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Effects of Storage Duration on Spread of Hatch, Chick Quality and Post-Hatch Performances in Tropical Climate

Bilalissi A*[1,2], Lombo Y[1], Voemesse K[1], Batimsoga BB[1,2], Kossoga KA[1,2] and Dossou E[1]

[1]Institut Togolais de Recherche Agronomique (ITRA, Togo), Togo

[2]Laboratory of Poultry Science, Regional of Excellence Center on Poultry Science (CERSA), University of Lome, Togo

Research Article

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***Corresponding author:** Bilalissi A, Institut Togolais de Recherche Agronomique (ITRA), Agoe Cacaveli, BP 1163 Lome, Togo, Laboratory of Poultry Science, Regional of Excellence Center on Poultry Science (CERSA), University of Lome (Togo), BP 1515, Lome, Togo, Email: abilalissi18@gmail.com; abidi.bilalissi@cersa-tg.org

Abstract

The objective of this study was to investigate the effect of pre-incubation egg storage duration on hatching traits and Sasso broilers post-hatch performances in tropical conditions.

A total of 900 hatching eggs were individually numbered, weighed and stored for 3 d, 7 d or for 15 d in a climate-controlled room of 16°C and 75 % of relative humidity. After storage period, eggs were reweighed and divided into 5 replications of 60 eggs each. Then, eggs were incubated in the incubator at a temperature of 37.7 ◦ C, relative humidity of 55 %, and turning once an hour until 18 d of incubation. At d 18 of incubation, the eggs were candled, and fertile eggs were transferred from the turning trays to the hatching baskets. During the last 3 d of incubation, the transferred eggs were checked individually every 3 h for hatching events and hatchability. After pull out at d 21.5, chicks were raised to 12-Wk-old of age for post-hatch growth measurements. The results showed that the egg weight loss increased with storage duration ($p= 0.0036$). The egg weight at setting and day old chick weight were significantly higher ($p<0.0001$) in 3 d stored eggs compared to 7 d and 15 d stored eggs. Hatchability significantly decreased ($p<0.0001$) with egg storage duration while, embryonic mortality increased ($p<0.0001$) with egg storage duration. Eggs stored for 3 d and for 7 d attained the different hatching stadia at significantly ($p < 0.0001$) earlier time points compared to 15 d stored eggs. The chicks weight up to 12 week, feed intake and weight gain were significantly higher ($p<0.05$) in 3 d stored eggs group compared to 15 d stored eggs group.

It can be concluded that Sasso broiler breeders eggs should not be stored more than 7 d in tropical conditions.

Keywords: Storage Duration; Tropical Conditions; Sasso; Chick Quality; Hatchability

Introduction

It's well accepted that pre-incubation egg storage is unavoidable in incubation practices. Chicken eggs are usually stored for different periods until these are in sufficient numbers so as to utilize maximum capacity of the incubator [1]. To reach a sufficient number of eggs to fill an incubator, eggs are most of time accumulated in storage until 2 week (wk) before incubation. Egg storage decreases the number of individual incubations and provides hatcheries with flexibility to meet market fluctuations in demand for day old chick. However, egg storage may be detrimental to the developing embryo and thereby compromise hatchability according to the duration or the storage temperature. There are a number of conflicting studies related to the best storage conditions for maximum hatchability and it is not clear how

these storage conditions affect chick quality, hatching time and water vapour loss during incubation [2]. Increasing storage duration increases the percentage of embryo mortality and consequently reduced the hatchability [3]. In fact, a rule-of-thumb in the incubation practice suggested that for every day after 10-days of storage, the number of hatched chicks will decrease by 1 % [4].

