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

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Primary Audience: Researchers, Hatchery Managers, Broiler Producers

SUMMARY

Nutritional and environmental conditions influence broiler flock performance. Besides these factors, other less-well-understood factors, such as incubating egg characteristics, affect the embryonic life of chicks. This study demonstrated that egg storage depressed egg albumen Haugh units (HU) and chick quality; these effects of storage were greater in egg and chicks from old breeders. Absolute weight gains (AG) during the first 7 d of rearing were negatively affected by storage and age of breeders. However, the effect of storage was more obvious in chicks from eggs of younger breeders. Field reports indicate that chick weights during the first 2 wk of rearing were lower for chicks from eggs of younger hens but were not affected by the storage time. At the end of the third week, chicks from fresh eggs were heavier than those from eggs stored for 7 d, and this difference increased until 42 d. During the same period, age of hens did not affect broiler weights. Average daily weight gain (ADG) was negatively affected from the end of fourth or fifth week of rearing by egg storage or increasing age of hens, respectively. There was a significant positive relationship between 7- to 35-d-old weights and broiler weights at slaughter age (42 d). It was concluded that growth potential of chicks 1 d posthatch is partly linked to the incubating egg quality and other characteristics that can be linked to the physiological stage of breeders (e.g., age).

Key words: egg storage, age of breeder, egg quality, production parameter, broiler performance

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DESCRIPTION OF PROBLEM

High broiler weight at slaughter is the main goal of the farmer. Factors that influence broiler flock performance, such as nutritional and environmental conditions, are well documented [1, 2, 3]. Other less-well-understood factors, such as age of the breeder and egg storage before incubation, may affect embryonic life of the chick and thereafter the quality of the hatched chick and the growth potential posthatch.

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Previous studies have determined the effects of egg storage and age of breeders on egg albumen characteristics, albumen/yolk ratio, embryo survival, hatchability, and chick hatching weight [4, 5, 6, 7, 8, 9]. Egg storage increases albumen pH and levels are higher in older compared to younger breeders [7]. It has also been shown that albumen height decreases with the age of the breeder and egg storage. Furthermore, egg storage extends the duration of incubation [9, 10, 11, 12], but reports are conflicting with regard to the effect of breeder age [5, 6]. Apart from increasing incubation duration, the effect of egg storage and its consequent rise in albumen pH on embryo survival, hatchability, and chick quality is still not fully understood. Benton and Brake [4] suggested that the low pH of fresh eggs may be detrimental to embryo survival and hatchability, whereas Reis et al. [5] found no effect of preincubation storage on viability and hatchability in young breeders and viability was even higher in fresh eggs from older hens. Furthermore, longer storage periods decreased embryonic growth rate, viability, and hatchability at all flock ages and was more pronounced in older flocks [7, 13]. These conflicting reports suggest that further studies are necessary to determine the effects of storage and age of breeders and their interaction on egg quality and hatchability.

Chick weight and chick quality may be influenced by egg parameters, preincubation storage duration, and age of breeder. Bray and Iton [14], Wilson [15], Silversides and Scott [8], and Tona et al. [16] have shown that egg weight is a dominant factor affecting chick weight at hatch. Other studies have demonstrated that this effect may depend on the age of breeder, storage duration, and incubation duration of the eggs [17, 18, 19].

Reis et al. [5] showed that eggs incubated on the day of lay (fresh eggs) tended to hatch later than stored eggs and produced heavier chicks. However, the factors that control chick quality have not been clearly defined. Because chick hatching weight may not describe the quality, we recently proposed a new method for determining chick quality based on several scored qualitative parameters and used it to determine quality [9]. The data showed a higher percentage of good quality chicks from fresh eggs compared with from stored eggs. There is, however, a lack of evidence on the posthatch performance up to slaughter age of broiler chicks from fresh or stored eggs and from different breeder ages. It is this end product that may determine the ultimate method for egg storage, age of breeder for incubating egg production, and the incubation method for optimal broiler production.

The objective of this study was to determine the effects of age of broiler breeders and egg storage on egg albumen quality, hatchability, chick weight at hatch, chick quality, posthatch growth rate, and body weight at slaughter age.

