Effect of posthatch feed and water access time on residual yolk and broiler live performance[1]

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ABSTRACT This study investigated the effect of feed and water access time on yolk sac utilization and subsequent broiler live performance. Hatching eggs were collected from commercial flocks of Ross 308 breeders at 35 and 39 wk of age in experiments 1 and 2, respectively. Chicks already out of their shells that still had some dampness on their down were removed, recorded, feather-sexed, and weighed at 488 h of incubation in both experiments. Chicks were weighed individually and received feed and water at 2 (immediate feed; **IF**), 8, 12, 16, 20, 24, 28, and 32 h after hatching (488 h) in experiments 1 and 2 (IF) and at 24, 26, 28, 32, 36, and 40 h after hatching in experiment 2.

The residual yolk sac weight was determined at 32 and 40 h after hatching (day 0) in all groups in experiments 1 and 2, respectively. Feed consumption and BW were recorded at 7, 14, 21, and 35 d and at the same age relative to placement on feed and water at the end of the growing period. Mortality was recorded twice daily in both experiments.

Feed and water access time did not influence yolk sac utilization in either experiment ($P > 0.05$). The IF group exhibited a higher ($P < 0.05$) BW than those that received feed at or after 28 h at 35 d in both experiments. There was a significant increase in feed consumption in the IF group compared with the groups with access to feed and water after 24 h at 35 d in experiment 2 ($P < 0.05$), with a similar trend in experiment 1 ($P > 0.05$). There were no significant differences in the feed conversion ratio (**FCR**) or mortality at 35 d of age, but the IF group tended to have a poorer FCR than the other groups in both experiments. When the total feed and water times were equalized among all groups, irrespective of the deprivation duration, there were no significant differences among the groups in the BW, feed consumption, the FCR, or mortality in both experiments.

It can be concluded that feed and water deprivation for 28 h or longer after hatching (≥28 h) negatively affects the final BW but tends to improve the FCR at 35 d of age compared with chicks that receive feed immediately (2 h after hatching). When the feeding period was equalized in all groups, feed and water deprivation up to 40 h under optimum conditions had no detrimental effect on final live performance. These results suggest that the total feeding period is more critical for broiler performance than the time of posthatch access to feed and water.

Key words: feed access time, yolk sac, BW, feed consumption, mortality

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INTRODUCTION

Continuous genetic selection of broilers for fast growth has resulted in reduced slaughter age, so early life conditions are critical for the development and performance of chicks later in life (Decuypere et al., 2001; Mitchell, 2009). Both the posthatch holding and feed access time (**FAT**) are crucial for the development and performance of chicks. In the last few decades, much attention has been given to the effect of the time of feeding on the performance of chicks, and previous experiments with newly hatched broiler chicks showed that feed or feed and water deprivation for 24 h appeared to be acceptable for growth performance (Noy and Sklan, 1998a; Vieira and Moran, 1999a; Gonzales et al., 2003; Juul-Madsen et al., 2004), but it had a negative effect on the final BW and livability when delayed for 48 h (Juul-Madsen et al., 2004). It was reported that performance after placement was negatively associated with the time

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that chicks remained in the hatcher after hatching (Kingston, 1979; Fanguy et al., 1980) and that delayed access to feed and water depressed the posthatch (7 d) growth rate (Careghi et al., 2005) and increased mortality (Hamdy et al., 1991). Furthermore, chicks being held in the hatcher for an extended period of time can lead to dehydration, diminished yolk sac reserves (Hager and Beane, 1983), reduced BW (Hager and Beane, 1983; Wyatt et al., 1985), and increased mortality before and after placement (Misra and Fanguy, 1978). Reduced growth and increased early mortality in chicks held without access to feed and water were associated with dehydration and a shortage of available energy (Vieira and Moran, 1999b), but holding chicks in the hatcher for 24 h has been reported to not clinically dehydrate chicks or affect live performance (Casteel et al., 1994; Joseph and Moran, 2005; Almeida et al., 2006; Lamot et al., 2014; Özlü et al., 2018). Work with respect to posthatch holding has often varied in that chicks were placed at or later than 24 h apart, but they were subsequently weighed on the same day in some experiments (Fanguy et al., 1980; Hager and Beane, 1983; Wyatt et al., 1985; Pinchasov and Noy, 1993; Vieira and Moran, 1999a) or on the basis of days on feed in other studies (Careghi et al., 2005; Almeida et al., 2006; Lamot et al., 2014).

