

Changes in nutrient content of quail (*Coturnix coturnix*) eggs stored at room (25°C) and refrigerator (4°C) temperatures for 28 days

Chinwe J. Aronu¹, Anne Morgan^{1*}, Patience C. Ugwu¹, Chimdinma G. Aronu² and John I. Ihedioha³

¹ Department of Animal Health and Production, Faculty of Veterinary Medicine, University of Nigeria, Nsukka, Nigeria.

² Department of Biochemistry, Faculty of Biological Sciences, University of Nigeria, Nsukka, Nigeria.

³ Department of Veterinary Pathology, Faculty of Veterinary Medicine, University of Nigeria, Nsukka, Nigeria.

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Abstract

Eggs are food items rich in essential nutrients, and quail eggs are particularly considered to be relatively superior to other eggs based on their nutritional profile. The effects of storage across time on nutrient composition of quail eggs have not been reported. This study evaluated changes that occurred in the nutrient composition of quail (*Coturnix coturnix*) eggs stored at room (25°C) and refrigerator (4 °C) temperature across a 28-day period. Seventy freshly laid eggs were randomly assigned into two groups: Group 1 - eggs stored at room temperature (n = 35) and Group 2 - eggs stored under refrigeration condition (n = 35). At days 0, 3, 7, 14, 21 and 28 of the storage, five eggs from each group were analyzed for egg yolk cholesterol, egg yolk triglycerides, egg yolk protein, egg white protein, egg yolk glucose, egg white glucose, egg yolk potassium and egg white potassium. Egg weights were also measured. Results showed significant ($p < 0.05$) increases in egg yolk cholesterol, triglycerides and egg white protein concentrations in eggs stored at both temperatures over time. Egg white potassium increased significantly in eggs stored at 25 °C, whereas egg yolk potassium increased in eggs stored at 4 °C. No significant changes were observed in egg yolk protein or glucose concentrations. Eggs stored at room temperature showed significant weight loss when compared to refrigerated eggs. The study demonstrated that refrigeration minimized egg weight loss. It was concluded that storage of quail eggs at both refrigerator (4°C) and room (25°C) temperatures led to significant increases in egg yolk and egg white cholesterol and triglyceride levels, egg white proteins, and egg yolk and egg white potassium levels, both in the refrigerated eggs and those stored at room temperature, though the changes were more in the eggs stored at room temperature.

Keywords: Quail eggs; Storage temperature; Egg nutrients; Refrigeration (4°C); Room temperature (25°C); Shelf life.

* **Correspondence:** Anne Morgan; Email: anne.morgan@unn.edu.ng. Phone number: +2348060799742

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Introduction

Eggs are nutrient-dense foods containing proteins, lipids, vitamins, minerals and growth factors essential for embryonic development and human nutrition (Nowaczewski, 2013). All egg categories are considered to be high biological value protein sources because they contain essential amino acids in optimal proportions (Layman and Rodriguez, 2009).

Quail eggs are particularly valued because of their reportedly superior nutrient profile stemming from the fact that despite their small size, they contain three to four times more nutrients than chicken eggs (Tunsaringkarn *et al.*, 2013). Moreover, when compared to chicken eggs, quail eggs contain higher concentrations of essential amino acids, minerals and vitamins. In addition, quail eggs may be tolerated by some individuals who are allergic to chicken egg albumen (Lalwani, 2011).

Quail eggs have also been reported to possess antimicrobial, antioxidant and anti-inflammatory properties (Jeke *et al.*, 2018). Due to rapid growth rate, early maturity, efficient feed conversion, low space requirements and disease resistance, which are characteristic of quail production, it represents a viable alternative source of animal protein (Furtado *et al.*, 2018; Taha *et al.*, 2019).

However, eggs are highly perishable biological materials and deterioration begins immediately after laying, especially when storage conditions are poor. Storage temperature and duration are established major determinants of egg quality preservation (Ibrahim *et al.*, 2020). There are no reports in available literature on the effects of storage temperature and time period on the nutrient content of quail eggs. The present study evaluated the effect of storage temperature and duration on nutrient composition and weight changes of quail eggs.

Materials and Methods

Experimental location: The study was conducted at the Poultry Unit of the Department of Animal Health and Production, University of Nigeria, Nsukka.