MATERIALS AND METHODS

Incubating eggs produced by commercial flocks of Cobb broiler breeders were used in 3 experiments to study the effects of egg storage and age of broiler breeders on broiler growth performance. All eggs used in this study were collected between 1000 and 1100 h. The collection was made after eggs from the previous evening were collected. All flocks used for egg collection were maintained under similar environmental and management conditions as prescribed by the breeder company.

Experiment 1

A total of 2,400 eggs composed 16 replications of 150 eggs each were incubated, and an additional 120 eggs were used to determine albumen quality. Half of the eggs were collected from young breeders (35 wk old), and the other half from older breeders (45 wk old). These comprised 4 replicates each of freshly laid eggs and 4 replicates of eggs already stored (70% RH and room temperature of 15°C) for 7 d from each age of broiler breeder to provide statistical replication during egg incubation. Prior to incubation, samples of 30 eggs per age per storage time were used to measure albumen quality. Then, 2,400 eggs were incubated in a forced-draft (single stage) incubator [20] at specific dry-bulb temperature of 37.6°C and wet-bulb temperature of 29°C. On d 18 of incubation, all eggs were candled, and those with evidence of living embryos were transferred from the turning trays to hatcher baskets. Clear eggs obtained from candling and those unhatched after 21 d of incubation were broken for macroscopic analysis to classify them as infertile eggs or eggs with dead embryos.

Measurement of Albumen Haugh Units. Samples of 30 fresh eggs per age group (day of lay) and 30 eggs per age group from stored eggs were weighed and broken to measure albumen Haugh units (HU). For each broken egg, an egg quality measurement system [21] was used to record the egg weight and the height of the albumen by connecting a transmission box and a balance to a personal computer. Then, after calibration of the albumen height gauge, for each weighed and broken egg, the height of albumen was measured (±0.25 mm) with a vertically mounted micrometer [21] with an electronic path. Between eggs, the micrometer was cleaned with wet and then dry absorbing paper. The standard software program version 2A [21] calculated the albumen HU using the egg weight and albumen height.

Production Parameters. At the end of incubation, the number of hatched chicks was recorded. Every chick was weighed and examined macroscopically to score them for classification into high-score or low-score chicks for quality measurement. A chick of good quality (saleable) was defined as being clean, dry, and free from deformities (no skin lesions, well-formed beak, normal conformation of legs), completely sealed navel, and no yolk sac or residual membrane protruding from the navel area [9, 22]. Within each replication, 30 chicks of good quality were selected at random, and their individual weights were recorded. For the purpose of comparing like with like, only chicks of high score were reared for this study. Every selected chick was identified by a leg ring number. Chicks were not sexed, and therefore the sex of chicks within each group was unknown. Sampled chicks were reared at 30 to 32°C in different pens according to age of breeders × storage time with 14 to 15 chicks per m^2. The photoperiod was 23L:1D, and a standard broiler starter diet (2,800 kcal metabolizable energy, 18% crude protein) and water were provided ad libitum.

The data recorded were used to calculate hatchability in relation to the number of fertile eggs and the percentage of chick of good quality as a function of number of hatched chicks. Weights of 1-d-old and 7-d-old chicks were used to calculate the 1) absolute weight gain (AG) and 2) relative growth (RG) as

$$AG = Wt_7 - Wt_0 \quad (1)$$

$$RG = 100 \times AG/Wt_0 \quad (2)$$

where Wt_0 = weight of 1-d-old chick, and Wt_7 = weight of 7-d-old chick.

Experiment 2

Four replications of 150 fresh eggs and 4 replications of 150 eggs stored for 7 d under practical conditions (70% RH and room temperature of 15°C) were incubated at a commercial hatchery company [23]. Eggs were collected from broiler breeders aged 45 wk. All the 8 replications corresponding to 8 trays were set at random at the same side of a trolley. The eggs were set in a commercial incubator [24] for incubation. The multistage incubation system was used. The incubation conditions (temperature and humidity) have been described previously by Tona et al. [25]. After 21.25 d of incubation, samples of 20 1-d-old high-quality chicks selected at random from each tray (20 chicks/group per replicate = 160 chicks in total) were reared for 42 d in a broiler farm to study the relationship between the weights at different stages and the weight at slaughter age. The chicks were weighed at take-off, and each was identified by leg ring number, but from d 7 a wing ring with number was used, and the leg ring was removed. As in experiment 1, the photoperiod was 23L:1D. The birds were fed ad libitum a standard commercial pelleted diet of 2,800 kcal metabolizable energy and 18% crude protein for starters (1 to 14 d) and 3,100 kcal metabolizable energy and 20% crude protein for growers (15 to 42 d). During the rearing period the birds were individually weighed at 7, 14, 21, 28, 35, and 42 d.

