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Effects of storage periods and positioning during storage on hatchability and weight of the hatched chicks from different egg sizes

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Abstract

Background: This study evaluates the effects of storage periods (1, 4, 7, 10, and 13 days), egg size (small 60–64 g, medium 65–69 g, and large ≥ 70 g), and egg positioning with air cell facing either down or up during storage on hatchability percentages and day-old chick's weight. One thousand and five hundred (1500) fertile eggs from Arbor acre broiler breed were purchased and arranged each according to egg sizes into five (5) different storage periods of 100 eggs per storage period. Each storage period was subdivided into 2 groups of 50 eggs each based on positioning during storage. A completely randomized design in 3 × 5 × 2 factorial arrangement was adopted. Stored eggs were incubated for hatch with recording of weights of the hatched chicks, and the hatchability rate was calculated.

Results: The results indicated eggs stored for a day and 4 days had maximum hatchability, but declined slightly as the storage period increased (92 to 78%). The eggs positioned down generally had better hatchability. However, medium-sized eggs had the highest hatchability percentage. On the other hand, large-sized eggs stored for longer period attained higher chick weight compared to medium- and small-sized eggs, but large-sized eggs positioned down gave a better chick weight. Generally, eggs stored with air cell down present superior chick weight.

Conclusion: Storage period and egg positioning during storage affect the subsequent egg hatchability and weight of the hatched chicks from different egg sizes. However, egg storage must not exceed 4 days for optimum hatchability and weight of the hatched chicks. In addition, storing of eggs with air cell down might also enhance the hatchability and weight of hatched chicks irrespective of the weight of the eggs.

Keywords: Egg storage, Egg positioning, Air cell, Hatchability, Day-old chick

Introduction

Egg weight and chick weight at hatching have been shown to be positively related (Khurshid et al. 2003). The embryo size before and at hatching can be altered by the weight of the egg and the incubation environment (Wilson 1991). It could, therefore, be suggested that the potential of the broiler chicken depends, in part, on the egg, an important parameter for embryogenesis as well as for day-old chick quality and growth. In line with this, Brake et al. (1997) reported that the effect of egg storage on embryonic viability depends on storage time duration, environmental conditions, hen age, and strain of breeder, while pre-incubation factors that determine embryo and eggshell quality may include parental genetics, nutrition, maternal age, and environmental conditions such as weather and lighting (French and Tullet 1991) as well as methods of egg collection and egg storage period

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(Nahm 2001). Egg storage conditions prior to incubation can influence hatchability and are thus of considerable concern to commercial hatchery practice (Butler 1991).

Fertility and hatchability are the major determinants of profitability in a hatchery enterprise (Peters et al. 2008). However, the storage of eggs for more than a week is known to increase embryonic abnormalities and mortality due to the degradation of the viscosity of egg albumen (Petek and Dikmen 2006). The elongated storage of eggs also shows reduced hatchability and an increase in the amount of incubation time required to hatch. In fact, a rule of thumb in the hatchery business is that for every day after 10 days of storage, hatchability will decrease by 1% (Bakst and Akuffo 2002). This elongated egg storage problem on hatchability and growth performances of brooder chicks is not extensively determined in western African conditions, as hatchability and growth performances of chicks differ according to species, breeds, environmental conditions, and other management. This study thus evaluates the effect of storage periods and egg positioning during storage on egg hatchability and weights of hatched chicks from different egg sizes.

Materials and methods

Experimental site

This study was carried out at the Sieberer Hatchery of Amo Byng Nigeria Limited, Awe, Oyo State, Nigeria.

Experimental layout and design

A total of one thousand and five hundred (1500) fertile broiler breeder (43 weeks old) eggs were purchased from the farm of Amo Byng Nigeria Limited, Awe, Oyo State, Nigeria, for the purpose of this trial and were arranged 500 eggs each according to egg sizes (small, medium, and large) into five (5) different storage periods of 100 eggs per storage period of 1, 4, 7, 10, and 13 days. Each storage period was subdivided into 2 groups of 50 eggs each based on positioning with broad end either upward or downward during storage. The egg storage temperature was set at 18 °C and 75% humidity throughout the storage periods for all the treatments. Setters were set at 37.5 °C and 55% humidity, while the hatcher had 37 °C and 60% humidity. A completely randomized design with the 3 × 5 × 2 factorial arrangement was adopted for the trial, i.e., egg sizes (small, medium, and large), storage periods (1, 4, 7, 10, and 13 days), and egg positioning.

