Effect of different storage period on egg weight, internal egg quality and hatchability characteristics of Fayoumi eggs

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Abstract

In this study, hatchability characteristics and some internal egg quality characteristics of 0, 2, 3, 4, 6 and 8 d stored Fayoumi eggs were examined. It was determined that the effect of storage time on hatchability, hatchability of fertile eggs, embryonic mortality, hatching weight, albumen weight, yolk weight, albumen index, yolk index and Haugh unit was significant (P<0.05). There was no positive or negative effect of storage time on the fertility rates, but there was a negative effect of storage time on egg weight, hatchability, embryonic development and hatching weight on d 4 (P<0.05). It was determined that prolonged storage time caused a decrease in the albumen weight, yolk weight, albumen index, yolk index and Haugh unit value of Fayoumi eggs. Fayoumi eggs should not be stored more than 3 d.

Introduction

In hatcheries, eggs are stored for varying periods until these are in sufficient numbers so as to utilize maximum capacity of the incubator which ultimately affects the hatchability (Butler, 1991). To attain a sufficient number of eggs to fill an incubator, eggs are usually accumulated in storage until 2 week (wk) before incubation. Increasing the length of storage period increases the proportion of embryonic mortality during storage and thereby increases the probability of failure to hatch (Samli et al., 2005). In fact, a rule-of-thumb in the hatchery is that for every day after 10-days (d) of storage, hatchability will decrease by 1% (Bakst and Akuffo, 2002). It has been shown that temperature, relative humidity (RH), storage duration and egg orientation play main roles in influencing embryo development during egg storage and incubation (Butler, 1991). In order to prevent embryonic development during the storage period, eggs must be stored at low temperature. For eggs stored for less than 4 d, egg room temperature should be 20-25°C, whereas for those stored 4-7 d, temperature should be maintained between 16 and 17°C, and for eggs stored for more than 7 d, temperature should be lowered to 10-12°C (Meijerhof, 1992).

Narahari et al. (1988) stored the hatching eggs of Japanese quails for a period of 1-7 d and determined that the highest rates of fertility and hatchability of fertile eggs were obtained in the eggs stored for 1-3 d. Similar results were obtained by Petek et al. (2003), who recommended that the storage period of eggs of quail should be no longer than 3 d. However, Romao et al. (2008) reported that quail eggs present great hatchability until 10 d of storage and that eggs offered to storage present a reduced weight loss during incubation. Different studies showed that hatchability of eggs decreases quickly after 8 d of storage period for pheasant (Demirel and Kirikci, 2009), 7 d of storage time for duck (Onbaır et al., 2007), 5 d of storage time for broiler breeder hen (Petek and Dikmen, 2006), 28 d of storage length for partridge (González-Redondo, 2010), 15 d of storage length for ostrich (Hassan et al., 2005) and 4 d of storage length for guinea fowl eggs (Moreki and Ditsalou, 2012). For chickens, it was suggested that pre-storage incubation has no effect on hatchability, when storage time is shorter than 8 d and can both be detrimental and beneficial when storage time is prolonged (Reijrink et al., 2009). Some negative changes in egg quality of all poultry species have been reported due to prolonged storage time (Tilki and Saatç, 2004). For example, water loss from eggs affects hatch results in pheasants due to the decreases in albumen index and Haugh unit seen in partridges.

Most studies related to effect of egg storage period on internal egg quality and hatchability characteristics are focused on Japanese quail and broiler breeder. However, these parameters have not been fully examined in Fayoumi, which is a rural poultry breed. Hence, the objective of the present study was to examine the effect of length of egg storage period on egg weight, internal egg quality characteristics, hatchability, embryonic death and hatching weight in Fayoumi breed.

