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Effects of egg storage methods and storage periods on hatchability and post-hatching performance of Japanese quails

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Additional keywords

Weight losses.
Embryonic mortality.
Hatch weight and growth.

SUMMARY

This study was conducted to determine the hatching characteristics of quail eggs stored for varying days in two different media and their post hatch performance. A total of 900 hatchable eggs were randomly divided into six groups. Eggs were stored by adopting two egg storage methods which include refrigeration (70C) and air conditioning (180C) and for different storage periods which include 0, 6, and 12 days, thus arranging the experiment in a Completely Randomized Design in a 2 x 3 factorial experimental layout. Further study was also carried out on the hatched chicks to investigate effects of both factors in a Completely Randomized Design. Results showed that egg storage weight loss was higher (P<0.05) in air-conditioned eggs than refrigerated eggs, however it increased (P<0.05) with increasing days of storage. Incubation weight loss and hatchability were higher (P<0.05) in refrigerated eggs (16.28% and 79.59%, respectively) than eggs stored in air conditioner (14.76% and 47.59%, respectively). Total embryonic mortality was highest (P<0.05) in eggs stored for 12 days (60.00%) prior to incubation and the least in eggs stored for 6 days (19.07%). Chick weight was not influenced (P>0.05) by egg weight but varied consistently with egg weight. It can be concluded that refrigeration of eggs minimized egg weight loss with resultant better hatchability, however prolonged egg storage reduced hatchability.

Efectos de los métodos de almacenamiento de huevos y los períodos de almacenamiento en la incubabilidad y el rendimiento post-eclosión de las codornices japonesas

Palabras clave adicionales

Pérdidas de peso.
Mortalidad embrionaria.
Peso y crecimiento a la eclosión.

SUMMARY

Este estudio se realizó para determinar las características de eclosión de los huevos de codorniz almacenados durante varios días en dos medios diferentes y su desempeño posterior a la eclosión. Un total de 900 huevos para incubar fueron divididos aleatoriamente en seis grupos. Los huevos se almacenaron adoptando dos métodos de almacenamiento de huevos que incluyen refrigeración (70C) y aire acondicionado (180C) y para diferentes períodos de almacenamiento que incluyen 0, 6 y 12 días, organizando así el experimento en un diseño completamente aleatorizado en 2 x 3 Disposición experimental factorial. También se llevaron a cabo estudios adicionales en los pollos incubados para investigar los efectos de ambos factores en un diseño completamente aleatorizado. Los resultados mostraron que la pérdida de peso por almacenamiento de huevos fue mayor (P<0.05) en los huevos con aire acondicionado que en los huevos refrigerados, sin embargo aumentó (P<0.05) al aumentar los días de almacenamiento. La pérdida de peso por incubación y la incubabilidad fueron mayores (P<0.05) en los huevos refrigerados (16.28% y 79.59%, respectivamente) que en los huevos almacenados en el aire acondicionado (14.76% y 47.59%, respectivamente). La mortalidad embrionaria total fue más alta (P<0.05) en los huevos almacenados durante 12 días (60.00%) antes de la incubación y la menor en los huevos almacenados durante 6 días (19.07%). El peso del pollito no fue influenciado (P>0.05) por el peso del huevo, pero varió consistentemente con el peso del huevo. Se puede concluir que la refrigeración de los huevos minimizó la pérdida de peso del huevo con una mejor incubabilidad resultante, sin embargo, el almacenamiento prolongado del huevo redujo la incubabilidad.

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INTRODUCTION

Production of quails in Nigeria is on a relatively small scale with producers combining production of eggs and chicks simultaneously. Since quails are not easily sexed at day old but until three weeks old, producers have automatic access to both sexes and tend to produce fertile eggs with a view to increase their stock and probably for sale. To obtain a sufficient number of eggs to fill an incubator due to small scale of produc-

tion, eggs are usually accumulated in storage for one or two weeks before incubation. Regardless of under how optimum conditions the eggs are stored; hatching success rate of incubated eggs stored more than a week will decrease (Mayes and Takeballi, 1984, p. 131). Storage causes eggwater loss by evaporation,which rate isinfluenced by temperature and relative humidity. Studies report that long storage periods are detrimental to table and hatching-egg quality (Samli *et al*.,2005, p. 543; .; Walsh *et al*.,1995, p. 1403).

Increasing the length of storage period increases the proportion of embryonic mortality during storage and thereby increases the probability of failure to hatch (Yoo and Wientjes, 1991, 733; Scott and Mackenzie, 1993, 459). Different studies showed that hatchability of eggs decreases quickly after 8days of storage period for pheasant (Demirel and Kırıkçı, 2009,p. 440), 7days of storage time for duck (Onbaılar *et al*., 2007), 5days of storage time for broiler breeder hen (Petek and Dikmen, 2006, p. 73), 28days of storage length for partridge (González-Redondo, 2010, 379- 383), 15days of storage length for ostrich (Hassan *et al*., 2005, 1908) and 4days of storage length for guinea fowl eggs (Moreki and Ditshupo, 2012, p. 631).