The residual yolk sac weight and composition are affected by many factors, such as genetic strain, hen age, egg storage, incubation conditions, and egg size (Shenstone, 1968; O'Sullivan et al., 1991; Vieira and Moran, 1998a,b; Şahan et al., 2014). During late development of the embryo, the residual yolk is enclosed within the abdominal cavity and provides immediate nutrition for maintenance and growth after hatching until exogenous feed is supplied (Romanoff, 1960). High resorption of the yolk sac is generally considered positive for chicken development and has been suggested to stimulate the transport of immunoglobulins from the yolk to the chicken (Moran and Reinhart, 1980). However, conflicting information in the literature on the relation between posthatch feed deprivation and yolk sac resorption exists. Early feeding (**EF**) after hatching, compared with delayed feeding (**DF**), appears to stimulate yolk utilization, as reported by Noy et al.(1996), Noy and Sklan (1998b), Speake et al. (1998), and Bhanja et al. (2009). Nevertheless, several studies indicated that the residual yolk sac weight was not affected by posthatch feed and water deprivation times (Bigot et al., 2003; Gonzales et al., 2003, 2008; Maiorka et al., 2003).

The present study examined the effect of posthatch feed and water access time on yolk sac utilization and subsequent broiler live performance until 35 d of age.

MATERIALS AND METHODS

All procedures in the present study were approved by the Animal Ethics Committee of Ankara University (2017-11-93).

Hatching Eggs and Incubation

Hatching eggs were obtained from commercial broiler breeder flocks of Ross 308 at 35 and 39 wk of age in experiments 1 and 2, respectively. In both experiments, hatching eggs were stored for 2 d at 18°C and 75% relative humidity (**RH**). Then, the eggs were incubated in a Petersime BioStreamer for setters and hatchers (Petersime, Zulte, Belgium) in a commercial hatchery (Beypiliç Inc., Bolu, Turkey) in both experiments. A single-stage incubation program with a gradually decreasing setpoint temperature of 38.1°C at embryonic day (**E**) 1 to 37.5°C at E19 was used. The hatchers began at a setpoint temperature of 37.2°C at E19 that was gradually decreased to 36.4°C at E21. RH was maintained at 70% during the first 10 d of incubation (minimum ventilated) and then ventilated to maintain 40% RH until transfer. Eggs were turned 90° on an hourly basis until E19 in all cases.

Chick Management and Experimental Design

At 488 h of incubation, chicks that still had some dampness on the down (indicating they had hatched within a short time) were removed from the hatcher, then counted, permanently identified with neck tags, feather-sexed, individually weighed, and brought to the experimental facility. Then, chicks were randomly distributed into 8 or 7 groups with different FAT in experiments 1 and 2, respectively. Chicks were weighed individually and received feed and water ad libitum at 2 (immediate feed [**IF**]), 8, 12, 16, 20, 24, 28, and 32 h after hatching (488 h) in experiment 1 and at 2 (IF), 24, 26, 28, 32, 36, and 40 h after hatching in experiment 2. The FAT groups in the 2 experiments are summarized in Table 1. In each of the 2 experiments, chicks with delayed access to feed and water were held in the hatcher at 36.4°C ± 0.4°C and 53 ± 2% RH before placement. During the holding period, the hatcher air temperature was programmed to maintain the optimal chick body temperature (40.0°C–40.5°C).

In each FAT group, chicks were assigned to 6 and 7 pens (1 × 1 m), each with 8 male and 8 female chicks

Table 1. Experimental design and treatments of experiment 1 and 2.

