Brazilian Journal of Poultry Science
Revista Brasileira de Ciência Avícola

ISSN 1516-635X Jan - Mar 2017 / v.19 / n.1 / 033-040

http://dx.doi.org/10.1590/1806-9061-2016-0264

Effects of Hen Age and Egg Weight Class on the Hatchability of Free Range Indigenous Chicken Eggs

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■Keywords

Egg weight, embryo mortality, Hassawi chicken, hatchability, hen age.

Submitted: March/2016
Approved: June/2016

ABSTRACT

In total, 806 eggs of free-range Hassawi indigenous chickens were collected from local farm in Saudi Arabia. Eggs were weekly collected for 11 weeks. Initial egg weight (IEW) was recorded, and eggs were graded into four classes (A: 35–40 g, B: 40–45 g, C: 45–50 g, and D: 50–55 g). Eggs were stored for seven days at 75–80% relative humidity and 14–16 C, after which egg weight losses (WL_0) were calculated. During incubation, eggs were weighed on days 7 (W_7) and 14 (W_{14}), and egg weight losses on days 7 (WL_7) and 14 (WL_{14}), and total loss (WL_{0-14}) were calculated. Hatchling weight (CW) was measured. The proportion of CW relative to egg weight loss (WL) on days0, 7 and 14 days of incubation ($CW:WL_0$; $CW:WL_7$ and $CW:WL_{14}$, respectively), and break out analyses, fertility (F),total hatchability (H_C) and hatchability of fertile eggs (H_F) were also calculated. IEW decreased ($p<0.05$) with hen age. Stored egg weight (SEW) were decreased as hen age increased ($p<0.05$). WL_7, WL_{14} and WL_{0-14} showed significant differences ($p<0.001$) and increased up to first six-week of egg collection time. Hen age affected CW:WL before incubation, and on days 7 and 14 of incubation. Fertility (F) was affected ($p<0.05$) in unpredicted way of increasing and decreasing by hen age. Egg weight class affected SEW, $W_7$and W_{14} ($p<0.001$). Class D eggs were the highest weight. Class C eggs had highest H_C. In summary, hatching eggs of Hassawi hens were affected by hen age and egg weight in randomly *increase* and *decrease*.

INTRODUCTION

Indigenous chickens play a major role in providing rich protein sources, such as eggs and meat, to low-income households in the rural areas of tropical regions (Albokhadaim, 2012). In general, the meat and eggs of indigenous chickens are preferred over those of exotic breeds because of their special flavor. In addition, indigenous chickens are better adapted to endemic diseases and other harsh environmental conditions. Their production system is simple: they are maintained in free range during the day and in elementary shelters during the night. In addition, indigenous chickens are known to be good foragers and minimal care is required for their growth and development (Alabbad, 2014).

Saudi Arabia has some indigenous chicken ecotypes, such as the Hassawi chicken, which originates from the Eastern region of the country, where harsh environmental conditions are predominant and poor performances was reported (Al-Aqil, 1998). The eggs of this indigenous breed have lower egg mass compared with those of commercial laying strains. Despite the importance of this ecotype for local communities, few studies have been performed to characterize its production cycle and to improve its productivity.

Many factors affect egg hatchability before and after incubation. Egg weight has significant effects on total hatchability, hatchability of fertile eggs, egg weight loss, embryonic death, and egg breakout analysis in broiler breeder chickens (Abiola *et al*. 2008; Caglayan *et al.,* 2008; Alsobayel *et al*. 2013; Abudabos, 2010). Generally, larger eggs produce larger chicks and a good-quality egg improves the probability of optimal hatchability and chick quality (Lourens *et al*., 2006; Yoho *et al*., 2008). Weight loss of hatching eggs is a result of evaporation and was reported to be related to egg weight (Reis *et al*., 1997).

The reproduction efficiency of broiler breeders decreases with age, because it negatively affects the quality of hatching eggs. Internal egg composition or ratio changes, higher egg weight, poorer egg shell quality, and increased early and late embryo mortality have been reported in older breeders (Elibol & Brake, 2003; Joseph & Moran, 2005). In addition, egg handling, collection management, and storage conditions are of prime concern as they affect egg hatchability (Alsobayel *et al*., 2013).

There are many studies on the optimal conditions for hatching eggs from commercial laying strains; however, this is not the case for free range production systems. Therefore, the current study aimed at evaluating the effects of egg collection time as an indication of hen age and egg weight class on the incubation performance and hatchability of Hassawi indigenous chickens in order to collect basic information on this breed and, consequently, to improve their performance.