Since hatcheries only collect eggs twice in a week, storage of quail eggs has been a challenging issue for the quail farmers. This is due to unaffordable storage facilities and fluctuation in power supply. However, domestic refrigerator seems to be an alternative as it is found in most homes.Vasconselose de Moraes*et al*. (2008), reported that storage of eggs in refrigerator at temperature between 13^0 - 16^0C improved hatchability and post hatching characteristic in quail birds. However, eggs are usually stored in air conditioned room in hatcheries before the setting day. Hence this study sought to investigate the egg storage weight loss, incubation weight loss, hatching characteristics and post hatching performance of quail birds as influenced by different storage durations of eggs in either refrigerator or air conditioner.

MATERIALS AND METHODS

Site of Experiment

Storage and hatching of eggs were carried out at Obasanjo Farms Nigeria, Owiwi Hatchery, Abeokuta, Ogun State, Nigeria. Post hatching performance study was done at the Poultry Unit of the Directorate of University Farm.

Source of Experimental Materials

A total of nine hundred (900) hatching eggs was sourced from a single flock of quail birds on the University farm. The strain is the commercial cinnamon brown of sixteen weeks of age.

Experimental Design and Egg Management

Eggs were stored by adopting two egg storage methods which include refrigeration (7^0C) and air conditioning (18^0C) and for different storage periods which include 0, 6, and 12 days, thus arranging the experiment in a Completely Randomized Design in a 2 x 3 factorial experimental layout. Eggs were cleaned before being randomly allotted to the different (6) treatment groups. Each group consisted of one hundred and fifty (150) eggs with three replicates of fifty (50) eggs each.

The eggs were fumigated using Potassium tetraoxomanganate VII ($KMnO_4$) and formaldehyde (HCHO) at ratio 1:2. The treatment lasted for 20 minutes in a closed chamber. The eggs were set in egg trays with broad ends upward to prevent rupture of air cell. Each egg tray was labeled according to the treatment groups and individual egg was numbered prior to setting to facilitate data collection on replicate and individual basis respectively.

Eggs were set in Petersime incubator (B-9870 model). Temperature (37.5°C) and humidity were automatically regulated. Egg turning was automatic on hourly basis to prevent developing embryos from adhering to the shell and to ensure uniform distribution of nutrients.

Data Collection

Determination of Incubation Weight Loss

The eggs were weighed before setting and on the 15th day, incubation weight loss was determined using the formula below:

Weight loss (g) = Initial weight (g) – Final weight (g)

$$Weightloss(\%) = \frac{\textbf{Weight loss (g)}}{\textbf{Initial weight}} * 100$$

Fertility (%)

This was determined using the formula below:

$$Fertility\ (\%) = \frac{No\ of\ fertile\ eggs}{No\ of\ eggs\ set} * 100$$

Hatchability (%)

This was determined using the formula below:

$$Hatchabilty\ (\%) = \frac{No\ of\ chicks\ hatched}{No\ of\ fertile\ eggs} * 100$$

Hatch Weight (g)

The weight of birds at hatch was determined by weighing the birds hatched in each replicate divided by the number of birds hatched per replicate.

$$Hatch\ weight\ (g) = \frac{Total\ weight\ of\ birds\ hatched}{Number\ of\ birds\ hatched} * 100$$

Determination of Embryonic Mortality

This was carried out in the laboratory. The unhatched incubated eggs were gently broken to observe the stage of embryonic mortality. This was categorized into two:

Dead-in-germ (early embryonic mortality) and Dead-in-shell (late embryonic mortality).

$$Dead-in-germ\ (\%) = \frac{No\ of\ Dead-in-germ}{No\ of\ fertile\ eggs} * 100$$

$$Dead-in-shell\ (\%) = \frac{No\ of\ Dead-in-shell}{No\ of\ fertile\ eggs} * 100$$

Egg: chick

This was evaluated as the ratio of egg weight to chick weight

Post Hatching Performance

Hatched quail chicks were further studied for the effect of storage methods and periods for five weeks. Thirty (30) chicks were selected per replicate in each treatment. Birds were fed *ad libitum* with diets containing 24.10% crude protein and 12.19MJ/kg metabolisable energy at the growing phase (0-6 weeks) as shown in **Table I**.

Data Collection

Growth Performance Evaluation

Weight gain (g) **-** The birds were weighed on replicate basis at the commencement of the experiment and subsequently on weekly basis.