Experiment 3

A total of 1,200 incubating eggs produced by breeders of 35 and 45 wk and stored for 7 d were used. As in experiment 2, 4 replications of 150 eggs per age group were incubated in the same hatchery. All the 8 replications corresponding to 8 trays were set at random at the same side of a trolley. The incubation conditions, chick sampling, rearing conditions, and broiler weighing were as described in experiment 2. The selected chicks were reared for 42 d on a broiler farm different from that used in experiment 2.

For experiments 2 and 3, average daily weight gains (ADG) were calculated at the end of each week. ADG was expressed as ADG = $(W_f - W_i)/7$, where W_f = weight at the end of the week, and W_i = weight at the beginning of the week.

Data were analyzed with a statistical software package [26].

RESULTS AND DISCUSSION

Experiment 1

Table 1 shows that there was a clearly negative effect of egg storage on HU. Although age of breeders and storage adversely affected HU ($P < 0.001$), the effect of storage (1.75 U/d of storage) was more pronounced than that of the age of breeders (0.68 U/wk). In both age groups of breeders, 7 d of egg storage resulted in decreased hatchability of approximately 4 and 7% in eggs from breeders of 35 and 45 wk of age, respectively. The percentage of chicks of high quality obtained from older breeders was lower than from young breeders ($P < 0.001$). This finding was further exacerbated by storage of eggs from older breeders for 7 d ($P < 0.001$). Storage had no effect on the quality of chicks obtained from young breeders. Weights of 1-d-old chicks were higher for chicks from older breeders ($P < 0.001$) but were not affected by storage of eggs in both groups of breeders. However, weights of 7-d-old chicks as well as AG and RG were significantly reduced by storage of eggs especially for chicks from young breeders ($P < 0.05$). The highest chick weights at 7 d, AG and RG were obtained from chicks that hatched from fresh eggs of young breeders. Even though weights of 1-d-old chicks were similar between fresh and stored eggs of young breeders, 7-d weight, AG, and RG were significantly different. From older breeders, although the weights of 1-d-old chicks were higher than those of young breeders, RG to 7 d were lower than those from young breeders.

Experiment 2

Table 2 indicates that from 1 to 42 d of age, broilers from fresh and stored eggs showed exponential increases in body weights. Interestingly, the average chick hatching weight was similar for fresh and stored eggs. Early growth up to the first 14 d of rearing was not significantly different between chicks from fresh or stored eggs, although broilers from fresh eggs were slightly heavier. However, at the end of 21 d of rearing and onward, broilers from fresh eggs were significantly heavier than those from stored eggs. In fact, broilers from fresh eggs were approximately 45 and 202 g heavier at 21 and 42 d of rearing, respectively, than those from stored eggs. Body weights at all ages except at 1 d of age were significantly correlated with weights of 42-d-old broilers in both groups. ADG varied from 16.97 ± 0.44 g to 77.86 ± 1.13 g for broilers from stored eggs and 17.85 ± 0.30 g to 85.40 ± 2.25 g for those from fresh eggs. There was a quadratic relationship ($r^2 = 0.99$) between ADG and the age of broilers, and the maximum value was obtained at 35 d of rearing. Before 28 d of rearing, the ADG was not affected by the storage of eggs, but ADG between 28 and 42 d of rearing for broilers from fresh eggs were significantly higher than those for broilers from stored eggs ($P < 0.05$).

Experiment 3

Average chick hatching weight was higher from eggs of older breeders (Table 3). Body weights up to the first 14 d of rearing were higher for birds from eggs of older hens ($P < 0.05$). However, from the end of 14th day of rearing to the 21st day, broilers from younger breeders showed greater growth rate than those from older breeders such that body weights at 21 d were similar between both groups and remained statistically the same until 42 d of age. As in experiment 1, only weights of 1-d-old chicks were not significantly correlated with weights of 42-d-old broilers. ADG varied

TABLE 1. Production parameters in relation to the age of breeders and egg storage