MATERIALS AND METHODS

Management

A total of 806 eggs were collected from a local farm of Hassawi chickens reared under a free-range system (Figure 1). The eggs were collected weekly for 11 weeks, starting in the first week of March 2015. Hens were 20 weeks old at the beginning of the collection period. The collected eggs were stored under cool and humid storage for less than seven days at 75-80% relative humidity and 14-16 C. During the experimental period, maximum and minimum environmental temperatures were recorded daily (Figure 2).

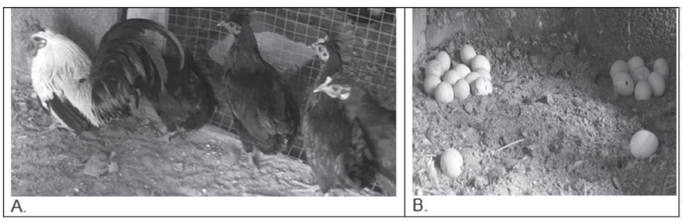
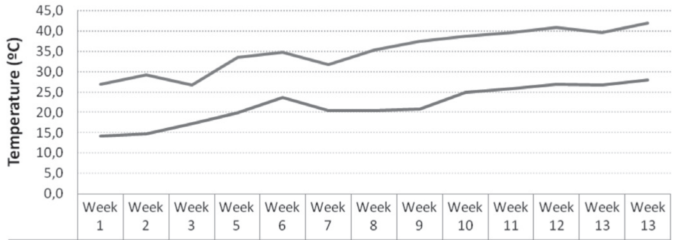


Figure 1 – A. Hassawi chicken reared under the free-range system. B. Eggs ready for collection and storage.



	Week 1	Week 2	Week 3	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11	Week 12	Week 13	Week 13
High	26,9	29,3	26,7	33,6	34,9	31,7	35,3	37,4	38,7	39,7	40,9	39,7	42,0
Low	14,1	14,7	17,3	19,9	23,7	20,4	20,4	20,7	24,9	25,9	27,0	26,7	28,0

Figure 2 – Temperature profiles during egg collection period from March till May. (Source: http://www.accuweather.com)

Eggs were graded according to weight, then were grouped into classes: class A, weighing 35 to 40 g (total number of eggs collected: 121); class B, weighing 40 to 45 g (total number of eggs collected: 349); class C, 45 to 50 g (total number of eggs collected: 289); and class D, weighing 50 to 55 g (total number of eggs collected: 47). The eggs were then set on trays and individually labeled for egg weight loss measurements on days 7 and 14 of incubation. The trays were divided using small pieces of wood in order to accurately measure hatchling weight. Trays representing all egg weight groups were distributed in the setter at 37.5°C temperature and 60% relative humidity of during the first 19 d of incubation. On 19 d of incubation, eggs were transferred to hatch baskets and placed in a Hatcher. In the Hatcher, the temperature was decreased to 37.0°C, and the humidity was increased to 75%.

Egg weight loss before incubation (as the result of storage) was calculated as the difference between egg weight at the time of collection and weight at incubation and was labeled as (WL_0). During incubation, eggs were weighed on days 7 and 14 days, and the weight was labeled as W_7 and W_{14}, respectively. Egg weight loss was calculated as the difference between egg weight at setting and egg weight on days 7 and 14, and labeled as WL_7 and WL_{14}, respectively. Total weight loss (WL_{0-14}) percentage was determined by adding WL_0, W_7, and W14.

At hatch, hatchlings from all groups were individually weighed (CW), and the proportion of hatchling weight (CW) to egg weight loss (WL) on days0, 7, and 14 of incubation was calculated and labeled as $CW:WL_0$, $CW:WL_7$ and $CW:WL_{14}$, respectively. All unhatched eggs were opened and examined to determine the cause of embryo mortality. Fertility percentage (F) was calculated as the number of fertile eggs/number of total eggs produced or set. Total hatchability (H_C) was calculated as the number of hatched eggs/number of eggs set in the incubator. The hatchability of fertile eggs (H_F) was calculated as the number of hatched eggs/ number of fertile eggs. Total mortality (M_T), mortality on days 7 (early embryo mortality; M_7) and on day 14 (intermediate embryo mortality; M_{14}) of incubation were determined.

Statistical Analysis

Data were analyzed according to randomized block design by analysis of variance using the General Linear Model procedure of the software Statistical Analysis System (SAS, 2008). When differences among treatments were significant, means were separated using the LSD test. Statistical significance was assessed at $p<0.05$.