Weight gain = Final weight – Initial weight

Feed intake (g)

A known quantity of feed was given to birds while the leftover of feed was weighed to determine daily feed intake and subsequently weekly feed intake. The feed intake was calculated as:

$$Feed\ intake\ per\ bird = \frac{Feed\ supplied - Left\ over\ of\ feed}{No\ of\ birds}$$

Feed conversion ratio (FCR)

The FCR of each of the group of birds was determined by calculating the ratio of feed intake to weight gain and thus calculated as:

$$Feed\ conversation\ ratio\ (FCR) = \frac{Total\ feed\ intake\ (g)}{Total\ body\ weight\ gain\ (g)}$$

Statistical Analysis

Data collected on hatching characteristics were subjected to one-way Analysis of variance in a 2 x 3 factorial experimental layout using SAS (1999) while data obtained on post hatching performance were subjected to Analysis of variance in a Completely Randomized Design (CRD) in the same package. Significantly ($p<0.05$) different means among variables were separated using Duncan Multiple Range Test of the software.

RESULTS

Effects of storage methods and storage periods on storage egg weight loss of Japanese quail eggs

Table I shows the main effect of storage methods and periods on weight loss of egg. Storage methods (refrigeration and air conditioner) significantly ($P<0.05$) influenced the weight loss in Japanese quail eggs with higher values noted for air condition stored eggs. Weight loss in gramme and percentage in both refrigerated and air conditioned eggs are 0.09g and 0.82% and 0.14g and 1.38%, respectively.

Egg weight loss (%) differ significantly ($P<0.05$) among the storage period groups, and increase in weight loss with increased storage days was observed. The weight loss (g) in 12, 6 and 0 day stored eggs were 0.22, 0.12 and 0.00g, respectively. The percentage weight losses were 2.18, 1.13 and 0.00% across the groups.

The weight loss of Japanese quail eggs as affected by the interaction between storage methods and periods is presented in **Table II**. There was significant ($P<0.05$) interactive effect of storage methods and periods on the weight losses (grammes and percentage). Weight loss in grammes ranged from 0.00 (unstored

Table I. Main effect of storage methods and storage periods on weight loss of Japanese quail eggs (Efecto principal de los métodos de almacenamiento y períodos de almacenamiento en la pérdida de peso de huevos de codorniz japonesa).

Parameters	Storage Methods		Storage Periods (days)		
	Refrigeration	Air conditioner	12	6	0
Initial weight (g)	10.10^{a}± 0.33	9.68^{b}± 0.45	9.95^{ab} ± 0.35	10.15^{a} ± 0.45	9.56^{b} ± 0.35
Final weight (g)	10.01^{a}± 0.29	9.54^{b} ± 0.38	9.73^{ab} ± 0.26	10.04^{a} ± 0.48	9.56^{b} ± 0.35
Weight loss (g)	0.09 ± 0.25	0.14 ± 0.15	0.22 ± 0.16	0.12 ± 0.29	0.00 ± 0.00
Weight loss (%)	0.82^{b} ± 2.40	1.38^{a} ± 1.51	2.18^{a} ± 1.60	1.13^{b} ± 2.78	0.00^{c} ± 0.00

^{abc}Means with different superscript on the same row differ significantly ($P<0.05$)

Table II. Effect of interaction between Storage methods and periods on the weight loss of Japanese quail eggs (Efecto de la interacción entre los métodos de almacenamiento y los períodos en la pérdida de peso de huevos de codorniz japonesa).

Parameters	Refrigeration			Air condition		
	12	6	0	12	6	0
Initial weight (g)	10.03^{a} ± 0.28	10.40^{a} ± 0.27	9.85^{ab} ± 0.22	9.87^{ab} ± 0.45	9.90^{a} ± 0.49	9.23^{b} ± 0.05
Final weight (g)	9.88^{ab} ± 0.12	10.29^{a} ± 0.30	9.85^{ab} ± 0.22	9.58^{bc} ± 0.31	9.77^{b} ± 0.54	9.23^{c} ± 0.05
Weight loss (g)	0.15^{b} ± 0.18	0.11^{c} ± 0.46	0.00^{d} ± 0.00	0.29^{a} ± 0.16	0.13^{b} ± 0.09	0.00^{d} ± 0.00
Weight loss (%)	1.50^{b} ± 1.70	0.97^{c} ± 4.30	0.00^{d} ± 0.00	2.86^{a} ± 1.46	1.30^{b} ± 0.91	0.00^{d} ± 0.00

^{abc}Means with different superscripts on the same row differ significantly ($P<0.05$)

eggs) to 0.29g (12 days air conditioned eggs). The highest (P<0.05) weight loss was found in eggs stored for 12 days in air condition (2.86%), however, similar (P>0.05) values were obtained in 12 days refrigerated (1.50%) and 6 days air conditioned (1.30%) eggs. 6 days refrigerated eggs prior to incubation had the least percentage weight loss among the stored eggs.

