quality, when stored for 4 days at room temperature and refrigeration could be used for storage of eggs for up to 7 days. Similarly, Raji *et al* (13) stated that poultry eggs could be stored for up to 28 days with refrigeration facilities, but not more than 7 days at room temperature. Therefore, fowl fresh egg storage method that could keep the desired quality for more than a month was envisaged in the present study. Hence, the shelf life of fresh fowl eggs, stored in locally fabricated egg packs, kept at different environmental conditions for 30 days was monitored.

Materials and methods

Climatic condition of the experimental site

The experiment was conducted at the Livestock Research and Demonstration Farm, Faculty of Agriculture, Nasarawa State University, Keffi, Shabu-Lafia campus, located on latitude 08° 35' N and longitude 08° 33' E in the Guinea savannah zone of north central Nigeria. Lafia has an altitude of 181m above sea level, temperature ranging from 32 to 35°C, relative humidity between 58 and 63%, average day light of 9 to 12

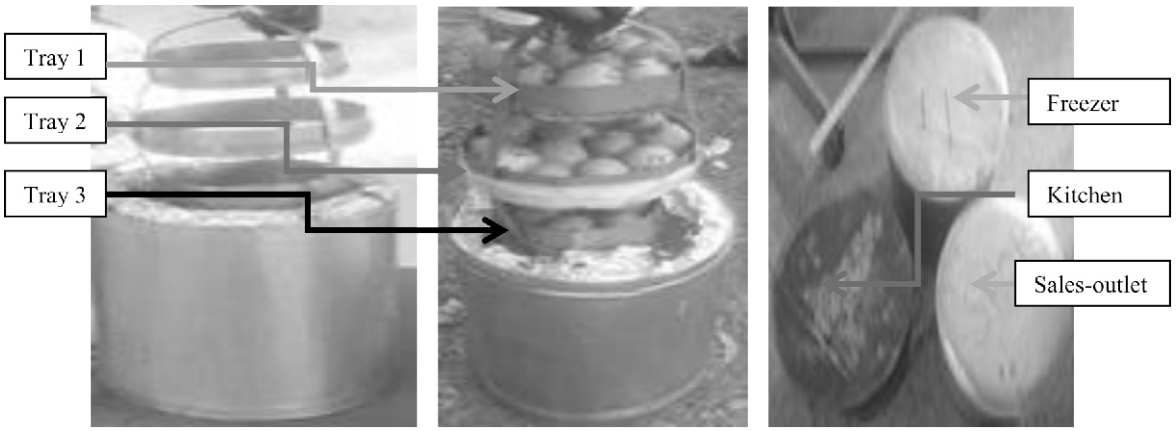

Plate 1: Locally fabricated egg pack

Plate 2: Fresh eggs in locally fabricated egg pack

Plate 3: Locally fabricated egg pack containing fresh eggs

hours and approximately 1,400mm rainfall per annum (14).

Egg pack fabrication

The egg packs were fabricated using available local materials like metal pan, foam and aluminium foil. The egg pack was designed such that it has egg-shape tray to be inserted in a cylindrical container with a lid to ensure airtight environment (see plates 1 – 3).

Experimental design

A total of 90 Isa brown freshly laid eggs (within 24 hours), were weighed using sensitive weighing balance (Atom electronic compact scale®) and allocated randomly based on weight in a completely randomized design to three storage methods such that each had 30 eggs. The treatments were designated as: Freezer storage (control), Kitchen storage and Sales-outlet storage with the eggs set in 3 separate trays (1, 2, 3) containing 10, 14 and 6 eggs respectively within the locally fabricated egg pack (see plate 2).