Storage and hatching of eggs

Used eggs were obtained in 5 batches according to storage time starting with that stored for 13 days. The eggs were weighed and grouped according to sizes before storage in the hatchery cold room under a temperature of 18 °C and 75% humidity. Hatching eggs were incubated for hatching according to Rashid et al. (2013). On day 21 (hatching day), all unhatched eggs were counted while the percentage of hatchability was calculated and the chick's weights were also taken. The hatching of eggs was done based on the procedure provided by the hatchery.

Determination of the hatchability of egg and weight of hatched chicks

The eggs spent a total number of 21 days in the incubator, after which the chicks were brought out. Counting was done based on the ranges set in the incubator. Percentage of hatchability was also determined using the formula:

$$\%\text{hatchability} = \frac{\text{total number of hatched chicks}}{\text{total number of fertile eggs incubated}} \times 100$$

Thereafter, the weight of each of the hatched chicks was determined using a digital sensitive scale, and the values were recorded.

Data analysis

All obtained data were subjected to a general linear model for completely randomized design with a factorial arrangement based on the three factors (storage periods, egg size, and position of eggs) using the Statistical Software package (SAS, 2008). The Duncan multiple range test was used to separate the mean difference between the treatments.

Results

Influence of storage period and position during storage on hatchability and weight of the hatched chicks from different egg sizes

The storage period, egg size, and egg position had a significant ($P < 0.05$) effect on the number of chicks hatched and their hatchability percentage (Table 1). The 4-day egg storage period had the highest number of hatched chicks with 92.96% hatchability though not significantly ($P > 0.05$) different from those stored for 1 day, while the lowest number of chicks hatched and percentage of hatchability (35.3 and 78.52%) was recorded for eggs stored for 13 days.

Also, significant ($P < 0.05$) differences were observed in the number of chicks hatched and their hatchability as the egg position during storage was interchanged. The highest number of hatched chicks was recorded in egg stored with air cell positioned down with 88.44% hatchability compared to 85.93% recorded for eggs positioned up. The number of chicks hatched and the hatchability of the egg sizes also differ in response to storage period and position. The highest was noticed in

Table 1 Effects of the storage period, egg size, and egg position on the number of chicks hatched and hatchability (%)

	Chicks hatch Mean ± SE	% hatchability Mean ± SE
Period (days)		
1	41.67 ± 0.48[a]	92.59 ± 1.06[a]
4	41.83 ± 0.38[a]	92.96 ± 0.85[a]
7	38.83 ± 0.38[b]	86.30 ± 1.93[b]
10	38.50 ± 0.71[b]	85.56 ± 1.58[b]
13	35.30 ± 0.70[c]	78.52 ± 1.55[c]
Position		
Up	38.67 ± 0.55[b]	85.93 ± 1.22[b]
Down	39.80 ± 0.52[a]	88.44 ± 1.16[a]
Egg size		
Small	37.80 ± 0.73[c]	84.00 ± 1.63[c]
Medium	40.70 ± 0.55[a]	90.40 ± 1.23[a]
Large	39.20 ± 0.59[b]	87.10 ± 1.31[b]

Small 60–64 g, medium 65–69 g, and large ≥ 70 g. *Down* air cell facing downwards, *Up* air cell facing upwards. [a,b,c]Means along the same column with different superscripts are significantly ($P < 0.05$) different

medium-sized eggs (90.40% hatchability) and the lowest in small size (84.00%).

The interactions between storage period and position, storage period and egg size, and egg size and egg position also had a significant ($P < 0.05$) effect on the number of chicks hatched and their hatchability percentage (Table 2). The highest number of chicks hatched and percentage of hatchability (42.67 and 94.82%, respectively) was recorded for eggs stored for 1 day and positioned down, while eggs positioned up and stored for 13 days had the lowest chick hatched and percentage of hatchability (34.33 and 76.30%, respectively). The interaction between egg position and egg size revealed that the highest chick hatched and percentage of hatchability (41.60 and 92.44%) was recorded for medium-sized eggs that were positioned down, while the small-sized eggs had the lowest chick hatched and percentage of hatchability (37.80 and 84.00%, respectively) for eggs positioned up and down, respectively. Also, the interaction between storage period and egg size revealed that chick hatched and percentage of hatchability (43.00 and 95.56%, respectively) was recorded for medium-sized eggs stored for 1 day, while small-sized eggs stored for 13 days had the lowest value of chick hatched and percentage of hatchability (32.50 and 72.22%, respectively).