Experiment	
1	2
Feed and water access time (h)[1]	
2	2
8	24
12	26
16	28
20	32
24	36
28	40
32	

[1]Feed and water access time (2–32 h in experiment 1 and 2–40 h in experiment 2) after hatching (488 h of incubation).

for a total of 768 and 784 chicks in experiments 1 and 2, respectively.

Grow-Out Housing and Management

Chicks were reared in floor pens on new wood litter shavings under uniform management conditions throughout the experimental period. The brooding facilities were preheated for 24 h before chick placement to achieve a stable and uniform litter temperature. At placement, the litter temperature was 33°C, which was gradually decreased to 20°C by 21 d of age and remained at that temperature until slaughter at 35 d of age. The chicks received a continuous light schedule (24 L:0 D), and the light intensity at the pen level was 25 lux throughout the grow-out period. Both feed and water were available for ad libitum consumption during all rearing periods in all groups. Starter (3,000 kcal ME/kg and 23.5% CP) and grower (3,200 kcal ME/kg and 22.0% CP) diets were fed for 0 to 10 and 11 to 28 d, respectively. A finisher (3,300 kcal ME/kg and 20.0% CP) diet was fed from 29 to 35 d, and diets were formulated to meet or exceed the National Research Council (1994) recommendations throughout the grow-out period (Table 2).

Measurements

Residual Yolk Sac Weight At the time of placement into pens before the introduction of feed and water, 20 randomly selected chicks from each FAT group were weighed and killed by cervical dislocation, and the residual yolk sac weight was determined. The residual yolk sac weight was also recorded from a similar number of chicks in the IF group at each placement time in both experiments to determine the yolk sac utilization of fasted and no-fastedchicks. Similarly, the yolk sac weight was measured at 32 h (day 0) and 56 h (day 1) in experiment 1 or at 40 h (day 0) in experiment 2 after hatching in all groups. A total of 580 and 360 chicks were necropsied in the present study in experiments 1 and 2, respectively.

Live Performance In this study, 32 h (experiment 1) or 40 h (experiment 2) after hatching was considered 0 d of age. Individual BW were recorded at the hatching time; placement time; 7, 14, 21, and 35 d; and the same age relative to placement with feed and water at the end of the growing period (all groups weighed at the same number of days + hours to equalize the total feeding period; 35 d + 30 h and 35 d + 38 h in experiments 1 and 2, respectively). Feed consumption was calculated by the difference in feed offered and feed remaining on a pen basis at the experimental times. Mortality was recorded twice a day in both experiments.

Statistical Analyses

All statistical analyses were performed with SAS, version 9.1 (SAS Institute Inc., Cary, NC). Comparisons of yolk sac weights between groups with access to feed and water (fasted/no-fasted) were performed using one-way ANOVA. Data on the yolk sac weight, feed consumption, and the feed conversion ratio (**FCR**) were analyzed using the GLM procedure according to the following model: $Y_{ij} = \mu + FAT_i + e_{ij}$, where μ is the overall mean, FAT_i is the FAT (i = 2–32 h in experiment 1; i = 2–40 h in experiment 2), and e_{ij} is the residual error term. Data on chick BWs were analyzed according to the following model: $Y_{ijk} = \mu + FAT_i + sex_j + (FAT \times sex)_{ij} + e_{ijk}$, where sex_j is the sex of the chick, $(FAT \times sex)_{ij}$ is the interaction between the FAT and sex, and e_{ijk} is the residual error term. The significant differences among the treatment means were determined by Duncan's multiple range test. The percent mortality was analyzed using the chi-square test with Minitab, version 14 (Minitab Inc., State College, PA). Significant differences were considered at $P \leq 0.05$.