RESULTS AND DISCUSSION

Egg weight, egg weight loss during incubation, and hatchling weight results as a function of collection week are presented in Table 1. Initial egg weight (IEW) was affected by collection week or hen's age ($p<0.05$), heavier eggs were produced in weeks 3 and 4 (45.42 and 45.48 g, respectively) compared with weeks 1, 2, 6, 7, 8, and 11 (44.72, 44.54, 44.59, 44.65 and 44.28 g, respectively). In other words, the heaviest eggs were produced by 23- and 24-week-old hens. Similarly, stored egg weight (SEW) also was affected by collection week ($p<0.001$), eggs collected in weeks 3 and 4 were the heaviest, but not different from week 6 (45.23, 45.44 and 44.97 g, respectively). Moreover, collection week had a significant effect on egg weight when eggs were weighed on days7 and 14 of incubation ($p<0.001$ and 0.001, respectively). The heaviest eggs measured on W_7 and W_{14} were those collected in weeks 3 and 4. The lowest egg weight on W_7 was obtained in eggs collected in week 1 (43.95 g), which however, was not different from those collected in weeks 7, 10 and 11 (44.44, 44.57 and 44.21 g, respectively). The lightest eggs (40.71 g) measured in W_{14} were collected in week 1. Eggs collected in weeks 3 and 4 were the heaviest onW_7 and W_{14}.

Collection week, and therefore, hen age had no effect ($p>0.05$) on egg weight loss as a result of storage (WL_0), as shown in (Table 1).However, WL_7, WL_{14} and $WL_{0-14}$of eggs collected in different weeks presented highly significant differences ($p<0.001$, 0.001 and 0.001, respectively). In general, eggs collected in week 3 showed the lowest WL_7, WL_{14} and WL_{0-14} compared with the other weeks (2.36, 3.07, and 6.22%, respectively), while those collected in week 1 presented the highest weight loss (7.27, 7.65, and 17.48%, respectively). The lightest hatchlings were obtained from eggs collected in week 1 (28.96 g), while eggs collected in week 2 produced intermediate-weight hatchlings (29.77 g) ($p<0.001$). The heaviest chicks hatched from eggs collected in weeks 3, 4, 6,

Table 1 – Egg weight, weight loss of hatching eggs and chick weight

Collection Week	IEW	SEW	W_7	W_{14}	WL_0	WL_7	WL_{14}	WL_{0-14}	CW	$CH:WL_0$	$CH:WL_7$	$CH:WL_{14}$
p<	0.036	0.001	0.001	0.001	ns	0.001	0.001	0.001	0.001	0.001	0.0017	0.001
1	44.72^{b}	43.95^{d}	41.35^{d}	40.71^{cd}	1.42	7.27^{a}	7.65^{a}	17.48^{a}	28.96^{d}	64.35^{a}	65.95^{c}	68.99^{d}
2	44.54^{b}	44.56^{bc}	42.39^{bc}	41.50^{b}	1.06	4.94^{b}	6.39^{abc}	12.88^{bc}	29.77^{bc}	67.12^{b}	67.08^{abc}	70.63^{bcd}
3	45.42^{a}	45.23^{a}	44.22^{a}	43.07^{a}	0.55	2.36^{d}	3.07^{e}	6.22^{e}	30.65^{a}	67.39^{b}	67.78a^{b}	69.33^{d}
4	45.48^{a}	45.44^{a}	44.01^{a}	43.03^{a}	0.59	3.21^{c}	3.87^{de}	7.82^{de}	30.99^{a}	67.58^{b}	67.98a^{b}	70.25^{cd}
5	45.02^{ab}	44.68^{bc}	42.62^{bc}	40.52^{cd}	1.24	4.65^{b}	5.45^{bed}	10.99^{bcd}	30.52^{ab}	67.71^{b}	68.12^{a}	72.08^{abc}
6	44.59^{b}	44.97^{ab}	42.86^{b}	40.86^{cb}	0.62	4.74^{b}	5.28^{ab}	10.61^{bcd}	30.70^{a}	67.88^{b}	68.41^{a}	72.35^{ab}
7	44.65^{b}	44.44^{bcd}	42.23^{c}	40.16^{d}	1.22	5.03^{b}	6.49^{ab}	13.04^{b}	30.56^{a}	68.43^{b}	68.48^{a}	72.50^{a}
8	44.86^{ab}	44.54^{bc}	42.54^{bc}	40.60^{cd}	0.95	4.55^{b}	5.43^{bcd}	10.94^{bcd}	30.62^{a}	67.97^{b}	68.66^{a}	72.38^{a}
9	44.77^{ab}	44.72^{bc}	42.70^{bc}	40.83^{c}	0.44	4.56^{b}	5.02^{cd}	10.06^{cd}	30.47^{ab}	68.01^{b}	68.16^{a}	71.94^{abc}
10	44.76^{ab}	44.57^{bcd}	42.39^{bc}	40.51^{cd}	0.55	4.89^{b}	5.21^{bcd}	10.40^{bcd}	29.46^{cd}	67.78^{b}	66.28^{bc}	70.02^{d}
11	44.28^{b}	44.21^{bcd}	42.12^{c}	40.20^{cd}	0.61	4.78^{b}	5.41^{bcd}	10.84^{bcd}	30.41^{ab}	69.04^{b}	68.54^{a}	72.34^{ab}
Mean	44.83	44.66	42.68	41.09	0.89	4.59	5.39	8.92	30.28	67.57	67.77	71.16
SEM	0.259	0.204	0.228	0.227	0.294	0.251	0.512	1.067	0.312	0.710	0.623	0.663

EIW: egg initial weight.

