Research Note: Effect of egg storage length on spread of hatch window, chick quality, and organ development in Transylvanian naked neck chickens

Monsuru Oladimeji Abioja ,*,[1] John Adesanya Abiona,* Obafemi Foluso Akinjute,*
Henry Temitope Ojoawo,† Victor Aanuoluwapo Adebowale,* Basit Oni,* and Peter Olufemi Omotara*

*Department of Animal Physiology, College of Animal Science and Livestock Production, Abeokuta 110001, Nigeria; and †Livestock Science and Sustainable Environment Programme, Centre of Excellence in Agricultural Development and Sustainable Environment, Federal University of Agriculture, Abeokuta 110001, Nigeria

ABSTRACT Two hundred and twenty eggs from Transylvanian naked neck (**TNN**) chickens aged 30 wk were used to determine the effect of storage length on hatch window, chick quality, and organ development. Forty-four eggs (11 eggs in 4 replicates) were stored in cold room (16±1.5°C) in batches for 0, 3, 6, 9, and 12 d before setting in incubator. Data collected were subjected to one-way analysis of variance. Hatchability of set and fertile eggs declined ($P < 0.001$) progressively as duration of storage increased, however, storage for 6 and 9 d differed not from each other. For 50% hatch, there was a decrease of 30 min/d in hatching time by 3 d-stored eggs before fresh eggs, while eggs stored for 6, 9, and 12 d had delay of 70, 65, and 30 min/d, respectively. Hatching commenced earlier ($P < 0.01$) in eggs stored for 0 and 3 d than in prolonged storage of eggs for 6 to 12 d. Eggs stored for 12 d recorded shorter ($P < 0.001$) hatch window than those stored for 0 to 9d. Significantly ($P < 0.01$) more eggs hatched per hour during hatch window in fresh eggs (3.9%/h) than other storage durations (1.70−2.12 %/h). Fresh and 6 d eggs hatched into heavier ($P < 0.05$) chicks (37.2 and 37.5 g, respectively) than 12d (32.7g). Chicks from 9 and 12 d storage were shorter in length than those for 0 to 6 d. Toe ($P < 0.01$) and shank+toe ($P < 0.001$) were longer in 0 d chicks than others. Activity and appearance were poorer ($P < 0.01$) in 12 d chicks than other groups. The quality of eye was better ($P < 0.05$) in 0 to 6 d chicks than 12 d group, however, 9 d chicks were similar to 12 d. Larger membrane remnant were found in 6 to 12 d chicks ($P < 0.001$) than in 0 d chicks, though not different from 3 d group. Navel of chicks from eggs stored for 0, 3, and 6 d were more closed than in 9 d, though not different from 12 d. Yolk remnant was larger in chicks of 3, 9, and 12 d storage length than in fresh and 6 d storage length. Tona score was higher in 0 to 6 d chicks than in 9 and 12 d chicks. There was no ($P > 0.05$) effect of egg storage length on chick yield and relative weight of chick organs. It could be concluded that in order to ensure good hatchability and quality chicks, TNN eggs could be stored for 3 d, but not beyond 6 d without intervention such as prewarming of long-stored eggs.

Key words: embryo, hatchery, hatch window, hatchling, hen, incubator

2022 Poultry Science 101:101834
https://doi.org/10.1016/j.psj.2022.101834

INTRODUCTION

There are many factors that do affect quality of chicks from fertilization of the ovum to the placement of day-old chicks on farm. One of such is the conditions surrounding the fertile eggs. Storage of chicken eggs for certain period between oviposition and setting for incubation cannot be totally avoided. The reason being that eggs need to stay for some time before setting as the best of embryonic development and hatchability are achieved in eggs stored for 3 to 5 d post-oviposition to allow for loss of some carbondioxide from the eggs (Onagbesan et al., 2007). Besides, the temperature of the eggs must be lowered to physiological zero around 15 to 16°C, in order to arrest further development of the embryo (embryonic diapause) prior to incubation (Pokhrel et al., 2021). Moreover, small-scale farmers accumulate eggs for a week to have sufficient number and to meet the hatchery schedule where eggs are set on weekly basis. It is customary to store chicken eggs in cold room with temperature between 15 and 18°C and relative humidity of 70 to 75% (Tona et al., 2003; Bergoug et al., 2013; Addo et al., 2018; Hamidu et al., 2019). However, extended storage of eggs negatively affects hatchability, chick development and quality

Received November 22, 2021.
Accepted March 3, 2022.

[1]Corresponding author: abiojamo@funaab.edu.ng

(Tona et al., 2003; Petek and Dikmen, 2006; Hamidu et al., 2011; Abioja et al., 2020a, 2021) Fasenko (2007). did a good review on the influence of egg storage on the development of embryo. This author stated that long-term storage of eggs induces cell death, except there are interventions put in place Schmidt et al. (2009). reported a 20% reduction in egg hatchability comparing storage length of 4 and 24 d. The authors discovered that each day extension in storage time caused 1.17% loss in hatchability. Loss in hatchability results from combination of egg weight loss, surface area shrinkage, lowered Haugh and internal quality unit, lowered yolk quality, increased blastoderm diameters, and increased percentage dead in germ Uyanga et al. (2020). reported that the loss in hatchability might be because of reduction in total blastodermal cell count in eggs stored for a prolonged period in both 43- and 65-wk-old flocks Bergoug et al. (2013). even stated that storage should not exceed 3 d if good hatchability is envisaged.

