The Effects of the Spread of Hatch and Interaction with Delayed Feed Access After Hatch on Broiler Performance Until Seven Days of Age

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ABSTRACT Delay in access to feed for 1-d-old chicks impairs posthatch growth. It is a standard practice that 1-d-old chicks are deprived of feed for about 48 h before they are placed on farms. During incubation, there is a spread of 24 to 48 h for late versus early hatching. As spread of hatch increases, number of chicks that are feed-deprived for a longer time before free access (IA) to feed and water increases. In this current study, we investigated the effects of time delay in feed access on chick juvenile relative growth (RG: a measure of speed of growth) up to d 7, taking into consideration the duration of egg storage and spread of hatch. Our results confirmed that delay in feed access caused weight loss during holding time and depressed growth rate after access to feed. The magnitude of the effect depended on the hatching period within the hatching window. It also depended on whether the biological age (BA) or the chronological age (CA) of the chick was considered. Immediate access to feed produced significantly different results depending on CA or BA. Both ways, the method seemed to benefit the late hatchers. This finding contrasts with the effect of delayed feeding in which early hatchers benefited more. Long duration of egg storage depressed RG not only of chicks with immediate access to feed but also in those denied access after hatch. Delay in feed access significantly aggravated the effects of long egg storage duration on RG. Triiodothyronine levels were lower in feed-deprived chicks, and the effect was greater in late hatchers. It is concluded that the beginning of delay in feed access should be determined from the time of hatch not at the end of hatch. It is suggested that the adverse effects of delay in feed access can be reduced by providing a source of energy in hatching baskets or during transportation.

(*Key words*: broiler, delayed feeding, hatching spread, egg storage, physiological parameter)

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INTRODUCTION

Improvement of broiler performance can be realized with 1-d-old chicks of high quality, which may be determined a posteriori by their survivability and growth potential (Christensen, 2001). Several factors in hatching eggs and newly hatched chicks can influence posthatch growth, and these include hatching egg characteristics, incubation conditions, and chick holding conditions (e.g., duration or transportation and environmental conditions) before their placement at a broiler farm. Several authors (Noy and Sklan, 1999; Noy et al., 2001; Gonzales et al., 2003; Halevy et al., 2003; Uni et al., 2003) have reported that delayed access to feed decreased broiler posthatch performance. These authors did not determine the differential effects that the length of delays might have on chicks during the hatching time. In general, delay before feed access is considered to be the time spent in the hatchery after hatch added to transportation time to the broiler farm. Previous reports have shown that a batch of 1-d-old chicks is not homogeneous due to the spread of hatch and, thus, results in chicks of different qualities (Tona et al., 2003). Moreover, there is the added hatch window of 24 to 48 h spread of late versus early hatching (Decuypere et al., 2001). Also, hatching spread and incubation duration can be influenced by the homogeneity or heterogeneity of incubating eggs (e.g., eggs stored a short period hatch earlier than those stored for a long period (Mather and Laughlin, 1977; Muambi et al., 1980; Tona et al., 2003). Mixing eggs from different storage conditions or time and variability in the incubator (temperature gradient) can affect this spreading. As the spread of hatch increases so does the number of chicks that are feed-deprived for a longer time before free access to feed and water. Tona et al. (2003) reported that the growth performance of 1-d-old chicks depends on the quality of the chicks and that the average quality of chicks from eggs stored for a long duration is often lower than that of chicks from eggs

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Abbreviation Key: BA = biological age; CA = chronological age; RG = relative growth; T_3 = triiodothyronine.

stored for a short duration. Thus we hypothesized that the storage duration of hatching eggs may also affect the effect of delayed feeding. Therefore we have assessed the possible combined effects of these practices (i.e., egg storage and delayed feeding) under 2 different experiments to model 1) sequential delay depending on the time of hatch with immediate access to feed compared with access at the end of total hatching period and 2) similar delay of 48 h after hatch according to 3 periods in the hatch window compared with immediate access to feed after hatch under similar periods. Almost all studies on delayed feeding so far have not taken into consideration the differential delay due to the spread of hatch in a batch. In this current study, we investigated the effects of time delay in feed access on chick juvenile growth up to d 7, triiodothyronine (T_3) levels, and the role that the size of the retracted yolk sac may play in the survival and growth rate of the chicks. The effects of egg storage on hatching time, spread of hatch, and its role in accentuating the effect of feed delay on performance were also determined.