Materials and methods

Fayoumi hatching eggs

Fayoumi fertile eggs were collected into three batches as shown in Table 1, from March 29 to April 7, 2012 (batch-1), from April 9 to April 18, 2012 (batch-2) and from April 23 to May 2, 2012 (batch-3). A flock of Fayoumi breeding stocks was maintained at Government Poultry Farm, Multan, Pakistan and housed at a density of 0.22 m² per bird. The hens were reared in floor pens and kept during lay under standard management conditions (FASS, 2010). At bird placement (20 wk of age) the male: female ratio was 1:10. All birds received the same mash brooder laying diet (16.50% CP, 11.72 MJ MEn/kg, 3.10% calcium, 0.35% available phosphorous), formulated to meet or exceed NRC (1994) requirements. Water was available for ad libitum consumption and natural daylight was supplemented with artificial light to give a 17-h photoperiod. Temperature recordings showed that low and high in-house air temperatures at egg collection day ranged from 16°C to 28°C at ages 32 to 35 wk. All flocks laid eggs at a normally expected rate. Eggs were collected at 32, 33 and 35 wk of age. Eggs were collected on a single day, as outlined in Table 1. Eggs laid before 8:00 h were removed from the nest boxes and discarded from the experiments. Eggs were collected from nests between 08:30 and 12:30 h, placed in setter trays (150 eggs per tray), and transported to the hatchery located near the poultry houses. A total of 5940 hatching eggs (1980 hatching eggs/batch) were used in
In this study (Table 1), at approximately 14:00 h, eggs were culled to exclude from the experiments those that were cracked, visibly dirty, or misshapen. After removing culled eggs, eggs from each flock were randomized into six groups (Table 1) and placed on incubator trolleys, to allow air circulation around the eggs. Thereafter, eggs were fumigated for 20 min with formaldehyde gas, and one group was set in the incubator on the same day (collection day), whereas the other five groups were stored for 2, 3, 4, 6 or 8 d in the store room at 16°C and 78% RH.

### Incubation and hatching

This experiment was conducted using electronically controlled, single-stage incubators (Model 2007; Chick Master, France). The eggs were pre-warmed in the incubator for 8:00 h at around 24°C and 65% RH, just before the incubation period, and fumigated in the incubator on the day of setting. The eggs were turned hourly through 90° and incubated according to the conditions summarized in Table 2. On the 18th d of incubation, eggs were individually candled in the transfer-room (around 24°C and 60% RH), using candling lamp. Clear eggs were removed and broken out for macroscopic examination, in order to determine early-dead embryo mortalities (<7 d) and those that were infertile, as outlined in Brake et al. (1997).

Unhatched eggs were opened, examined macroscopically, and assigned to one of the following categories: early-dead (1-7 d), mid-dead (8 to 18 d) and late-dead (after 19 d). From the data, hatchability (number of saleable chicks hatched per all eggs set: 100) was calculated. In fact, some very early dead will likely be classified as infertile using macroscopic examination (Novo et al., 1997).

### Internal egg quality analysis

To determine quality characteristics of eggs, 20 eggs were used from each flock. The eggs were broken out individually onto a flat surface and allowed to sit for 5 min. The heights of yolk and albumen, the long and short diameters of albumen, and the diameter of yolk were measured using the caliper. Yolks were separated from albumen, and both were weighed. From the values obtained, the following data were calculated using the formulas shown below (Yannakopoulos and Tserveni-Gousi, 1986):

- **Yolk index = (yolk height/yolk diameter) × 100**
- **Albumen index = [albumen height/(long diameter of albumen + short diameter of albumen)/2] × 100**

The egg weight and Haugh unit were measured automatically by Egg Analyzer™ manufactured by Orka Food Technology Ltd. (Ramat HaSharon, Israel). Haugh units were calculated from the records of albumen height and egg weight using the formula:

\[
\text{Haugh unit} = 100 \times \log (\text{albumen height} + 7.57 - 1.7 \times \text{egg weight}^{0.37})
\]

(Nesheim et al., 1979).

### Statistical methods

The quality and hatchability characteristics of Fayoumi eggs were determined at storage times of 0, 2, 3, 4, 6 and 8 d. When differences among storage periods were significant, means were separated using Duncan’s multiple range tests at the 0.05 level of significance (Steel and Torrie 1984). The analyses were conducted using SPSS 15.0 software (SPSS, 2006).