Age of breeders (wk) and egg storage	Production parameter							
	Egg[A] weights (g)	Albumen Haugh units	Hatchability (%)	Chicks scored for high quality (%)	Day-old chick weights (g)	7-d-old chick weights (g)	Weight gains up to 7 d (g)	Relative growth up to 7 d (%)
35								
Fresh eggs	$66.44^{c} \pm 0.53$	$88.56^{a} \pm 1.03$	$92.37^{a} \pm 0.65$	$97.73^{a} \pm 1.30$	$45.27^{b} \pm 0.43$	$141.41^{a} \pm 2.04$	$96.14^{a} \pm 2.05$	$206.97^{a} \pm 5.14$
7 d of storage	$64.19^{d} \pm 0.85$	$76.62^{c} \pm 0.96$	$88.36^{a} \pm 2.27$	$96.92^{a} \pm 1.78$	$44.76^{b} \pm 0.47$	$127.39^{b} \pm 2.00$	$82.63^{c} \pm 2.03$	$186.43^{b} \pm 5.45$
45								
Fresh eggs	$70.56^{a} \pm 0.56$	$82.06^{b} \pm 1.15$	$91.75^{a} \pm 2.42$	$93.67^{b} \pm 2.20$	$49.44^{a} \pm 0.38$	$140.44^{a} \pm 1.84$	$91.00^{ab} \pm 1.86$	$185.46^{b} \pm 4.19$
7 d of storage	$69.02^{b} \pm 0.80$	$69.45^{d} \pm 1.05$	$84.63^{b} \pm 3.47$	$79.36^{c} \pm 3.19$	$48.73^{a} \pm 0.41$	$137.56^{a} \pm 2.16$	$88.83^{b} \pm 2.22$	$184.39^{b} \pm 5.34$
P-value								
Age	0.001	0.001	NS	<0.001	<0.001	<0.001	<0.001	0.037
Storage	0.01	0.001	0.028	<0.001	NS	0.029	NS	0.023
Age × storage	NS	NS	0.037	<0.001	NS	0.008	0.016	NS

[a–d]Within columns, values (average ± SEM) with no common letters are significantly different ($P < 0.05$).
[A]Egg weights represent means ± SEM of all eggs set for incubation.

TABLE 2. Weekly weights (g) of broilers hatched from incubated eggs of 45-wk-old broiler breeders

Age of chickens (d)	Fresh eggs	7 Days of storage	r	*P*-value
1	48.23[a] ± 0.88	47.87[a] ± 0.88		NS
7	173.21[a] ± 3.00	166.67[a] ± 3.93	0.4	0.01
14	459.17[a] ± 7.37	433.38[a] ± 8.73	0.68	0.001
21	876.13[a] ± 19.82	831.00[b] ± 21.34	0.72	<0.001
28	1,438.75[a] ± 35.54	1,334.23[b] ± 36.09	0.88	<0.001
35	2,036.58[a] ± 51.33	1,879.23[b] ± 44.01	0.95	<0.001
42	2,578.75[a] ± 62.67	2,376.54[b] ± 49.07		

[a,b]Within rows, broiler weights with no common letters are significantly different ($P < 0.05$).
[A]Data are shown according to storage duration and significance of relationships between weights at different ages and slaughter weights.

from 14.74 ± 0.24 g to 91.15 ± 2.96 g for broilers from eggs of younger hens and from 16.13 ± 0.17 g to 85.58 ± 2.25 g for those from eggs of older hens. There was a quadratic relationship ($r^2 = 0.99$) between ADG and the age of broilers, but the maximum values were not obtained at the same period of rearing as was the case in the experiment 1. ADG at 42 d was significantly higher in chicks from young breeders.

A few studies [7, 9, 27] have established that the age of broiler breeders and egg storage before incubation are fundamental factors that may affect poultry production parameters such as hatchability, chick quality, and broiler growth up to slaughter at 42 d of age. The eggs used in this study were from 2 flocks of different ages. However, the flocks were kept under similar standard environmental and management conditions such that differences could not have been due to these variables. Our results further clarify how age of the breeder interacts with storage of incubation eggs to alter egg quality, hatchability, quality of chicks, and posthatch growth potential of these broiler chicks. The storage of eggs clearly depressed egg quality (HU) with disparate effects on hatchability and chick quality between young and older breeders. These disparate effects suggest the influence of interaction of age with storage rather than storage alone per se. Furthermore, with small effect of storage on hatchability and chick quality in young breeders, the greater depression of the quality of chicks from stored eggs of older breeders could be attributed to greater deterioration of egg quality. This severe effect in older breeders where eggs were stored for 7 d suggests that shortening storage duration or incubation without storage may be a method of improving the percentage of high quality chicks obtained from older breeders. This finding of reduced HU due to storage or age of broiler breeders is consistent with the reports of Lapão et al. [7], Benton and Brake [4], Scott and Silversides [28], Silversides and Scott [8]. Others have reported deteriorations along with the HU include pH, viscosity [4, 7,

