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Influence of Egg Storage Time on Egg Quality, Hatchability and Chick Quality Traits of Commercial and Egyptian Local Broiler Breeders

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ABSTRACT

1,680 eggs were used to investigate the effect of egg storage time (EST) on egg quality, hatchability and chick quality traits of Hubbard (HU), Cairo B-2 (B2) and Fayoumi (FA) broiler breeders (48 wk of age). The HU are commercial broiler breeders, B2 is a new Egyptian broiler cross-line between Arbor Acres males and Egyptian native White Baladi females in the 8th generation and FA is an Egyptian native breed. There were 12 groups (4 replicates per group) arranged factorially with 3 broiler breeders (HU, B2 and FA) and 4 ESTs (0, 3, 7 and 10 d). Fertility rates were 94.6, 89.2, and 84.8% for HU, B2, and FA, respectively. No interaction effects were detected for all traits except for Haugh units that were of HU´s eggs in between FA's eggs values (the highest) and B2's eggs values (the lowest) for all ESTs except for 10 d that, the values decreased faster in HU´s eggs than other breeders' ones. Results indicated that HU fresh egg and chick weights (71.8 and 46.6 g) were higher than FA (52.1 and 33.4 g) and B2 (67.1 and 43.4 g) were intermediate, respectively (P<0.0001). The same trend was observed in hatchability (88.5 vs. 82.3 vs. 74.2%) for HU, B2 and FA, respectively. Increasing EST to 7 or 10 d negatively (P<0.0001) affected egg weight (63.8, 63.0, 61.7 and 60.9 g), hatchability rate (84.2, 83.3, 80.3 and 78.9%) and chick weight (42.2, 41.6, 40.6 and 40.0 g) for 0, 3, 7 and 10 d ESTs, respectively. However, egg shape index, yolk color, shell thickness, clear eggs, piping eggs, embryonic mortality, mortality rate at hatch, percentage of culled chicks at hatch and chick navel quality were not affected by increasing EST up to 10 d. To conclude, HU, B2 and FA breeds were different in egg weights, egg Haugh units, yolk index, yolk color, shell thickness, fertility, hatchability, late embryonic mortality (19-21 d of incubation), one-d-old chick weights and chicken mortality rates at hatch. Also, EST for 7 d or more was not recommended for these breeds.

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INTRODUCTION

Broiler breeders from different lines or genetic strains varied in hatchability and embryonic development (Hamidu *et al*., 2007; Bakst *et al*., 2012). Yassin *el al.* (2008) reported that among different strains, differences were also found in egg weight and components like the yolk and albumen percentage, yolk:albumen ratio, shell percentage, and incubation time. In addition, Amer (1965) reported that Fayoumi (FA) hens produced smaller eggs than the eggs produced by Rhode Island Red, North Holland Blue or Single Comb White Leghorn hens. In the same context, FA's eggs had lower Haugh units, higher yolk index, and higher shell thickness than Rhode Island Red eggs (Amer, 1972). Moreover, Kaur *et al*. (2013) compared among heritage (FA and Light Sussex) and commercial (Lohmann Lite and Lohmann Brown) breeds and observed that egg weight and eggshell quality traits varied among them (P<0.05).

In 90th, a statement often heard is that “an egg is at its maximum hatching potential the moment it is laid”, but Brake (1995) stated that eggs set fresh, without a period of storage are poorer than average, whereas Meijerhof (1992) concluded that fertile eggs can be stored for several days without a major loss in hatchability when appropriate conditions are maintained. Reis *et al*. (1997) stated that small improvements in the hatchability of broiler breeder eggs can result in important economic gains. Nowadays, egg storage before setting is a common practice in the poultry industry (Bakst *et al*., 2012; Akhlaghi *et al*., 2013). Due to variable market demand for one-day-old chicks in the poultry industry and the maximum hatchery capacity, the total length of egg storage varies between a few days and several weeks (Reijrink *et al*., 2010a,b). Generally, with

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storage times a week or less there is minimal impact on hatchability (Fasenko, 2007). Elibol *et al*. (2002) reported that hatchability, early mortality and late mortality rates were impaired when EST increased to 14 d and these traits were not affected when eggs stored 7 d before incubation for hatch.

Changes in internal egg quality during storage might have consequences for the protection of the embryo against microorganisms and for the availability of nutrients for the embryo during incubation and therefore might affect hatchability as well as chick quality (Reijrink *et al*., 2009). It has been suggested that early embryonic mortality was associated with albumen quality, which play an important role by interfering with gas exchange (CO_2, H_2O, and O_2) during early incubation (Walsh *et al*., 1995). Ebrahimi *et al*. (2012) measured Haugh units, yolk index, and yolk proportion plus the hatchability to evaluate the quality of long-term stored eggs treated with *in ovo* injection of different buffers and antioxidants. It is has been reported that eggshell structure influence incubation (Fasenko *et al*., 1992) and hatchability (Liao *et al*., 2013). The egg internal characteristics, which constitute the surrounding micro-environment of the embryo, change during the storage period, thereby affecting cell death, embryonic viability, hatchability (Reijrink *et al*., 2008), and hatchling quality (Van den Brand *et al*., 2008). Parameters such as appearance, activity, and quality of the navel area are often used in the commercial hatcheries to identify second-grade chicks (culled chicks) on the day of hatch (Reijrink *et al.*, 2010a,b).

Currently, in Egypt a new local broiler cross-line called Cairo B-2 (B2) was established since 2003 (Nassar *et al*., 2012). Therefore, this study was conducted to examine the impacts of egg storage time (EST; 0 vs. 3 vs. 7 vs. 10 d) on egg quality, hatchability and chick quality traits of 3 mid-lay broiler breeders (Hubbard (HU) as a commercial breed, B2 as a local broiler cross-line and FA as an Egyptian native breed) that are commonly used in Egypt. These breeders exhibit differences in fertility rates as HU is the highest followed by B2 then FA.