Effects of storage methods and periods on incubation weight loss of Japanese quail eggs

The main effects of storage methods and periods on incubation weight loss of Japanese quail eggs are presented in **Table III**. Incubation weight losses were statistically higher (P<0.05) in refrigerated eggs than the other storage method. The respective incubation weight loss in grammes and percentage in refrigerated eggs were 1.63g and 16.28% while in air conditioned eggs were 1.41g and 14.76%.

Incubation period significantly (P <0.05) varied with storage days. Percentage incubation weight loss was highest in unstored (0 day) eggs than the stored eggs (6 and 12 days). The percentage loss across the groups are 15.01, 14.13 and 17.43% in 12, 6, 0 days, respectively.

The incubation weight loss of Japanese quail eggs as influenced by the interactive effect of storage methods and periods is presented in **Table IV**. Incubation weight loss varied (P<0.05) across the groups. The highest (P<0.05) incubation weight loss (g) was recorded in 0 day refrigerated eggs (2.00g), while others gave relatively comparable values. Similarly, percentage weight loss was highest (P<0.05) in 0 day refrigerated eggs (20.32%) and least in 6 days refrigerated eggs (12.81%), while values obtained from other groups were statistically similar (P>0.05).

Effects of storage methods and periods on the hatching characteristics of Japanese quail eggs

The main effects of different storage methods and periods (days) on hatching characteristics of quail eggs are shown in **Table V**. The weight of eggs incubated was higher (P<0.05) in refrigerated eggs (10.01g) than the air conditioned eggs (9.54g). Hatchability was higher (P<0.05) in eggs stored in refrigerator (79.59%) than those stored air conditioned room (47.59%). Total embryonic mortality was significantly (P< 0.05) higher in air condition stored eggs (52.40%) than refrigerated eggs (20.41%). Though the late embryonic mortality (dead-in-shell) was statistically similar (P>0.05) between the two storage methods, percentage early embryonic mortality (dead-in-germ) was significantly (P<0.05) higher in air conditioned eggs than refrigerated eggs. A significantly higher (P<0.05) hatch weight of 6.65g was obtained in refrigerated eggs.

Weight of eggs incubated statistically differs (P<0.05) among the storage days. Hatchability was significantly (P<0.05) highest in 6 days (80.99%) pre incubation stored eggs, followed by 0 day (69.79%) and the least in 12 days (40.00%) pre incubation stored eggs. The highest (P<0.05) total embryonic mortality (60.00%) and early embryonic mortality (51.26%) were recorded in eggs stored for 12 days prior to incubation, while similar (P>0.05) and lower early mortality were obtained between eggs stored for 6days (8.39%) and 0 day (15.51%). Late embryonic mortality did not differ significantly (P>0.05) among the pre incubation egg storage groups. Similar (P>0.05) hatch weight was recorded in eggs stored for 6 days (6.63%) and 0 day (6.26%) prior to incubation.

Hatching characteristics of Japanese quails as influenced by the interactive effect of storage methods and periods is presented in **Table VI**. Egg weight

Table III. Main effect of Storage methods and storage periods on the incubation weight loss of Japanese quail eggs (Efecto principal de los métodos de almacenamiento y períodos de almacenamiento en la pérdida de peso de incubación de huevos de codorniz japonesa).

Parameters	Storage Methods		Storage Periods (days)		
	Refrigeration	Air conditioner	12	6	0
Initial weight (g)	10.01^{a}± 0.29	9.54^{b} ± 0.38	9.73^{ab} ± 0.26	10.04^{a} ± 0.48	9.56^{b} ± 0.35
Final weight (g)	8.38 ± 0.58 8.	8.13 ± 0.42	8.27^{ab} ± 0.24	8.62^{a} ± 0.59	7.89^{b} ± 0.38
Weight loss (g)	1.63 ± 0.43	1.41 ± 0.23	1.46 ± 0.17	1.42 ± 0.34	1.67 ± 0.49
Weight loss (%)	16.28^{a} ± .55	14.76^{b} ± 2.34	15.01^{b} ± 1.62	14.13^{b} ± 3.47	17.43^{a} ± 4.73

^{abc}Means with different superscripts on the same row differ significantly (P<0.05)

Table IV. Effect of interaction between storage methods and storage periods on the incubation weight loss of Japanese quail eggs (Efecto de la interacción entre métodos de almacenamiento y períodos de almacenamiento en la pérdida de peso de incubación de huevos de codorniz japonesa).