SEW: stored egg weight

W_7, W_{14}: egg weight on d 7 and 14 of incubation, respectively.

WL_{0-14}:total egg weight loss from storage to 14 days of incubation.

CW: hatchling weight

$CH:WL_0$, $CH:WL_7$and $CH:WL_{14}$: proportion of hatchling weight to egg weight loss on d 0, 7 and 14 of incubation, respectively.

$^{a-e}$ Values followed by different superscripts within columns are significantly different ($p<0.05$). ns: not significant.

7, and 8 (30.65, 30.99, 30.70 and 30.56, respectively). Egg weight loss affects hatchability and hatchling quality, and the differences in hatchling weight are a function of egg weight loss (Tullett & Burton, 1986).

The proportion of hatchling weight to egg weight loss (CW:WL) either before incubation (CW:WL_0) or on days 7 and 14 of incubation was significantly influenced by collection week. For instance, eggs collected in week 1 presented the highest CW:WL_0 (64.35%), but the lowest CW:WL_7 and CW:WL_{14} (65.95 and 68.99%, respectively). This may be partially explained by changes in environmental temperature, which was lower temperature in weeks 3 and 4 compared with weeks 5, 7, and 11 (Fig. 2). In general, in order to prevent hatching egg loss before incubation, the temperature of the eggs must be reduced from body temperature (40 °C) to "physiological zero" (26-27 °C) within six hours, and temperature fluctuations must be avoided as much as possible under practical conditions (Lourens *et al.,* 2006). Egg storage temperature in the range of 27-37 °C leads to unbalanced embryo development and causes early embryonic mortality (Schulte-Drüggelte & Svensson, 2011). On the other hand, eggs which were collected in weeks 5, 6, 7, 8, 9 and 11 showed the highest CW:WL_7 proportions (67.78, 67.98, 68.12, 68.41, 68.48, 68.66, and 68.54%, respectively). The CW:WL_{14} was the highest in the eggs collected in weeks 7 and 8 (72.50 and 72.38%, respectively).

Fertility and hatchability results according to collection week are presented in Table 2. Total hatchability (H_C) and hatchability of fertile eggs (H_F) were not affected by collection week (p>0.05). However, fertility (F) was influenced by collection week (p<0.05), with eggs collected in week 3 presenting the lowest fertility percentage (60.45%), which, however, was similar to those collected in weeks 2, 6, 8, and 9 (73.68, 71.53, 71.79, and 71.14%, respectively). The present research shows that true fertility was significantly influenced by collection week. True fertility was 84.65% in eggs collected in week 1 and declined to 71.14% in week 9. Age has been shown to affect the fertility of broiler breeders (Brotherstone *et al*., 2000), and this effect is more pronounced in female than in male breeders (Brommer & Rattiste, 2008).In females, egg quality and behavioral and physiological factors, such as prevalence of sperm storage tubules, are most significant (Siegel, 1965), whereas in males, several sperm quality traits, such as sperm metabolism, semen concentration, sperm motility, and the percentage of abnormal or dead sperm cells are affected (Bramwell *et al*., 1996).

Table 2 – Total hatchability,hatchability of fertile eggs, andbreakout analysis.

	Hatchability			Breakout analysis		
Collection Week	F	HC	HF	M_T	M_7	M_{14}
p<	0.048	ns	ns	ns	0.009	ns
1	84.65^{a}	73.86	87	12.5	7.13^{abc}	5.37
2	73.68^{abc}	61.47	83.39	14.41	8.64^{ab}	5.77
3	60.45^{c}	55.96	92.21	5.81	5.02^{abc}	0.79
4	78.77^{ab}	66.81	84.43	13.84	10.35^{a}	3.48
5	67.56^{bc}	54.49	80.08	19.37	12.05^{a}	7.32
6	71.53^{abc}	64.02	89.21	10.31	0.82b^{c}	9.49
7	79.15^{ab}	70.01	88.19	11.45	0.73^{c}	10.72
8	71.79^{abc}	67.51	94.06	5.67	0.53^{c}	5.15
9	71.14^{abc}	62.07	86.69	12.82	0.85^{bc}	11.96
10	77.00^{ab}	61.17	78.72	20.73	11.29^{a}	9.44
11	80.96^{ab}	66.64	82.07	17.38	7.38^{abc}	9.99
Mean	74.24	64	86.01	13.12	5.89	7.23
SEM	5.361	5.876	4.809	4.72	3.06	3.79

F: fertility
H_C:total hatchability.
H_F: hatchability of fertile eggs.
M_T: total embryo mortality
M_7: mortality on d 7 of incubation
M_{14}: mortality on d 14 of incubation
$^{a-c}$ Values followed bydifferent superscripts within columns are significantly different (p<0.05)
ns:not significant.