MATERIALS AND METHODS

Experimental Design:

The Ethics of Animal Use in Research Committee (EAURC) of Cairo University approved the experiment that was conducted under practical circumstances in a commercial hatchery. The experiment was a complete randomized design with 12 treatments (3 x 4) that included 3 broiler breeders (HU, B2 and FA) and 4 ESTs (0, 3, 7 and 10 d). The HU is the commercial broiler breeder, B2 is a cross breed (8^{th} generation) between Arbor Acres males (female line) and Egyptian native White Baladi females (Nassar *et al*., 2012), and FA is an Egyptian native breed. Eggs from broiler breeder farms, each housing separate 48-wk-old flocks consisting of HU, B2 and FA were shipped to the hatchery and arrived the same day within 12 h of lay. All hens mated naturally with a male:female ratio of 1:8.

Egg Collection and Egg Storage:

The day before egg collection, all eggs from each broiler breeder farm were cleared from the nests before darkness. Eggs were collected between 0700 and 0930 h. 3, 7 or 10 d before setting (n=140 per each breed). Eggs from each breed were separated by breed upon delivery, transferred to plastic setter trays (35 eggs/tray), and placed in a cool room maintained at 16.5 to 17.1°C and 70% humidity (range was 66 to 75%). During storage the eggs were not subjected to special handling or treatments.

Egg Weight, Egg Weight Loss and Egg Quality Traits:

All eggs were weighed individually at egg collection and on the last day of storage. Egg weight loss that occurred between egg collection and the last day of storage was expressed as a mean per g and as a percentage of fresh egg weight. A total of 5 eggs per replicate (20 eggs per treatment) were selected at random to measure the external and the internal egg quality at the setting day. Egg length and egg width were measured by a stainless steel caliper, and the egg shape index was calculated by dividing egg length by egg width (Safaa *et al*., 2008a). Then, all the eggs were broken each in a separate glass dish and the shell with the membranes and the yolk were separated and weighed as described by Safaa *et al*. (2009). Egg components relative proportions (% of egg weight) were determined. Albumen height (±0.1 mm) was measured using a height gauge then Haugh units were calculated on the input of egg weight and albumen height (Keener *et al*., 2006). Yolk index was calculated according to the equation: 100 x yolk height divided by yolk diameter (Ebrahimi *et al*., 2012), and yolk color was determined by using the Roche Color Fan. Shell thickness was measured in these eggs by using a digital micrometer (Safaa *et al*., 2008b). Then all components of each egg were transferred in the same glass dish to an oven (105ºC) for 24 h. Each glass dish was weighed before and after putting in the oven and the difference between the 2 weights was used to calculate egg humidity as a percentage of egg weight.

Incubation:

A total of 30 eggs per each replicate were distributed at random over 1 setter tray. Between each egg, an empty space was included. Per each treatment, 4 setter trays were used. Each setter tray contained 30 eggs of 1 storage time. Therefore, the setter tray could be used as the smallest experimental unit. Relative humidity varied between 50 and 60% and the inlet and outlet valve of the setter were controlled to keep CO_2 levels below 0.35%. Eggs were turned 90° every hour until d 18 of incubation. All eggs that contained a living embryo were individually placed in hatching boxes (30 × 30 cm), which were placed in the same hatcher at d 18 of incubation. The hatcher temperature was set at 36.7°C. Hatchability, embryonic mortality, and chick quality on the day of hatch were measured.

Hatchability and Embryonic Mortality:

Eggs were candled at d 7and 18 of incubation. After 522 h of incubation, all unhatched eggs were collected. Hatchability was calculated as a percentage of fertile eggs. Clear eggs, which were removed during candling, were counted to calculate its percentage to the set eggs. The piping eggs were counted and its percentage to the fertile eggs was calculated. All unhatched eggs were broken open to determine the age at death (Hamburger and Hamilton, 1951), and divided into 4 categories: embryonic mortality from d 0 to 3, from d 4 to 9, from d 9 to 18, and from d 18 to 21. Embryonic mortality was calculated as a percentage of fertile eggs.

Chick Quality:

Twelve hours after each individual chick emerged from the eggshell, chick quality was measured in terms of body weight (BW), culled chicks, mortality and navel quality at hatch. All hatched chicks were divided into culled and un-culled chicks, as first- and second-grade chicks based on physical parameters as described by Tona *et al*. (2004). Briefly, a chick was classified as a first-grade chick if the chick was clean, dry, free of deformities or lesions, had bright eyes, and if the chick was given a navel score of 1 or 2. Other chicks were classified as second-grade chicks (culled chicks). The percentage of culled chicks was calculated as a percentage of total chicks hatched. Navel quality was analyzed and given a score of 1 if the navel was completely closed and clean; a score of 2 if the navel was discolored (color different from skin color) or opened to a maximum of 2 mm, or both; and a score of 3 was given if the navel was discolored or opened more than 2 mm, or both (Reijrink *et al*., 2010a).

Statistical Analysis:

The experimental design was completely randomized (3 breeders x 4 ESTs) with 12 treatments (each with 4 replicates). The experimental unit was a replicate which consisted of 5 eggs for egg components and egg quality traits and of 30 eggsfor the other traits. Data for egg components and naval quality 1 and 2 were statistically analyzed by analysis of variance (ANOVA) two-ways with interaction according to Snedecor and Cochran (1967) using General Linear Model (GLM) Procedure of SAS software (SAS Institute, 2004). Non-normal distributed data (all data for all traits except for egg components and naval quality 1 and 2) were analyzed by using the CATMOD procedure (SAS Institute, 2004). When the model was significant, Tukey's test was used to compare among treatment means. Differences between treatment means were considered significant at $P<0.05$ (Steel and Torrie, 1980). The variance of all the data measured was homogeneous as tested by the HOVTEST option of the GLM procedure. Results in tables are presented as least square means.