MATERIALS AND METHODS

Experimental Design

Hatching eggs produced by commercial flocks[2] of Cobb breeders were studied in 2 different experiments. The eggs were set for incubation in forced-draft incubators[3] at a specific dry bulb temperature of 37.6°C and wet bulb temperature of 29°C and were turned once every hour until d 18 of incubation. At d 18 of incubation, the eggs were candled, and those with evidence of living embryos were transferred from turning trays to hatcher baskets. Between 472 and 510 h of incubation, the transferred eggs were frequently checked individually, and the hatched chicks were individually marked and weighed. Hatched chicks were reared for 7 d posthatch and weighed again at the end of this period. The chicks were raised at standard conditions of light and temperature. A broiler corn-wheat-soybean-based starter diet (3,100 kcal of ME, 22.02% crude protein) and water were provided ad libitum.

Experiment 1

Hatching eggs were collected from breeders aged between 38 and 58 wk. Eggs were stored, without turning, for 3 or 18 d at 15°C and 75% of relative humidity before setting for incubation. Four replications of 150 eggs per storage duration were studied. Eggs in each replicate were randomly selected to include those from the different breeder ages. Eggs were individually marked and weighed before setting. Between 472 and 510 h of incubation and at 2-h intervals, all the hatched chicks (i.e., chicks already out of their shells and fairly dried) were recorded, marked, weighed individually, and sorted into 2 groups. One group had access to feed immediately at hatch, and for the second group, feed and water were provided only at the end of hatch (510 h of incubation) whatever their hatching time. The chicks of the second group were weighed again at the time of their access to feed. The weights at hatch (Wt0) and the weights at the time of access to feed (Wt0′) were used to calculate the absolute weight loss as Wt0 – Wt0′. The chicks were reared up to 7 d posthatch and were weighed again. For each chick, weight at hatch and 7-d-old weight (Wt7) were used to calculate relative growth rate (RG) as RG = 100 × (Wt7 – Wt0)/Wt0.

Experiment 2

Hatching eggs were collected from breeders aged 32 wk. Eggs were stored, without turning, for 3 d at 15°C and 75% of relative humidity before setting for incubation. A total of 600 eggs were weighed individually and set for incubation. Between 476 and 504 h of incubation, the eggs were checked every hour, and hatched chicks were removed from the incubator. Three different stages were considered during hatching, namely early hatchers, peak of hatch (midperiod hatch), and late hatchers. The 80 earliest (476 to 482 h of incubation), the 80 closest to the midperiod hatch (489 to 491 h of incubation), and the 80 late hatched chicks (497 to 503 h) were marked with a numbered leg ring and weighed individually. For each hatching group, chicks were assigned to 4 pens, each of 20 chicks; 2 pens were fed immediately after hatch, and 2 pens were fed 48 h after hatch. The 48 h of delay times were calculated from the average hatching time of each group. The birds were raised until their chronological age (CA: age calculated from end of hatch of the whole batch) of 7 d, which corresponded with the biological age (BA: age calculated from the precise time of hatch) of 7 d for the late hatchers. At CA7, chick biological ages were 7 d and 21 h, 7 d and 10 h, and 7 d for early, midperiod, and late hatchers, respectively. At BA1 and BA2, 10 chicks per hatching period × feeding treatment were euthanized, and blood samples were collected to determine plasma T_3 levels. Also, the retracted yolk sacs of the same chicks were removed and weighed.

At BA of 2 d (BA2), BA of 4 d (BA4), or BA of 7 d (BA7) and at CA of 7 d (CA7), chick body weights were recorded. These weights and the weights at hatch were used to calculate body weight losses for delayed birds or RG up to BA2, CA7, or BA7. Weight loss = 100 × (Wt0 – Wt2) / Wt0, and RG = 100 × (Wt_f – Wt0)/Wt0, where Wt0 = weight at hatch, Wt2 = weight at BA2, and Wt_f = weight at CA7 d or BA7.