It has been reported that hatched chicks of eggs decreases quickly after 7 d of storage time for ducks and 4 d of storage duration for guinea fowl eggs [5]. Kustra, et al. [6] reported that golden pheasants eggs hatchability decrease after 3 to 4 d of storage. For chickens eggs, it was observed that storage length had no effect on hatchability, when storage duration was shorter than 8 d and can be detrimental when storage duration was prolonged [7]. Indeed, Whitehead, et al. [8] demonstrated that the maximum storage duration for chicken hatching egg must be 7 d and every extension of this duration decreases hatchability by increasing embryonic mortality. Furthermore, every day exceeding 7 d of post-ovipositional storage results in extending the average hatching time for one hour, due to retarded pre-hatch development. In fact, Bilalissi, et al. [9] showed that eggs stored for 7 d attained the different hatching stadia at significantly earlier time points compared to 18 d stored eggs. Some negative changes in egg quality of all poultry species have been reported due to prolonged storage time [10]. One of the earlier indicators of changes occurring during storage is weight loss in eggs [11]. This can be related to the fact that increasing storage duration increased the loss of CO_2 and water through the eggshell [12].

Most of studies related to the effect of storage duration on egg weight loss were conducted in temperate climate and one may question about the effect of egg storage duration on egg water loss (egg weight loss) in tropical conditions. Additionally, most studies related to the effect of egg storage period on spread of hatch and chick quality are focused on Cobb broiler breeder eggs. However, these parameters and post-hatch growth parameters have not been examined in Sasso broiler breeder eggs, which is the most broiler strain used in tropical climate.

This study aim to investigate the effect of pre incubation storage duration on hatching traits and post-hatch growth performances in tropical conditions.

Material and Methods

Experimental Location

The experiment was carried out at the Poultry Research Center of Avetonou, Togolese Institute of Agronomic Research (ITRA, Togo).

Experimental Design

Eggs (n=900) with no crack and visible dirt were collected from a flock of Sasso chicken broiler line aged 42 weeks and were used to perform this study. Eggs were individually numbered, weighed and stored for 3 d, 7 d or for 15 d in a climate-controlled room of 16°C and 75 % of relative humidity. Experiment were planned such that egg collection and storage were timed to the exact setting period [9]. Eggs of 15 d storage were collected 8 d prior to the collection of eggs of 7 d storage; and eggs of 7 d storage were collected 4 d prior to the collection of eggs of 3 d storage. After storage period, eggs were reweighed and divided into 5 replications of 60 eggs each. Then, eggs were incubated in the incubator at a temperature of 37.7°C, relative humidity of 55 %, and turning once an hour until 18 d of incubation. At d 18 of incubation, the eggs were candled, and those with evidence of a living embryo were transferred from the turning trays to the hatching baskets. During the last 3 d of incubation, the transferred eggs were checked individually every 3 h for hatching events and hatchability of fertile eggs.

Pipping, Hatching Events, Hatchability, and Chicks Quality Determination

During the last 3 days of incubation, the eggs transferred into the hatching baskets were checked individually every 3 h for hatching events. Eggs in which the beak of embryo penetrates the inner shell membrane (internal pipping, IP) where transferred to a new basket and checked individually every 3 h for eggs in which the shell over the air cell is then cracked (external pipping, EP) [9].

The external pipped eggs were put in separate baskets to determine individual hatching time. All individual times of IP, EP and hatching were recorded to determine average time and duration of IP, EP and hatch. At IP, EP, or hatching stages, incubation duration was defined as the time between setting and the occurrences of these events for each egg. Then, the timing of the occurrence of hatching events was used to calculate their durations as follows:

IP duration (dIP) = duration between IP and EP
EP duration (dEP) = duration between EP and hatching, and
Hatching duration (dHatch) = duration between IP and hatching

The total incubation duration was defined as the duration between setting and hatching.

On the day of hatch, the numbers of the hatched chicks were recorded according to storage duration to determine fertile hatchability. Eggs that failed to hatch were counted, opened, and visually evaluated to determine embryonic

mortality (EM). Day old chicks were then weighed according to treatments to determine average 1-day-old chick weight.