TABLE 3. Weekly weights (g) of broilers hatched from stored incubating eggs from 35- or 45-wk-old broiler breeders

Age of chickens (d)	Age of breeders (wk) 35	45	r	*P*-value
1	45.91[b] ± 0.48	47.45[a] ± 0.41		NS
7	149.12[b] ± 2.15	160.36[a] ± 1.59	0.3	0.01
14	443.13[b] ± 6.21	465.68[a] ± 4.90	0.35	0.001
21	930.29[a] ± 12.11	957.55[a] ± 11.25	0.43	<0.001
28	1,458.76[a] ± 18.67	1,475.49[a] ± 19.14	0.82	<0.001
35	2,077.82[a] ± 18.82	2,074.58[a] ± 18.99	0.93	<0.001
42	2,715.85[a] ± 33.34	2,626.39[a] ± 36.76		

[a,b]Within rows, broiler weights with no common letters are significantly different ($P < 0.05$).
[A]Data are shown according to the age of breeders and significance of relationships between weights at different ages and slaughter weights.

8, 29], and embryo viability [5, 7]. Both Lapão et al. [7] and Benton and Brake [4] showed that although the changes in pH occur mostly in the first 4 d of storage, albumen height and embryo viability continue to diminish with each additional day of storage.

The lack of effect of storage on hatchability in young broiler breeders compared with older breeders in this study is consistent with previous reports [5, 7, 30]. Lapão et al. [7], however, found differential hatchability in young breeder eggs. Hatchability of fresh eggs from older breeders was as good as that of young hens but declined significantly with storage probably as a result of the lower quality of the albumen. Because there was no effect of storage on young hens' eggs, the data affirm an earlier suggestion by Kirk et al. [30] and Meijerhof [31] that eggs of young breeders can be stored instead of those of older breeders.

Chick quality showed higher percentage of high score chicks from young breeders with little effect of storage. Older breeders produced lower percentage of high quality chicks with a significant effect of age × storage. To our knowledge, this is a first report on the effect of age × storage on quality of chicks. The lack of effect of storage alone in young hens compared with older hens suggests, again, the involvement of differential age-related effects.

The finding that storage had no effect on 1-d-old chick weights is in agreement with a previous report by Reis et al. [5]. O'Sullivan et al. [32] reported that the weights of 18-d embryos increased with parental age. The heavier embryos and chicks from older breeders have been attributed to heavier incubating egg weights at setting. The lack of correlation between quality score and 1-d-old weight emphasizes that both are different and independent parameters and that high weight at 1 d of age may not necessarily mean good quality as further substantiated by the growth performance of the chicks.

The depressive effect of egg storage on body weight at 7 d was greater in young breeders, apparently due to lower daily weight gains. Even though broilers from older birds had higher weights at 1-d of age, weights at 7 d were similar for chicks from fresh eggs of both age groups, mainly due to greater body weight gains per day, which is indicative of greater RG by chicks from younger hens as pointed out by Wilson [15]. This finding probably suggests that there is advantage in having high quality chicks at hatch. However, not only chick quality but also egg quality parameters may affect subsequent growth independently from each other. This is shown by the fact that egg storage depressed body weight and RG of chicks from young breeders even though hatching weights or chick quality score were similar to those from fresh eggs.

Posthatch production parameters up to 7 d (e.g., 1-d-old or 7-d-old chick weight, number of good quality chicks, RG rate) could not be explained solely by egg weight, HU, or hatchability. Neither these parameters nor 1-d-old chick weight alone could explain 7-d chick weights or RG. Whereas the HU tended to be partly linked with the number of good quality chicks and RG to 7 d, it had no relationship with 1-d or 7-d chick weights. In the same vein, egg weights had a partial relationship to 1-d chick weights but not to 7-d weights or RG. In older birds, 1-d-old chick weights only had a link with 7-d-old weights but not in young breeders. In a previous report [9], it was reported that broiler growth performance and RG to 7 d of age are correlated with quality score. Also, it was shown that a chick's qualitative aspect affects its growth, depending on whether eggs are stored or not and whether eggs or chicks are from young or older breeders [9].