RIA of T3

The T_3 concentrations were measured in plasma samples by RIA as described previously (Huybrechts et al., 1989; Darras et al., 1991). The intraassay coefficient of

[2]Avibel, Zoersel, Belgium.
[3]PasReform, Zeddam, The Netherlands.

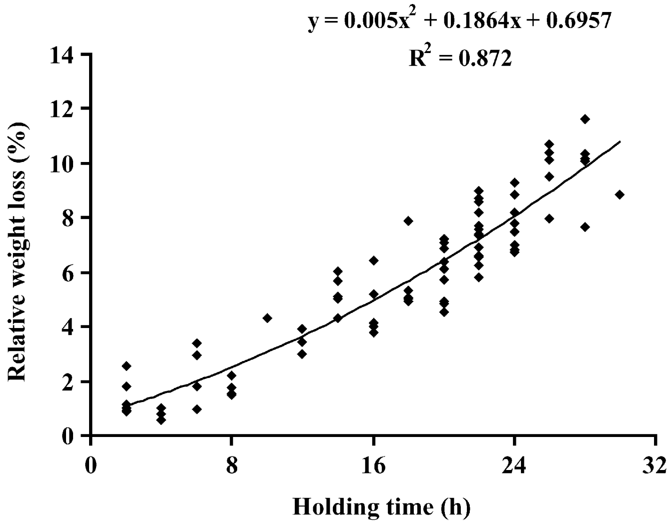

FIGURE 1. Chick relative weight loss during the holding time after hatch.

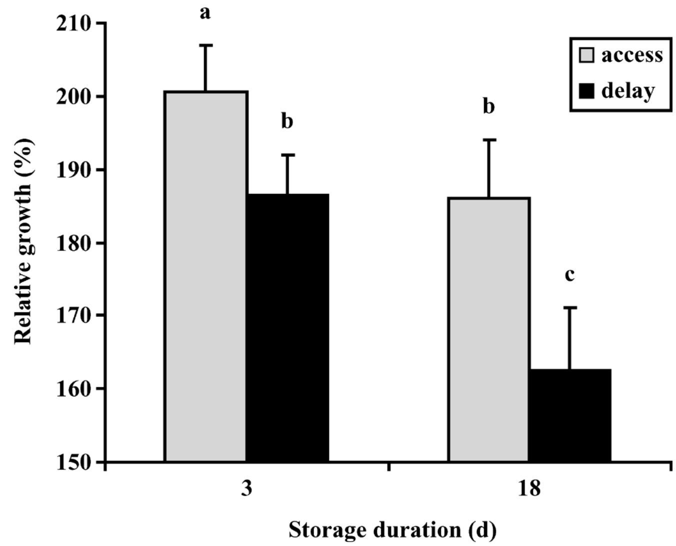

FIGURE 2. Relative growth (RG) according to egg storage duration and feed treatments. Data sharing no common letter are different ($P < 0.05$).

variation was 4.8%. Antisera and T_3 standards were purchased.[4]

Statistical Analysis

The data were processed with the statistical software package SAS (2001). The general linear model was used to analyze egg weights at setting, chick weights at hatch, T_3 levels, yolk sac weights, chick weight losses, and RG in relation to storage time, hatching period, and their interactions with feeding treatments. The model was

$$Y_{ijk} = \mu + \alpha_i + \tau_j + (\alpha\tau)_{ij} + e_{ijk}$$

where Y_{ijk} = egg weights at setting, chick weights at hatch, T_3 levels, yolk sac weights, chick weight losses, and RG of eggs from storage duration or hatching period i with feeding treatment j; μ = overall mean; α_i = main effect of storage of hatching period i; τ_j = main effect of feeding treatment j; $(\alpha\tau)$ = interaction between storage duration or hatching period and feeding treatment, and e_{ijk} = random error term for egg weight at setting, chick weight at hatch, T_3 level, yolk sac weight, chick weight loss, and RG of egg k.