Table 3 shows that storage period and egg position had no significant ($P > 0.05$) effect on the chick's weight. The chick's weight increased ($P < 0.05$) as the egg size increased. The interaction of storage period and position had a significant ($P < 0.05$) effect on the chick's weight such that the highest chick weight was recorded in eggs stored for 7 days and positioned down (Table 4). The storage period and egg size were also significant ($P < 0.05$) with large eggs stored for 7 days having the highest chick weight, while the lowest chick weight was recorded

Table 2 Effects of the interaction between storage period and position, storage period and egg size, and egg size and position on chicks hatched and hatchability percentage

		Chicks hatch Mean ± SE	% hatchability Mean ± SE
Period*position			
1	Down	40.67 ± 0.78	90.37 ± 1.74
	Up	42.67 ± 0.33	94.82 ± 0.74
4	Down	37.33 ± 1.48	82.96 ± 3.29
	Up	40.33 ± 0.67	89.63 ± 1.48
7	Down	41.67 ± 0.53	92.59 ± 1.17
	Up	42.00 ± 0.58	93.30 ± 1.28
10	Down	39.33 ± 0.67	87.41 ± 1.48
	Up	37.67 ± 1.24	83.70 ± 2.75
13	Down	34.33 ± 0.73	76.30 ± 1.61
	Up	36.33 ± 1.13	80.74 ± 2.51
Position*size			
Down	Large	40.00 ± 0.60	88.89 ± 1.34
	Medium	41.60 ± 0.46	92.44 ± 1.01
	Small	37.80 ± 1.21	84.00 ± 2.68
Up	Large	38.40 ± 0.98	85.33 ± 2.19
	Medium	39.80 ± 0.97	88.44 ± 2.16
	Small	37.80 ± 0.88	84.00 ± 1.95
Period*size			
1	Large	41.50 ± 0.43	92.20 ± 0.95
	Medium	43.00 ± 0.37	95.56 ± 0.81
	Small	40.50 ± 1.18	90.00 ± 2.61
4	Large	35.00 ± 1.39	77.78 ± 3.09
	Medium	42.00 ± 0.37	93.33 ± 0.81
	Small	39.50 ± 0.76	87.78 ± 1.70
7	Large	42.50 ± 0.43	94.40 ± 0.95
	Medium	41.50 ± 0.76	92.22 ± 1.70
	Small	41.50 ± 0.76	92.22 ± 1.70
10	Large	39.50 ± 0.43	87.78 ± 0.95
	Medium	41.00 ± 0.37	91.11 ± 0.81
	Small	35.00 ± 0.97	77.78 ± 2.15
13	Large	37.50 ± 0.43	83.33 ± 0.95
	Medium	36.00 ± 1.39	80.00 ± 3.09
	Small	32.50 ± 0.43	72.22 ± 0.95
Period*position		*	*
Period*size		*	*
Position*size		*	*

Large ≥ 70 g, medium 65–69 g, small 60–64 g. *NS* not significant, *Down* air cell facing downwards, *Up* air cell facing upwards. *Significant at $P < 0.05$

Table 3 Effects of the storage period, egg size, and egg position on chick's weight

	Chick's weight (g)
Period (days)	
1	47.67 ± 0.27
4	47.05 ± 0.32
7	49.89 ± 2.06
10	49.62 ± 1.94
13	47.87 ± 0.28
Position	
Up	48.38 ± 0.77
Down	48.45 ± 0.89
Size	
Large	53.23 ± 1.38[a]
Medium	47.38 ± 0.09[b]
Small	44.67 ± 1.16[c]

Small 60–64 g, medium 65–69 g, and large ≥ 70 g. *Down* air cell facing downwards, *Up* air cell facing upwards. [a,b,c]Means along the same column with different superscripts are significantly ($P < 0.05$) different

Table 4 Effects of the interaction between storage period and position, storage period and egg size, and egg size and position on chick's weight