Besides, prolonged storage of eggs delays the commencement of hatching, thereby extending the incubation period and causing delay in the time to receive chicks from the hatchery (Tona et al., 2003; Bergoug et al., 2013; Abioja et al., 2020a). This delays the onset of initiating feeding the chicks Tona et al. (2003). discovered that eggs stored for 3 d hatched earlier than those stored for 14 d. The 3-d storage group achieved 50% hatch by 486 h of incubation while it took 502 h for 18-d storage group. The extended incubation period for stored eggs can easily be compensated by prewarming or setting older egg earlier than fresher eggs. In the same vein, hatch window may also be affected by prolonged storage. Though Tona et al. (2003) did not obtain significant effect of storage length on hatch window, Abioja et al. (2020a) found that to achieve 95% hatch, there was a delay of 65 min/day between eggs stored for 4 d and those stored for 16 d in FUNAAB-alpha (**Fα**) chickens.

Chick quality has been found to be affected by egg storage length (Tona et al., 2003; Abioja et al., 2020a). Longer periods of egg storage resulted in chicks with severe anomalies and lower quality scores. Anomalies could be seen in the lower level of activity, wet and dirty down feather and poor appearance, closed eyes, poor leg conformity, non-closed and discolored navel and presence of large yolk remnant in chicks (Tona et al., 2003) Abioja et al. (2020a). found that 16-d egg storage yielded chicks that are shorter in length, less active with larger remnant yolk sac compared to 4-d egg storage group Goliomytis et al. (2015). reported that prolonged storage duration may cause immunosuppression in chicks. The effects of storage length on all these parameters may, however, be species-dependent.

Transylvanian naked neck (**TNN**) chickens, also known as *Turken* and reputed for high thermotolerance (Pârvu et al., 2007), have just been recently introduced to humid tropical region in Nigeria and reported by Abioja et al. (2020b). The chickens are well-known in the Asia, indigenous to Hungary, found in hill regions of Transylvania in Romania but new to the region of south-western Nigeria. The physical features of TNN chickens were described by Roberts (2008). Adaptation capability, egg production, quality, and hatchability of TNN chickens were recently compared with Nigerian local (**NL**) and Fα chickens (Abioja et al., 2020b; Omotara et al., 2020). Transylvanian naked neck chickens are found to possess the capacity to adapt and survive under the prevailing hot conditions of the tropics. The birds make use of the prominent wattle and comb, in addition to naked neck skin for effective heat loss. In terms of egg production, TNN stands between NL and Fα chickens. Though egg fertility was lower, yethatchability was similar to NL and Fα chickens. However, TNN chickens lay eggs of better quality, yielding heavier chicks with higher chick to egg ratio than NL and Fα chickens. TNN chicken is one of the promising genotypes for the humid tropical regions, there is need to fine-tune the pre-incubation conditions of eggs in TNN chickens in order to optimize the hatching success. However, there is still dearth of information on this genotype. Therefore, the present study aimed at determining the effect of egg storage length on hatchability, spread of hatch, hatch window, chick quality, and organ development in TNN chickens.

MATERIALS AND METHODS

Experimental Location

The study was carried out at the Poultry Unit of University Farms, Federal University of Agriculture, Abeokuta, Nigeria (latitude 7° 13'N; longitude 3° 26'E (Google Earth, 2021) and altitude 76 m above sea level).

Experimental Materials

Hatchable eggs (n = 220) with no crack and visible dirt collected from the flocks of *Transylvanian naked neck* (TNN) breeder hens aged 30 wk were used for the experiment. Artificial insemination was used twice weekly in the flock to ensure good fertility rate. Egg collections was done in batches based on the length of storage required. Eggs laid between 18.00 h of previous night and 06.00 h the following morning were collected from pens and moved immediately into the cold room of PEARLS-FUNAAB Hatchery (which is in close proximity to the pens), in crates for storage. Egg movement and fumigation with formaldehyde gas were done within the next 1 h.

Egg Storage

Eggs collected on each day of storage were weighed, labeled, and stored in egg trays with broad end up (under 16 ± 1.5°C and 75 ± 1.5°C relative humidity) for 0, 3, 6, 9, or 12 d. There were 44 eggs in each group with 4 replicates and 11 eggs per replicate. Eggs for 0 d storage were collected at 06.00 h of the incubation day, weighed, labeled and moved into the hatchery

immediately for fumigation and setting without storage. All the (stored and non-stored) eggs were set within 2 to14 h post-oviposition.

Incubation, Candling, and Hatching

All the eggs were set at the same time (08.00 h) in an incubator (N.V. Petersime EV1/EN2 Incubator, Belgium) under identical conditions maintained at 37.5°C dry bulb and 29.5°C wet-bulb temperature on incubation day. The candling was done on d 18 of incubation before transfer.

Data Collection

Hatchability and Hatching Time Hatchability of eggs was calculated from the data of number hatched in egg storage group. As the predicted hatching time (501 h) was approaching, eggs in the hatcher were monitored every 6 h starting from 460 h incubation time to monitor the commencement and the end of hatch. The hatch window was taken as difference between incubation time at the commencement and the end of hatch. The number of chicks hatched at every interval was recorded and used to plot a graph of percentage hatch against incubation time. The hatch was concluded 48 h postpredicted time. Incubation time of achieving 25, 50, 75, and 95% hatch was traced in the graph for each storage length and recorded. The calculated time delay of hatch resulting from additional storage after 0 d was estimated. Hatching rate was calculated as percentage hatch per hour during the hatch window.

