

Effects of Egg Storage Time on Spread of Hatch, Chick Quality, and Chick Juvenile Growth

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ABSTRACT A total of 1,800 incubating eggs produced by a commercial flock of Cobb broiler breeders was used to determine the effects of storage duration (3 or 18 d) on spread of hatch and chick quality. Chick relative growth (RG) at the end of 7 d of rearing was also determined as a measure of the chick performance. Chick quality was defined to encompass several qualitative characteristics and scored according to their importance. Eggs stored for 3 d hatched earlier than those stored for 18 d ($P < 0.05$). Hatching was normally distributed in both categories of eggs, and the spread of hatch was not affected by storage time ($P = 0.69$). Storage duration of 18 d reduced the percentage of day-old chick with high

quality as well as average chick quality score ($P < 0.05$). RG varied with length of egg storage, quality of day-old chick, and the incubation duration ($P < 0.05$). Eighteen-day storage of eggs not only resulted in longer incubation duration and lower quality score but also depressed RG. Chick quality as defined in this study was correlated to RG and storage time. It was concluded that day-old chick quality may be a relatively good indicator of broiler performance. The results suggest however that in order to improve performance prediction power of chick quality, it would be better to define it as a combination of several qualitative aspects of the day-old chick and the juvenile growth to 7 d.

(Key words: chick quality, relative growth, spread of hatch, storage time)

2003 Poultry Science 82:736–741

INTRODUCTION

The performance potentiality of the broiler depends, in part, on egg quality. Egg quality is an important parameter for embryogenesis as well as for 1-d-old chick quality and growth. In hatchery management, the judgement of the quality of a day-old chick is usually based on qualitative aspects, such as abnormalities and contamination. Thus, day-old chick quality when removed from the hatcher seems to be an all-or-none question. Improved quality of a broiler flock at slaughter age can only be realized with high-quality day-old chicks as starting material. This ensures greater survivability and better growth potential during the first days or first week of life (Christensen, 2001). According to Deeming (1995), day-old chick quality can be related to several factors, such as incubator quality, incubation environment, and egg characteristics. Although egg storage is a normal practice after egg collection and often a necessity in commercial

incubation, it negatively influences egg quality and embryo development and results in a longer incubation time (Mirosh and Becker, 1974; Muambi et al., 1980). Furthermore, the spread of hatch can be influenced by the storage length of incubating eggs (Muambi et al., 1980; Christensen et al., 2001), resulting in an increase in the number of chicks that experience delayed access to first feed (Decuyper et al., 2001). Because the end of 7 d of rearing is often considered as the true starting point for production, the performance (RG) of the chicks at this time may be an additional indication of chick quality. RG rather than absolute weight gain measure the speed of growth in time and had previously been used to determine chick performance (Kühn et al., 1982). Therefore, this study aims to investigate the effect of egg storage duration on egg weight before setting, incubation duration, and spread of hatch as they affect chick quality and chick relative growth at the end of 7 d of rearing. To our knowledge, no information is as yet available about these aspects. A more encompassing method of assessing chick quality will be devised to include all physical parameters on the chick that may bear on the survival and perfor-

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Received for publication June 10, 2002.

Accepted for publication January 24, 2003.

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Abbreviation Key: RG = relative growth.

mance potential. The latter will then be measured as relative growth in the following 7 d after hatch. If chick quality shows correlation with RG, it could therefore be applied as a predictor of broiler performance and also result in refinements to management practices for egg storage and incubation.

MATERIAL AND METHODS

Incubation Management

A total of 1,800 incubating eggs produced by a commercial flock of Cobb broiler breeders were studied. The eggs were collected between 1000 and 1100 h and were stored for 3 or 18 d at $15 \pm 1^\circ\text{C}$ and 70 to 75% of relative humidity. Experiments were carefully planned such that egg collection and storage were timed to the exact setting period. Eggs of 18-d storage were collected 15 d prior to their collection of eggs of 3-d storage. In each experiment, eggs for 18- and 3-d storage were thus collected 18 and 3 d previous to setting. Each egg was numbered and weighed prior to the beginning of incubation.