Results:

Egg Weight, Egg Weight Loss and Egg Quality Traits:

Only one interaction was observed between main effects for Haugh units ($P<0.0001$). This interaction indicated that HU eggs´ Haugh units were in between FA's values (the highest) and B2's values (the lowest) for all ESTs except for 10 d EST that, the values of HU decreased faster than other breeders' eggs (Fig. 1). Egg weight, egg weight loss and egg components in response to different EST for different broiler breeders are presented in Table (1). Also, all egg quality traits are shown in Table (2). In general, results indicated that HU produced bigger eggs with lower shell thickness (0.340 mm) than FA (0.399 mm) with B2 intermediate (0.372 mm). However, FA eggs had higher Haugh units, yolk index and darker yolk color than either HU or B2 ($P<0.0001$). Fresh egg weight did not differ among the different storage days. Egg weight loss values were increased for eggs stored 7 d or more. Albumen weight was decreased ($P=0.0251$) and shell weight ratio was increased ($P=0.0174$) for eggs stored 10 d comparing to fresh eggs with either the eggs stored for 3 or 7 d intermediate. Storing eggs for 10 d reduced Haugh units (76.4) and yolk index (38.4) in compare to EST of 0, 3 and 7 d (83.4, 82.5 and 81.4 for Haugh units and 40.4, 40.2 and 40.0 for yolk index, respectively). In addition, egg humidity was decreased by increasing EST ($P<0.0001$), however storing eggs 3 or 7 d had a similar effect for this trait.

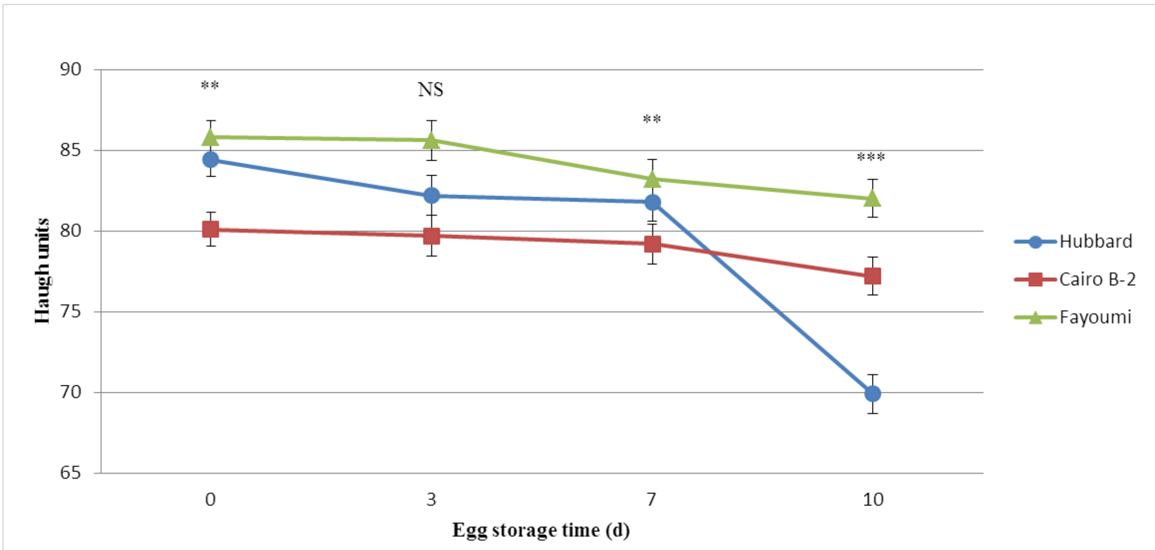

Fig. 1: Effect of egg storage time on Haugh units of different broiler breeder eggs. NS = not significant at P<0.05; **P<0.01; ***P<0.001.

Table 1: Effect of egg storage time (EST) on egg weight, egg weight loss and egg components of eggs from different broiler breeders

	Egg weight (g)		Egg weight loss[1]		Egg components (g)			Egg components (%)		
Item	Fresh	At set	(g)	(%)	Shell	Yolk	Albumen	Shell	Yolk	Albumen
Breed										
Hubbard	71.8[a]	70.3[a]	1.47	2.04	8.3[a]	20.2[a]	41.8[a]	11.8	28.8	59.4
Cairo B-2	67.1[b]	65.8[b]	1.33	1.96	8.3[a]	19.0[a]	38.5[b]	12.7	28.8	58.5
Fayoumi	52.1[c]	50.9[c]	1.21	2.33	6.3[b]	15.1[b]	29.5[c]	12.3	29.7	58.0
SEM (n=16)	0.19	0.13			0.20	0.42	0.46	0.31	0.66	0.73
EST (d)										
0	64.0	63.8[a]	0.28[b]	0.45[b]	7.4	18.7	37.7[a]	11.4[b]	29.4	59.2
3	63.6	63.0[b]	0.57[b]	0.91[b]	7.6	18.3	37.1[ab]	12.0[ab]	29.1	58.9
7	63.7	61.7[c]	1.96[a]	3.10[a]	7.6	17.9	36.2[ab]	12.4[ab]	29.0	58.6
10	63.5	60.9[d]	2.53[a]	3.97[a]	7.9	17.5	35.5[b]	13.1[a]	28.8	58.1
SEM (n=12)	0.22	0.14			0.23	0.48	0.54	0.35	0.77	0.84
Breed x EST (d)										
Hubbard x 0	72.0	71.7	0.26	0.36	8.1	20.7	42.9	11.3	28.9	59.8
Hubbard x 3	71.7	71.1	0.62	0.86	8.3	20.5	42.3	11.7	28.8	59.5
Hubbard x 7	71.8	69.7	2.12	2.95	8.2	20.0	41.5	11.8	28.7	59.5
Hubbard x 10	71.5	68.1	2.88	4.03	8.4	19.6	40.6	12.2	28.6	59.2
Cairo B-2 x 0	67.5	6712	0.30	0.44	7.7	19.8	39.6	11.5	29.5	59.0
Cairo B-2 x 3	66.7	66.1	0.56	0.84	8.2	19.1	38.8	12.4	28.9	58.7
Cairo B-2 x 7	67.0	65.1	1.96	2.92	8.4	18.6	38.1	12.9	28.6	58.5
Cairo B-2 x 10	67.3	64.8	2.48	3.69	9.0	18.4	37.5	13.8	28.3	57.9
Fayoumi x 0	52.6	52.4	0.28	0.53	6.0	15.7	30.7	11.4	30.0	58.6
Fayoumi x 3	52.2	51.7	0.54	1.03	6.2	15.3	30.2	12.0	29.6	58.4
Fayoumi x 7	52.2	50.5	1.80	3.45	6.4	14.9	29.2	12.6	29.5	57.9
Fayoumi x 10	51.5	49.2	2.22	4.31	6.4	14.5	28.3	13.0	29.4	57.6
SEM (n=4)	0.38	0.25			0.41	0.83	0.93	0.61	1.33	1.46
Probability										
Breed	0.0001	0.0001	0.5951	0.5982	0.0001	0.0001	0.0001	0.1396	0.5645	0.3893
EST	0.2801	0.0001	0.0001	0.0001	0.2888	0.3140	0.0251	0.0174	0.9412	0.8824
Breed x EST	0.7643	0.3678	0.9807	0.9980	0.9329	1.0000	1.0000	0.9541	1.0000	1.0000

[a,b,c]Least squares means within column and main effect lacking a common superscript differ significantly (P<0.05).
[1]Analyzed by CATMOD procedure (SAS Institute, 2004).