Total embryonic mortality (M_T) and embryonic mortality on day14 (M_{14}) were not affected by collection week (p>0.05). However, early embryonic mortality, i.e., on day 7 (M_7), was significantly affected by collection week (p<0.01) (Table 2). Early embryonic mortality (first seven days of incubation) is a result of failure of the embryo to resume development after having been stored and placed in the setter (North and Bell, 1990), while mid-term embryonic mortality is usually related to nutritional deficiencies in the broiler breeder diet or embryonic abnormalities. Embryonic mortality is influenced by breeder age.

Egg weight, egg weight loss during incubation, and hatchling weight results as a function of egg weight class are presented in Table 3. Initial egg weight (IEW) was affected by egg weight class (p<0.001). As the eggs were sorted into these classes, this was expected. Class D corresponded to the heaviest eggs (51.71 g) and class A to the lightest eggs (37.47 g).Egg weight class affected stored egg weight (SEW), W_7, and W_{14}(p<0.001). Class D eggs (50 to 55 g, original weight) were the heaviest during incubation in all evaluated periods. In general, a linear trend was observed, with class D eggs being the heaviest and class A the lightest in all periods. Egg weight class did not affect (p>0.05) egg weight loss (WL) at setting (WL_0) or on day 14 of incubation (WL_{14}). However, WL_7 was significantly different (p<0.05) among egg weight classes. The

Table 3 – Egg weight, weight loss of stored and incubated eggs, and hatchling weight as function of egg weight class.

Egg Class	IEW	SEW	W_7	W_{14}	WL_0	WL_7	WL_{14}	WL_{0-14}	CW	F	H_C	H_F	M_T	M_7	M_{14}
p<	0.001	0.001	0.001	0.001	ns	0.015	ns	ns	0.001	ns	0.013	ns	ns	ns	ns
A	37.47^d	37.28^d	35.60^d	34.06^d	0.53	4.94^a	5.31	9.55	25.79^d	69.09	55.23^b	79.89	19.91	7.69	12.22
B	42.72^c	42.58^c	40.72^c	39.16^c	0.84	4.49^{ab}	5.24	8.80	28.84^c	72.06	62.03^b	86.33	13.27	5.62	7.64
C	47.41^b	47.30^b	45.34^b	43.60^b	0.94	4.19^b	4.91	8.55	31.68^b	79.06	71.11^a	90.12	9.58	2.64	6.94
D	51.71^a	51.49^a	49.05^a	47.54^a	0.81	4.92^a	6.11	8.76	34.81^a	76.76	67.63a^b	87.69	9.71	7.62	2.10
Mean	44.83	44.66	42.68	41.09	0.78	4.59	5.39	8.92	30.28	74.24	64.00	86.01	13.12	5.89	7.23
SEM	0.183	0.147	0.165	0.164	0.201	0.181	0.361	0.350	0.227	3.877	4.250	3.499	3.434	2.225	2.756

Egg weight class: A: 35-40 g, B: 40-45 g, C: 45-50g, and D: 50-55 g.

EIW: egg initial weight.

SEW: stored egg weight

W_7, W_{14}: egg weight on d 7 and 14 of incubation, respectively.

WL_{0-14}:total egg weight loss from storage to 14 days of incubation.

CW: hatchling weight

CH:WP_0, CH:WP_7 and CH:WP_{14}: proportion of hatchling weight to egg weight loss on d 0, 7 and 14 of incubation, respectively.

F: Fertility

H_C:hatchability

H_F: hatchability of fertile eggs

M_T: total Mortality

M_7: mortality at 7 d of incubation

CH:WL_0, CH:WL_7 and CH:WL_{14}: proportion of hatchling weight to egg weight loss on d 0, 7 and 14 of incubation, respectively.