Experimental design: Four crates of freshly laid quail eggs were purchased from a farm in Jos, Nigeria. On arrival 70 of the quail eggs were sorted out and randomly assigned to two groups: Group A represented eggs that were stored at room temperature (25°C), and Group B represented eggs stored at refrigeration temperature (4°C). Each of the groups contained 35 eggs. Five eggs from each group were labeled and weighed on day 0, reserved for repeated weight measurements. Another five eggs from each group were analyzed immediately to establish baseline nutrient values. On days 3, 7, 14, 21 and 28 of the study, five eggs were randomly selected from each group for biochemical analysis while previously labeled eggs were re-weighed.

Egg sample preparation for analysis: The eggs were carefully broken and the yolk was separated from albumen. A 0.5 ml sample of yolk was diluted with 1.5 ml distilled water (1 in 4 dilution). The same procedure was applied to egg white.

Biochemical analysis of the eggs. The diluted yolk and egg white samples were then subjected to biochemical assay using a Diatek semi-automated Biochemistry analyzer (Wuxi-Hiwell Diatek Instruments Co. Ltd, Wuxi, China) and commercially available biochemistry test kits obtained from Quimica Clinica Aplicada (QCA), Spain and Randox Laboratories Ltd, County Antrim, UK.

The cholesterol content of the egg was determined by the modified enzymatic colorimetric method, while the triglyceride determination was based on enzymatic method (Rifai *et al.*, 2008), using the QCA total cholesterol and triglyceride test kits (QCA, Spain), respectively on the Diatek Semi-automated Biochemistry Analyzer. The total

protein content of both the diluted yolk and egg white were determined based on the modification of the direct Biuret method (Johnson, 2008), using Randox total protein test kit (Randox, UK), on the Diatek Semi-automated Biochemistry Analyzer. The glucose content of the diluted yolk and egg white were determined by the modified glucose oxidase method (Sacks, 2008), while the potassium content of the diluted yolk and egg white were determined based on the modified turbidimetric method (Scott *et al.*, 2008), using the QCA glucose and potassium tests kits (QCA, Spain), respectively on the Dietek semi-automated biochemistry analyser.

Statistical analysis: Data obtained from each group of eggs were subjected to repeat measure analysis of variance (ANOVA). Variant means were separated using the least significant difference (LSD) method. The values obtained for the two groups were compared using student's t-test. Significance was accepted at $p < 0.05$. Results were expressed as mean \pm standard error of mean.

Results

The egg yolk cholesterol and triglyceride levels (Tables 1 and 2) showed significant ($p < 0.05$) increase after day zero in both groups (both refrigerated and room temperature stored eggs), but there were no significant differences ($p > 0.05$) between the yolk cholesterol/triglyceride levels of the eggs kept at refrigerator temperature and those kept at room temperature all through the period of the study.

No significant changes ($p > 0.05$) were recorded for egg yolk protein levels across the 28 days of storage and between the two groups (Table 3). The egg white protein levels significantly ($p < 0.05$) increased across the storage period in both groups, but at all points of assay there were no significant ($p > 0.05$) differences between the two groups (Table 4).

No significant differences ($p > 0.05$) were recorded for both the egg yolk and egg white glucose levels across the 28 day storage period and between the two groups (Tables 5 and 6).

Table 1. Egg yolk cholesterol levels of quail eggs stored at room (25°C) and refrigerator (4°C) temperatures for 28 days.

Storage time (days)	Mean egg yolk cholesterol levels (mg/dl) \pm standard error	
	Eggs stored at room temperature (25°C).	Eggs stored at refrigerator temperature (4°C).
Day 0	1722.55 \pm 32.44 ^a	1722.69 \pm 32.88 ^a
Day 3	2174.79 \pm 45.59 ^b	2082.64 \pm 89.26 ^b
Day 7	1989.37 \pm 78.69 ^b	2153.88 \pm 89.64 ^b
Day 14	2243.78 \pm 67.40 ^b	2243.28 \pm 53.64 ^b
Day 21	2196.85 \pm 86.35 ^b	2183.70 \pm 50.39 ^b
Day 28	1987.57 \pm 46.99 ^b	2118.79 \pm 62.04 ^b

^{a, b}. Different superscript in a column indicates significant ($p < 0.05$) change in yolk cholesterol levels of each group across the 28 days of keeping. There was no significant difference ($p > 0.05$) between the yolk cholesterol levels of the eggs kept at refrigerator (4°C) and room (25°C) temperatures all points of assay.