Parameters	Refrigeration			Air condition		
	12	6	0	12	6	0
Initial weight (g)	9.88^{ab} ± 0.12	10.29^{a} ± 0.30	9.85^{ab} ± 0.22	9.58^{bc} ± 0.31	9.77^{b} ± 0.54	9.23^{c} ± 0.05
Final weight (g)	8.33^{ab} ± 0.27	8.97^{a} ± 0.11	7.85^{b} ± 0.58	8.21^{ab} ± 0.25	8.27^{ab} ± 0.71	7.92^{b} ± 0.15
Weight loss (g)	1.55^{ab} ± 0.21	1.32^{b} ± 0.30	2.00^{a} ± 0.51	1.37^{b} ± 0.08	1.51^{ab} ± 0.41	1.35^{b} ± 0.14
Weight loss (%)	15.73^{ab} ± 2.17	12.81^{b} ± 2.58	20.32^{a} ± 5.34	14.29^{ab} ± 0.59	15.46^{ab} ± 4.27	14.53^{ab} ± 1.53

^{abc}Means with different superscripts on the same row differ significantly (P<0.05)

Table V. Main effect of storage methods and storage periods on hatching characteristics of Japanese quail eggs (Efecto principal de los métodos de almacenamiento y los períodos de almacenamiento en las características de eclosión de los huevos de codorniz japonesa).

Parameters	Storage Methods		Storage Periods (days)		
	Refrigeration	Air conditioner	12	6	0
Egg weight (g)	10.01^{a}± 0.29	9.54^{b} ± 0.38	9.73^{ab} ± 0.26	10.04^{a} ± 0.48	9.56^{b} ± 0.35
Hatchability (%)	79.59^{a} ± 8.42	47.59^{b} ± 36.45	40.00^{c} ± 43.90	80.99^{a} ± 9.20	69.79^{b} ± 8.40
Total mortality (%)	20.41^{b} ± 8.42	52.40^{a} ± 36.45	60.00^{a} ± 43.90	19.01^{c} ± 9.20	30.21^{b} ± 8.40
Early mortality (%)	12.15^{b} ± 5.12	37.96^{a} ± 40.04	51.26^{a} ± 43.02	8.39^{b} ± 5.09	15.51^{b} ± 7.92
Late mortality (%)	8.26 ± 4.69	14.44 ± 11.16	8.73 ± 12.63	10.62 ± 8.93	14.70 ± 2.69
Hatch weight (g)	6.65^{a} ± 0.22	4.14^{b} ± 3.12	3.31^{b} ± 3.62	6.63^{a} ± 0.37	6.26^{a} ± 0.29
Egg : chick	1.51^{a} ± 0.05	1.02^{b} ± 0.77	0.75^{b} ± 0.82	1.52^{a} ± 0.03	1.53^{a} ± 0.06

^{abc}Means with different superscripts on the same row differ significantly (P<0.05).

Table VI. Effect of interaction between storage methods and storage periods on hatching characteristics of Japanese quail eggs (Efecto de la interacción entre los métodos de almacenamiento y los períodos de almacenamiento en las características de eclosión de los huevos de codorniz japonesa).

Parameters	Refrigeration			Air condition		
	12	6	0	12	6	0
Egg weight (g)	9.88^{ab} ± 0.12	10.29^{a} ± 0.30	9.85^{ab} ± 0.22	9.58^{bc} ± 0.31	9.77^{b} ± 0.54	9.23^{c} ± 0.05
Hatchability (%)	80.00^{a} ± 4.33	85.36^{a} ± 10.60	73.40^{ab} ± 6.67	0.00^{c} ± 0.00	76.62^{ab} ± 6.47	66.18^{b} ± 9.64
Total mortality (%)	20.00^{c} ± 4.33	14.64^{c} ± 10.60	26.60^{bc} ± 6.67	100.00^{a} ± 0.00	23.38^{bc} ± 6.47	33.84^{b} ± 9.64
Early mortality (%)	13.64^{b} ± 3.18	9.00^{b} ± 6.97	13.82^{b} ± 4.87	88.89^{a} ± 19.25	7.78^{b} ± 3.86	17.21^{b} ±11.17
Late mortality (%)	6.36 ± 3.43	5.63 ± 5.05	12.78 ± 2.06	11.11 ± 19.25	15.60 ± 9.97	16.61 ± 1.66
Hatch weight (g)	6.62^{ab} ± 0.21	6.85^{a} ± 0.09	6.48^{ab} ± 0.18	0.00^{d} ± 0.00	6.40^{b} ± 0.42	6.05^{c} ± 0.18
Egg : chick	1.49 ± 0.04	1.50 ± 0.04	1.52 ± 0.08	0.00 ± 0.00	1.53 ± 0.02	1.53 ± 0.05

^{abc}Means with different superscript on the same row differ significantly (p<0.05).