$^{a-d}$ Values followed by different superscripts within columns are significantly different ($p<0.05$). ns: not significant.

highest egg weight losses on day 7 of incubation were observed in Class A and Class D eggs (4.94 and 4.92%, respectively), while Class C eggs presented the least weight loss (4.19%). Deeming (1994) concluded that large eggs lose less weight than small and medium eggs. Collection week had no significant effect ($p>0.05$) on total egg weight loss, calculated as losses during storage and 14 days of incubation (WL_{0-14}), as shown in Table 3. Christensen and McCorkle (1982) concluded that egg weight losses during incubation are a function of egg characteristics, such as initial egg weight, as well as of the conditions in the incubator, including temperature and humidity. Reis *et al*. (1997) examined compared weight loss due evaporation of large eggs and small eggs, and concluded that larger eggs tended to lose more weight in grams but less in percentage when compared to smaller eggs. In general, larger eggs have less shell area per unit of egg weight than smaller eggs (Roque & Soares, 1994).

Egg weight class influenced hatchling weight (Table 3). The results of the current experiment showed that the lightest hatchlings derived from class A eggs (25.79 g), while the heaviest from class D eggs (34.81 g) ($p<0.001$), with average chick weight of 30.28 g for all groups. Likewise, Caglayan & Inal (2006) reported higher chick weight with increasing egg weight. These results are consistent with Sinclair *et al*. (1990), who reported that chicks that hatch from older breeder flocks are larger and of higher quality, because they are naturally more resistant to dehydration upon hatching compared with smaller chicks from young breeder flocks.

Fertility (F) and hatchability of fertile eggs (H_F) were not affected by egg weight class ($p>0.05$). Alabi *et al*. (2012) also reported that egg weight had no effect on the fertility rate of an indigenous South African breed. Egg weight class influenced total hatchability (H_C) of Hassawi eggs, which ranged between 55.2-71.1%. Class C eggs presented the highest hatchability (71.11%) compared with all other classes ($p<0.05$). This result is in agreement with other studies (Wilson, 1991; Abiola *et al.*, 2008), which reported higher hatchability of medium-size eggs than of small and large eggs. Hatchability declines with age, and optimal hatchability is achieved when egg weight ranges between 55 and 65 g in commercial layer strains; however, there is very little information on indigenous chicken breeds (Alabi *et al*., 2012). In practice, eggs of different sizes are incubated together at an average incubation temperature; however, different incubation conditions are required for eggs from different breeder age classes. Larger eggs are known to hatch earlier and suffer more from post-hatch holding in the Hatcher than smaller eggs (Vieira & Mora, 1998). In addition, more heat is produced by larger eggs during incubation, since they have larger embryos (French, 1997). If eggs of different age classes are to be incubated together, incubation conditions should be accordingly adjusted.

Embryonic mortality (M_7, M_{14} and M_T) was not affected by egg weight class ($p>0.05$). However, in a study conducted by McNaughton *et al*. (1978), egg weight influenced embryonic mortality, with higher mortality reported in eggs weighing 47-54 g compared with those weighing either 57-62 g or 67-74 g.

Figure 3 shows the proportion of hatchling weight to egg weight loss (CW:WL) on days 0, 7, and 14 of incubation. Egg weight class significantly affected CW:WL effect on all evaluated days. Class A eggs presented higher $CW:WL_0$, $CW:WL_7$, and$CW:WL_{14}$ compared with class C eggs ($p<0.01$), where as intermediate values were obtained in class B and D eggs. Contrary to the findings of the current study, Alabi *et al*.(2012) reported higher weight loss in chicks hatched from larger eggs. Deeming (1994) reported lower egg weight loss in large eggs than in small and medium eggs.

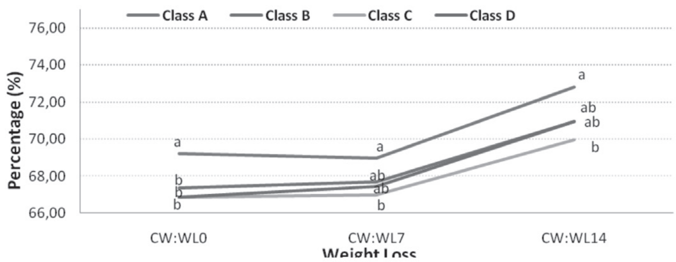


Figure 3 – Effect of egg class onegg weight loss of chick weight at 0, 7 and 14 days of incubation.

Letters (a-c) with different superscript are significantly different ($p<0.05$).