Chick's quality was determined using Tona scoring method [13]. According to this method, physical parameters including reflex, down and appearance, eyes, conformation of legs, navel area, yolk sac, remaining membranes, and yolk were scored. The chick quality score was defined as the sum of the scores assigned to each quality parameter.

$$\text{Hatchbility}(\%) = \frac{\text{total number of hatched chicks at the end of incubation}}{\text{number of fertile eggs transfered to hatching baskets at ED18}} \text{X100}$$

$$\text{EM}(\%) = \frac{\text{total number of hatched chicks at the end of incubation}}{\text{number of fertile eggs transfered to hatching baskets at ED18}} \text{X100}$$

Post-Hatch Growth

A total of 450-d-old chicks for all experimental groups were individually weighed and then transferred into randomly assigned floor pens in groups of 150-d-old chicks per pen according to treatments, with 5 replicates (30 chicks/replicates) for each treatment. The chicks were raised to 12-Wk-old of age under similar environmental and management conditions.

Weekly, body weight and feed intake of each replication were recorded to determine the body weight gain and feed conversion ratio of each treatment.

Statistical Analysis

The data were processed with a commercial scientific 2D graphics and statistics software GraphPad Prism 8 (GraphPad software Inc., California, USA). One way ANOVA model was used to analyze the egg and chick's weight, hatching events durations, feed intake, and average weight gain. The model was as follows:

$$Yi = \mu + \alpha i + \varepsilon i$$

Where, Yi = egg or chicks weights, IP and EP duration or total incubation duration of egg from storage time i, μ = overall mean, αi = main effect of storage time i, and εi = random error term from storage. When the overall p value was statistically significant ($p < 0.05$), further comparisons among groups were made according to Tukey's test.

Results

Effect of Storage Duration on Egg Weight after Storage and Egg Weight Loss during Storage

The effect of egg storage duration on egg weight after storage and egg weight loss during storage was shown in Table 1.

There was no significant difference (p=0.149) in initial egg weights of the groups at collection. However, the egg weight after storage of 3 d stored eggs was significantly higher (p <0.0001) compared to egg weight of 7 and 15 d stored eggs. Overall, the egg weight loss increased with storage duration. The higher (p= 0.0036) egg weight loss was observed in 15 d stored eggs (d15 > d7 > d3).

Effect of Egg Weight at Setting, Hatchability, Embryonic Mortality and Day Old-Chick Weight

The egg weight at setting (Figure 1) and day old chick weight (Figures 2-5) were significantly higher (p<0.0001) in 3 d stored eggs compared to 7 d and 15 d stored eggs. Hatchability significantly decreased (p<0.0001) with egg storage duration (d3>d7>d15) (Figure 3). However, embryonic mortality increased (p<0.0001) with egg storage duration (d3<d7<d15) (Figure 4).

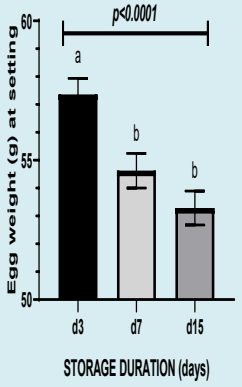

Figure 1: Egg weight at setting according to egg storage duration a,b means data sharing no common letter are significantly different; P<0.05.

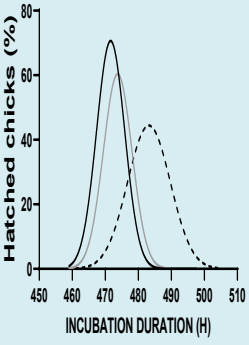

Figure 2: Spread of hatch of hatching time expressed as percentage of hatched chicks according to egg storage duration.

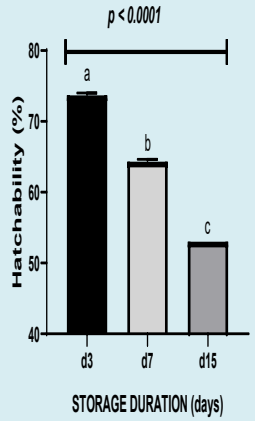

Figure 3: Hatchability of fertile eggs according to egg storage duration a,b,c means data sharing no common letter are significantly different; P<0.05.

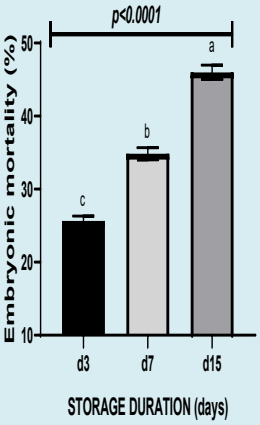

Figure 4: Embryonic mortality according to egg storage duration a,b,c means data sharing no common letter are significantly different; P<0.05.