was statistically (P<0.05) different across the various treatment groups with the highest (10.29g) in eggs refrigerated for 6days and least (9.23g) in unstored eggs under air conditioner. The best (P<0.05) hatchability were noticed in eggs refrigerated for 12 days (80.00%) and 6 days (85.36%). Similar hatchability was observed in 0 day refrigerated eggs (73.40%), 6 days air conditioned eggs (76.62%) and 0 day air conditioned eggs (66.18%). No (0.00%) hatchability was recorded in eggs stored for 12 days in air conditioned room. Total embryonic mortality was least (P<0.05) in eggs refrigerated for 6 days (14.64%), which was also similar to the value (20.00%) recorded for eggs that were stored for 12 days in refrigerator. Other treatment groups had comparable total embryonic mortality except egg stored for 12 days in air conditioned room which gave (P< 0.05) 100%. Early embryonic mortality were similar (P>0.05) among the treatment group except (P<0.05) 12 days air conditioned with a value of 88.89%. Statistically similar (P>0.05) late embryonic mortality was recorded among the treatment groups. Hatch weight values were different significantly (P<0.05) among the groups that hatched. Egg to chick weight among the group that hatched was similar (P>0.05).

Effect of interaction between storage methods and periods on the post hatching performance of Japanese quails eggs

The interactive effect of storage methods and periods on the post hatching performance of Japanese quail eggs for 5weeks is presented in **Table VII**. The initial weight varied across the treatment groups and ranged from 6.15 to 6.85g. Weight at the 5th week (final weight) was significantly different (P<0.05) with the highest (150.00g) in chicks obtained from 0day air conditioned eggs and the least (103.00g) in chicks from 6days refrigerated eggs, while others are similar (P>0.05). Total and daily weight gain maintained the same trend as the final weight across the groups and ranged from 96.18g to 143.86g and 2.75g to 4.11g, respectively.

Total feed intake (299.05g to 335.46g) and daily feed intake (8.54g to 9.58g) were similar (P>0.05) among the groups. Feed conversion ratio was best (2.22) in chicks obtained from 0day air conditioned eggs and the poorest (3.11) in chicks from 6days refrigerated eggs, while others did not differ significantly (P>0.05). No statistical difference (P>0.05) was noted for mortality in percentage and ranged from 1.01 to 2.63%.

DISCUSSION

Egg storage prior to incubation can have both detrimental and beneficial effects (Brake *etal.*1993, p. 30-41). The result obtained in this study showed that egg weight reduced due to moisture loss which agrees with Schmidt *etal.*(2009, p. 1) who reported that long storage of eggs decreases egg weight. Higher weight

Table VII. Effect of storage methods and periods of Japanese quail eggs on post hatching performance
(Efecto de los métodos y los períodos de almacenamiento de huevos de codorniz japonesa en el rendimiento post eclosión)

	Storage Method : Storage Days				
Parameters	RF:12days	RF:6days	RF:0day	AC:6days	AC:0day
Initial weight (g)	$6.62^{ab} \pm 0.21$	$6.85^{a} \pm 0.10$	$6.48^{ab} \pm 0.19$	$6.40^{ab} \pm 0.42$	$6.15^{b} \pm 0.06$
Final weight (g)	$125.00^{ab} \pm 0.00$	$103.00^{b} \pm 5.25$	$126.58^{ab} \pm 16.92$	$133.03^{ab} \pm 21.33$	$150.00^{a} \pm 23.57$
Total weight gain/ bird (g/bird)	$118.38^{ab} \pm 0.21$	$96.18^{b} \pm 5.21$	$120.10^{ab} \pm 16.91$	$126.63^{ab} \pm 21.72$	$143.86^{a} \pm 23.51$
Daily weight gain/bird (g/bird/day)	$3.38^{ab} \pm 0.01$	$2.75^{b} \pm 0.15$	$3.43^{ab} \pm 0.48$	$3.62^{ab} \pm 0.62$	$4.11^{a} \pm 0.67$
Total feed intake/bird (g/bird)	311.79 ± 6.33	299.05 ± 28.30	325.15 ± 12.24	335.46 ± 17.58	316.76 ± 12.66
Daily feed intake/bird(g/bird/day)	8.91 ± 0.18	8.54 ± 0.18	9.29 ± 0.35	9.58 ± 0.50	9.05 ± 0.36
Feed conversion ratio	$2.63^{ab} \pm 0.06$	$3.11^{a} \pm 0.24$	$2.75^{ab} \pm 0.48$	$2.69^{ab} \pm 0.37$	$2.22^{b} \pm 0.28$
Mortality (%)	1.01 ± 1.75	1.96 ± 3.40	1.19 ± 2.06	1.11 ± 1.92	2.63 ± 3.72

[abc]Means with different superscript on the same row differ significantly (P<0.05).
RF = Refrigeration; AC= Air condition.

loss of eggs stored in air conditioned room in comparison with the refrigerated eggs in the present study could be as a result of variation in temperature of the two storage medium. According to Bell (1996, p. 1) storage period, temperature, packaging materials and shell soundness are the key factors affecting the rate of weight loss in eggs. This result is in harmony with the report of Ekine and Ajuogu, (2011, p. 92) in a related study (0.2 vs 0.4g, in refrigerated and air conditioned eggs, respectively) for chicken eggs. According to Khan *et al*. (2013, p. 211) weight losses which occur during the storage of eggs are related to the temperature and humidity of the environment in which the eggs are stored and to the length of the storage period.