Correlation coefficients between the variables measured in this trial are shown in Table 4. Egg collection week was negatively correlated with egg weight class ($r=-0.189$, $p<0.001$) and WL_0 ($r=-0.106$, $p<0.05$), and positively correlated with WL_{0-14} ($r=0.243$, $p<0.001$) and M_7 ($r=0.10$, $p<0.05$). On the other hand, egg class presented a positive correlation with H_C ($r=0.094$, $p<0.01$), H_F ($r=0.101$, $p<0.05$), and CW ($r=0.754$, $p<0.001$), and a negative correlation with WL_7 ($r=-0.118$, $p<0.01$), WL_{0-14} ($r=-0.182$, $p<0.001$), M_7 ($r=-0.102$, $p<0.05$), and M_{14} ($r=-0.115$, $p<0.01$). According to Wilson (1991), the correlation between embryo weight and egg weight increases and is maximal at the time of hatching. In the current study, a high correlation between egg weight class and hatchling weight was obtained ($r=0.754$, $p<0.001$).In general, chick weight is estimated at approximately 62-78% of the egg weight, and it is determined by initial egg weight and weight loss during incubation, eggshell weight, strain, incubation time and conditions, breeder age, and chick sex (Wilson, 1991).

CONCLUSIONS

Initial and stored egg weight losses were influenced by hen age, indicating that weight loss increased as hens aged. Furthermore, egg weight loss on days 7 and 14 and total egg weight loss from storage to 14 days of incubation significantly increased with hen age. Hen age influenced hatchling weight relative to egg weight loss before incubation and weight on days 7 and 14 of incubation. Fertility was also unexpectedly decreased as hen age increased. The heaviest eggs were

Table 4 – Pearson's Correlation Coefficients

	Egg Class	H_C	H_F	WL_0	WL_7	WL_{14}	WL_{0-14}	CW	M_7	M_{14}	M_T
Collection week	-0.189^{***}	-0.023^{ns}	-0.037^{ns}	-0.106^{*}	0.042^{ns}	-0.100^{ns}	0.243^{***}	-0.043^{ns}	-0.045^{ns}	0.100^{*}	0.051^{ns}
Egg weight class		0.094^{**}	0.101^{*}	0.017^{ns}	-0.118^{**}	-0.070^{ns}	-0.182^{***}	0.754^{***}	-0.051^{ns}	-0.102^{*}	-0.115^{**}
H_C			1.000^{***}	-0.046^{ns}	0.180^{***}	0.084^{ns}	0.233^{***}	0.198^{***}	-0.587^{***}	-0.742^{***}	-0.978^{***}
H_F				-0.051_{ns}	-0.022_{ns}	-0.040_{ns}	-0.082_{ns}	0.196_{***}	-0.587_{***}	-0.742_{***}	-0.978_{***}
WL_0					0.161^{**}	0.617^{***}	0.519^{***}	-0.052^{ns}	0.152^{**}	-0.040^{ns}	0.056^{ns}
WL_7						0.876^{***}	0.688^{***}	-0.290^{***}	-0.104^{*}	0.102^{*}	0.016^{ns}
WL_{14}							0.842^{***}	-0.270^{***}	0.014^{ns}	0.061^{ns}	0.060^{ns}
WL_{0-14}								-0.300^{***}	-0.001^{NS}	0.130^{*}	0.108^{*}

W_7, W_{14}: egg weight on d 7 and 14 of incubation, respectively.

WL_{0-14}: total egg weight loss from storage to 14 days of incubation.

CW: hatchling weight

$CH:WP_0$, $CH:WP_7$ and $CH:WP_{14}$: proportion of hatchling weight to egg weight loss on d 0, 7 and 14 of incubation, respectively.

F: fertility

H_C:total hatchability

H_F: hatchability of fertile eggs

M_T: total mortality

M_7: mortality ond 7 of incubation

M_{14}: mortality on d 14 of incubation

Values with different superscriptsare significantly different (* $p<0.05$, **$p<0.01$, ***$p<0.001$, ns: not significant).

produced by 23 and 24-week-old hens. The heaviest eggs at collection (Class D) were also the heaviest after storage and on days 7 and 14 of incubation. Class C eggs presented higher total hatchability. The negative correlation of hen age with egg weight and the positive correlation of hen age with weight loss indicate that eggs laid by older hens were lighter and lost more weight. It was concluded that heavier eggs laid by Hassawi hens produced heavier chicks. Finally, the results of the present study provided further information on the Hassawi breed, and may contribute to improve its productivity.

ACKNOWLEDGMENTS

This project was funded by the National Plan for Science, Technology and Innovation (MAARIFAH), King Abdulaziz City for Science and Technology, Kingdom of Saudi Arabia, Award Number 12-AGR2555-02.

REFERENCES

Abiola SS, Meshioye OO, Oyerinde BO, Bamgbose MA. Effect of egg size on hatchability of broiler chicks. Archivos de Zootecnia 2008; 57:83-86.

Alabi OJ, Ng`ambi JW, Norris D, Mabelebele M. Effect of egg weight on hatchability and subsequent performance of potchefstroom koekoek chicks. Asian Journal of Animal and Veterinary Advances 2012; 7:718-725.

Abudabos A. The effect of broiler breeder strain and parent flock age on hatchability and fertile hatchability. International Journal of Poultry Science 2010; 9(3):231-235.