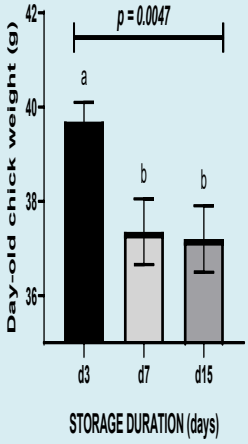

Figure 5: 1-day old chick weight according to egg storage duration a,b means data sharing no common letter are significantly different; P<0.05.

Hatching Process

The average time of the different hatching events was dependent on the storage duration (Tables 1-2). Eggs stored for 3 d and for 7 d attained the different hatching events at significantly ($p < 0.0001$) earlier time points compared to 15 d stored eggs. Additionally, the total incubation duration was shorter in 3 d and 7 d stored eggs compared to 15 d stored eggs. The duration between internal and external pipping (dIP) was significantly shorter ($p = 0.0015$) for 3 and 7 d stored eggs compared to 15 d stored eggs (Table 3). The duration between external pipping and hatching (dEP) ($p = 0.0205$) and between internal pipping and hatching (dHatch) ($p= 0.0117$) were significantly affected by storage duration, where 3 and 7 d stored eggs showed shorter durations compared to 15 d stored eggs.

Items	Storage duration			p Value
	3d	7d	15d	
Egg weight before storage (g)	57.65 ± 0.57a	55.9 ± 0.62a	55.26 ± 0.62a	0.149
Egg weight after storage (g)	57.37 ± 0.57a	54.63 ± 0.62b	53.29 ± 0.61b	<0.0001
Egg weight loss during storage (%)	0.46 ± 0.01c	2.14 ± 0.14b	3.28 ± 0.28a	0.0036

a,b For each row, data sharing no common letter are significantly different (P < 0.05).

Table 1: Effect of storage duration on egg weight after storage and egg weight loss during storage.

Items (h)	Storage duration			p Value
	3d	7d	15d	
Incubation duration up to IP	451.1 ± 0.69b	451.0 ± 0.66b	459.1 ± 1.356a	<0.0001
Incubation duration up to EP	458.3 ± 0.84b	459.1 ± 0.90b	472.0 ± 1.30a	<0.0001
Total incubation duration	472.9 ± 0.79b	474.8 ± 0.93b	485.1 ± 1.34a	<0.0001
Chick quality score	97.8 ± 0.76a	93.4 ± 1.04ab	88.6 ± 2.57b	0.0022

a, b For each row, data sharing no common letter are significantly different (P < 0.05).

Table 2: Incubation duration (h) up to internal pipping (IP), external pipping (EP), and hatching (Hatch) and chick quality score according to egg storage duration.

Items (h)	Storage duration			p Value
	3d	7d	15d	
dIP	7.1 ± 0.1b	8.05 ± 0.05b	12.45 ± 0.45a	0.0015
dEP	14.3 ± 0.3b	13.05 ± 0.05b	15.35 ± 0.35a	0.0205
dHatch	21.4 ± 0.4b	23.4 ± 0.4ab	25.6 ± 0.4a	0.0117

a, b For each row, data sharing no common letter are significantly different (P < 0.05).

Table 3: Duration (h) of internal pipping (dIP), external pipping (dEP), and the total hatching process (dHatch) according to egg storage duration.

Figure 2 shows the spread of hatch according to egg storage duration treatments. The eggs stored for 3 d hatched better and earlier than those stored for 15 d. About 70 % of the chicks from eggs stored for 3 d hatched before 470 h of incubation, whereas such percentage was not obtained in eggs stored for 15 d until after 500 h. The first hatch occurred before 465 h in eggs stored for 3 and 7 d but not until 471 h in eggs stored for 15 d. The dispersion around the average hatching time was higher in eggs stored for 15 d (σ = 7.58) than those of the eggs stored for 3 d (σ = 5.62) and 7 d (σ = 5.89).