		Chick's weight (g)
Period*position		
1	Down	47.28 ± 0.40
	Up	47.96 ± 0.36
4	Down	47.29 ± 0.43
	Up	46.78 ± 0.47
7	Down	51.67 ± 4.17
	Up	48.15 ± 0.33
10	Down	51.35 ± 3.92
	Up	47.95 ± 0.38
13	Down	47.99 ± 0.40
	Up	47.72 ± 0.38
Position*size		
1	Large	51.91 ± 0.24
	Medium	47.83 ± 0.15
	Small	42.99 ± 0.25
4	Large	53.06 ± 0.33
	Medium	46.75 ± 0.20
	Small	42.54 ± 0.27
7	Large	57.14 ± 5.17
	Medium	47.44 ± 0.20
	Small	44.38 ± 0.24
10	Large	51.54 ± 0.42
	Medium	47.45 ± 0.19
	Small	50.51 ± 6.51
13	Large	51.48 ± 0.29
	Medium	47.49 ± 0.23
	Small	43.91 ± 0.31
Size*position		
Large	Down	54.47 ± 2.58
	Up	51.83 ± 0.21
Medium	Down	47.44 ± 0.12
	Up	47.35 ± 0.13
Small	Down	46.13 ± 0.17
	Up	43.24 ± 2.34
Period*position		*
Period*size		*
Size*position		*

Large ≥ 70 g, medium 65–69 g, small 60–64 g. *Down* air cell facing downwards, *Up* air cell facing upwards. *Significant at $P < 0.05$

in small eggs stored for 4 days. Furthermore, the highest chick weight was recorded in large eggs positioned down.

Discussion

The decrease in the number of chicks hatched and hatchability percentage with an increase in storage period beyond day 4 as recorded in this study could be possibly due to water loss and albumen degradation during storage. This result indicated that egg storage declines hatchability percentage of 92 to 78% if stored till 13 days. This result was in line with the findings of Ewonetu (2016) who studied the effect of storage periods on egg weight loss, hatchability, and growth performance of chicks and found that there is a decline in hatchability when eggs are stored for prolonged periods, and this result was also consistent with previous reports (Uddin et al. 1994; Deeming 2000). Similarly, Yassin et al. (2008) opined that storage duration beyond 7 days has a pronounced effect on hatchability. On average, each extra day of storage up to the seventh day of storage reduces hatchability by 0.2%, while this percentage increases to 0.5% after the seventh day of storage (Yassin et al. 2008). Egg positioning also influenced the number of chicks hatched and hatchability percentage, which was confirmed in the present study. The eggs positioned down had better hatchability when compared to those positioned up. This result agreed with the findings of Alsobayel et al. (2012) and Ahmad et al. (2012) who stated that upside-down positioning of eggs had an effect on hatchability, but did not affect the weight and length of chicks. In their study, total hatchability in flocks with 46, 73, and 107 weeks of age was 79.0, 77.0, and 53.3%, respectively. During incubation, hatchability in the upside-down eggs was 4.3% lower than that of the normal position eggs. As the negative effect of the increased egg storage on hatchability has been well documented (Wilson 1991; French 1997), it was expected that the negative effects of upside-down position on hatchability in the old flock that produced heavier eggs be higher than the young flocks. Several studies have also reported that the upside-down position during incubation led to decreased hatchability between 2 and 27% (Yoho et al. 2008; Butcher and Nilipour 2009; Tullet 2009). It has been reported that setting eggs upside down inside the incubator has a significant effect on hatchability and causes higher embryonic mortality in late of incubation period in Japanese quail (Bahojb et al. 2010). A simple approach to preserve hatchability is to turn the eggs down during storage and allow normal position during incubation (Schulte-Drüggelte 2011). This method of turning eggs down during storage and allowing normal position during incubation was adopted in the present study and recorded an increased hatchability of 2.92 % above the normal position.