Chick Quality Completely dried chicks were removed from the hatcher and weighed. Chick yield was calculated as the ratio of chick weight to egg weight in percentage. Tona hedonic scale (Abioja et al., 2020a) was adopted to grade the chick quality traits. Traits observed include chick activity, downs and appearance, retracted yolk, eye, leg, navel, remnant membrane, remnant yolk sac, total Tona grade, and chick length.

Statistical Analysis

Data collected were subjected to one-way analysis of variance using Minitab Statistical software (Minitab, 2013). The statistical model employed was as follows: $Y_{ij} = \mu + D_i + \Sigma_{ij}$, where Y_{ij} is trait of interest; μ is population mean; D_i is the i^{th} effect due to duration of egg storage (i = 0, 3, 6, 9, 12); and Σ_{ij} is residual error. Means, considered significantly different at $P \leq 0.05$, were separated with Tukey's HSD test.

RESULTS AND DISCUSSION

Effect of storage length on egg hatchability in Transylvanian naked neck (TNN) chickens is shown in Figure 1. Hatchability of fertile (**HF**) and set (**HS**) eggs were significantly ($P < 0.001$) reduced steadily by storage length. Both HF and HS declined progressively as duration of storage increased however, storage for 6 and 9 d differed not from each other for both HF and HS Figure 2. presents the chart showing the spread of hatch in relation to egg storage length. From the chart, Tables 1 and 2 were drawn out to show the incubation time, calculated time delay of hatch resulting from additional storage after 0 d and hatch window. For 50% hatch, there was a gain of 30 min/d in hatching time of 3 d stored eggs before fresh eggs, while eggs stored for 6, 9, and 12 d had delay of 70, 65, and 30 min/d, respectively. Hatching commenced 6 h earlier ($P < 0.01$) in eggs stored for 0 and 3d than in longer storage of eggs. Eggs stored for 12 d recorded a shorter ($P < 0.001$) hatch window than those stored for 0 to 9 d. Significantly ($P < 0.01$) more eggs hatched per hour in fresh eggs (3.9%) than other storage durations (1.70 −2.12 %/h).

Table 3 shows the effect of egg storage length on chick quality. Chick weight was significantly ($P < 0.05$) reduced by 1 2d egg storage. Fresh eggs hatched into heavier chicks (37.2 g) than 12 d (32.7 g). Chick yield was not ($P > 0.05$) affected by egg storage, but the

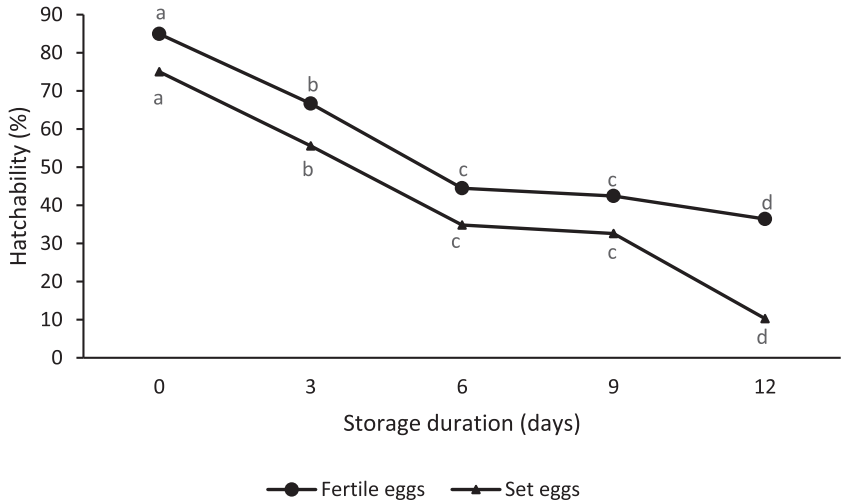

Figure 1. Effect of storage duration on egg hatchability in Transylvanian naked neck chickens. [a,b,c,d]Means with different letters differ significantly ($P = 0.000$).

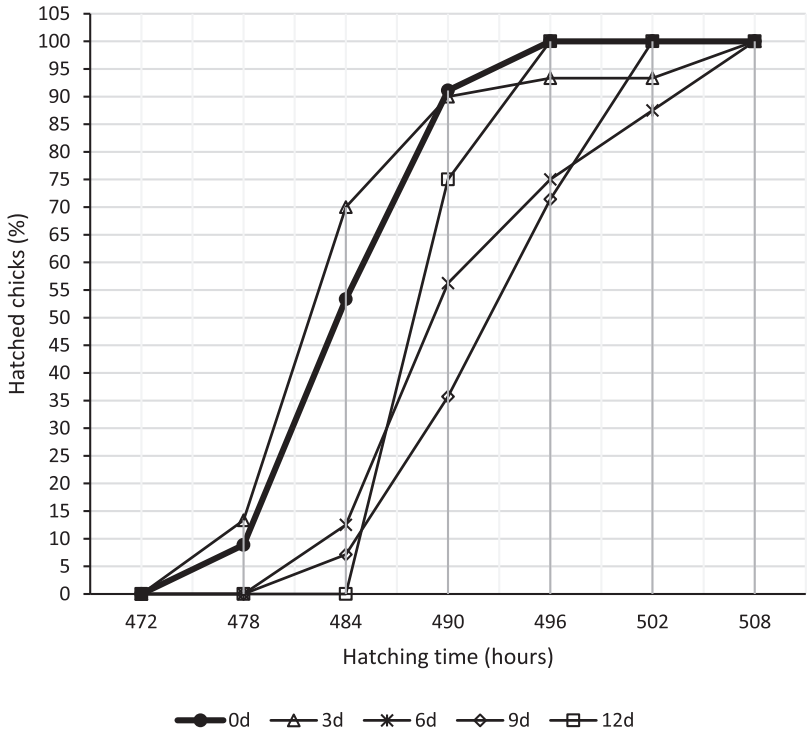

Figure 2. Spread of hatch in relation to egg storage duration in Transylvanian naked neck chickens.