RESULTS AND DISCUSSION

Residual Yolk Weight

The effect of the FAT on the residual yolk weight at the time of placement, day 0, and day 1 in experiments 1 and 2 is shown in Table 3. In both experiments, there were no significant differences in the residual yolk weight between the IF and other FAT groups at placement, day 0, and day 1. The weights of the yolk sac in the IF group and the group subjected to 32 h of fasting after hatching were 3.63 g and 3.59 g at day 0 and 1.57 g and 1.83 g at day 1, respectively, in experiment 1 ($P > 0.05$). Similar to experiment 1, the residual yolk weight was 3.17 g and 2.63 g in the IF group and in the chicks subjected to 40 h of fasting after hatching at day 0, respectively, in experiment 2 ($P > 0.05$). In the present study, the

Table 2. Starter, grower, and finisher diet compositions for both experiments.

Calculated analysis[1]	Starter (0–10 d)	Grower (11–28 d)	Finisher (29–35 d)
	(g/kg diet)		
ME, Kcal/kg diet	3,000	3,200	3,300
CP	235.00	220.00	200.00
Methionine	5.52	5.05	4.76
Lysine	14.26	12.75	11.74
Methionine + cysteine	10.73	9.83	9.34
Calcium	9.54	8.66	8.08
Available phosphorus	4.75	4.33	4.02

Abbreviation: NRC, the National Research Council.
[1]Calculated according to the NRC (1994).

Table 3. The effect of feed access time the on residual yolk weight (g) at placement, day 0 (experiments 1 and 2), and day 1 (experiment 1) in both experiments.

Experiment	FAT[1]	Age at sampling, h								
		2	8	12	16	20	24	28	32 (day 0)	56 (day 1)
	(h)	(g)								
1	2	6.91^{a}	7.01	6.36	5.59	5.00	3.81	3.75	3.63	1.57
	8	-	6.37^{b}	-	-	-	-	-	3.57	1.98
	12	-	-	6.00^{b,c}	-	-	-	-	3.69	2.14
	16	-	-	-	5.73^{c}	-	-	-	3.73	1.88
	20	-	-	-	-	4.66^{d}	-	-	3.73	1.64
	24	-	-	-	-	-	4.33^{d}	-	3.72	1.78
	28	-	-	-	-	-	-	3.85^{e}	4.00	1.57
	32	-	-	-	-	-	-	-	3.59^{e}	1.83
	SEM[2]	-	0.27	0.27	0.22	0.28	0.28	0.24	0.23	0.22
	P-value	-	0.094	0.345	0.656	0.409	0.146	0.771	0.936	0.163

Experiment	FAT[1]	2	24	26	28	32	36	40 (day 0)
	(h)	(g)						
2	2	6.63^{a}	5.14	4.34	4.24	3.40	3.34	3.17
	24	-	4.51^{b}	-	-	-	-	3.11
	26	-	-	3.82^{c}	-	-	-	3.11
	28	-	-	-	3.77^{c}	-	-	2.64
	32	-	-	-	-	2.96^{d}	-	3.14
	36	-	-	-	-	-	2.89^{d}	2.59
	40	-	-	-	-	-	-	2.63^{d}
	SEM[2]	-	0.35	0.21	0.21	0.21	0.20	0.19
	P-value	-	0.219	0.092	0.107	0.162	0.238	0.067

[a-e]Means in the diagonal with different superscripts differ significantly ($P = 0.001$; SEM was 0.169 or 0.216 for experiment 1 or 2, respectively).
[1]FAT: feed access time (2–32 h in experiment 1 and 2–40 h in experiment 2).
[2]SEM for n = 20.

relative weight of the yolk sac was 15% of the live weight at hatching, and almost 50% of the yolk weight was used within 32 h after hatching in all groups in both experiments.