RESULTS

Experiment 1

The duration between hatch and time of access to feed varied from 2 to 30 h with average values of 21.00 ± 1.10 h and 8.23 ± 1.40 h for chicks from eggs stored for 3 and 18 d, respectively. Figure 1 indicates that, irrespective of the storage duration, chick weight loss was positively correlated with holding time ($r^2 = 0.85$; $P < 0.001$). Chick relative weight loss varied from 0.075 to 0.65 g. On average, weight losses per hour were 0.18 ± 0.01 g or 0.19 ± 0.02 g for chicks from eggs stored for 3 or 18 d, respectively. Figure 2 shows RG according to feeding treatment and storage duration. Overall, RG for chicks fed immediately at hatch (196.05 ± 5.04%) was higher than that for chicks with delay to feed access (173.67 ± 4.70%; $P < 0.001$). Moreover, the effect of delay in feed access was more pronounced in chicks from eggs stored for 18 d, although the duration between hatch and time to feed access was shorter for chicks from these eggs ($P < 0.05$).

Experiment 2

Table 1 shows egg weights at setting, chick weights at hatch, chick weight losses or RG at BA2 and between BA2 and BA4 according to the hatching period and feeding treatments. The egg weights, at setting, of chicks that hatched late were higher than those of early hatchers ($P < 0.01$). Chick weights at hatch were not significantly different between the hatching periods. Irrespective of hatching period, all chicks lost weight when delayed for 48 h before access to feed. Average relative weight losses were similar between hatching groups. At BA2, chicks fed immediately after hatch had positive RG with significantly higher RG in the hatchlings from the mid and late periods. During the period between BA2 and BA4, RG increased significantly in all groups of IA chicks. However, RG was only different between the late hatchers and the early hatchers ($P < 0.05$). An important observation was the significantly higher RG in the first 2 d of access to feed in the delayed chicks compared with the first 2 d of access in those without delay. Moreover, at BA4, the fasted chicks still had greater RG than the chicks without delay.

[4]Byk-Sangtec, Dietzenbach, Germany.

TABLE 1. Hatching weights, weight loss, and relative growth (RG) up to 4 d posthatch according to feed treatments and hatching time

Performance parameters	Feeding treatment[1]	Hatching period		
		Early	Mid	Late
Egg weights (g)		58.99 ± 0.44[b]	60.28 ± 0.44[a,b]	60.70 ± 0.39[a]
Hatching weights (g)	IA	44.26 ± 0.57	44.88 ± 0.46	45.31 ± 0.46
	48-h delay	44.30 ± 0.66	45.02 ± 0.50	45.60 ± 0.40
Weight loss up to BA2 (%)	48-h delay	15.15 ± 0.87	16.03 ± 0.70	15.35 ± 0.62
RG up to BA2 (%)	IA	6.91 ± 1.68[b]	15.03 ± 1.39[a]	14.96 ± 1.55[a]
RG between BA2 and BA4 (%)	IA	49.30 ± 3.06[b]	56.18 ± 2.60[a,b]	57.70 ± 1.49[a]
	48-h delay	62.09 ± 1.86[b]	69.14 ± 2.18[a]	62.96 ± 1.83[a,b]
Body weights at BA4 (g)	IA	70.16 ± 2.36[b]	79.08 ± 1.29[a]	82.84 ± 1.81[a]
	48-h delay	60.48 ± 1.04[b]	64.24 ± 1.10[a]	62.63 ± 1.03[a,b]

[a,b]Within rows, data sharing no common letter were different ($P < 0.05$).

[1]IA = Immediate access.

Figure 3 depicts the RG, up to 7 d, of chicks from the different periods of the hatching window and were given immediate or 48 h delayed to feed. Figure 3A presents RG in relation to BA of the chicks, and Figure 3B presents RG in relation to CA of the chicks. In relation to the BA, chicks hatched at early, mid, or late period and given immediate access had higher RG than chicks hatched at corresponding periods but with delayed access. Moreover, RG was significantly reduced in early hatchers compared with those hatched during mid or late period. This differential RG between hatching periods was absent in the delayed chicks. When expressed with regard to chronological age, RG were significantly higher in chicks with immediate access to feed whatever the period of hatching compared with chicks having delayed access to feed. However, RG was not different among chicks from early, mid, and late periods of hatch. In contrast, RG decreased with delay in hatching resulting in a significantly reduced RG in the late hatchers compared with the early and mid period hatchlings.