Six experiments of 150 eggs per group per incubation setting were followed. The eggs were set for incubation in a forced-draft incubator² at specific dry-bulb temperature of 37.6°C and wet-bulb temperature of 29°C . Between 432 to 436 h of incubation, the eggs were candled, and those with evidence of living embryos were transferred from the turning trays to hatcher baskets.

Hatching

Between 472 and 510 h of incubation, the transferred eggs were checked individually every 2 h, and the hatched chicks were recorded and weighed. For each egg, the incubation duration was defined as the time between setting and hatching. The spread of hatch was defined as the dispersion around the average incubation duration.

Chick Quality and Relative Growth

After 510 h of incubation, all the hatched chicks were examined macroscopically in order to identify the different characteristics that can be associated with good, average, or poor quality chicks. Based on information collected from hatcheries and broiler farms on varying physical appearances of day-old chicks, the following criteria were selected for inclusion in the estimation of chick quality; these included physical conditions, such as activity, feathering, eyes, conformation of legs, aspect of navel area, yolk absorption, and so on. The methods for assessing these conditions are stated in Table 1. These characteristics were scored according to their importance within a total scale of 100 (Table 2). The level of the score for each parameter was related to its importance in the

survival of the chick and the severity of any anomaly it may carry. This was expressed in a hedonic score according to our judgment. The quality score for a chick was defined as the sum of the scores quoted for all characteristics.

After the quality scoring, chicks from 3- or 18-d egg storage were marked, weighed, and randomly assigned to pens at 14 to 15 chicks per m^2 . Chicks from 3-d egg storage and 18-d egg storage were penned separately (10 pens/group). During the 7 d of feeding, a standard broiler starter diet (2,800 kcal ME/kg and 18% CP) was provided ad libitum, and the photoperiod was 23L:1D. For each chick, day-old weight (Wt0) and 7-d-old weight (Wt7) were used to calculate the chick relative growth (RG) where RG was defined as $\text{RG} = 100 \times (\text{Wt7} - \text{Wt0})/\text{Wt0}$.

Statistical Analysis

The data were processed with the statistical software package SAS version 8.2.³ Because the conditions for incubation were kept constant for each repeat experiment, the data were pooled for analysis.

The Kolmogorov-Smirnov test, at significance level of 0.01 was used to assess the normality of the distribution of hatching time. From the hatching time distribution, the median and 25, 75, and 95% quartiles were calculated. A two-tailed test for comparison of variances was used to analyze the effect of storage time on spread of hatch.

A general linear model was used to analyze (1) the relationship between egg weights at setting, day-old chick weight, and RG and the relationship between the incubation duration and RG, and (2) the differences between the average scores and RG according to the storage time.

In a second analysis, day-old quality scores were considered as binomial in distribution in the chicks of quality scores of 100, on one hand, and on the other hand, the chicks of quality scores lower than 100. A two-tailed test for comparison of variances was used to analyze the influence of storage time on proportion of chicks of quality score of 100. The general linear model was also used to analyze the effect of the dichotomized chick quality on RG.

RESULTS

Effect of Egg Weight on Chick Weight

The average egg weights were $69.56 \text{ g} \pm 0.54$ and $66.92 \text{ g} \pm 0.68$, respectively, for 3-d and 18-d egg storage. The difference in egg weight was a result of water loss during storage, since there was no significant difference in initial egg weights of the groups at collection. Overall, day-old chick weights increased with the egg weights. Irrespective of the storage time, day-old chick weights at hatch were positively correlated with the egg weights at setting: Chick weight = $0.827 \times (\text{egg weight}) - 6.122$ ($r = 0.93$; $P < 0.001$).

²PasReform, Zeddam, The Netherlands.

³SAS Institute Inc., Cary, NC.