Higher resorption of the yolk sac is generally considered positive for chick development and has been suggested to stimulate the transport of immunoglobulins from the yolk to the chicken (Moran and Reinhart, 1980). However, based on previous studies, the effects of feed and water deprivation on yolk sac resorption are conflicting. Several authors (Noy et al., 1996; Speake et al., 1998; Noy and Sklan, 1999, 2001) reported that the residual yolk in chicks with access to feed after hatching was reduced more rapidly than that in fasted birds. Similarly, Bhanja et al. (2009) indicated that the residual yolk was used up more quickly by the chicks that had access to feed immediately after hatching than by those that were fasted for 48 h. Nevertheless, several studies indicated that the yolk sac weight was not affected by posthatch feed and water deprivation during the first 3 d after hatching when chicks were subjected to a 36- to 72-h fasting period (Gonzales et al., 2003; Maiorka et al., 2003; Franco et al., 2006; Gonzales et al., 2008; Van den Brand et al., 2010). Furthermore, among the chicks that had access to feed and water 6 h (EF) and 54 h (DF) after hatching, yolk sac resorption was similar in both groups during the first 3 d after hatching. However, at 4 d of age, the yolk sac weight was significantly higher in the EF group (1.13 g) than in the DF group (0.75 g) (Bigot et al., 2003). In addition, in a recent study, the FAT after hatching did not affect the residual yolk sac weight at day 4 (Lamot et al., 2014). In the present study in which the maximum fasting period was 32 h and 40 h after hatching in experiments 1 and 2, respectively, the retraction of the yolk sac was not affected by fasting. However, the yolk sac weight (g) decreased linearly with duration after hatching regardless of immediate or delayed access to feed and water in both experiments (Table 3; $P = 0.001$).

Yolk-Free Body Mass

At hatching, the total chick weight is a combination of the actual chick weight (yolk-free body mass [**YFBM**]) and the residual yolk sac weight. Hatched chicks undergo complex metabolic processes as they decrease in the BW at a rate of approximately 4 g per 24 h due in part to moisture loss and utilization of nutrients available from the yolk and pectoral muscles (Noy and Sklan, 1998b; Tona et al., 2003; Careghi et al., 2005). In this study, at placement, the YFBM in the IF group and the groups with delayed feed access up to 28 h was similar, mainly because of similar yolk utilization during this period ($P > 0.05$). However, chicks with delayed feed access at 32 h (after 28 h) possessed less ($P < 0.05$) YFBM than the IF group in both experiments (Table 4). Pinchasov and Noy (1993) found that the BW loss during the first 24 h after hatching was associated with yolk sac utilization. Therefore, under optimum

Table 4. Effect of the feed access time on the yolk-free body mass at placement in both experiments.

Experiment 1		Experiment 2	
FAT[1]	YFBM[2]	FAT	YFBM
—(h)—	—(g)—	—(h)—	—(g)—
2	39.06[a]	2	39.13[a]
8	38.47[a,b]	24	37.93[a,b]
12	38.23[a,b]	26	37.96[a,b]
16	38.42[a,b]	28	37.96[a,b]
20	38.07[a,b]	32	37.80[b]
24	38.04[a,b]	36	37.36[b]
28	38.00[a,b]	40	37.38[b]
32	37.48[b]	-	-
SEM[3]	0.446	SEM[3]	0.498
P-value	0.003	*P*-value	0.038

[a,b]Means in a column with different superscripts differ significantly ($P \leq 0.05$).
[1]FAT: feed access time (2–32 h in experiment 1 and 2–40 h in experiment 2).
[2]YFBM: Yolk-free body mass = chick weight–residual yolk sac weight at the placement time.
[3]SEM for n = 20.

conditions, the posthatch BW loss may be a result of both yolk absorption and dehydration. Moreover, Hamissou Maman et al. (2019) demonstrated that dehydration in day-old chicks was mostly dependent on the body temperature, and when the body temperature is maintained at an optimum level, the duration between hatching and arrival at the farm becomes less important because dehydration is prevented, mainly because of yolk sac utilization (Bergoug et al., 2013; Jacobs et al., 2016; Özlü et al., 2017). The findings of this study suggested that the nutrients available in the yolk sac were sufficient to allow weight (YFBM) maintenance of chicks that received no feed and water up to 28 h after hatching under thermal comfort conditions.