Data collection and statistical analysis

The experimental eggs were weighed before storage (representing the initial weight) and reweighed after storage (representing the final weight) to obtain egg weight loss and the percentage weight loss was determined using Suresh *et al* (15) procedures.

$$\text{Weight loss} = \frac{\text{Initial egg weight - egg weight after storage}}{\text{Initial egg weight}} \times 100$$

Thermometer was placed on each of the fabricated egg pack (except in the freezer) to monitor the temperature which was recorded every morning, afternoon and evening during the experimental period. At 30 days of storage, the fabricated egg packs were brought to the laboratory and the eggs were carefully windowed for wholesomeness evaluation, using albumen/yolk colour, viscosity and smell as indices according to Williams (16). Stored eggs with watering albumen/yolk, off colour and offensive smell were regarded to as "spoilt eggs", while those with intact colour, viscosity without offensive smell were termed "good eggs". Where applicable, data collected were subjected to simple descriptive statistics and analysis of variance procedure prescribed by SPSS (17) and the means were separated using Duncan Multiple Range Test of the same software package at 5% probability.

Results

The daily temperature recorded on the body of the locally fabricated egg pack stored at different environmental conditions is given in table 1. It was shown that the recorded temperature values varied by day however, that of the Freezer treatment could not be determined because it was within sub-zero temperature. While Kitchen temperature somewhat ranged from 32 – 41°C, that of Sales-outlet varied between 30 and 34°C.

Table 2 presents the weight loss of fowl fresh eggs stored in locally fabricated egg packs kept at different environmental conditions. There were significant differences ($P<0.05$) in all the parameters measured except the initial egg weight. It was observed that the eggs stored in the Freezer and Kitchen lost more weight (14.58 g and 13.92 g, respectively), compared to those stored in the Sales-outlet that lost 5.31 g. In a similar trend, the percentage egg weight loss was highest (23.65%) in the Freezer, slightly followed by 22.6% (Kitchen) and 8.38% in those stored in the Sales-outlet.

Table 1: Daily temperature (°C±STD) of the locally fabricated egg pack stored in the Freezer, Kitchen and Sales-outlet for 30 days

Day	Freezer	Kitchen	Sales-outlet
1	ND	37.33±4.50	34.33±2.08
2	ND	39.33±2.51	33.33±2.08
3	ND	34.33±1.52	32.00±1.00
4	ND	35.00±4.00	31.33±1.15
5	ND	38.33±3.78	32.67±0.57
6	ND	41.67±3.51	33.67±0.57
7	ND	37.33±3.05	32.00±1.00
8	ND	39.33±1.52	33.67±0.57
9	ND	37.00±2.64	32.00±1.00
10	ND	37.33±3.05	32.00±1.00
11	ND	37.00±1.73	33.33±1.15
12	ND	36.33±2.08	33.00±1.00
13	ND	37.67±3.21	33.67±1.52
14	ND	36.67±4.04	33.67±1.52
15	ND	38.00±2.00	33.00±1.00
16	ND	36.67±3.05	32.00±1.00
17	ND	36.33±2.51	33.33±0.57
18	ND	38.33±1.53	33.67±0.57
19	ND	37.33±3.21	32.33±1.15
20	ND	37.33±2.51	33.33±0.57
21	ND	35.33±1.15	33.00±1.00
22	ND	37.00±1.73	32.00±1.00
23	ND	37.33±2.31	33.00±1.00
24	ND	36.67±1.52	33.67±0.57
25	ND	38.00±2.00	33.67±0.57
26	ND	40.33±2.08	33.33±0.57
27	ND	36.67±4.51	32.33±1.52
28	ND	38.00±2.64	32.00±2.00
29	ND	32.00±0.00	33.00±0.57
30	ND	33.67±3.21	30.33±0.57

ND: Not determined because the locally fabricated egg pack was kept inside the freezer.