TABLE 1. Assessment of different parameters for determining chick quality

Parameters	Assessment
Activity	Activity is assessed by laying the chick on its back to determine how quickly it returned to its feet. A quick spring back onto its feet was regarded as good, but trailing back onto its feet or remaining on its back was assessed as weak.
Down and appearance	The chick body was examined for dryness and cleanliness. It was regarded as normal if it is dry and clean. If it is wet or dirty or both (which can be a source of contamination), then it is not good.
Retracted yolk	The chick was put on its back obliquely on the hand palm until abdominal movement totally stopped. The height of its abdomen was estimated. The consistency of the abdomen to touch was then estimated. If the height of abdomen was estimated to be higher and harder to touch than normal, then yolk retracted was regarded as large and consistent.
Eyes	The chick was put on the legs, and its eyes were observed. The state of brightness and wideness of the gape of the eyelids were estimated.
Legs	The chick was put on its feet to determine if it remained upright well. The toes were examined for their conformation. If the chick remained upright with difficulty, articulations of the knees were examined to detect signs of inflammation or redness or both.
Navel area	Navel and surrounding areas were examined for closure of the navel and its coloration. If the color was different from the skin color of the chick, then it was regarded as bad.
Remaining membrane	Observation of the navel area allowed estimation of the size of any remaining membrane. The size of any remaining membrane was classified as very large, large, or small.
Remaining yolk	Observation of the navel area allowed estimation of the size of any remaining yolk. The size of any remaining yolk was classified as very large, large, or small.

Effect of Egg Storage on Incubation Duration and Spread of Hatch

The eggs stored for 3 d hatched better and earlier than those stored for 18 d. About 80% of the chicks from eggs stored for 3 d hatched before 490 h of incubation, whereas such percentage was not obtained in eggs stored for 18 d until after 500 h. The first hatch occurred before 472 h in eggs stored for 3 d but not until 484 h in eggs stored for 18 d. The dispersion around the average hatching time was higher in eggs stored for 18 d ($\sigma = 7.01$) than those of the eggs stored for 3 d ($\sigma = 6.92$). However, the spread of hatch was not affected by increasing storage time (P

= 0.69). Figure 1 shows that although hatching was normally distributed in both cases, the average incubation duration was different between storage times ($P < 0.05$).

Results in Table 3 show that, in the spread of hatch, eggs stored for 18 d hatched later than those stored for 3 d ($P < 0.001$). The delay in hatching due to one additional day of storage was calculated to be higher (64 min) at the median (50%) hatching time.

Effect of Egg Storage on Chick Quality

The lowest chick quality scores were 68 and 66, respectively, for 3-d and 18-d egg storage. This longer storage

TABLE 2. Allocation of scores to different parameter observations

Parameters	Characteristics	Scores
Activity	Good	6
	Weak	0
Downs and appearance	Clean and dry	10
	Wet	8
	Dirty and wet	0
Retracted yolk	Body with normal swallowed yolk	12
	Body with swallowed large yolk and rather hard to touch	0
Eyes	Opened and bright	16
	Opened and not bright	8
	Closed eyes	0
Legs	Normal legs and toes	16
	One infected leg	8
	Two infected legs	0
Navel	Completely closed and clean	12
	Not completely closed and not discolored	6
	Not closed and discolored	0
Remaining membrane	No membrane	12
	Small membrane	8
	Large membrane	4
	Very large membrane	0
Remaining yolk	No yolk	16
	Small yolk	12
	Large yolk	8
	Very large yolk	0

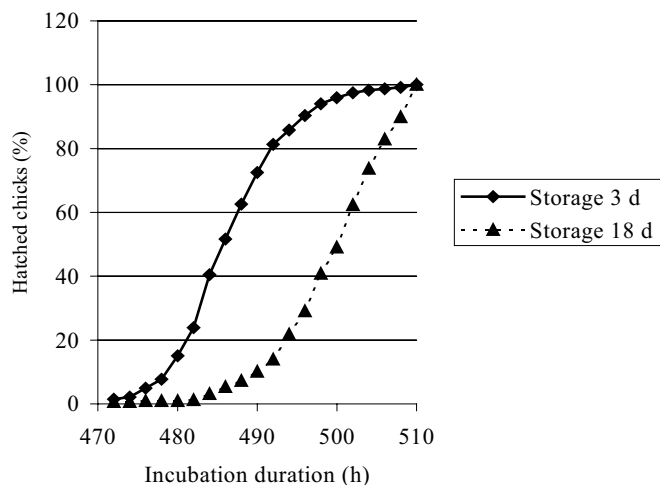


FIGURE 1. Distribution of hatch in relation to the egg storage time.

had a greater depressive effect on day-old chick quality than to the shorter storage. There was greater occurrence of severe anomalies in chicks from eggs stored for 18 d than those of the chicks from eggs stored for 3 d hence the lower quality scores. Results presented in Table 4 show that the percentage of day-old chicks of quality score of 100 was higher in the eggs stored for 3 d ($P < 0.02$). Also, the average quality score of day-old chicks when all chicks of a group was considered in totality was lower in eggs stored for 18 d ($P < 0.001$). A similar result was also obtained when all chicks with quality scores lower than 100 was considered within each group ($P < 0.001$).