The relationship that exists between egg storage period and egg position influenced chicks' hatchability percentage. The best performance in terms of chick hatched and hatchability percentage was observed in eggs positioned down and stored for a day. However, this better performance was also observed in eggs stored for 4 days, but positioned down. This result indicated that eggs stored for more than 7 days will decline hatchability percentage from 94.82 to 76.30%. This result agreed with the reports of Onbasilar et al. (2007) who studied the effects of egg storage period on hatching egg quality, hatchability, chick quality, and relative growth in Pekin ducks. The interaction of egg position and egg size had a significant influence on hatchability percentage. The medium-sized egg positioned down had better performance in terms of hatchability percentage. This result agreed with the reports of Rashid et al. (2013) who reported that percentage hatchability of medium-sized eggs was higher than that in large-sized eggs in Fayoumi, Desi, and crossbred (Rhode Island Red × Fayoumi) chickens. Storage period and egg size had a significant influence on hatchability percentage. The medium-sized eggs stored for a day performed best (95% hatchability) compared to 93% for medium eggs stored for 7 days, 92.22% for medium eggs stored for 4 days, and 91.11% for medium eggs stored for 10 days, while the medium-sized eggs stored for 13 days recorded 80% hatchability. This result indicated that hatchability declines as egg storage length or period increased. In line with this, Heba (2015) and Van de Ven (2004) reported that the main cause of low hatchability of long-stored egg was the decrease of albumen viscosity and increased pH of the albumen. According to Scott and Silversides (2000), Romao et al. (2008), and Schmidt et al. (2009), a long storage period could be detrimental to hatching egg quality and can also reduce hatchability.

Chick weight is the most widely used indicator for day-old chick quality assessment (Decuypere et al. 2002). It is known that a positive correlation exists between egg size and chick weight in broiler chickens (Abiola et al. 2008). Abiola et al. (2008) also reported that small chicks hatched from small eggs, while large chicks hatched from large eggs in Anak broiler breeder. The positive correlation observed between egg size and chick hatching weight clearly identified the advantage of initial bigger egg size at the time of setting. Chick weight was highly influenced by storage period and position in this present study. Previous studies proved that the hatching weight is determined by many factors such as genetic, egg weight, incubator environment, storage length, and weight loss in the incubator (Schmidt et al. 2009). When internal egg quality was affected by egg orientation (Proudfoot 1973), it was expected that chick quality and incubation parameters would also be affected. Excluding disease, the age of the bird that laid the egg is the most important factor affecting the albumen quality. Storage in the upside-down position and turning during storage may prevent changes in the albumen or membranes that negatively affect the development of the chorioallantoic membrane. Proper functioning of the chorioallantoic membrane is crucial during embryonic development, and when this membrane is not able to function properly, hatchability and chick quality are negatively affected (Reijrink et al. 2009). Chick yield is one of the important factors in the incubation process and relates to the initial egg weight (Tullet 2009). However, egg stored with air cell down (upside down) consistently recorded higher chick weight compared to those with pointed end up. This was contrary to the report by PasReform (2008) that both, chick quality and liveability, decreased when chicken eggs were in the upside-down position. In this study, eggs stored for 7 and 10 days, but positioned down recorded the highest chick weight of 51.67 and 51.35 g, respectively. The result indicated that an increased egg storage period could reduce chick weight and change in egg positioning as storage period increased could alter the chick weight positively, which is in agreement with the findings of Ewonetu (2016). Fasanko (2007) explained the decrease of newly hatched chick weight in the long-stored eggs as that the long storage causes the delay in the growth and metabolism of the embryo after incubation and causes slow developmental rate. Storage period and egg size also had an influence on the chick weight as the highest chick weight was observed in the large-sized eggs stored for 7 days. This result suggests that large-sized eggs can be stored for a long period of time and still attain high chick weight compared to the medium- and small-sized eggs. This result agreed with the report of Ahmad et al. (2012) who stated that upside-down positioning of eggs had no effect on the weight and length of chicks, and also in line with the report of Javid et al. (2016) who recorded higher chick weight for large-sized eggs of broiler breeder.

Conclusion

Storage period and egg positioning during storage affect the egg hatchability and weight of the hatched chicks from different egg sizes. It could, therefore, be inferred that storage must not exceed 4 days for optimum hatchability and weight of the hatched chicks. However, if eggs are to be stored for more than 4 days, it could be suggested that storing of eggs with air cell down might enhance the hatchability and weight of hatched chicks irrespective of the weight of the eggs.

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Authors' contributions
JOA designed the study. All authors managed the activities of the experiment and interpreted the data collectively. AOA and MA prepared the proposal of the study. AOA, FAI, and GEO prepared the first draft of the manuscript. JOA reviewed the first draft. AOA and MA prepared the second draft. All authors read and approved the final manuscript.

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