Table 2: Weight loss of fowl fresh eggs stored in locally fabricated egg packs kept in the Freezer, Kitchen and Sales-outlet for 30 days

Parameters	Freezer	Kitchen	Sales-outlet
Initial egg weight (g)	61.71±2.12	61.66±1.84	63.50±1.40
Final egg weight (g)	47.13±1.44^{b}	47.74±4.99^{b}	58.19±1.96^{a}
Egg weight loss (g)	14.61±3.29^{a}	13.94±1.98^{a}	5.34±2.46^{b}
Percentage egg weight loss (%)	23.65±0.25^{a}	22.61±0.15^{b}	8.38±0.18^{c}

abc: mean values on the same row with different superscripts are significantly different at 5% probability.

Expressed in figure 1 is the rate of spoilage of fowl fresh eggs stored in locally fabricated egg packs kept in the Freezer, Kitchen and Sales-outlet. It was shown that all the eggs stored in the Freezer (100%) were still good at 30 days of storage but the shells were all cracked.

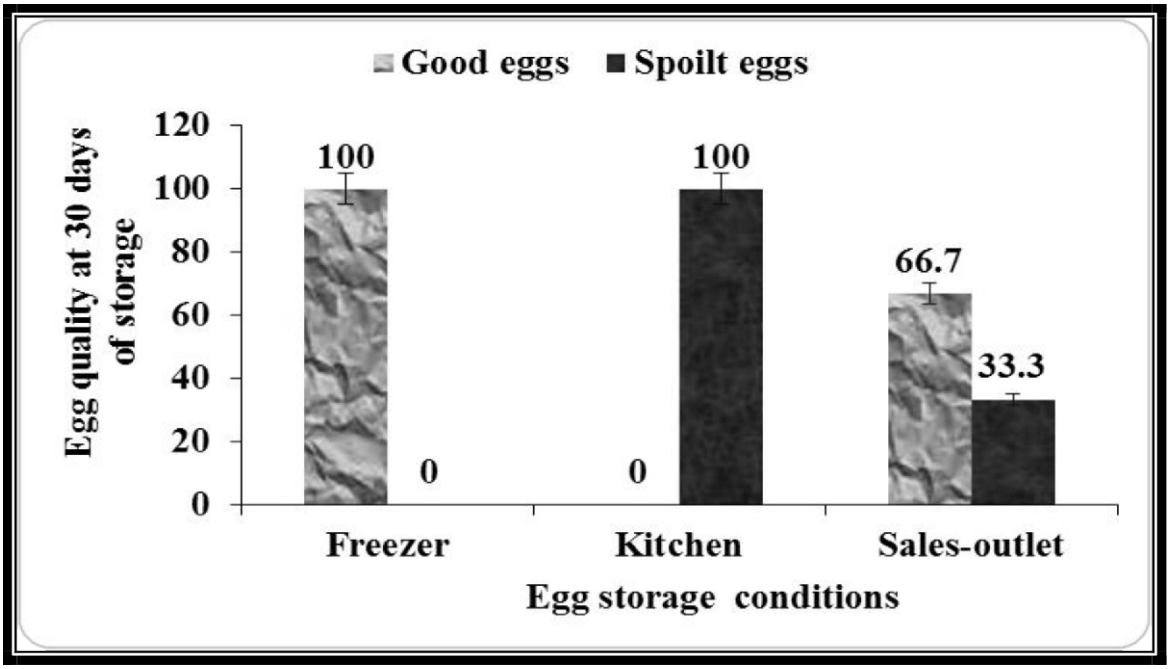

Figure 1: Spoilage of fowl fresh eggs stored in locally fabricated egg packs kept in the Freezer, Kitchen and Sales-outlet for 30 days

On the other hand, all the eggs stored in the Kitchen (100%) got spoilt whereas, 20 eggs representing 66.7% of the 30 eggs stored in the Sales-outlet had normal viscosity, albumen and yolk colour without offensive smell (see plates 4 – 6).