Because only the chicks assigned higher scores, supposedly of similar quality, were used in this study, the effects of age of breeders or egg storage on growth performance suggests that some unknown intrinsic factors are involved in delivering the effects of age and storage on posthatch production qualities. The factors may include those present either in the breeder and transmitted to the egg or in the developing chick embryo. These factors may become active or inactive as a function of different breeder ages or egg storage and incubation conditions, and they may not be manifested in the HU, egg weight, hatchability, hatching weight, or chick quality. Therefore, HU does not completely describe the quality of the incubating egg and changes in albumen proteins with storage, and age of the hen may be involved. The loss of CO_2

linked with changes in the pH of the albumen, as proposed by Walsh [29] and Heath [33], may also explain the differential viabilities and hatchabilities between these groups [4, 7]. Eggshell characteristics, important factors in H_2O and CO_2 losses, may also be involved in embryo development [34, 35, 36].

Experiments 2 and 3 were conducted to determine growth potentials of the broilers as a function of different variables in experiment 1 until the slaughter age of 42 d. These experiments were conducted under practice conditions but ensuring similar management conditions on the rearing farms. This experimental method was used to link results under large-scale production with those under laboratory conditions (experiment 1). The study clearly demonstrates the effects of storage of incubation eggs and age of breeder on growth performance. The trend of the results from these 2 experiments, even though conducted on different farms using different flocks, closely reflects that from experiment 1. The lack of correlation between 1-d-old weights and weight at 42 d in this study is in agreement with previous reports [37, 38, 39]. Egg storage reduced growth rate after 14 d of age resulting in significant decrease in final broiler weight at slaughter.

On the other hand, chicks from younger breeders had an enhanced growth rate after 14 d of age, thus enabling a better growth rate of broilers up to slaughter age and yielding broilers of similar weights as those from the heavier 1- and 7-d-old chicks of older breeders. These data show that even when storage of eggs is the only option, stored eggs from young breeders still produced slightly (but not significantly) heavier broilers at slaughter even though they have lower weights at 1 d and 7 d of age. Catch-up growth leading to heavier broilers from fresh eggs (Table 2) and young breeders (Table 3) actually occurred between 7 and 21 d of growth. Overall, there was no significant effect of egg storage or age of breeder on mortality of broilers. Mortality during the rearing period was low (0.55% total). Although the number of the deaths amongs broilers hatched from stored eggs was slightly higher than that from fresh eggs, the difference was not significant.

CONCLUSIONS AND APPLICATIONS

1. Data from this study showed that egg storage and age of broiler breeder alter incubation egg quality, and the effects are manifested at different stages of chick development such as at hatch (hatchability and 1-d-old chick quality and weight) and at different stages of posthatch growth.
2. Fresh eggs from young breeders had better albumen quality, hatched better, and produced higher percentages of high quality 1-d-old chicks, although with lower weights at hatch, compared with older breeders but showed greater posthatch growth rate.
3. Storage for 7 d adversely affected hatchability and chick quality and more so for older than for younger breeders. However, storage also affected posthatch growth in a negative way, but this was more obvious in younger than in older breeders.
4. The mechanisms by which age and storage influence prehatch egg qualities and posthatch chick production parameters could not be fully established in this study.
5. If incubating eggs need to be stored, it is recommended that eggs from younger breeders be stored rather than those from older breeders.

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26. The data were processed with a statistical software package (SAS Version 8.2, SAS Insititute Inc., Cary, NC) and were analyzed on individual egg and chick data. One-way ANOVA was used to analyze broiler weights and ADG as a function of egg storage or age of breeders. Two-way ANOVA was used to analyze HU, weights of 1- and 7-d-old chicks, AG, and RG in relation to storage and age of breeders. In a second analysis, hatchability and 1-d-old chick quality were considered as a binomial distribution. Logistic regression was used to analyze hatchability or percentage of chicks of good quality in relation to storage, age of breeders, and their interaction. Significance implies $P < 0.05$.

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