length of chick, toe, and shank+toe (S+T) were reduced ($P < 0.01$) by egg storage length. Eggs stored for 9 and 12 d yielded shorter chicks than 0, 3, and 6 d eggs. Chick toe and S+T were longer for fresh eggs than in stored eggs. Chicks from 12 d eggs were less ($P < 0.01$) active and poorer downs and appearance than others. Eggs stored for 0 to 9 d were hatched into chicks with brighter ($P < 0.05$) eyes than in 12 d eggs. There was a gradual significant ($P < 0.001$) increase in the remaining membrane in chicks as the length of storage increased, though membrane in fresh eggs was similar to that of 3 d. Storage length had significant ($P < 0.001$) effect on closeness of navel, yolk remnant, and Tona score. Chicks from eggs stored for 0, 3, and 6 d had navels that are closer than from 9d, though not different from 12 d. Yolk remnant was larger in chicks of 3, 9, and 12 d storage length than in fresh and 6d storage length. Tona score was higher in 0 to 6 d chicks than in 9 and 12 d chicks. Influence of storage length on the relative weight of organs in chicks is presented in Table 4. There were no significant ($P > 0.05$) differences in the organ weight of chicks.

It is well known that prolonging the post-oviposition storage of eggs negatively affect egg hatchability in chickens (Tona et al., 2003; Petek and Dikmen, 2006; Hamidu et al., 2011; Khan et al., 2014; Addo et al.,

Table 1. Incubation time (hours) and calculated time delay of hatch resulting from additional storage after 0 day (d) in Transylvanian naked neck chickens.

	Incubation time (h)							Delay (min/d)			
Spread of hatch (%)	0d	3d	6d	9d	12d	SEM	*P*	3 d	6 d	9 d	12 d
25	480.0^{b}	479.0^{b}	485.3^{a}	487.5^{a}	487.5^{a}	0.970	0.000	+20.0	−52.5	−50.0	−37.5
50	482.5^{c}	481.0^{c}	489.3^{ab}	492.25^{a}	488.5^{b}	0.851	0.000	+30.0	−70.0	−65.0	−30.0
75	487.3^{bc}	485.9^{c}	496.0^{a}	497.0^{a}	489.6^{b}	0.802	0.000	+27.5	−87.5	−65.0	−11.9
95	492.6^{bc}	498.3^{abc}	503.3^{a}	501.0^{ab}	490.9^{c}	2.060	0.003	−112.5	−106.3	−55.8	+8.8

^{a,b,c}Means within the same row under incubation time with different superscripts differ significantly.

Table 2. Hatch window during incubation time for Transylvanian naked neck chicken eggs stored for different length of time.

Parameter	0 d	3 d	6 d	9 d	12 d	SEM	*P* value
Number of observations	4	4	4	4	4		
Commencement of hatch (h)	472.0^{b}	472.0^{b}	481.0^{a}	482.5^{a}	485.5^{a}	1.22	0.000
End of hatch	493.0^{b}	500.5^{ab}	505.0^{a}	502.0^{ab}	491.5^{b}	2.63	0.009
Hatch window (h)	21.0^{a}	28.5^{a}	24.0^{a}	19.5^{a}	6.0^{b}	2.51	0.000
*Hatching rate (%/h)	3.90^{a}	2.12^{b}	1.45^{b}	1.70^{b}	1.71^{b}	0.378	0.002

^{a,b}Means within the same row with different superscripts differ significantly.
*Hatching rate means percentage hatch per unit time during hatch window.

Table 3. Effect of egg storage duration on Transylvanian naked neck chick quality traits.