In this study, a progressive egg weight loss was noted with increased storage days which is consistent with reports by Egbeyale*et al*. (2013, p. 416) for pullets egg, Reijrink *et al*. (2009, p. 2649) for broiler breeder eggs and González-Redondo (2010, p. 379) for redlegged partridge.

The results of this study revealed the significance of interaction between storage methods and storage days on storage weight loss of eggs. The interaction depicts that egg weight loss can be minimised by refrigeration even at longer storage.

Water loss is a normal process during incubation; usually 12 to 14% of water is lost in broilers and turkeys eggs (Rahn *et al*., 1981, 253). However, too low or too high water loss influences embryo development (Rahn and Ar, 1974), and consequently, egg hatchability (Meir et al., 1984, 1489).Eggs normally loose a total of 18% of their weight during incubation due to loss of water vapour which diffuses across the egg shell (Bourne, 1998). Mayes and Takeballi (1984, 131) determined that 10-12% weight loss is necessary during incubation in order to get a good incubation result in stored and non-storede ggs. In the present study, higher incubation weight loss in refrigerated eggs could be as a result of lower weight loss during storage due to temperature difference. Incubation weight loss obtained in this study falls within range reported by Egbeyale *et al*. (2013, p. 416) for chicken eggs.

Fresh (unstored) incubated eggs presented the highest incubation weight loss which is consistent with report by Egbeyale *et al*. (2013, p. 416) and Romao et al.(2008, p. 143)who stated that eggs stored for longer periods presented lower levels of weight loss during incubation as compared to fresh incubated eggs or those that were subjected to a few days of storage.

Hatchability was better in refrigerated eggs than air conditioned eggs in this study which is at variance with the report by Ekine and Ajuogu (2011, p. 92) who reported 54.6% and 84.6% hatchability in chicken eggs stored in refrigerator (8^{o}C) and air condition (19^{o}C), respectively. Variation in storage weight loss due to difference in storage temperature could probably be responsible for the variation in hatchability of the eggs.

Significantly poor hatchability in egg stored for 12days strongly agrees with the results of several studies. According toHamre (2008), chicken eggs should be incubated within 7 to 10days after they are laid as hatchability declines rapidly when incubation is postponed for more than10days.Carole (2009) recommends optimum storage time for guinea fowl eggs as seven days as further storage increases embryonic death and chick quality. Whitehead *et al*.(2002, p. 295) stated that the period of eggstorage before incubation affects the hatching success. Prolonged storage of eggs of poultry species decreases egg quality, increases embryonic mortality, and extend incubation time. The current results are also consistent with Petek and Dikmen (2006) and Romao et al. (2008, p. 143) who found that long storage time prior to incubation decreased hatchability.

In this study, lower hatchability of eggs set for incubation on the day laid when compared with the 6 days stored eggs could be as a result of lower albumen pH and excessive carbon dioxide of fresh eggs which corroborates the result of some earlier studies. Asmudndson and MacLlriath, (1948, p.394) reported that eggs stored for a few days prior setting presented higher hatchability than those set in an incubator immediately after lay. Benton and Brake (1996, p. 1069) reported that low pH of fresh eggs may be detrimental to hatchability. Excess carbon dioxide loss causes the albumen to have an excessively high pH and which negatively affects the initiation of embryo development. If the loss of

carbon dioxide is too low, the pH of the albumen will also be too low which explains why hatchability is poor in too fresh eggs (Khan *et al*., 2013, p. 211). This process of carbon dioxide loss is also temperature-dependent and may be stimulated by cooling after oviposition (Lapao *et al*., 1999, p. 640). Literature showed that the rise in albumen pH with storage time is related with a decrease in albumen index. Albumen liquefaction probably facilitates the movement of nutrients from the albumen to the blastoderm and may reduce resistance to gaseous diffusion (Lapao *et al*., 1999p. 640). Contrarily,Reis *et al*. (1997, p. 1459) stated that low pH of fresh eggs was not detrimental to embryo survival and hatchability in their study.

Failure of eggs stored in air conditioned room for 12 days to hatch could be as a result of excessive weight loss of eggs during storage. Long storage at 18°C could have excessively increased the pH of albumen due to excessive loss of carbon dioxide and eventually depletion of nutrient reserve for embryo and hence death of blastoderm. This confirms results of Aroraand Kosin (1966, p. 958) and Mather and Laughlin(1979, p. 595) who reported evidence of necrosis and regressive changes inthe blastodermeven atstorage temperaturesof13°C as well as shrinking of the blastoderm at 10°C (Funk and Bieller, 1944, p. 538; Mather and Laughlin, 1979, p. 595). In a similar study, Mani *et al*. (2008, p. 350) compared the hatchability of quail eggs stored at room temperature (25- 29°C) for 0 – 20 days and reported that hatchability of eggs declined drastically after 10days and that no hatchability of eggs after 12 days of pre-incubation egg storage.