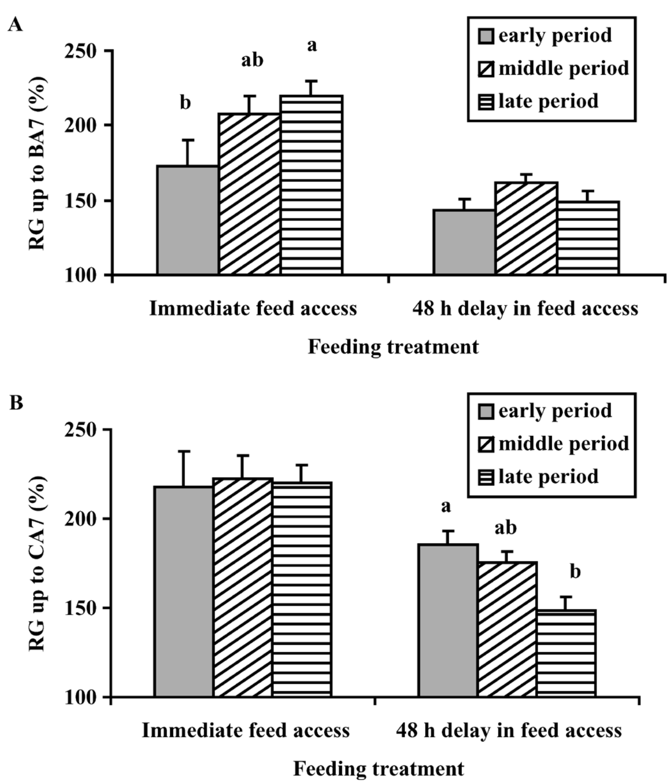

FIGURE 3. Relative growth up to the chronological age of 7 d (CA7) (A) and up to the biological age of 7 d (BA7) (B) according to feeding treatments and hatching time. Within feeding treatments, data sharing no common letter are different ($P < 0.05$).

There was a sharp decrease in retracted yolk sac weights between BA1 and BA2 in all hatching groups as well as all feeding treatment groups (Table 2). Although retracted yolk sac weights of early hatchers were slightly higher compared with the 2 other hatching groups, there was no significant difference between hatching × feeding treatment groups.

Figure 4 shows T_3 levels at BA1, BA2, and BA4 of chicks with immediate access to feed (Figure 4A) and chicks with a 48-h delay in feed access (Figure 4B). In chicks with immediate access to feed, T_3 levels were similar among BA1, BA2, and BA4 as well as among hatching groups. However, chicks with delay in feed access had lower T_3 levels compared with those of chicks with immediate access to feed ($P < 0.05$) except at BA4. Moreover, T_3 levels at BA1 were higher than those at BA2 ($P < 0.05$), and at both ages T_3 levels decreased with increasing hatching time ($P < 0.05$). At BA4 when chicks had had access to feed for 48 h, T3 increased significantly to levels similar to those in chicks with immediate access and without differences between hatching periods.

DISCUSSION

The results from this study confirm some of the effects of posthatch holding of chicks before access to feed. These effects include weight loss during holding time and depressed growth rate after access to feed. Extended posthatch holding (in the hatcher) has been reported to dehydrate chicks, reduce broiler performance, and depress immune response (Casteel et al., 1994). Several reports have also demonstrated that delay in feed intake after hatch adversely affected posthatch performance of chicks, especially growth (Becker, 1960; Pinchasov and Noy, 1993; Bigot et al., 2003; Gonzales et al., 2003). However, the data from our experiments suggests that there

TABLE 2. Yolk weights up to 5 d biological age posthatch according to feed treatments and hatching time