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Table 2: Effect of egg storage time (EST) on egg quality traits and egg humidity of eggs from different broiler breeders[1]

Item	Egg shape index	Haugh units	Yolk index	RCF[2]	Shell thickness (mm)	Egg humidity (%)
Breed						
Hubbard	135.0	79.6[b]	38.7[b]	9.5[b]	0.340[c]	87.0
Cairo B-2	132.8	79.1[b]	39.3[b]	9.9[b]	0.372[b]	87.0
Fayoumi	132.0	84.2[a]	41.3[a]	11.1[a]	0.399[a]	86.6
EST (d)						
0	133.2	83.4[a]	40.4[a]	10.1	0.372	88.5[a]
3	134.9	82.5[a]	40.2[a]	10.1	0.373	87.2[b]
7	132.3	81.4[a]	40.0[a]	10.1	0.367	86.0[b]
10	132.8	76.4[b]	38.4[b]	10.2	0.369	85.7[c]
Breed x EST (d)						
Hubbard x 0	134.6	84.4[ab]	39.4	9.6	0.336	88.6
Hubbard x 3	136.9	82.2[abc]	38.8	9.4	0.350	87.5
Hubbard x 7	132.6	81.8[abc]	39.2	9.4	0.340	86.2
Hubbard x 10	136.0	69.9[d]	37.3	9.6	0.334	85.9
Cairo B-2 x 0	132.4	80.1[abc]	39.9	9.8	0.378	88.5
Cairo B-2 x 3	129.8	79.7[bc]	39.6	9.8	0.376	87.4
Cairo B-2 x 7	136.1	79.4[bc]	39.7	9.8	0.360	86.1
Cairo B-2 x 10	132.8	77.2[c]	38.0	10.0	0.372	85.9
Fayoumi x 0	132.6	85.8[a]	42.0	11.0	0.402	88.5
Fayoumi x 3	137.9	85.6[ab]	42.3	11.2	0.394	86.7
Fayoumi x 7	128.2	83.2[a]	41.1	11.2	0.400	85.8
Fayoumi x 10	129.4	82.0[abc]	40.0	11.0	0.400	85.4
Probability						
Breed	0.4111	0.0001	0.0001	0.0001	0.0001	0.5204
EST	0.7917	0.0001	0.0005	0.9969	0.7919	0.0001
Breed x EST	0.3396	0.0001	0.9235	0.9974	0.7135	0.9960

[a,b,c]Least squares means within column and main effect lacking a common superscript differ significantly (*P*<0.05).
[1]All traits were analyzed by CATMOD procedure (SAS Institute, 2004).
[2]Roche color fan.

Hatchability and Embryonic Mortality:

No interaction effects between hen breeder types and ESTs were observed in hatchability, clear eggs, piping eggs or embryonic mortality from 1 to 21 d of incubation (Table 3). The HU hen breeders had higher hatchability (88.5%) and produced lower clear eggs (5.41%) than FA (74.2 and 15.21%, respectively) with B2 hens (82.3 and 10.83%, respectively) intermediate (*P*<0.0001). Embryonic mortality rates were not affected by hen breeder type except for mortality during 19-21 d of incubation that was higher for FA eggs than either HU or B2 eggs (*P*=0.0024). Regarding EST effects, hatchability values were reduced by increasing EST to 7 or 10 d (*P*<0.0001) comparing to eggs stored for either 0 or 3 d and embryonic mortality during the first 3 d of incubation tended to increase in response to increase EST (*P*=0.0671). However, no significant effects were noted for clear eggs, piping eggs and the embryonic mortality during the rest periods of incubation.

Chick Quality:

No interaction effects between breed and ESTs were observed in chick quality traits (Table 4). The HU hens produced chicks heavier (46.6 g) with lower mortality (1.24%) than FA (33.4 g and 2.70%, respectively) with B2 hens (43.4 g and 1.04%, respectively) intermediate (*P*<0.05). Storing eggs prior to incubation for 7 d or more reduced chick weight at hatch comparing to either 0 or 3 EST (*P*<0.0001). No significant effects of EST on the percentage of neither culled chicks nor navel quality were observed.

Discussion:

No information is available in the literature regarding the comparison among the breeds obtained in the current trial. Therefore, discussion for breed effect is very limited.

Egg Weight, Egg Weight Loss and Egg Quality Traits:

An interaction between main effects for Haugh units was obtained in the current experiment. Results indicated that storing HU eggs' for 10 d dramatically decreased the Haugh units more than the reduction observed for this trait in either FA or B2 eggs (Fig. 1). We suggested that the commercial breeds are more sensitive to the negative effects of EST more than 7 d on albumen quality than Egyptian local or cross breeds because of their high productivity. Also, these findings might supported by the differences obtained among these breeds in shell thickness (Table 2), hatchability, fertility (clear eggs) and embryonic mortality from 19-21 d of incubation (Table 3).