Storage condition in terms of temperature and humidity which eventually yielded variation in the weight loss of eggs during storage suggests the reason for higher mortality in air condition stored eggs in this study. High embryonic mortality (total and early embryonic mortality) result of 12days pre incubation egg storage in this study agrees with the result of Romao et al.(2008, p. 143) who found that increased storage time increases embryo mortality rate during storage and incubation. These results agreed with Fasenko (1996) who found that early embryonic mortality increased when eggs were stored for extended periods of time. Fasenko (1996) stated that long-term storage of eggs may result in an increase in energy requirements of the embryo and this could deplete glycogen resources below levels critical for survival. Similar results were also reported in domestic fowl and turkey eggs when their eggs were stored for up to two weeks (Bakst and Gupta, 1997, p. 374). Lapao*et al*. (1999, p. 640) determined that pre-incubation egg storage lead to morphological changes in the blastoderm and malformations with increased cell necrosis. This could be as a result of degeneration of blastoderm during the prolonged storage. It has been suggested that prolonged egg storage may induce embryonic stress, manifested inincreased embryonic necrotic and apoptotic cell death, depressed embryonic metabolism, and developmental delays; as a result, irreparable damage to the embryo may occur, thus resulting in increased embryonic mortality and decreased chick performance (Fasenko,1996; Fasenko, 2007, p. 1020; Hamidu *et al*., 2010, p. 901).

Higher hatch weight of refrigerated eggs could not be attributed to differences in storage medium but as result of their egg weight which was higher than those stored under air conditioner. This is in agreement with the findings of Maiorka *et al*. (2004, p. 19) who reported that hatch weight is positively related with the egg weight. Abiola et al.(2008, p. 83) similarly determined that there was a positive correlation between egg weight and chick weight in chickens. Similarly, Egbeyale (2010, p. 123) concluded that there was positive correlation between egg weight and hatching weight of dominant black and Yaffa Brown strains of chickens.

Variations in hatch weight in this study among the storage period groups could not be adduced to storage days but the differences in individual weight of eggs set. Variations in hatch weight were consistent with variation in egg weight. The same trend of variation was observed for the interaction between storage methods and periods on hatch weight of eggs.

The higher hatch weight in some groups does not necessarily translate to better post hatch performance and this is consistent with the result of Wyatt et al. (1985, p. 2049) who reported that the advantage of initially higher weight attributable to a larger egg diminishes rapidly after hatching while food intake is the main factor that affected final body weight. Egbeyale (2010, p. 123) reported that higher hatching weight positively influenced the growth performance of chicks only up to the end of starter phase.

The differences in the final weight, total weight gain and daily weight gain in this study could not be attributed to storage methods and periods but the differences in the number and body weight of male and female quails in each group since sexing could not be done at the initial stage of life of the birds. Japanese quail is a sexually dimorphic bird with females having a larger body size than males, unlike other poultry species. Shim (2005) stated that adult male weighs between 100 to140g while adult female is slightly heavier than themale, weighing from 120 to160g. Abdel-Azeem (2010) reported higher livebody weight of female at 21, 28, 35, and 42 d of age compared with malequails. Souza *et al*. (1995, p. 85) indicated that female birds were fatter than male because female hormone stimulated fat deposition. Also, Ayoola *et al*. (2014, p. 43) reported better weight gain and FCR in female quails than in male quails which he attributed to heavier gonads in females than in males.This submission is consistent with the report by Decuypere and Bruggeman (2007, p. 1037) who stated that good hatchability does not necessarily positively correlate with a high percentage of good-quality chicks and that maximal hatchability is not always linked to the highest posthatch quality and growth of the chick. Petek and Dikmen (2006, p. 73) reported that neither the time of pre-storage incubation period treatment nor the egg storage periods significantly affected the subsequent body weight of the progeny.

Differences in the FCR could be adduced to the same reason responsible for the differences in the body weights. In the previous study, Egbeyale *et al*. (2013, p.416) and Petek et al.(2003, p. 242) stated that FCR was not affected by length of egg storage. This result is at variance with Abdou *et al*. (1990, p. 165) who reported that prolonged storage of local hatching eggs also affected the post-hatching growth performance ofchicks.

CONCLUSION

It can be concluded based on this study that there was a significant decline in hatchability and high incidence of total and early embryonic mortality in eggs stored for 12days. Refrigeration of eggs minimized egg weight loss during storage and reduced embryonic mortality even at longer days. Hence, quail eggs should be stored in refrigerator especially when there is need to store for longer period prior to incubation to ensure significant hatching success.

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