BW

The effect of the FAT on the BW in experiments 1 and 2 is presented in Table 5. The BW of chicks at hatching was similar among all FAT groups. However, the IF group exhibited a higher BW than the other groups at placement ($P = 0.001$). Deprivation of feed and water for 24 h or longer significantly reduced the BW compared with that of the IF group at 7 d and 14 d ($P = 0.001$) in both experiments. At 21 d of age, the BW was not influenced when the FAT (fasting) had maximum durations of 24 h and 26 h in

Table 5. Body weight of broiler chickens from the hatching time to 35 d of age according to the feed access time in both experiments.

Experiment	FAT[1]	HT[2]	PT[3]	day of age[4] 7	14	21	35	day of age + hours[5] 35
	(h)			(g)				
1	2	46.0	45.9[a]	214.5[a]	552.3[a]	1,133[a]	2,539[a]	2,539
	8	45.3	44.8[b]	217.2[a]	556.5[a]	1,145[a]	2,535[a]	2,567
	12	45.1	44.0[b]	211.7[a,b]	551.4[a]	1,146[a]	2,522[a]	2,562
	16	45.6	44.1[b]	212.8[a,b]	555.4[a]	1,134[a]	2,546[a]	2,587
	20	45.5	42.8[c]	212.0[a,b]	552.4[a]	1,131[a,b]	2,500[a,b]	2,539
	24	45.4	42.2[c,d]	208.1[b,c]	539.2[b]	1,123[a,b]	2,515[a,b]	2,570
	28	45.3	41.6[d,e]	204.7[c]	536.6[b]	1,104[b,c]	2,465[b]	2,548
	32	45.9	41.0[e]	194.5[d]	514.5[c]	1,078[c]	2,460[b]	2,570
	SEM[6]	0.3	0.3	2.1	4.9	10.3	20.3	20.8
	P-value							
	FAT	0.217	0.001	0.001	0.001	0.001	0.005	0.410
	Sex	0.404	0.411	0.010	0.001	0.001	0.001	0.001
	FAT x Sex	0.556	0.440	0.259	0.888	0.975	0.913	0.912
	(h)			(g)				
2	2	45.7	45.6[a]	214.9[a]	553.0[a]	1,074[a]	2,332[a]	2,332
	24	45.5	42.3[b]	198.9[b,c]	534.7[b]	1,042[a,b]	2,292[a,b]	2,357
	26	45.0	41.7[b]	197.2[b,c]	532.1[b]	1,041[a,b]	2,281[a,b,c]	2,364
	28	46.2	41.5[b,c]	201.3[b]	525.5[b]	1,036[b,c]	2,255[b,c]	2,360
	32	45.5	40.8[c,d]	195.1[c]	521.0[b]	1,025[b,c]	2,248[b,c]	2,356
	36	45.4	40.2[d]	193.5[c]	520.1[b]	1,029[b,c]	2,241[c]	2,370
	40	46.0	40.1[d]	187.7[d]	502.4[c]	1,002[c]	2,240[c]	2,369
	SEM[7]	0.3	0.3	1.9	6.1	12.0	19.6	20.0
	P-value							
	FAT	0.120	0.001	0.001	0.001	0.003	0.007	0.775
	Sex	0.209	0.060	0.008	0.001	0.001	0.001	0.001
	FAT x Sex	0.634	0.729	0.145	0.759	0.889	0.623	0.761

[a-d]Means in a column with different superscripts differ significantly in each experiment ($P \leq 0.05$).
[1]FAT: feed access time (2–32 h in experiment 1 and 2–40 h in experiment 2).
[2]HT: hatching time (488 h in both experiments).
[3]PT: placement time = HT + FAT.
[4]day of age: 0 d was 32 h and 40 h after hatching in experiments 1 and 2, respectively.
[5]day of age + hours: all groups had the same feeding period (35 d + 30 h and 35 d + 38 h in experiments 1 and 2, respectively).
[6]SEM for n = 96.
[7]SEM for n = 112.