Table 3: Effect of egg storage time (EST) on hatchability, clear eggs, piping eggs, and embryonic mortality of different broiler breeders[1]

Item	Hatchability (%)	Clear eggs (%)	Piping eggs (%)	Embryonic mortality (%)			
				1-3 d	4-9 d	9-18 d	19-21 d
Breed							
Hubbard	88.5[a]	5.41[c]	1.25	2.29	0.62	0.48	1.45[b]
Cairo B-2	82.3[b]	10.83[b]	1.25	2.08	0.62	0.63	2.29[b]
Fayoumi	74.2[c]	15.21[a]	1.46	2.91	1.04	1.23	3.95[a]
EST (d)							
0	84.2[a]	10.83	0.83	1.66	0.28	0.26	1.94
3	83.3[a]	10.83	1.11	1.94	0.56	0.32	1.94
7	80.3[b]	10.27	1.67	2.77	0.83	1.11	3.05
10	78.9[b]	10.00	1.67	3.33	1.38	1.39	3.33
Breed x EST (d)							
Hubbard x 0	90.8	5.83	0.83	1.67	0.02	0.02	0.83
Hubbard x 3	90.8	5.83	0.83	1.67	0.02	0.02	0.83
Hubbard x 7	87.5	5.00	1.67	2.50	0.83	0.83	1.67
Hubbard x 10	85.0	5.00	1.67	3.33	1.67	0.84	2.49
Cairo B-2 x 0	84.2	11.66	1.67	0.83	0.02	0.02	1.60
Cairo B-2 x 3	84.2	10.83	0.83	1.67	0.83	0.02	1.62
Cairo B-2 x 7	80.8	10.83	0.83	2.50	0.83	0.88	3.33
Cairo B-2 x 10	80.0	10.00	1.67	3.33	0.83	1.68	2.49
Fayoumi x 0	77.5	15.00	0.00	2.50	0.83	0.84	3.33
Fayoumi x 3	75.0	15.83	1.67	2.50	0.83	0.84	3.33
Fayoumi x 7	72.5	15.00	2.50	3.33	0.83	1.67	4.17
Fayoumi x 10	71.7	15.00	1.67	3.33	1.67	1.63	5.00
Probability							
Breed	0.0001	0.0001	0.9261	0.3389	0.6642	0.2492	0.0024
EST	0.0001	0.8658	0.5627	0.0671	0.3212	0.1489	0.1715
Breed x EST	0.8156	0.9977	0.6572	0.9749	0.9446	0.9946	0.9832

[a,b,c]Least squares means within column and main effect lacking a common superscript differ significantly ($P<0.05$).
[1]All traits were analyzed by CATMOD procedure (SAS Institute, 2004).

Table 4: Effect of egg storage time (EST) of different broiler breeder eggs on chick body weight, mortality rate and navel quality at hatch[1]

Item	Body weight (g)	Mortality (%)	Culled chicks (%)	Navel quality[1]		
				1[2]	2[2]	3
Breed						
Hubbard	46.6[a]	1.24	1.04	55.5	42.1	2.4
Cairo B-2	43.4[b]	1.04	1.04	56.6	41.2	2.2
Fayoumi	33.4[c]	2.70	0.42	57.0	40.6	2.4
SEM (n=16)				1.15	1.08	
EST (d)						
0	42.2[a]	2.22	0.56	56.8	40.9	2.3
3	41.6[a]	1.11	0.56	55.6	41.9	2.5
7	40.6[b]	1.39	0.83	56.6	41.3	2.1
10	40.0[b]	1.94	1.39	56.5	41.0	2.5
SEM (n=12)				1.33	1.24	
Breed x EST (d)						
Hubbard x 0	47.5	1.67	0.83	60.5	36.8	2.7
Hubbard x 3	47.1	0.83	0.83	53.3	44.8	1.9
Hubbard x 7	46.2	0.83	0.83	56.3	41.8	1.9
Hubbard x 10	45.4	1.67	1.67	52.0	45.0	3.0
Cairo B-2 x 0	44.2	1.66	0.83	55.8	42.3	1.9
Cairo B-2 x 3	43.8	0.83	0.83	55.5	41.5	3.0
Cairo B-2 x 7	43.1	0.83	0.83	57.0	41.3	1.7
Cairo B-2 x 10	42.6	0.83	1.67	58.3	39.8	1.9
Fayoumi x 0	35.0	3.33	0.00	54.3	43.8	1.9
Fayoumi x 3	33.9	1.67	0.00	58.0	39.5	2.5
Fayoumi x 7	32.6	2.50	0.83	56.5	41.0	2.5
Fayoumi x 10	32.1	3.33	0.83	59.3	38.3	2.4
SEM (n=4)				2.31	2.15	
Probability						
Breed	0.0001	0.0436	0.4384	0.6359	0.6388	0.9551
EST	0.0001	0.5017	0.5295	0.9169	0.9394	0.9846
Breed x EST	0.3733	0.9898	0.9966	0.1176	0.0604	0.9810

[a,b,c]Least squares means within column and main effect lacking a common superscript differ significantly ($P<0.05$).
[1]Naval quality scored with score 1 to 3. Percentage of chicks with score 1, 2, or 3 (total percentage per row is 100%).
[2]Analyzed by GLM procedure (SAS Institute, 2004).

Results of the current trial indicated that HU produced heavier eggs with less shell thickness than FA with B2 intermediate. Also, FA eggs had higher Haugh units, yolk index and darker yolk color than either HU or B2 (P<0.0001). These findings are in agreement with Amer (1965) who concluded that breeds differ significantly with respect to egg weight when he compared among FA, Rhode Island Red, North Holland Blue and Single Comb White Leghorn. In addition, Kaur *et al*. (2013) reported that commercial hens (Lohmann Lite and Lohmann Brown) produced heavier eggs with higher eggshell thickness and albumen height than heritage breeds (FA and Light Sussex). On the other hand, Amer (1972) compared between FA and Rhode Island Red in egg quality traits. He found that FA eggs had lower Haugh units (79.6) but, had higher yolk index (50.5) and shell thickness (0.0144 inch) than Rhode Island Red eggs (84.6, 51.2, and 0.0126 inch, respectively; P<0.05). Moreover, Amer (1962) reported that the embryonic mortality for FA during the first week of incubation was higher than that during the second week of incubation and the mortality during the third week was the highest, representing twice that during the first and second week of incubation.