Table 2. Egg yolk triglyceride levels of quail eggs stored at room (25°C) and refrigerator (4°C) temperatures for 28 days.

Storage time (days)	Mean egg yolk triglyceride levels (mg/dl) ± standard error	
	Eggs stored at room temperature (25°C).	Eggs stored at refrigerator temperature (4°C).
Day 0	2296.32 ± 32.85 ^a	2296.14 ± 34.04 ^a
Day 3	2708.38 ± 18.77 ^b	2573.86 ± 48.49 ^b
Day 7	2564.26 ± 46.44 ^c	2757.71 ± 77.85 ^c
Day 14	2982.27 ± 37.76 ^d	3014.43 ± 57.29 ^d
Day 21	2788.50 ± 51.05 ^b	2870.60 ± 15.13 ^c
Day 28	2688.96 ± 30.84 ^b	2766.73 ± 44.66 ^c

a, b, c, d. Different superscript in a column indicates significant ($p < 0.05$) change in yolk triglyceride levels of each group across the 28 days of keeping. There was no significant difference ($p > 0.05$) between the yolk triglyceride levels of the eggs kept at refrigerator (4°C) and room (25°C) temperatures all points of assay.

Table 3. Egg yolk protein levels of quail eggs stored at refrigerator (4°C) and room (25°C) temperatures for 28 days.

Storage time (days)	Mean egg yolk protein levels (g/dl) ± standard error	
	Eggs stored at room temperature (25°C).	Eggs stored at refrigerator temperature (4°C).
Day 0	20.76 ± 0.64	20.73 ± 0.66
Day 3	19.16 ± 0.51	19.69 ± 0.45
Day 7	18.97 ± 0.54	19.74 ± 0.46
Day 14	18.86 ± 0.55	18.90 ± 0.39
Day 21	18.93 ± 1.51	19.90 ± 0.76
Day 28	19.10 ± 0.45	19.09 ± 0.44

There were no significant ($p > 0.05$) variations in the yolk protein levels of each group across the 28 days of keeping. There was no significant difference ($p > 0.05$) between the yolk protein levels of the eggs kept at refrigerator (4°C) and room (25°C) temperatures all points of assay.

Table 4. Egg white protein levels of quail eggs stored at refrigerator (4°C) and room (25°C) temperatures for 28 days.

Storage time (days)	Mean egg white protein levels (g/dl) ± standard error	
	Eggs stored at room temperature (25°C).	Eggs stored at refrigerator temperature (4°C).
Day 0	12.58 ± 0.91 ^a	12.23 ± 0.90 ^a
Day 3	15.08 ± 0.16 ^b	14.08 ± 0.70 ^{ab}
Day 7	14.50 ± 0.54 ^b	13.52 ± 0.61 ^{ab}
Day 14	14.80 ± 0.81 ^b	13.60 ± 0.34 ^{ab}
Day 21	15.82 ± 0.35 ^b	13.20 ± 0.33 ^{ab}
Day 28	14.63 ± 0.42 ^b	14.41 ± 1.01 ^b

^{a, b, c.} Different superscript in a column indicates significant ($p < 0.05$) change in egg white protein levels of each group across the 28 days of keeping. There was no significant difference ($p > 0.05$) between the egg white protein levels of the eggs kept at refrigerator (4°C) and room (25°C) temperatures all points of assay.

Table 5. Egg yolk glucose levels of quail eggs stored at room (25°C) and refrigerator (4°C) temperatures for 28 days.

Storage time (days)	Mean egg yolk glucose levels (mg/dl) ± standard error	
	Eggs stored at room temperature (25°C).	Eggs stored at refrigerator temperature (4°C).
Day 0	304.20 ± 8.06	305.93 ± 9.83
Day 3	296.00 ± 9.44	300.09 ± 14.50
Day 7	295.10 ± 9.83	296.57 ± 4.69
Day 14	304.01 ± 15.40	286.32 ± 7.77
Day 21	284.65 ± 16.73	288.20 ± 13.95
Day 28	279.65 ± 6.77	299.84 ± 7.84

There were no significant ($p > 0.05$) variations in the yolk glucose levels of each group across the 28 days of keeping. There was also no significant difference ($p > 0.05$) between the yolk glucose levels of the eggs kept at refrigerator (4°C) and room (25°C) temperatures all points of assay.