Performance parameter	Feeding treatment[1]	Hatching period Early	Mid	Late
BA1	IA	4.64 ± 0.27	3.15 ± 0.29	3.62 ± 0.69
	48-h delay	4.02 ± 0.47	3.31 ± 0.45	3.25 ± 0.23
BA2	IA	2.37 ± 0.44	1.59 ± 0.20	1.63 ± 0.22
	48-h delay	1.78 ± 0.18	1.94 ± 0.16	2.10 ± 0.53
BA3	IA	0.93 ± 0.17	1.51 ± 0.22	1.17 ± 0.19
	48-h delay	1.35 ± 0.19	1.22 ± 0.35	0.84 ± 0.07
BA4	IA	0.78 ± 0.18	0.79 ± 0.13	0.91 ± 0.27
	48-h delay	0.47 ± 0.18	0.66 ± 0.16	0.44 ± 0.06
BA5	IA	0.58 ± 0.25	0.43 ± 0.04	0.41 ± 0.10
	48-h delay	0.26 ± 0.02	0.32 ± 0.08	0.42 ± 0.10

[1]IA = Immediate access.

may be additional factors that can aggravate this effect of delay in feed access or vice-versa. This synergic effect can be observed when comparing chicks from eggs stored for short vs. long duration before incubation or early hatched chicks vs. late hatchers.

Our 2 experimental models showed conclusively that delay in feed access after hatch depressed the relative growth rate of chicks. Moreover, the magnitude of the effect depended on the hatching period within the hatching window. This factor has often been ignored in previous studies and in hatchery practice. It was apparent from the results of experiment 2 that delayed feeding had profound depressing effect on the growth to 7 d of late hatchers when the CA was taken into account, a condition that was not apparent when BA was considered. This was in spite of the fact that all chicks had exactly the same length of delay (48 h).

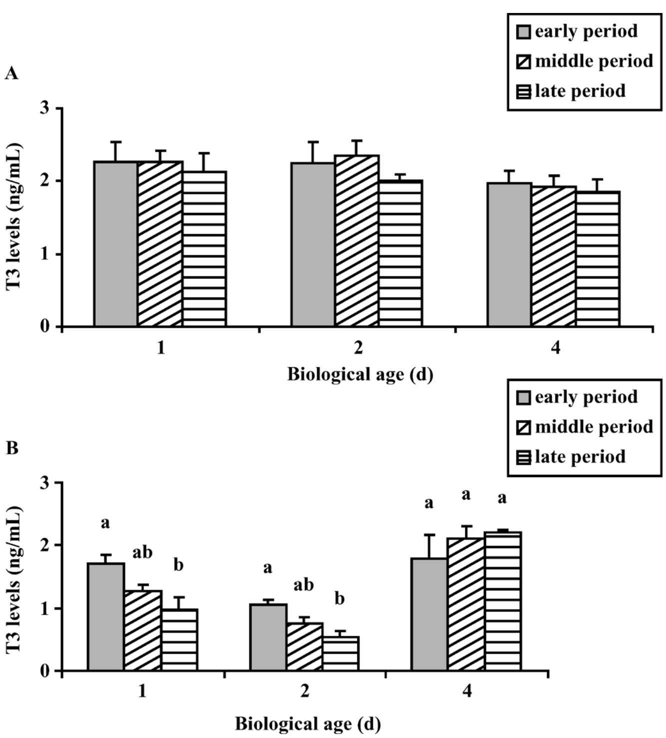

FIGURE 4. Triiodothyronine (T_3) levels of chicks with immediate access to feed (A) and chicks having a 48-h delay in feed access (B) according hatching time and biological age. At each biological age, data sharing no common letter are different ($P < 0.05$).

Chick weight loss during holding period is common and is mainly due to dehydration and yolk consumption (Noy and Sklan, 1999; Vieira and Moran, 1999). The data from experiment 1 demonstrated a positive curvilinear relationship between percentage of chick weight loss and holding time. In experiment 2, chicks had similar weight loss after similar delays, but with apparently different RG at 7 d on the basis of CA. The absence of this phenomenon in chicks of the CA group that had immediate access to feed may suggest that the first hours of initial weight loss are more decisive in the early performance of chicks. This finding also points to certain unknown intrinsic factors that depress RG in late hatchers and are aggravated by delayed feeding. This effect was not apparent when chicks were considered on the basis of BA and thus presented all chicks from the different hatching periods as homogenous after 48 h of denied access to feed. Therefore, the determination of chick weight loss should be from the exact time of hatch but not at the end of whole hatching of a batch. This finding may explain why Bigot et al. (2003) reported no significant difference (7%) between chick body weights after 2 d of delay in feed access, contrary to the results of the current study that showed about 15% difference between body weights at hatch and at 48 h of fasting.