Regarding EST effects, in this trial, results indicated that EST for more than 7 d did not affect fresh egg weight however, it is negatively affected the egg weight and most of egg quality traits. For example, storing eggs for more than 7 d increased egg weight loss and shell weight ratio however, albumen weight, Haugh units and egg humidity were decreased. The authors suggested that during prolonged egg storage water evaporation from the egg increased which impaired albumen quality and some of this moisture were retained in the eggshell which represented in an increase in eggshell ratio. These findings supported by Walsh *et al*. (1995), who reported that water loss increased and albumen height decreased with length of egg storage (7 and 14 d). They hypothesized that during preincubation storage, water from the egg is lost through evaporation at a rate that is influenced by the temperature and relative humidity of the storage environment. In agreement with our results, Reijrink *et al*. (2009) also observed that storing the commercial Cobb broiler breeder eggs for 3, 5, 8 or 12 d before setting to hatch did not affect fresh egg weight but, increased egg weight loss during storage by 0.24, 0.53, 0.74 and 1.28%, respectively (P<0.05). Moreover, Reijrink *et al*. (2010a) noted that eggs stored for 4 d lost 0.53% less weight during storage than eggs stored for 14 d. Also, they noted that eggs stored for 4 d lost 0.01% more weight per storage day than eggs stored for 14 d. Among the egg internal characteristics, albumen structure is said to be a dominant factor in successful development of the germ from anaerobic to aerobic metabolism (Walsh *et al*., 1995; Christensen *et al*., 2001). Akhlaghi *et al*. (2013) stated that Haugh units in the eggs from Ross 308 breeder flock (48-wk-old) were different (79.1, 74.1, 70.0 and 63.3; P<0.05) in response to store them before setting for 1, 3, 8 or 13 d, respectively.

Hatchability and Embryonic Mortality:

Great differences were detected in hatchability and fertility (clear eggs ratio, Table 3) among breeds. We hypothesized that the differences in shell thickness detected, in the current trial, among HU, B2 and FA might explain, at least in part, the results of hatchability for these breeds, as well as shell thickness reduced the chick easy to peck the shell for hatching. Liao *et al*. (2013) concluded that eggshell thickness and mammillary layer thickness affected hatchability. They observed that hatchability (>90 vs. $\leq$ 75%) is correlated with eggshell thickness (31.7 vs. 29.8 mm, respectively; P<0.05) and mammillary layer thickness (75.2 vs. 68.4 µm, respectively; P<0.05) when they compared among eggs from Rhode Island White flock from 29 and 40 wk of age. Moreover, differences among breeds in hatchability might be due to various reasons such as: differences in the ranges of perivitelline layer sperm holes, blastoderm diameter, cell count or embryo weights which attributed to different egg weights (Bakst *et al*., 2012). They compared between 2 different lines from commercial broiler breeder farms.

Negative effects of prolonged egg storage on hatchability were detected in the current trial, which confirmed that egg storage beyond 7 d is associated with a decline in hatchability (Becker, 1964; Fasenko *et al*., 2001; Tona *et al*., 2004; Fasenko, 2007; Reijrink *et al*., 2009). It has been reported that storage longer than 7 d hatchability begins to decline, in part due to early embryonic mortality (Fasenko, 2007). This author reviewed the impact of egg storage on properties of the egg, such as albumen quality and moisture loss. Reijrink *et al*. (2009) reported that storing the commercial Cobb broiler breeder eggs for 3, 5, 8 or 12 d before setting decreased hatchability of fertile eggs (83.4, 85.0, 82.6 and 77.1%, respectively; P=0.005), increased embryonic mortality during the first 2 d of incubation (5.3, 3.5, 4.1 and 8.4%, respectively; P=0.0006) and during the first 2 d of hatch (3.3, 2.8, 3.9 and 4.7%, respectively; P=0.03). The same trend was observed, in the current trial, for hatchability (P<0.0001). However, for the embryonic mortality, a tendency was noted during the first 3 d of incubation (P=0.0671) and no differences were detected during the rest of incubation periods. In addition, Yassin *et al*. (2008) observed that prolonged egg storage (8 to 14 d at the hatchery) decreased hatchability in the eggs of young (25 to 30 wk) and old (51 to 60 wk) breeders however; these effects were noted more in eggs of young breeders (0.8 vs. 0.4% per storage day). Moreover, Elibol *et al*. (2002) and Tona *et al*. (2004) reported that the decrease in hatchability was higher for old breeders (59, 52-53, and 45 wk, respectively) than for young breeders (37, 31-30, and 35 wk, respectively). These results are difficult to explain because the source for the negative effects of prolonged egg storage is not clear. Reijrink *et al*. (2008, 2010b) stated that these negative effects may be attributed to changes in the embryo, egg characteristics, or both. In the same context, Hamidu *et al*. (2010 and 2011) observed a drop in broiler blastodermal cell number and viability with each successive storage period (4 and 14 d).

Fasenko *et al*. (2001) hypothesized that embryos advanced to the developmental stage, according to the classification table of Eyal-Giladi and Kochav (1976; EG), EG12 or EG13 are more resistant for prolonged egg storage than embryos less or further advanced. At these stages, the embryo has completed hypoblast formation, and cell migration and differentiation is minimal (Bellairs, 1986). These embryos, therefore, contain more cells than embryos less advanced and are in a more quiescent stage of development than embryos further advanced, which probably make them more resistant against prolonged egg storage. In embryos less or further advanced, damage caused by prolonged storage times might be irreversible and might cause embryonic mortality. Reijrink *et al*. (2009) hypothesized that there is an optimal developmental stage or an optimal range of developmental stages of the embryo to maintain embryo viability during prolonged egg storage. When eggs are stored at temperatures below physiological zero, further embryo development is reversibly suppressed (Fasenko, 2007). To prevent changes in the embryo, eggs are normally stored below the temperature at which embryonic development continues. Edwards (1902) reported that this temperature is below 20 to 21°C, whereas Funk and Biellier (1944) suggested that this temperature is below 27°C. Upon incubation, normal embryogenesis commences. In the same context, Bakst and Akuffo (2002) observed successive drops in turkey blastoderm cell numbers on d 1, 2 and 3, post oviposition, followed by a slight, non-significant increase in cell number on d 14 of storage. Moreover, Reijrink *et al*. (2010b) supporting an earlier suggestion by Arora and Kosin (1968), concluded that during the course of egg storage at temperatures thought to suppress cell activity (<20°C), a subpopulation of blastodermal cells remains capable of initiating mitosis. By 2 wk of egg storage, overall blastodermal cell loss has slowed down, and due to mitotic activity, the net number of blastodermal cells may increase, accounting for the increased blastodermal cell numbers observed by Reijrink *et al*. (2010b).