Parameter	0 d	3 d	6 d	9 d	12 d	*P* value
Number of observations	17	17	16	8	4	
Chick weight (g)	37.2 ± 0.47[a]	36.5 ± 0.50[ab]	37.5 ± 0.66[a]	34.7 ± 1.04[ab]	32.7 ± 1.48[b]	0.013
Chick yield (%)	69.2 ± 1.24	68.8 ± 1.33	73.8 ± 1.75	69.8 ± 2.77	67.7 ± 3.92	0.184
Chick length (cm)	17.1 ± 0.08[a]	17.1 ± 0.09[a]	17.0 ± 0.12[a]	16.5 ± 0.18[b]	16.1 ± 0.26[b]	0.000
Toe length (cm)	2.31 ± 0.040[a]	2.09 ± 0.040[b]	2.18 ± 0.041[b]	2.14 ± 0.058[b]	2.00 ± 0.083[b]	0.001
Shank+toe length (cm)	4.42 ± 0.042[a]	4.19 ± 0.042[b]	4.16 ± 0.043[b]	4.15 ± 0.061[b]	4.00 ± 0.086[b]	0.000
Tona chick quality scores						
Activity	6.0 ± 0.17[a]	6.0 ± 0.17[a]	6.0 ± 0.17[a]	6.0 ± 0.24[a]	4.5 ± 0.34[b]	0.003
Downs and appearance	10.0 ± 0.06[a]	10.0 ± 0.06[a]	10.0 ± 0.06[a]	10.0 ± 0.08[a]	9.5 ± 0.12[b]	0.003
Retracted yolk	12.0 ± 0.00	12.0 ± 0.00	10.0 ± 0.00	12.0 ± 0.00	12.0 ± 0.00	1.000
Eyes	16 ± 0.33[a]	16 ± 0.33[a]	16 ± 0.34[a]	15 ± 0.48[ab]	14 ± 0.68[b]	0.038
Legs	12.0 ± 0.00	12.0 ± 0.00	10.0 ± 0.00	12.0 ± 0.00	12.0 ± 0.00	1.000
Membrane remnant	12.0 ± 0.47[a]	10.9 ± 0.47[ab]	9.3 ± 0.48[b]	9.5 ± 0.69[b]	8.0 ± 0.97[b]	0.000
Navel	12.0 ± 0.71[a]	11.1 ± 0.71[a]	10.1 ± 0.73[a]	6.0 ± 1.03[b]	7.5 ± 1.46[ab]	0.000
Yolk remnant	15.5 ± 0.42[a]	13.6 ± 0.42[b]	16.0 ± 0.43[a]	12.0 ± 0.61[b]	11.0 ± 0.86[b]	0.000
Tona score	99.5 ± 1.25[a]	95.7 ± 1.25[a]	95.4 ± 1.29[a]	86.5 ± 1.82[b]	82.5 ± 2.58[b]	0.000

[a,b]Means within the same row with different superscripts differ significantly.

2018; Abioja et al., 2021). This is corroborated by the findings of the present study. Eggs of TNN hens set immediately (between 2 and 14 h) after oviposition had the highest hatchability (85%), which decreased consistently as the eggs aged. Storage for 3, 6, 9, and 12 d yielded hatchability of fertile eggs of 67, 45, 42, and 36%, respectively. Reduction of hatchability may be attributed to loss of quality in yolk and albumen (King'-ori, 2011; Addo et al., 2018; Abioja et al., 2021). Quality of albumen is of utmost importance in the development of chicken embryo. Transylvanian naked neck chicken eggs seem to be highly sensitive to storage extension, in that storage for 3, 6, and 9 d had already caused a reduction of 18.2, 40.4, and 42.5%, respectively. Usually, hatchability in chicken eggs increases slightly to reach a peak between 3 and 5 d after oviposition (Addo et al., 2018; Ayeni et al., 2020; Nasri et al., 2020; Rahardja et al., 2020; Abioja et al., 2021). Thereafter, further storage causes steady reduction in egg hatchability. Similar to the present findings, other authors reported consistent decline in hatchability without any peak as eggs increased in days post-oviposition (Khan et al., 2013, 2014). It may be more economical to limit storage of TNN eggs to 3 d, or at most 4 or 5 d if other intervention could be put in place Ayeni et al. (2020). limited days of egg storage to 4 d for optimum hatchability while Khan et al. (2014) pegged it at 3 d.

Prolonging egg storage length in TNN chickens increased incubation time especially for 6 and 9-d storage in the present study. Hatching commenced earlier in 0 and 3 d storage groups than others Tona et al. (2003). stated it is well known in previous studies (Mather and Laughlin, 1976, 1979) that extension of storage time caused delay in commencement of hatching in eggs. Similar delay in commencement of hatching was reported in FUNAAB-alpha eggs subjected to prolonged storage (Abioja et al., 2020a) Bergoug et al. (2013). in a review noted that long storage of eggs might delay hatching time, resulting in 50% of the total hatched chicks attained longer than 486h. In this study, eggs stored for 6, 9, and 12 d reached the 50% hatch at 489.3, 492.3, and 488.5 h incubation time respectively. This was attributed to a delay in the initiation of embryogenesis and slow embryonic development rate after storage (Fasenko, 2007). The delay might result from depletion of readily available energy sources in extendedly stored eggs toward pipping and hatching. Some chicks as such may depend on gluconeogenesis to survive and complete hatching process. Besides, delayed commencement and extension in hatch window may cause irregularity in hatchery procedures as many eggs are yet to hatch while some earlier hatch chicks are overstayed in the hatcher. This, as well, prevents early feeding of chicks and prolong period of waiting laying of chicks on farm. Prewarming or setting older eggs earlier than freshly laid eggs may be a possible way of adjustment. Hatch window was significantly lower in 12 d storage length (6 h) than others that ranged between 19.5 and 28.5 h. This is in contrast to the findings of Tona et al. (2003) that observed no difference in hatch window. However, the significantly low hatch window in 12 d group may be as

Table 4. Effect of egg storage length on relative weight (%) of body organs in Transylvanian naked neck chicks.