Table 6. Egg white glucose levels of quail eggs stored at room (25°C) and refrigerator (4°C) temperatures for 28 days.

Storage time (days)	Mean egg white glucose levels (mg/dl) ± standard error	
	Eggs stored at room temperature (25°C).	Eggs stored at refrigerator temperature (4°C).
Day 0	347.57 ± 20.12	347.02 ± 19.76
Day 3	370.95 ± 23.85	371.45 ± 11.68
Day 7	370.69 ± 18.25	375.96 ± 11.69
Day 14	367.32 ± 19.52	389.86 ± 11.24
Day 21	342.11 ± 20.83	363.09 ± 13.04
Day 28	348.11 ± 12.18	374.86 ± 41.18

There were no significant ($p > 0.05$) variations in the egg white glucose levels of each group across the 28 days of keeping. There was also no significant difference ($p > 0.05$) between the egg white glucose levels of the eggs kept at refrigerator (4°C) and room (25°C) temperatures all points of assay.

The egg yolk potassium levels of the refrigerated eggs significantly ($p < 0.05$) increased across the storage period, but there were no significant changes ($p > 0.05$) in the egg yolk potassium levels of the eggs stored at room temperature across time (Table 7). The egg yolk potassium levels of the eggs stored at room temperature was significantly lower ($p < 0.05$) than that of those stored in the refrigerator on day 21 of storage (Table 7). In contrast, egg white potassium levels of the eggs stored at room temperature significantly increased ($p < 0.05$) across the time of storage while that of refrigerated eggs did not

significantly ($p > 0.05$) change (Table 8). The egg white potassium levels of eggs kept at room temperature were significantly higher than that of those kept in the refrigerator on days 21 and 28 of storage (Table 8).

The weight of eggs kept at room temperature significantly ($p < 0.05$) decreased across the 28-day storage, but there were no significant ($p > 0.05$) in the weight of those stored in the refrigerator all through the 28 days of the study (Table 9). The weights of the two groups did not significantly differ ($p > 0.05$) all through the 28 days of the study (Table 9).

Table 7. Egg yolk potassium levels of quail eggs stored at room (25°C) and refrigerator (4°C) temperatures for 28 days.

Storage time (days)	Mean yolk potassium levels (mEq/L) ± standard error	
	Eggs stored at room temperature (25°C).	Eggs stored at refrigerator temperature (4°C).
Day 0	46.69 ± 3.98	46.81 ± 4.14 ^a
Day 3	48.94 ± 3.56	44.87 ± 3.81 ^a
Day 7*	46.72 ± 1.49	61.09 ± 1.53 ^b
Day 14	54.34 ± 3.43	59.21 ± 3.29 ^b
Day 21*	48.96 ± 1.94	62.16 ± 1.48 ^b
Day 28	50.55 ± 4.82	59.23 ± 2.79 ^b

^{a, b}. Different superscript in a column indicates significant ($p < 0.05$) change in yolk potassium levels of each group across the 28 days of storage. * Asterisk superscript on a day indicates significant difference ($p < 0.05$) between the yolk potassium levels of the eggs kept at room (25°C) and refrigerator (4°C) temperatures on such days of assay.

Table 8. Egg white potassium levels of quail eggs stored at room (25°C) and refrigerator (4°C) temperatures for 28 days.

Storage time (days)	Mean egg white potassium levels (mEq/L) ± standard error	
	Eggs stored at room temperature (25°C).	Eggs stored at refrigerator temperature (4°C).
Day 0	29.87 ± 1.10 ^a	29.46 ± 1.14
Day 3	29.28 ± 1.03 ^a	31.19 ± 2.09
Day 7	29.21 ± 1.77 ^a	31.68 ± 0.86
Day 14	33.74 ± 1.11 ^b	32.05 ± 0.82
Day 21*	36.34 ± 0.78 ^{bc}	30.50 ± 1.70
Day 28*	39.05 ± 0.95 ^c	31.67 ± 1.75

^{a, b, c.} Different superscript in a column indicates significant ($p < 0.05$) change in yolk potassium levels of each group across the 28 days of keeping. * Asterisk superscript on a day indicates significant difference ($p < 0.05$) between the yolk potassium levels of the eggs kept at room (25°C) and refrigerator (4°C) temperatures on such days of assay.