Chick Quality:

Results of the current trial proofed that commercial breeder hens (HU) produced heavier chicks with low mortality at hatch than Egyptian local cross breeds (B2) or native breeds (FA). However, these breeds no differ significantly in neither the percentage of culled chicks nor the navel quality. We suggested that the differences among these breeds in egg weight and eggshell thickness logically explain these findings.

Egg storage beyond 7 d is associated with a decline in chick quality (Byng and Nash, 1962; Tona *et al*., 2003, 2004; Van den Brand *et al*., 2008). Tona *et al*. (2003) determined the negative effects of prolonged egg storage on chick quality in terms of physical parameters on the day of hatch such as appearance, activity, and quality of the navel area (Willemsen *et al*., 2008). However, in the current trial no significant effects were detected in chick quality in response to increase EST up to 10 d except for chick weight at hatch that decreased by store eggs 7 d or more. These results are in accordance with Hamidu *et al*. (2011) who observed that eggs from Ross 308 broiler-breeder (33-wk-old) flocks stored for 4 and 14 d under light between 16 and 18°C and 70 to 80% RH before hatching hatched chicks with different weights at hatch (46.56 vs. 44.32 g, respectively; $P \leq 0.05$). Reijrink *et al*. (2009) reported that storing the commercial Cobb broiler breeder eggs up to 12 d before hatch tended to increase the percentage of second grade chicks (culled chicks in the current experiment) and did not affect the navel quality. Also, Reijrink *et al*. (2010a) stated that the navel quality did not affected when storage time increased up to 14 d. In contrast, they observed that the percentage of second-grade chicks increased when EST increased from 4 to 14 d. However, in the current trial this trait was not affected by prolonged egg storage that may be because EST not exceeded 10 d.

Conclusion:

It could be concluded from this study that HU, B2 and FA breeds were different in most egg quality traits, hatchability and chick weights at hatch. In addition, EST for 7 or 10 d declined hatchability and chick weights at hatch therefore, storing eggs before setting for 7 d or more is not recommended for these breeds.

REFERENCES

Akhlaghi, A., Y.J. Ahangari, S.R. Hashemi, B. Navidshad, Z.A. Pirsaraei, H. Deldar, M.R. Ebrahimi, M. Dadpasand, H. Atashi and J.B. Liang, 2013. Prestorage in ovo injection of biological buffers: An approach to improve hatchability in long-term stored eggs. Poult. Sci., 92: 874-881.

Amer, M.F., 1962. Embryonic mortality and malpositions in Fayoumi chicken. Poult. Sci., 41: 1707-1712.

Amer, M.F., 1965. A comparison of sexual maturity age and egg weight between standard breeds and Fayoumi chickens in subtropics. Poult. Sci., 44: 1180-1184.

Amer, M.F., 1972. Egg quality of Rhode Island Red, Fayoumi and Dandarawi. Poult. Sci., 51: 232-238.

Arora, K.L. and I.L. Kosin, 1968. The response of the early chicken embryo to pre-incubation temperature as evidenced from its gross morphology and mitotic pattern. Physiol. Zool., 41: 104-112.

Bakst, M.R. and V. Akuffo, 2002. Impact of egg storage on embryo development. Pages 125-131 in Proc. Int. Congr. Bird Reprod., Tours, France (1999). Avian Poult. Biol. Rev., (Special issue).

Bakst, M.R., V. Akuffo, D. Nicholson and N. French, 2012. Comparison of blastoderm traits from 2 lines of broilers before and after egg storage and incubation. Poult. Sci., 91: 2645-2648.

Becker, W.A., 1964. The storage of White Leghorn hatching eggs in plastic bags. Poult. Sci., 43: 1109-1112.

Bellairs, R., 1986. The primitive streak. Anat. Embryol., (Berl.) 174: 1-14.

Brake, J.T., 1995. Key points in the management of hatching eggs and incubation. Pages 1–20 in: Proceedings of the IV International Seminar on Poultry Breeding and Incubation, International Poultry Consultants and University of Guelph, Cambridge, ON, Canada.

Byng, A.L. and D. Nash, 1962. The effects of storage on hatchability. Br. Poult. Sci., 3: 81-87.

Christensen, V.L., M.J. Wineland, G.M. Fasenko and W.E. Donaldson, 2001. Egg storage effects on plasma glucose and supply and demand tissue glycogen concentrations of broiler embryos. Poult. Sci., 80:1729-1735.

Ebrahimi, M.R., Y.J. Ahangari, M.J. Zamiri, A. Akhlaghi and H. Atashi, 2012. Does preincubational *in ovo* injection of buffers or antioxidants improve the quality and hatchability in long-term stored eggs? Poult. Sci., 91: 2970-2976.

Edwards, C.L., 1902. The physiological zero and the index of development for the eggs of the domestic fowl (*Gallus domesticus*). Am. J. Physiol., 6: 351-396.

Elibol, O., S.D. Peak and J. Brake, 2002. Effect of flock age, length of egg storage and frequency of turning during storage on hatchability of broiler hatching eggs. Poult. Sci., 81: 945-950.

Eyal-Giladi, H. and S. Kochav, 1976. From cleavage to primitive streak formation: Complementary normal table and a new look at first stages of the development of the chick. I. General morphology. Dev. Biol., 49: 321-337.

Fasenko, G.M., 2007. Egg storage and the embryo. Poult. Sci., 86: 1020-1024.

Fasenko, G.M., R.T. Hardin, and F.E. Robinson, 1992. Relationship of hen age and egg sequence position with fertility, hatchability, viability, and preincubation embryonic development in broiler breeders. Poult. Sci., 71: 1374-1383.

Fasenko, G.M., F.E. Robinson, A.I. Whelan, K.M. Kremeniuk and J.A. Walker, 2001. Prestorage incubation of long-term stored broiler breeder eggs: 1. Effects on hatchability. Poult. Sci., 80: 1406-1411.

Funk, E.M. and H.V. Biellier, 1944. The minimum temperature for embryonic development in the domestic fowl (*Gallus domesticus*). Poult. Sci., 23: 538-540.