Parameter	0 d	3 d	6 d	9 d	12 d	*P* value
Retracted yolk	10.7 ± 1.13	12.7 ± 1.13	13.8 ± 1.26	13.0 ± 1.46	12.9 ± 1.79	0.481
Gizzard	5.45 ± 0.299	5.76 ± 0.473	5.63 ± 0.334	5.13 ± 0.386	6.13 ± 0.473	0.536
Proventriculus	0.93 ± 0.084	1.00 ± 0.084	0.84 ± 0.094	0.82 ± 0.108	0.76 ± 0.132	0.478
Heart	0.90 ± 0.091	0.79 ± 0.091	0.69 ± 0.102	0.74 ± 0.118	0.65 ± 0.144	0.521
Lungs	0.63 ± 0.080	0.63 ± 0.080	0.72 ± 0.089	0.63 ± 0.103	0.85 ± 0.126	0.588
Intestine	3.68 ± 0.216	3.91 ± 0.216	3.66 ± 0.242	3.29 ± 0.279	4.21 ± 0.342	0.314
Liver	2.48 ± 0.158	2.41 ± 0.158	2.37 ± 0.177	2.53 ± 0.204	2.74 ± 0.250	0.781
Yolk-free body weight	83.0 ± 1.42	84.4 ± 1.42	81.7 ± 1.59	81.2 ± 1.83	79.5 ± 2.25	0.405

a result of an extremely few eggs that eventually hatched, which took place later than others but within a short period of time Araújo et al. (2016). had earlier stated that delayed hatching toward the end of hatch window has negative implications. Such chicks remain in hatcher for insufficient time for them to have complete dryness of navel, with wet downs. Chicks hatching too early and/or too late in the hatch window are usually affected negatively (Willemsen et al., 2008). Early birds remain in the hatcher for too long a time with consequential denial of water and food while late birds leave too early (Calil, 2013). Per unit time in the window, nonstored eggs exhibit higher percentage hatch than all stored eggs in the present study.

Post-hatch performance in chickens is directly related to the chick quality (van den Ven et al. 2012). Some of the quality indicators in chicks include chick weight, chick yield, chick length, toe, and shank length. Liveweight of chicks as a measure of chick quality at day-old is important for early post-hatch growth (Decuypere et al., 2002). Extended egg storage length negatively affected chick weight, especially at 12 d storage. Chick weight decreased with increase in storage duration Khan et al. (2014). in line with the above, reported that storage of Rhode Island Red eggs for 9 d had negative influence on the weight of the chicks. As well, Goliomytis et al. (2015) observed lower weight in chicks hatched from Ross 308 eggs stored for 4 and 16 d. The present finding however disagrees with the report of no significant effect of egg storage duration on the weight of Cobb (Tona et al., 2004), leghorn (Senbeta, 2016), heterozygous naked neck (Addo et al., 2018), FUNAAB-alpha (Abioja et al., 2020a) and broiler breeder (Nasri et al., 2020) chicks at day-old Tona et al. (2004). only compared fresh eggs with those stored for 7 d. The present study, however, examined eggs in storage up to 12 d and the lowered chick weight was observed only in 12-d-stored group. Lower body weight at day-old in extendedly stored eggs might be an offshoot of underdevelopment of the chick digestive system at hatch Yalcin et al. (2016). reported that chicks from eggs stored for 14 d had less developed digestive system and might be less adapted to absorption of carbohydrate and proteins than those from 3 d storage Abioja et al. (2020a). did not observed a difference in chick weight in eggs stored for 0 to 16 d. There may exist strain differences in the ability of poultry eggs to withstand prolong storage as different results are obtained by different authors in other species (Onbaşılar et al. 2007). The importance of the storage temperature on chick weight was also highlighted by the report of Addo et al. (2018). One of the indicators of hatching efficiency is chick yield. It is a measure of transformation of egg content to chick. Chick yield was similar in all TNN egg storage length groups in the present study. This is in agreement with the reports of Goliomytis et al. (2015) and Abioja et al. (2020a). However, Alsobayel et al. (2013) reported a decrease in chick yield as length of storage increased from 0 to 14 d. However, Çopur Akpınar and Günenç (2019) discovered that chick yield in Japanese quail was not affected by storage length.

In this trial, storing eggs for 9 and 12 d caused a reduction in chick length. Chick length is an index of chick quality. Previous studies had indicated that extended storage reduced chick length (Reijrink et al., 2010; Goliomytis et al., 2015) Addo et al. (2018)., however, did not observe significant variation in chick length in egg storage length of 1 to 14 d. The report of Abioja et al. (2020a) on effect of egg storage duration on FUNAAB-alpha chick length was not regular. The longest chicks were obtained in eggs stored for 8 d while the least was in 16-d storage group. Chick toe and shank +toe were longer in nonstored than stored eggs in this trial. These are also chick quality parameters that indicated the chicks from nonstored eggs were better than the stored ones. This finding on toe and shank length corroborates the report of reduction in chick shank length in eggs stored for 1, 3, 7, 10, and 14 d. Chick activity and quality of downs, appearance, and eyes are lower in 12 d storage than others in this present study Abioja et al. (2020a). reported that eggs stored for 16 d had poorer chick activity that others stored for 0, 4, 8, and 12 d, though quality of downs, appearance and eyes were not affected by storage length. Chicks that hatched from prolonged egg storage were less active because of tiredness from stress during hatching and/or inability to assess nutrient reserves in the yolk sac. Larger remnant membrane and yolk were recorded in prolonged storage groups. Drier navel and higher Tona score were observed in chicks from 0, 3, and 6 d storage than extended egg storage groups in the present study. In contrast, Goliomytis et al. (2015) reported similarity in navel quality and Tona score in chicks from eggs stored for 4, 12, and 16 d. In the same vein, no difference was observed in Tona score for FUNAAB-alpha chicks obtained from eggs stored for 0 to 16 d. In agreement however, chick quality score was lowered by 7 d storage, especially in older birds (Tona et al., 2004).