Discussion

The experimental eggs' weight was more than 54 – 59 g recorded elsewhere in laying hens at peak of production (18, 19) but close to a range of 64.0 to 69.9 g described as extra-large eggs and within 56 – 65 g categorised as large eggs (20). Since the experimental eggs were apparently within the normal egg sizes, they were probably suitable for the present study. Loss of weight in eggs stored in the Freezer and Kitchen were more than 0.16 – 1.03 g (representing 0.4 – 2.8%) weight loss recorded in Fayoumi, Lohmann Light-Brown and Naked neck hens' eggs stored at different temperature conditions (18, 19, 21). The egg weight loss at the Sales-outlet was comparable to 5.4g, recorded in eggs stored at room temperature for 21 days by Dudusola (12).

Plate 4: Fresh fowl eggs stored in locally fabricated egg pack kept in the Freezer for 30 days

Plate 5: Fresh fowl eggs stored in locally fabricated egg pack kept in the Kitchen for 30 days

Plate 6: Fresh fowl eggs stored in locally fabricated egg pack kept in the Sales-outlet for 30 days

However, the egg weight recorded in the present study was less than a range of 88.4 to 99.2% weight loss reported in Half white (Embrapa White Leghorn CC strain) and Half brown strains' (Embrapa Rhode Island Red GG) eggs, stored at room temperature and under refrigeration during the Summer and Autumn seasons (22). These observations corroborated several reports that fresh eggs are bound to lose weight in storage as a result of evaporation as influenced by ambient temperature and relative humidity, especially during long storage periods (9, 23).

This phenomenon could be due to the blastoderm believed to be the only living portion of the poultry egg that requires metabolic pathways involving water utilisation. Since the nutrients that will nourish the blastoderm vis-à-vis embryo growth and development are contained within the membrane, yolk and albumen, water will be used up in the bioprocess, resulting in water loss in the form of egg weight loss. This water loss or egg weight loss may be responsible for the creation of airspace that commonly lies between the outer and inner membranes as well as the crater often found at the blunt-end of a hardboiled poultry egg. It is believed that airspace in poultry eggs is formed when the contents of the egg cool and contract after the egg is laid hence, the older an egg, the wider the airspace but Idahor *et al*. (24) described the scenario as the beginning of poultry eggs deterioration.

Temperatures of the locally fabricated egg pack stored in the Kitchen and Sales-outlet, were more than a range of 20 – 25°C (room temperature) recommended for fresh eggs to be stored for less than 4 days, 16 – 17°C for those to be stored within 4 – 7 days and 10 – 12°C for fresh eggs to be stored for more than 7 days (25). Similarly, the temperature was more than 16°C room temperature used in storing Fayoumi eggs for 8 days yet, found out that storage time decreased hatchability, caused some changes in interior quality of the eggs and concluded that eggs can be stored for only 3 days (21). However, the recorded temperature of the fresh eggs storage methods in the present study was close to 30.5°C, 32°C and 34°C reported as room/shed temperature in Nigerian native chickens, laying hens and Brazilian laying hens' eggs stored at different conditions (10, 11). Meanwhile, it was less than 40°C designated as high temperature but similar to 32°C referred to as room temperature by Raji *et al* (13) who observed spoilage of the stored eggs within 14 days.

Room temperature is determined by the prevailing environmental weather conditions, which may be responsible for the disparities observed in the studies. More essentially, in these studies, it was proven that egg storage temperature played a vital role in fresh eggs deterioration and spoilage, hence the need to store fresh eggs at low temperature. Unfortunately, what "low or high temperature" means in this context has not been defined, particularly at the temperate and tropical regions of the world. For instance, the eggs stored in the Freezer in the present study were supposedly at low temperature yet, all the fresh eggs cracked thereby exposing the egg content to myriads of contaminations. Thus, making frozen fresh eggs apparently unwholesome for human consumption, conforming to the report of Techer *et al* (26) that the presence of crack in stored fresh eggs, increased the risk of contamination. Therefore, it was speculated that integrity of eggshell appeared to be the best defences against spoilage bacteria and it was presumed that preservation of the natural egg barriers (mainly the integrity of the eggshell), would reduce the occurrence of egg spoilage problems.