Effect of Egg Storage duration on Post-Hatch Performances

Figure 7 shows the chicks weight up to 12 weeks according to egg storage duration. Chick's weight from 3 and 7 d stored eggs was significantly higher compared to chick's weight from 15 d stored eggs.

The feed intake (Figure 6) and weight gain (Figure 8) were significantly higher (p<0.05) in 3 d stored eggs group compared to 15 d stored eggs group.

The feed conversion ratio was significantly lower (p=0.0341) in 3 d stored groups compared to 15 d stored groups (Figure 9).

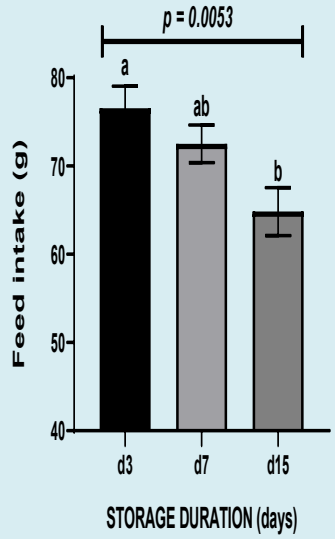

Figure 6: Feed intake according to egg storage duration a,b means data sharing no common letter are significantly different; P<0.05.

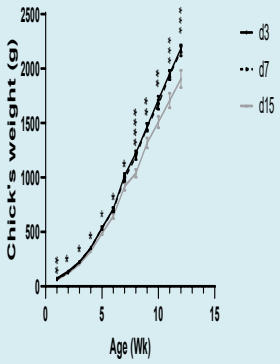

Figure 7: Chick weight up to 12 weeks according to egg storage duration.

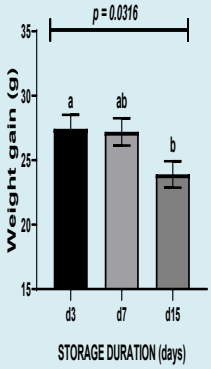

Figure 8: Chicks weight gain according to egg storage duration a,b means data sharing no common letter are significantly different; P<0.05.

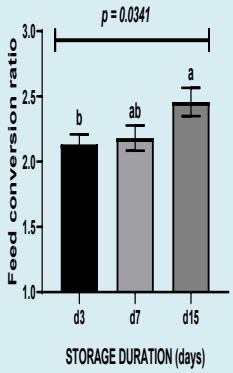

Figure 9: Feed conversion ratio according to egg storage duration. a,b means data sharing no common letter are significantly different; P<0.05.

Discussion

Pre incubation egg storage duration is well known as an important factor affecting hatching traits and post hatch growth performances [14]. In this study, it is pointed out that long term storage duration of chicken hatching eggs is detrimental for hatchability and post-hatch growth.

The difference in egg weight after storage or at setting was a result of water loss which increased with storage duration, since there was no significant difference in initial egg weights of the groups at collection. This result corroborates the recent report of Bilalissi, et al. [9] and Kouame, et al. [5] who showed that egg weight loss increased with storage duration. During storage, eggs lose CO_2 and water from the albumen [12]. Thus, the increase of egg weight loss with storage duration can be attributed to the excessive diffusion of water from inside to the outside of the egg. Overall, day-old chick weights increased with the egg weights. Thus, the higher chick weight for chicks from 3 d stored eggs can be attributed to their egg weight which was higher compared to others groups. This finding was in line with the reports of Tona, et al. [13] who demonstrated that, irrespective of the storage duration, day-old chick weights at hatch were positively correlated with the egg weights at setting.

It was suggested that during storage, eggs lose water, and CO_2 from the albumen and increase in the albumen pH occur with prolonged storage duration. Alkalinisation of the albumen pH destabilizes the lysozyme-ovomucine complex and results in increasing liquidity of the albumen which negatively affect the egg quality. Day-old chick quality and embryonic mortality is related to egg characteristic such as egg quality [15]. In the present study, the lower chick quality score for chicks from 7 and 15 d stored eggs can be attributed to the degradation of the egg quality. Indeed, Tona KF, et al. [13] reported the negative effect of long storage duration of hatching on egg internal quality, chick quality, and post-hatch growth performance of broiler chickens.