There were no differences in relative weight of retracted yolk, gizzard, proventriculus, heart, lungs, intestine, liver, and yolk-free body weight among egg storage length groups in this study. Similar to this, Abioja et al. (2020a) reported that prolonged egg storage length had no effect on proventriculus, heart, lungs, intestine, and liver of chicks. The same authors observed that storage length, however, had effect on gizzard and yolk sac.

ACKNOWLEDGMENTS

The Pioneer Head of Department of Animal Physiology, Retired Professor Olusegun Ayodeji Osinowo is hereby acknowledged for the good foundation he laid for us. The authors acknowledge the support and pieces of advice offered by Mr. Akintayo Akintade.

Animal welfare statement: The experimental procedure has been approved by the Animal Experimental Board of the Department of Animal Physiology, College

of Animal Science and Livestock Production, Federal University of Agriculture, Abeokuta Nigeria. The Guideline for Animal Research of Nigerian Institute of Animal Science (NIAS) was followed.

DISCLOSURES

There is no conflict of interest of any sort in this work.

REFERENCES

Abioja, M. O., J. A. Abiona, O. F. Akinjute, and H. T. Ojoawo. 2021. Effect of storage duration on egg quality, embryo mortality and hatchability in FUNAAB-α chickens. J. Anim. Physiol. Anim. Nut. 105:715–724.

Abioja, M. O., O. P. Omotara, O. S. Iyasere, J. A. Abiona, L. T. Egbeyale, and O. F. Akinjute. 2020b. Comparative study of adaptation in three chicken genotypes under humid tropical conditions of Nigeria. J. Anim. Physiol. Anim. Nut. 104:1401–1409.

Abioja, M. O., O. F. Akinjute, J. A. Abiona, and H. T. Ojoawo. 2020a. Effect of egg storage duration on spread of hatch, chick quality and organ development in FUNAAB-alpha chickens. Trop. Agric. 97:164–172.

Addo, A., J. A. Hamidu, A. Y. Ansah, and K. Adomako. 2018. Impact of egg storage duration and temperature on egg quality, fertility, hatchability and chick quality in naked neck chickens. Intern. J. Poult. Sci. 17:175–183.

Alsobayel, A. A., M. A. Almarshade, and M. A. Albadry. 2013. Effect of breed, age, storage period on egg weight, egg weight loss and chick weight of commercial broiler breeders raised in Saudi Arabia. J. Saudi Soc. Agric. Sci. 12:53–57.

Araújo, I. C. S., N. S. M. Leandro, M. A. Mesquita, M. B. Café, H. H. C. Mello, and E. Gonzales. 2016. Effect of incubator type and broiler breeder age on hatchability and chick quality. Braz. J. Poult. Sci. Special Issue 2:17–26.

Ayeni, A. O., J. O. Agbede, F. A. Igbasan, G. E. Onibi, and M. A. Ayeni. 2020. Effects of storage periods and positioning during storage on hatchability and weight of the hatched chicks from different egg sizes. Bull. Nat. Res. Centre 44:101–106.

Bergoug, H., C. Burel, M. Guinebretière, Q. Tong, N. Roulston, C. E. B. Romanini, V. Exadaktylos, I. M. McGonnell, T. G. M. Demmers, R. Verhelst, C. Bahr, D. Berckmans, and N. Eterradossi. 2013. Effect of pre-incubation and incubation conditions on hatchability, hatch time and hatch window, and effect of post-hatch handling on chick quality at placement. Worlds Poult. Sci. J. 69:313–334.

Calil, T. A. C. 2013. Inovação nos procedimentos de incubação, transferência e nascimento do pinto. Pages 345−370 in Manejo da Incubação. M. Macari, E. Gonzales, I. S. Patrício, I. A. Naass and P. C. Martins, eds. 3rd ed. FACTA, Campinas.

Çopur Akpınar, G., and A. Günenç. 2019. Effects of transportation and storage duration of Japanese quail eggs on hatchability. South Afr. J. Anim. Sci. 49:253–261.

Decuypere, E., K. Tona, F. Bamelis, C. Careghi, B. Kemps, B. De Ketelaere, J. De Baerdemaker, and V. Bruggeman. 2002. Broiler breeders and egg factors interacting with incubation conditions for optimal hatchability and chick quality. Arch. Für Geflügelk. 66:56–57.

Fasenko, G. M. 2007. Egg storage and the embryo. Poult. Sci. 86:1020–1024.

Goliomytis, M., T. Tsipouzian, and A. L. Hager-Theodorides. 2015. Effects of egg storage on hatchability, chick quality, performance and immunocompetence parameters of broiler chickens. Poult. Sci. 94:2257–2265.

Google Earth. 2021. Accessed September 2021. http://www.google.earth.

Hamidu, J. A., D. A. Jerebi, M. A. Okai, D. Wakpal, and L. A. Konadu. 2019. Pre-hatch and post-hatch egg breakout and hatchability analysis as an indicator to increase layer breeder performance and egg hatchability. J. Appl. Sci. 18:818–826.

Hamidu, J. A., Z. Uddin, M. Li, G. M. Fasenko, L. L. Guan, and D. R. Barreda. 2011. Broiler egg storage induces cell death and influences embryo quality. Poult. Sci. 90:1749–1757.

Khan, M. J. A., S. H. Khan, A. Bukhsh, and M. Amin. 2014. The effect of storage time on egg quality and hatchability characteristics of Rhode Island Red (RIR) hens. Vet. Arhiv 84:291–303.