Hamburger, V. and H.L. Hamilton, 1951. A series of normal stages in the development of the chick embryo. J. Morphol., 217: 49-92.

Hamidu, J.A., G.M. Fasenko, J.J.R. Feddes, E.E. O'Dea, C.A. Ouellette, M.J. Wineland and V.L. Christensen, 2007. The effect of broiler breeder genetic strain and parent flock age on eggshell conductance and embryonic metabolism. Poult. Sci., 86: 2420-2432.

Hamidu, J.A., A. Rieger, G.M. Fasenko and D.R. Barreda, 2010. Dissociation of chicken blastoderm for examination of apoptosis and necrosis by flow cytometry. Poult. Sci., 89: 901-909.

Hamidu, J.A., Z. Uddin, M. Li, G.M. Fasenko, L.L. Guan and D.R. Barreda, 2011. Broiler egg storage induces cell death and influences embryo quality. Poult. Sci., 90: 1749-1757.

Kaur R., B.M. Rathgeber, K.L. Thompson and J. MacIsaac, 2013. Uterine fluid proteins and egg quality characteristics for 2 commercial and 2 heritage laying hen lines in response to manipulation of dietary calcium and vitamin D_3. Poult. Sci., 92: 2419-2432.

Keener, K.M., K.C. McAvoy, J.B. Foegeding, P.A. Curtis, K.E. Anderson and J.A. Osborne, 2006. Effect of testing temperature on internal egg quality measurements. Poult. Sci., 85: 550-555.

Liao, B., H.G. Qiao, X.Y. Zhao, M. Bao, L. Liu, C.W. Zheng, C.F. Li and Z.H. Ning, 2013. Influence of eggshell ultrastructural organization on hatchability. Poult. Sci., 92: 2236-2239.

Meijerhof, R., 1992. Pre-incubation holding of hatching eggs. World's Poult. Sci. J., 48: 57-68.

Nassar, F.S., R.E.A. Moghaieb, A.M. Abdou and F.K.R. Stino, 2012. Microsatellite markers associated with body and carcass weights in broiler breeders. African J. Biotechnology, 11: 3514-3521.

Reijrink, I.A.M., R. Meijerhof, B. Kemp and H. van den Brand, 2008. The chicken embryo and its micro environment during eggstorage and early incubation. World's Poult. Sci. J., 64: 581-598.

Reijrink, I.A.M., R. Meijerhof, B. Kemp, E.A.M. Graat and H. van den Brand, 2009. Influence of prestorage incubation on embryonic development, hatchability, and chick quality. Poult. Sci., 88: 2649-2660.

Reijrink, I.A.M., D. Berghmans, R. Meijerhof, B. Kemp and H. van den Brand, 2010a. Influence of egg storage time and preincubation warming profile on embryonic development, hatchability, and chick quality. Poult. Sci., 89: 1225-1238.

Reijrink, I.A.M., R. Meijerhof, B. Kemp and H. van den Brand, 2010b. Influence of egg warming during storage and hypercapnic incubation on egg characteristics, embryo development, hatchability, and chick quality. Poult. Sci., 89: 2470-2483.

Reis, L.H., L.T. Gama and M.C.Soares, 1997. Effects of short storage conditions and broiler breeder age on hatchability, hatching time, and chick weights. Poult. Sci., 76: 1459-1466.

Safaa, H.M., M.P. Serrano, D.G. Valencia, X. Arbe, E. Jiménez-Moreno, R. Lázaro and G.G. Mateos, 2008a. Effects of the levels of methionine, linoleic acid, and added fat in the diet on productive performance and egg quality of brown laying hens in the late phase of production. Poult. Sci., 87: 1595-1602.

Safaa, H.M., M.P. Serrano, D.G. Valencia, M. Frikha, E. Jiménez-Moreno and G.G. Mateos, 2008b. Productive performance and egg quality of brown egg-laying hens in late phase of production as influenced by level and source of calcium in the diet. Poult. Sci., 87: 2043-2051.

Safaa, H.M., E. Jiménez-Moreno, D.G. Valencia, M. Frikha, M.P. Serrano and G.G. Mateos, 2009. Effect of main cereal of the diet and particle size of the cereal on productive performance and egg quality of brown egg-laying hens in early phase of production. Poult. Sci., 88: 608-614.

SAS Institute, 2004. SAS/STAT User's Guide. Version 9.1. SAS Institute Inc., Cary, NC, USA.

Snedecor, G.W. and W.G. Cochran, 1967. Statistical Methods. 2nd Ed. Iowa Univ. Press. Ames, Iowa, USA.

Steel, R.G.D. and J.H. Torrie, 1980. Principles and Procedures of Statistics, 2nd ed. McGraw-Hill International, NY, USA.

Tona, K., F. Bamelis, B. De Ketelaere, V. Bruggeman, V.M.B. Moreas, J. Buyse, O. Onagbesan and E. Decuypere, 2003. Effects of egg storage time on spread of hatch, chick quality, and chick juvenile growth. Poult. Sci., 82: 736-741.

Tona, K., O. Onagbesan, B. De Ketelaere, E. Decuypere and V. Bruggeman, 2004. Effects of age of broiler breeders and egg and post-hatch growth to forty-two days. J. Appl. Poult. Res., 13: 10-18.

Van den Brand, H., I.A.M. Reijrink, L.A. Hoekstra and B. Kemp, 2008. Storage of eggs in water affects internal egg quality, embryonic development, and hatchling quality. Poult. Sci., 87: 2350-2357.

Walsh, T.J., R.E. Rizk and J. Brake, 1995. Effects of temperature and carbon dioxide on albumen characteristics, weight loss, and early embryonic mortality of long stored hatching eggs. Poult. Sci., 74: 1403-1410.

Willemsen, H., N. Everaert, A. Witters, L. De Smit, M. Debonne, F. Verschuere, P. Garain, D. Berckmans, E. Decuypere and V. Bruggeman, 2008. Critical assessment of chick quality measurements as an indicator of posthatch performance. Poult. Sci., 87: 2358-2366.

Yassin, H., A.G.J. Velthuis, M. Boerjan, J. van Riel and R.B.M. Huirne, 2008. Field study on broiler eggs hatchability. Poult. Sci., 87: 2408-2417.