Effect of Egg Storage Duration on RG

Relative growth was calculated from data obtained from day-old chick weight (Wt_0) and weight at 7 d old (Wt_7) in the model, $RG = 100 \times (Wt_7 - Wt_0)/Wt_0$. RG calculated for chicks from eggs stored for 3 d varied from 39.36 to 269.21%. Those for chicks from eggs stored for 18 d were between 36.97 to 251.10%. The overall RG showed a relationship with storage duration and day-old chick quality scores. The average RG of the chicks from eggs stored for 3 d was higher ($P < 0.05$) than that of chicks from eggs stored for 18 d ($176.15 \pm 3.55\%$ vs $164.40 \pm 4.62\%$). A further analysis of the data, when day-old

TABLE 3. Incubation duration (h) and calculated time delay of hatch resulting from additional storage after 3 d

Spread of hatch (%)	Egg storage time		Delay (min/d)
	3 d	18 d	
25	484 ^b	496 ^a	48
50	486 ^b	502 ^a	64
75	492 ^b	506 ^a	56
95	500 ^b	510 ^a	40

^{a,b}Within rows, Incubation duration sharing no common letter were significant different according to the storage time ($P < 0.01$).

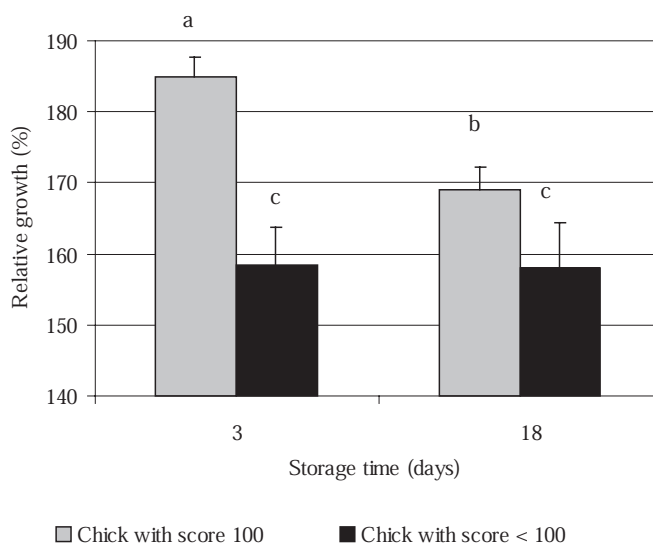


FIGURE 2. Relative growth (RG) according to the storage time and the chick quality score. RG sharing no common letter were different ($P < 0.05$).

chick quality scores were taken into account, showed that within the two storage groups, chicks with quality scores of 100 had significantly higher RG compared with those with quality scores less than 100 (Figure 2). However, between the storage groups, the RG of chicks with scores of 100 was higher in eggs stored for 3 d ($P < 0.001$), whereas there was no difference in the RG of chicks with quality scores of less than 100.

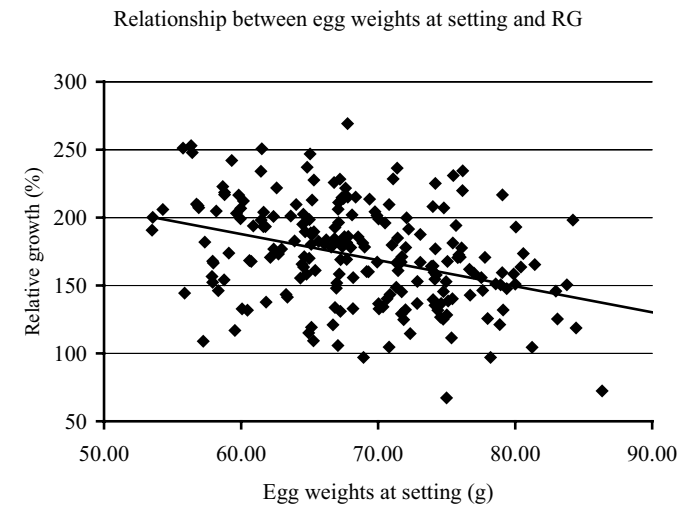
Interrelationships Between Egg Weight, Chick Weight, Incubation Duration, Chick Quality and RG