Khan, M. J. A., S. H. Khan, A. Bukhsh, M. I. Abbass, and M. Javed. 2013. Effect of different storage period on egg weight, internal egg quality and hatchability characteristics of Fayoumi eggs. Italian J. Anim. Sci. 12:211–216.

King'ori, A. M. 2011. Review of the factors that influence egg fertility and hatchability in poultry. Int. J. Poult Sci. 10:483–492.

Mather, M. C., and K. F. Laughlin. 1976. Storage of hatching eggs: the effect on total incubation period. Br. Poult. Sci. 17:471–479.

Mather, M. C., and K. F. Laughlin. 1979. Storage of hatching eggs: the interaction between parental age and early embryonic development. Br. Poult. Sci. 20:595–604.

Minitab 17 Statistical Software. 2013. Minitab Inc. Version 17.1.0. Minitab, Inc, State College, Pennsylvania, USA.

Nasri, H., H. van den Brand, T. Najar, and M. Bouzouaia. 2020. Interactions between egg storage duration and breeder age on selected egg quality, hatching results, and chicken quality. Animals 10:1–18.

Omotara, O. P., M. O. Abioja, O. S. Iyasere, and L. T. Egbeyale. 2020. Comparison of egg production, quality and hatchability in three chicken genotypes under humid tropical conditions of Nigeria. J. Agric. Res. Dev. 19:38–52.

Onagbesan, O. M., V. Bruggeman, L. De Smit, M. Debonne, A. Witters, K. Tona, N. Everaert, and E. Decuypere. 2007. Gas exchange during storage and incubation of avian eggs: effects on embryogenesis, hatchability, chick quality and post-hatch growth. Worlds Poult. Sci. J. 63:557–573.

Onbaşılar, E. E., Ö. Poyraz, and E. Erdem. 2007. Effects of egg storage period on hatching egg quality, hatchability, chick quality and relative growth in Pekin ducks. Eur. Poult. Sci. 71:187–191.

Pârvu, M., C. Dinu, and I. C. Andronie. 2007. Study of the thermoregulation capacity of Transylvania naked neck chicks compared to Rhode Island chicks. ISAH 13:345–349.

Petek, M., and S. Dikmen. 2006. The effects of prestorage incubation and length of storage of broiler breeder eggs on hatchability and subsequent growth performance of progeny. Czech J. Anim. Sci. 51:73–77.

Pokhrel, N., D. Sela-Dnenfeld, and Y. Cinnamon. 2021. The chick blastoderm during diapause, a landmark for optimization of preincubation storage conditions. Poult. Sci. 100:101227.

Rahardja, D. P., M. R. Hakim, E. T. Sahrul, and R. D. Savitri. 2020. Effects of weight and storage duration of hatching eggs of Indonesian Local Chicken on several measures of internal quality and hatchability. IOP Conf. Ser. Earth Environ. Sci. 492:1–7.

Reijrink, I., D. Berghmans, R. Meijerhof, B. Kemp, and H. van den Brand. 2010. Influence of egg storage time and preincubation warming profile on embryonic development, hatchability, and chick quality. Poult. Sci. 89:1225–1238.

Roberts, V. 2008. British Poultry Standards. 6th ed Blackwell Publishing, UK.

Schmidt, G. S., E. A. P. Figueiredo, M. G. Saatkamp, and E. R. Bomm. 2009. Effect of storage period and egg weight on embryo development and incubation results. Braz. J. Poult Sci. 11:1–5.

Senbeta, E. K. 2016. Effect of egg storage periods on egg weight loss, hatchability and growth performances of brooder and grower leghorn chickens. IOSR J. Agric. Vet. Sci. 9:75–79.

Tona, K., F. Bamelis, B. Ce Ketelaere, V. Bruggeman, V. M. B. Moraes, J. Buyse, O. Onagbesan, and E. Decuypere. 2003. Effects of egg storage time on spread of hatch, chick quality, and chick juvenile growth. Poult. Sci. 82:736–741.

Tona, K., O. Onagbesan, B. De Ketelaere, E. Decuypere, and V. Bruggeman. 2004. Effects of age of broiler breeders and egg storage on egg quality, hatchability, chick quality, chick weight, and chick posthatch growth to forty-two days. J. Appl. Poult. Res. 13:10–18.

Uyanga, V. A., O. M. Onagbesan, J. A. Abiona, L. T. Egbeyale, O. E. Oke, and O. F. Akinjute. 2020. Blastodermal development, hatchability and chick quality of Marshall broiler breeders of different flock ages during egg storage. J. Anim. Physiol. Anim. Nut. 104:1748–1756.

van den Ven, L. J. F., A. V. van Wagenberg, K. A. Uitdehaag, P. W. G. Groot Koerkamp, B. Kemp, and H. van den Brand. 2012. Significance of chick quality score in broiler production. Anim 6:1677–1683.

Willemsen, H., N. Everaert, A. Witters, L. de Smit, M. Debonne, and F. Verschuere. 2008. Critical assessment of chick quality measurements as an indicator of posthatch performance. Poult. Sci 87:2358–2366.

Yalcin, S., I. Gursel, G. Bilgen, G. T. Izzetoglu, B. H. Horuluoglu, and G. Gucluer. 2016. Egg storage duration and hatch window affect gene expression of nutrient transporters and intestine morphological parameters of early hatched broiler chicks. Anim 10:805–811.