Alabbad AH. Establishment and characterization of two native Saudi chicken lines and assessing their performance potentials [thesis]. Al Hufuf (Saudi Arabia): King Faisal University; 2014.

Al-Aqil AM. Biological and physiological responses to baladi and exotic layers to seasonal changes in temperature [thesis]. Al Hufuf (Saudi Arabia): King Faisal University, Faculty of Agricultural Sciences and Food; 1998.

Albokhadaim I. Hematological and some biochemical values of indigenous chickens in Al-Ahsa, Saudi Arabia during summer season. Asian Journal of Poultry Science 2012; 6:138-145.

Alsobayel AA, Almarshad MA, Albadry MA. Effect of breed, age and storage period on egg weight, egg weight loss and chick weight of commercial broiler breeders raised in Saudi Arabia. Journal of the Saudi Society of Agricultural Sciences 2013; 12(1):53–57

BramwellRK, McDaniel CD, Wilson JL, Howarth B. Age effect of male and female broiler breeders on sperm penetration of periveitelline layer overlying the germinal disc. Poultry Science 1996; 75:755-762.

Brommer JE, Rattiste K. Hidden reproductive conflict between mates in a wild bird population. Evolution 2008; 62:2326-2333.

Brotherstone S, White IMS, Meyer K. Genetic modelling of daily milk yield using orthogonal polynomials and parametric curves. Animal Science 2000; 70:407-415.

CaglayanT, Garip M, Kirikci K, Gunlu A. Effect of egg weight on chick weight, egg weight loss and hatchability in rock partridges (*A. graeca*). Italian Journal of Animal Science 2008; 8:567-574.

Caglayan T, Inal S. Effect of egg weight on hatchability, growth and survival rate in Japanese quail. Veteriner Bilimleri Dergis 2006; 22:11-19

Christensen VL, McCorkle FM. Turkey egg weight loss and embryonic mortality during incubation. Poultry Science 1982; 61:1209–1213.

Deeming DC. Hatchability and egg size in ostrich. Ostrich News 1994; 8:57-59.

Elibol O, Brake J. Effect of frequency of turning from three to eleven days of incubation on hatchability of broiler hatching eggs. Poultry Science 2003; 82:357-359.

French NA. Modeling incubation temperature: The effect of incubator design, embryonic development, and egg size. Poultry Science 1997; 76:124–133.

Joseph NS, Moran ET Jr. Effect of age and post emergent holding in the Hatcher on broiler performance and further processing yield. Journal of Applied Poultry Research 2005; 14:512–520.

Lourens A, Molenaar R, van den Brand H, Heetkamp MJ, Meijerhof, Kemp B. Effect of egg size on heat production and the transition of energy from egg to hatchling. Poultry Science 2006; 85:770-776.

McNaughton JL, Deaton JW, Reece FN, Haynes RL. Effect of age of parents and hatching egg weight on broiler chick mortality. *Poultry Science*1978; 57 (1):38-44.

North MO, Bell, DD. Commercial chicken production manual. 4th ed. New York: AVI; 1990.

Reis LH, Gama LT, Chaveiro Soares M. Effects of short storage conditions and broiler breeder age on hatchability, hatching time, and chick weights. Poultry Science 1997; 76:1459-1466.

Roque L, Soares MC. Effects of eggshell quality and broiler breeder age on hatchability. Poultry Science 1994; 73:1838-1845.

SAS - Statistical Analysis Systems -. User's guide: Version 9.2. 2nd ed. Cary: SAS Institute; 2008.

Schulte-Drüggelte R, Svensson S. Hatchery management guide. Cuxhaven: LTZ; 2011.

Siegel PB. Genetics of behavior: selection for mating ability in chickens. Genetics 1965; 52:1269-1277.

Sinclair RW, Robinson FE, Hardin RT. The effects of parent age and posthatch treatment on broiler performance. Poultry Science 1990; 69:526-534.

Tullett SG, Burton FC. The recent reawakening of interest in bird physiology particular eggs, eggshell and embryonic respiration. *Wissenschaftliche Zeitschrift der Humboldt-Universität zu Berlin.* Math. Nat. Research 1986; 35:273–284.

Vieira SL, Mora Jr. T. Eggs and chicks from broiler breeders of extremely different age. Journal of Applied Poultry Research 1998; 7:372–376.

Wilson HR. Interrelationships of egg size, chick size, post hatching growth and hatchability. World's Poultry Science Journal 1991; 47:5–20.

Yoho DE, Moyle JR, Swaffar AD, Bramwell RK. Effect of incubating poor quality broiler breeder hatching eggs on overall hatchability and hatch of fertile. Poultry Science 2008; 87(Suppl 1):148.