experiments 1 and 2, respectively. Feed and water deprivation up to 24 h after hatching had a transient detrimental effect on the growth of broiler chickens, as by day 21, they had compensated for the initial loss in growth. This finding was consistent with that of Bhanja et al. (2009). Furthermore, Juul-Madsen et al. (2004) reported that 24-h food-deprived chickens compensated for the delay in the BW gain by day 8, whereas 48-h food-deprived chickens did not equalize until day 42; feed restriction for 24 h appears to be acceptable for growth performance. Similarly, in the present study, the IF group exhibited a higher ($P < 0.01$) BW than those that received no feed and water for 28 h or longer at 35 d in both experiments. Bhanja et al. (2009) reported that chicks fed within 24 h after hatching had a significantly ($P < 0.05$) higher weight at 5 wk of age than those that received feed between 32 and 48 h. Furthermore, Gonzales et al. (2003) found that a maximum fasting time of 24 h after hatching preserved broiler productivity at market age (42 d). In addition, previous studies on newly hatched broiler chicks showed a negative effect on the final performance at 42 d of age, when the fasting period was prolonged beyond 24 h (Noy and Sklan, 1998b; Juul-Madsen et al., 2004). However, Vieira and Moran (1999a) reported that broiler chicks held for 24 h after take-off and transport before placement had a decreased early BW gain that was not recovered by the time of marketing at 7 wk. The present data clearly demonstrated that the maximum fasting period, which had no significant negative effect on the final BW (35 d), was 24–26 h after hatching, whereas 28 h of food deprivation had an effect, and the chicks could not compensate for the loss in growth compared with the IF group at 35 d.

When birds and feed were weighed relative to the actual time on feed, all groups were equalized according to the total feeding period, and there were no significant differences among the FAT groups in the BW in both experiments at 35 d (Table 5). It has been reported that extended delayed access to feed after hatching reduces broiler chick BW at placement, which negatively influences the final BW (Fanguy et al., 1980; Hager and Beane, 1983; Wyatt et al., 1985). However, in these early trials, chicks were placed 24 h apart but weighed on the same day relative to hatching. This introduced a confounding factor and may be misleading. Using a different experimental protocol, Casteel et al. (1994) divided chicks after 528 h of incubation into 2 groups that were either placed in floor pens or returned to the hatcher for an additional 24 h. The chick BW was reduced after holding for 24 h, as chicks lost approximately 5% of their BW compared with the initial hatch BW, but the BW of the groups were similar by 43 d of age when the birds were weighed at the same age relative to placement on feed and water. In the present study, when the feeding period was equalized in all groups, feed deprivation for up to 32 h (experiment 1) or 40 h (experiment 2) under optimum holding environmental conditions had no detrimental effects on the final BW (Table 5).

There was no interaction ($P > 0.05$) between the feed and water access time and sex for the BW during the growing periods, and as expected, males exhibited higher BW than females from 7 d after hatch in both experiments (data not shown; $P \leq 0.01$).

Feed Consumption and Feed Conversion Ratio

The effects of the FAT on feed consumption and the FCR in experiments 1 and 2 are shown in Table 6. There was a significant increase in feed consumption in the IF group compared with the groups with access to feed and water after 24 h at 35 d in experiment 2 (P = 0.001), with a similar trend in experiment 1 ($P >$ 0.05). This result was consistent with previous studies (Pinchasov and Noy, 1993; Corless and Sell, 1999; Gonzales et al., 2003; Franco et al., 2006; Powell et al., 2016; Özlü, 2016). This was because the birds placed earlier had a longer feeding time than the birds placed at or after 24 h after hatching, and the increased feed intake usually continued throughout life. These findings are consistent with the BW data shown in Table 5, which clearly demonstrated a negative effect of the FAT of longer than 24–26 h resulting in a reduced feed intake.