Because there was a positive correlation between egg weight at setting and day-old chick weight, it was necessary to determine whether both of these weights were interrelated with RG. Figure 3 shows that there was a negative linear relationship between RG and egg weight ($r = 0.34$; $P < 0.001$) and between RG and day-old chick weight ($r = 0.42$; $P < 0.001$), suggesting that RG decreased with increasing egg weight or chick weight. On the other hand, Figure 4 illustrates the negative quadratic relationship between RG and incubation duration ($P < 0.05$): $y = -45611.78 + 186.77x - 0.19x^2$ ($r = 0.33$) where $y = RG$ and $x = incubation\ duration$. The relationship between RG

TABLE 4. Effect of storage time on chick quality

Quality parameters	Storage time	
	3 d	18 d
Chicks with score 100 (%)	62.22 ^a	48.04 ^b
Average score of all chicks	96.59 \pm 0.43 ^a	92.04 \pm 0.96 ^b
Average score of chicks with score < 100	90.97 \pm 0.75 ^a	84.68 \pm 1.12 ^b

^{a,b}Within rows, values sharing no common letter were significant different according to the storage time ($P < 0.05$).



Relationship between day-old chick weight and RG

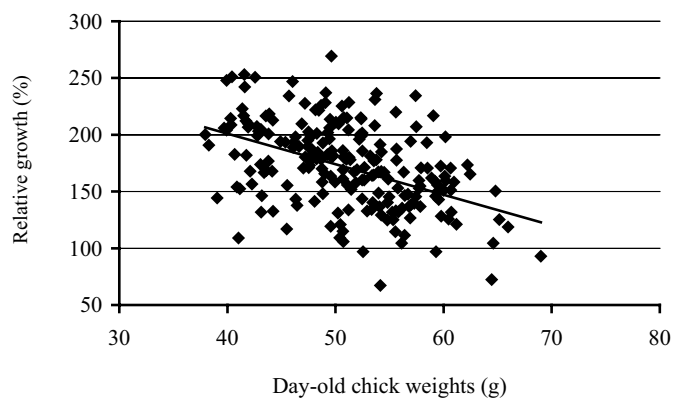


FIGURE 3. Relationship between egg weights or 1-d-old chick weights and relative growth (RG).

and incubation duration suggests that shorter incubation improved RG.

DISCUSSION

The linear relationship between egg weight and the day-old chick weight is in accordance with the results of Merritt and Gowe (1965) and Moran (1990). Since this relationship becomes poor and negative when considering RG, it can be hypothesized that the chick's growth may be related to other variables than just egg weight or day-old chick weight (Becker, 1960; Merritt, 1970). Factors, such as egg storage duration and incubation factors, are indeed other items that hitherto have been discounted in the total quality of the chick.

It is well known that extended storage of eggs prior to incubation results in a delay of hatching. This delay in hatching has been related to a delay in the initiation of embryogenesis (Becker et al., 1968; MacLaury and Insko, 1968; Mather and Laughlin, 1976) and in a decrease in rate of embryo development after storage (Mather and