Table 9. Weights of quail eggs stored at room (25°C) and refrigerator (4°C) temperatures for 28 days.

Storage time (days)	Mean egg weights (g) ± standard error	
	Eggs stored at room temperature (25°C).	Eggs stored at refrigerator temperature (4°C).
Day 0	11.09 ± 0.27 ^a	11.22 ± 0.34
Day 3	10.99 ± 0.26 ^a	11.13 ± 0.33
Day 7	10.90 ± 0.24 ^{ab}	11.07 ± 0.33
Day 14	10.69 ± 0.20 ^{ab}	10.94 ± 0.34
Day 21	10.51 ± 0.18 ^{ab}	10.81 ± 0.34
Day 28	10.25 ± 0.17 ^b	10.70 ± 0.35
Percentage change in egg weight	- 7.57%	- 4.64%

^{a, b.} Different superscript in a column indicates significant ($p < 0.05$) change in yolk potassium levels of each group across the 28 days of keeping. There was no significant difference ($p > 0.05$) between the egg weight of the eggs kept at refrigerator (4°C) and room (25°C) temperatures all points of assay.

Discussion

The evaluation of nutrient content of eggs forms the basis for which nutritionist can recommend nutrients that satisfy varying physiological and biochemical needs of the body. Eggs reportedly comprise 75% water, after which they are mainly made up of proteins and lipids (Li-Chan and Kim, 2008). Quail eggs reportedly have superior nutrient content than other eggs and are strong providers of antioxidants, minerals and vitamins, thus providing much more nourishment than other foods (Tunsaringkarn *et al.*, 2013).

The significant increases in egg yolk cholesterol and triglyceride levels across the storage time period is thought to be due to a relative increase in concentration as a result of water (moisture) loss (decrease in weight). Though refrigeration has been reported to preserve egg internal quality by reducing biochemical changes associated with storage deterioration (Miles and Henry 2004; Samli *et al.*, 2005), it is believed that these increases across time recorded in the present study are relative changes with regards to water (moisture) loss.

The lack of significant change across time in the egg yolk protein levels in the two groups in this study suggests minimal effects on egg yolk structural proteins during storage. However, the significant increase in egg white protein levels in both the refrigerated eggs and those kept at room temperature may be attributed to water loss resulting in relative concentration effects on the egg white. Moisture loss during storage had previously been associated with similar findings (Miles and Henry, 2004; Samli *et al.*, 2005; Demirel and Kirikçi, 2009; Reijrink *et al.*, 2009; González-Redondo, 2010; Garip and Dere, 2011).

The lack of significant changes in both egg yolk and egg white glucose levels across the 28-day storage period and between the groups is

worth noting: water (weight) loss did not seem to significantly affect the glucose levels.

The relatively higher potassium concentration in yolk compared with albumen recorded in the present study agrees with earlier reports by Réhault-Godbert *et al.* (2019) on mineral contents of eggs. Increased dietary potassium intake has been reported to be good for heart health in the prevention of stroke and coronary health disease (WHO, 2012; Weaver, 2013). The significant increases recorded across time in the yolk potassium levels of refrigerated eggs and egg white potassium levels of eggs kept at room temperature is believed to be due to loss of water (moisture) across time and/or mineral migration as earlier reported by Kruenti *et al.* (2023).

The significant loss in weight of the eggs kept at room temperature when compared to the refrigerated ones is believed to be due to higher level of moisture evaporation through the shell pores at the relatively higher environmental temperature of the room (25°C); evaporative loss of water will be less at refrigerator (4°C) temperature. Losses in moisture/weight by eggs stored across time have been severally reported in literature to be related to higher storage temperature and low relative humidity (Demirel and Kirikçi, 2009; Reijrink *et al.*, 2009; González-Redondo, 2010; Garip and Dere, 2011).

Conclusion: Storage of quail eggs at both refrigerator (4°C) and room (25°C) temperatures led to significant increases in egg yolk and egg white cholesterol and triglyceride levels, egg white proteins and egg yolk and egg white potassium levels, both in the refrigerated eggs and those stored at room temperature, though the changes were more in the eggs stored at room temperature.

Conflict of Interest

The authors declare no conflict of interest.

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