In both experiments, there were no significant differences in the FCR at 35 d of age, but the IF group tended to have a poorer FCR than the other groups. A similar trend was also found in a recent study reported by Kang et al. (2018). Effects on the FCR due to the FAT have also not been apparent at market age in other studies (Wyatt et al., 1985; Nir and Levanon, 1993; Casteel et al., 1994; Joseph and Moran, 2005; Franco et al., 2006; El Sabry et al., 2013).

When birds and feed were weighed relative to the actual time on feed, there were no significant differences among treatment groups in feed consumption or the FCR in both experiments (Table 6).

Mortality

The mortality percentage in all groups ranged from 1.0 to 2.1% in experiment 1 and 1.0 to 5.0% in experiment 2, and there were no significant differences among the FAT groups in mortality at 35 d of age in both experiments (data not shown; $P > 0.05$). This finding was consistent with those of Wyatt et al. (1985), Casteel et al. (1994), Corless and Sell (1999), Daşkiran et al. (2012), and Blake et al. (2013). A meta-analysis of data from multiple studies showed that 48 h or longer of posthatch feed and water deprivation had long-term effects on total mortality at 42 d of age (De Jong et al., 2016). The reduction in growth and increased posthatch mortality were primarily due to inaccessibility of feed and water, resulting in dehydration and a shortage of available energy (Vieira and Moran, 1999b). However, this was not the case in the present study, which clearly demonstrated that up to 40 h of delayed access to feed and water under optimum chick

Table 6. Feed intake and feed conversion ratio at 35 d of age according to the feed access time in both experiments.

Experiment	FAT[1]	Feed intake		Adjusted FCR	
		35 d of age[2]	35 d of age + hours[3]	35 d of age	35 d of age + hours
	(h)	(g/chicken)		(g/g)	
1	2	3,858	3,858	1.529	1.529
	8	3,827	3,881	1.520	1.520
	12	3,791	3,860	1.521	1.532
	16	3,863	3,976	1.514	1.534
	20	3,790	3,884	1.516	1.530
	24	3,803	3,920	1.510	1.524
	28	3,725	3,902	1.512	1.532
	32	3,721	3,945	1.513	1.535
	SEM[4]	40.5	42.1	0.011	0.011
	P-value	0.108	0.073	0.702	0.993
	(h)	(g/chicken)		(g/g)	
2	2	3,602[a]	3,602	1.555	1.555
	24	3,492[a,b]	3,661	1.505	1.533
	26	3,453[b]	3,652	1.511	1.542
	28	3,476[b]	3,696	1.528	1.550
	32	3,360[b,c]	3,591	1.523	1.552
	36	3,398[b,c]	3,670	1.526	1.558
	40	3,304[c]	3,582	1.514	1.552
	SEM[5]	46.7	48.3	0.019	0.022
	P-value	0.001	0.119	0.671	0.155

[a-c]Means in a column with different superscripts differ significantly in experiment 2 ($P \leq 0.05$).
[1]FAT: feed access time (2–32 h in experiment 1 and 2–40 h in experiment 2).
[2]35 d of age: 0 d was 32 h and 40 h after hatching in experiments 1 and 2, respectively.
[3]35 d of age + hours: All groups had the same feeding period; (35 d + 30 h and 35 d + 38 h in experiments 1 and 2, respectively).
[4]SEM for n = 6.
[5]SEM for n = 7.

holding environmental conditions did not affect mortality compared with the IF group.

CONCLUSIONS

It was concluded that the FAT did not influence yolk sac utilization in either experiment, as demonstrated by the lack of a significant difference in the residual yolk weight of 940 chicks in total. Both experiments clearly demonstrated that the chicks with access to feed and water at 28 h or more after hatching were not able to compensate for their posthatch BW loss at 35 d compared with the IF group. However, this finding was explained by the difference in feeding opportunity times, which resulted in a reduced feed intake for the groups with delayed access to feed and water. When the feeding period was equal in all groups, feed and water deprivation for up to 40 h after hatching under optimum conditions had no detrimental effects on final live performance. These results suggest that the total feeding period is more critical for broiler performance than the feed and water access time after hatching.

DISCLOSURES

All authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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