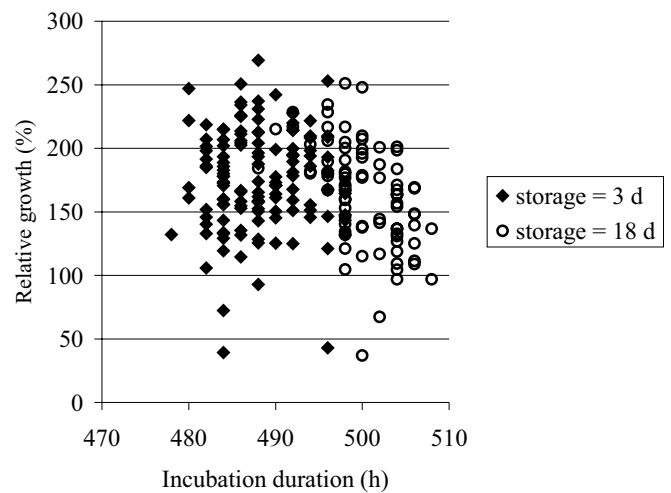


FIGURE 4. Relative growth (RG) in relation to the incubation duration.

Laughlin, 1979). In the current study, there was no significant effect of storage on spread of hatch, but there was a significant delay in hatching of eggs stored for longer period.

As observed earlier by Deeming (1995), the effects of subnormal characteristics of day-old chick on postnatal growth during the first week was confirmed in this study. The results of this study suggest that quality of day-old chicks can be related to the quality of incubating eggs, since the percentage of chicks with different quality scores and incubation duration varied with egg storage time. Similarly, the results showed that the growth potential of the hatched chick (RG) ultimately will depend on the cumulative effects of these factors. Primarily, however egg storage time showed strong influence on all aspects that lead to higher RG of the chick.

The negative effect of increasing storage time on RG is in accordance with the observations of Becker (1960). These effects of storage may be explained by the deterioration of the egg internal quality, especially albumen height during storage (Hurnik et al., 1978; Lâpao et al., 1999; Tona et al., 2002). In fact, during incubation, albumen proteins move into the amniotic fluid and are swallowed by the embryo. Because these proteins are then either digested in the gut or transferred into the yolk sac where they can be utilized after hatching (Deeming, 1989), the potential performance of day-old chick may depend on the quality of the albumen in the incubating egg at this stage. Moreover, Mather and Laughlin (1977, 1979) showed that chick embryogenesis and embryonic life deteriorate with egg storage. We speculate therefore that poor chick quality may be occurring for similar reasons. It is intriguing, however, that even when the quality score of chicks was 100 in eggs stored either for 3 d or 18 d, RG was still lower in those stored for 18 d. It is possible that factors influencing RG may severely be affected during storage of incubating eggs. Further studies are needed to elucidate the nature of such factors.

The quadratic relationship between incubation duration and RG affirms the fact that incubation duration may influence postnatal juvenile growth. It has been suggested that the delay in feed intake after hatch affect adversely the posthatch performance of chicks, especially growth (Becker, 1960; Pinchasov and Noy, 1993). The data from our study suggests that this may be an additional phenomenon that can aggravate the already lingering effect of long storage of eggs. This effect can be clearly seen when one compares early hatched chicks with late hatchers in the quadratic relationship. Since storage time affects incubation duration it can be hypothesized that the earlier/narrower the hatching time, the better the overall RG will be under practical conditions in which delay in providing feed is real. However, the effect of incubation duration on growth can also be linked with a decrease in plasma triiodothyronine (T_3) concentrations in newly hatched chicks as the incubation duration increases (Iqbal et al., 1989).

In conclusion this study demonstrates that

1. Long egg storage time increases incubation duration. It affects adversely day-old chick quality and first week performance.
2. Chick quality affects RG until d 7, while storage affects chick quality, hence, RG. However, storage also influences RG to some extent independently from chick quality as defined here.
3. Further studies are needed to establish the effect of storage on internal constituents of incubating eggs related to potential growth performance.
4. In practice, day-old chick quality is an indicator of potential broiler performance, but it is recommended to define chick quality as a combination of several day-old chick qualitative aspects combined with the juvenile growth up to 7 d of rearing.

ACKNOWLEDGMENTS

K. Tona was supported by an O. T. fellowship from K. U. Leuven. Avibel n.v., Watermolen 9, Halle-Zoersel, Belgium, is gratefully acknowledged for material assistance. V. Bruggeman is a postdoctoral fellow from the Fund for Scientific Research, Flanders, Belgium. F. Bamelis was supported by a grant from the Vlaams Instituut voor de bevordering van het Wetenschappelijk-Technologisch onderzoek in de industrie (IWT).

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