Egg storage duration has previously been implicated in chick embryo development and their posthatch performance (Elibol et al., 2002; Tona et al., 2003). The results of the current study showed clearly that the duration of storage of the hatching eggs depressed RG, not only of chicks with immediate access to feed but also those denied access after hatch. Delay in feed access significantly aggravated the effects of egg storage duration on RG, indicating a storage × access to feed interaction. As we have demonstrated earlier (Tona et al., 2003) that eggs stored for long durations often produced low quality chicks, it may be hypothesized that the greater depression of RG observed in the chicks from eggs stored for 18 d may be a consequence of the greater susceptibility of lower quality chicks to delayed feeding. A similar hypothesis may probably be advanced for the late hatchers if they are considered on the basis of CA. Although we did not determine the quality of the chicks in this study, Tona et al. (2003) already showed that late hatchers were weaker, had lower T3 and partial pressure of CO_2 and constituted the majority of the lower quality chicks in a batch of hatchlings.

The effects of delayed feeding have been ascribed to different factors among which are physiological and morphological factors. Previous studies have shown that yolk sac resorption through the intestine could be increased by greater intestinal development before and when chicks have first access to feed. Noy et al. (2001), Uni et al. (1998, 1999), and Bigot et al. (2003) have shown that feed deprivation posthatch delays intestinal growth in poults and chicks. Uni et al. (1998), Corless and Sell (1999), and Geyra et al. (2001) also reported adverse effects of delayed feeding on the morphology of the intestine and the secretion of vital digestive enzymes. Yolk provides energy for maintenance and protein for small intestine development during the first 4 d posthatch. Our data showed no differences in the weights of yolk resorbed by chicks of early, mid, and late period hatches in the first 4 d or between chicks allowed immediate access and those denied access. Thus the differences in RG could not be due to differential yolk resorption. Bigot et al. (2003) reported similar finding previously. Therefore, the differential growth rate to 7 d may be partly due to the differences in the levels of intestinal development and utilization of nutrients.

In addition to intestinal ontology, our data on plasma T_3 levels suggest that delayed access to feed lowered T_3 levels and may indicate a lowered metabolic rate. However, after feeding, T_3 increased significantly to levels found in the control groups. This result is in agreement with a previous report by Noy et al. (2001). The decrease in T_3 with increased hatching time before feeding mimicked the RG obtained at d 7, which may give a precise indication of the subsequent growth performance of the broilers. Even though T_3 levels were restored to levels in the unfasted chicks at d 4, there was no effect on the subsequent RG at 7 d. Taken together, these data showed that delay in feed access at the vital periods after hatch may have a lasting effect on RG up to 7 d. Because chick body weight between d 7 to 10 has been shown to be linearly related to the body weight at slaughter age (Decuypere, 1979; McLoughlin and Gous, 1999; Tona et al., 2003), performance at 7 d of age was considered in this study to be a good indicator of the effects of delay in feed access.

In conclusion, the overall adverse effects of delay in feed access observed in this study are in accordance with the previous observations of Noy and Sklan (1999), Turner et al. (1999), Geyra et al. (2001), and Gonzales et al. (2003), who pointed out that the common practice whereby feed being first available to chicks one or more days posthatch may depress subsequent development. Feed delay did not have the same effect on early and late hatchers, the latter benefiting more from early access to feed after hatch than the former, both when taken at biologically or chronologically similar ages after hatch. Therefore, the effects of feeding treatment × hatching time interaction on growth performance suggests that some unknown intrinsic factors related to time of hatch are involved in posthatch growth potential of differently hatched groups. Delayed feeding after hatch also aggravates the effect of long storage of eggs on subsequent posthatch growth. It is concluded that the beginning of delay in feed access must be considered from the time of hatch but not from the end of hatch. Data from this study suggest that the adverse effects of delay in feed access can be reduced by providing a source of energy in the hatching basket or during transportation.

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