On the other hand, all the eggs kept in the Kitchen were spoilt, whereas some (66.67%) of the eggs stored at Sales-outlet were still wholesome, based on the physical integrity of the fresh eggs. However, since the microbial and nutritional qualities of the so-called wholesome eggs were not determined, they might not actually be fit for human consumption. Consequently, neither freeze temperature ("low temperature") nor "high temperature" may be suitable for fresh eggs storage. If low ambient temperature is associated with the temperate region of the world and the tropics is known for its characteristic high temperature. It becomes pertinent to establish the exact temperatures safe for fresh eggs storage, based on the two distinct weather conditions (temperate and tropical climates), rather than the supposedly "low" or "high" temperatures that are commonly misconstrued. Although there are several reports that fresh eggs can be stored for some days, weeks, months even years (century, millennium eggs) as the case may be (2, 27, 28), fresh egg processing before storage may be a better option that will guarantee quality and safety. However, at the end of 30 days when all the experimental eggs were carefully windowed in the present study, it was observed that all the eggs in the locally fabricated egg pack kept in the Freezer were all good except for the shells that were

cracked. Following careful thawing, the egg white and yolk were still viscous with normal colour without offensive smell thus, buttressed earlier suggestions that refrigeration may be more suitable for fresh eggs storage (10, 12, 13).

Raji *et al* (13) asserted that refrigerated eggs were able to maintain their quality, unlike those stored at room temperature and emphasised that though oiling of eggs also maintained egg quality up to 28 days yet, it should not be a replacement for refrigeration. Also, Feddern *et al* (22) stated that eggs stored under refrigeration, had lower variability on quality parameters and satisfied international quality standards, more than eggs stored under room temperature. It was therefore suggested, that eggs stored at room temperature should be consumed in 2 weeks or kept under refrigeration for up to 8 weeks. Furthermore, Dudusola (12) reported that quail eggs were best stored, at low temperature without deterioration and stressed that for storage of fresh eggs up to 7 days, refrigeration, oiling and black polythene bag methods could be preferred, but the best storage medium was refrigeration. Although the essence of the locally fabricated egg pack to reduce eggshell freezing with attendant cracking was not achieved in the present study, refrigeration seemed to be more suitable for fresh eggs storage, thus corroborated earlier reports (11, 13).

For the fresh eggs stored in the Kitchen, the temperature inside the airtight locally fabricated egg pack was probably increased, thereby causing all the stored eggs to spoil within 30 days of storage. Consequently, temperature as high as 32 – 41°C may not be suitable for fresh eggs storage. This observation agreed with several reports that fresh eggs stored at relatively high ambient temperature, may not be wholesome for human consumption (13, 29, 30). However, 66.7 % of the fresh eggs stored in a similar airtight locally fabricated egg pack but kept in a Sales-outlet, with temperature variability of 30 – 34°C, were wholesome based on the eggs physical characteristics evaluated. This was possibly due to ventilation, aeration and maintenance of near constant temperature, with a fluctuation range of ±4°C throughout the study period. As a result, locally fabricated egg pack may be suitable for fresh egg storage.

Conclusion

While the temperature in the Freezer was within sub-zero, that of the Kitchen was higher than what was recorded in the Sales-outlet. The eggs stored in the Freezer and Kitchen lost more weight, compared to those stored in the Sales-outlet. All the eggs stored in the Freezer were good though cracked and a larger proportion of those in the Sales-outlet were also good whereas, all in the Kitchen got spoilt within the 30 days study period. Therefore, egg pack could be used in storing fresh eggs in the freezer and at room temperature. However, since this is a preliminary study, in depth investigations become imperative to further express the relevance of keeping poultry eggs in an airtight medium during storage.

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Conflicts of interest: No conflict of interest

Ethics approval and consent to participate: "Not applicable"

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