In the present study, no significant effect of storage time was found on hatchability of eggs stored for 3 d before incubation, but eggs stored for 7 and 15 d showed a significant decrease in hatchability due to the increase in embryonic mortality. Our results coincide with findings of Mahmud, et al. [16] in broiler breeder, Muhammad, et al. [17] in Fayumi breeder, Kouame YEA, et al. [5] in guinea fowl breeder; whose eggs have no appreciable loss in hatchability when stored for 3 d. Our findings also partly coincide with other studies. Petek M, et al. [18] reported that hatchability of eggs of broiler breeder stored for 5 d were significantly better compared to eggs stored for 15 d. Similarly, Reijrink IAM, et al. [7] found that hatchability of fertile eggs in broiler breeder stored for 3, 5 and 8 d were higher than hatchability

of fertile eggs stored for 12 d. According to Fasenko GM, et al. [19], the effect of pre-incubation storage duration on hatchability depends on the developmental stage of the embryo after pre-storage incubation. They hypothesized that embryos advanced to the developmental stage, according to the classification table of Eyal-Giladi, et al. [20] EG12 or EG13 are more resistant for prolonged egg storage than embryos less or further advanced. The embryos of eggs stored for 15 d showed noticeably lower hatchability and higher mortality during incubation. This result was in line with the finding of Petek M, et al. [18], who reported that most of embryonic deaths were noticed in broiler breeder eggs stored for 15 d as compared to 5 d storage period. Elibol, et al. [21,22] showed that embryonic death was increased with increasing egg storage duration. Schmidt GS, et al. [23] reported that storage duration linearly influenced hatchability and embryo mortality, with an estimated 1.17% reduction and a 1.15% increase, respectively for each 1 day of storage.

Embryonic development from eggs of long storage duration did not immediately initiate in response to incubation temperatures and these embryos proceeded at a slower rate during the first phase of incubation [19]. It is known that embryos from long storage duration eggs not only lag behind in development, but their metabolism proceeds at a slower rate than embryos from eggs of short storage duration [23]. This can explain the fact that chicks from 3 d and 7 d stored eggs commenced to hatch earlier than those from 15 d stored eggs. As consequence the hatching curve of chicks from 3 d stored eggs was shorter than those from 15 d stored eggs.

Significant differences were found in post-hatch growth performances. The higher chick's weight and weight gain of 3 d stored eggs group compared to 15 d stored eggs group can be linked to feed intake and feed conversion ratio. The negative effect of increasing storage duration on post-hatch growth is in accordance with the report of Bilalissi A, et al. [9], Kouame YEA, et al. [5] and Tona K, et al. [13]. These effects of storage may be due the deterioration of the egg internal quality, especially albumen height during storage [24]. These results of the present study agreed also with the findings of Garip M, et al. [26] who reported that hatchling weight of quail decreased from 1 d to 15 d of egg storage periods. However, our results are in contradiction with the findings of other researchers Garip M, et al. [27,28] who reported that post-hatch performances was not affected by pre-incubation storage duration. This may be explain by the shortage storage period employed, different breeds and different environment conditions [29].

From the results of this study, it can be concluded that storage duration of Sasso breeders hatching eggs prolonged incubation duration and negatively affects hatching and post-hatching performances. Further studies are needed to establish the effect of storage duration on egg internal components and physiological indices of Sasso breeders hatching eggs in tropical climate. In practice, it is recommended not to store Sasso breeders hatching eggs at a temperature of 18°C more than 7 d in tropical climate.

Ethics Approval

The present study was approved by the Institutional Animal Ethics Committee guidelines of the Regional Center of Excellence on Poultry Sciences, University of Lome, Togo (CERSA-UL).

Author Contributions

A.B conceived, designed, performed the study and write the paper. Y.L supervised and approved the experimental design of the study, critical revision of the manuscript and final approval for paper submission. K.V for constructive criticism. B.B.B, K.A.K, and E.D. participated in the practical work.

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Conflict of Interest

None.

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