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**Table 1. Experiment design.**

| Trials | Egg collection time | Number of eggs used at different storage periods |
|--------|---------------------|-----------------------------------------------|
|        | Flock age | Date | 0 d | 2 d | 3 d | 4 d | 6 d | 8 d |
| 1      | 32 weeks | March 29, 2012 | 330 | 330 | 330 | 330 | 330 | 330 |
| 2      | 33 weeks | April 9, 2012 | 330 | 330 | 330 | 330 | 330 | 330 |
| 3      | 35 weeks | April 23, 2012 | 330 | 330 | 330 | 330 | 330 | 330 |

**Table 2. Incubating temperatures and relative humidity.**

| Incubation time, h | Wet bulb temperature, °C | Relative humidity, % |
|--------------------|---------------------------|-----------------------|
| Setter             |                           |                       |
| 0-72               | 29.8                      | 57                    |
| 73-173             | 29.2                      | 54                    |
| 174-274            | 29.2                      | 54                    |
| 275-375            | 29.2                      | 54                    |
| 376-429            | 29.2                      | 54                    |
| Transfer           |                           |                       |
| 430-431            | 29.8                      | 57                    |
| Hatcher            |                           |                       |
| 432-456            | 29.8                      | 57                    |
| 457-481            | 30.9                      | 62                    |
| 482-506            | 32.0                      | 68                    |

*Eggs transferred at room temperature and humidity (approximately 24°C and 60% relative humidity).*
Results and discussion

Egg weight
The initial and final weights during the storage period and weight losses of the fertile eggs during storage period are shown in Table 3. No differences were found in the initial weight of the fertile eggs before their storage (P<0.05). Significant differences were found in fertile egg weight loss during the storage period as a function of its length (P<0.05). The fertile egg weight loss progressively increased with storage time before incubation, the eggs stored for 8 d showing the maximum weight loss (2.60%). The egg weight loss increased together with days of storage as reported by researchers for many poultry species. The egg weight loss observed during storage in the present research followed the expected pattern and was higher than that found by Rejink et al. (2009) for broiler breeder eggs when stored at 16 to 18°C and unspecified relative humidity and by González-Redondo (2010) for red-legged partridge eggs when stored at room temperature (15°C) and 80% RH. Weight losses which occur during the storage of eggs are related to the temperature and humidity of the environment in which the eggs are stored and to the length of the storage period. Garip and Dere (2011) reported that egg weight losses in quail eggs stored for the 10 d period is lengthened, internal quality in pheasants eggs, corroborate the findings of other authors for pheasants. When storage period is lengthened, internal quality in pheasants eggs steadily decline due to losing moisture from the egg. Evaporation of water and carbon dioxide results in an increase of albumen pH. By this the activity of albumen proteins is reduced. This results on the one hand in a decreased albumen height and on the other hand in a reduced antimicrobial activity of proteins (Demirel and Kirıkçı, 2009).

Internal quality characteristics
Internal quality characteristics of Fayoumi eggs during different storage period are presented in Table 4. There was a significant effect of storage time on yolk weight (P<0.05) with yolk weight increasing as storage time increased. The yolk weights of Fayoumi eggs recorded in the present study are almost similar to those of other some researchers (Dottavio et al., 2005; Islam and Dutta, 2010). There was no significant effect of storage time on albumen weight. However, numerically albumen weight decreased with increased storage period. The albumen weights of Fayoumi eggs in the present study are almost similar to the values reported by Akhtar et al. (2007) and Khawaja et al. (2012). Albumen index values decreased significantly with increased storage period (P<0.05). While albumen index values determined at 2d of the storage were 6.60, there was a decrease to 6.02 in the 8 d experiment. Water loss from the egg or movement of water from albumen to the yolk is the most likely reason this finding. Albumen index values in the present study were almost similar to reported values (Easa, 2009). Yolk index values showed a significant decrease with increased egg storage period (P<0.05), most likely due to water loss from the egg. The yolk index values were similar to findings of Abdel-Azim and Farahat (2009).

Hatching performance and hatching weight
The number of incubated eggs, fertile eggs, and hatched eggs; the fertility and hatchability of the incubated eggs; the hatchability of the fertile eggs, according to their storage time before incubation; embryonic mortality and hatching weight are shown in Table 5. The average fertility of the eggs recorded in this study (85.7%) was higher than in previous report on Fayoumi under farming conditions (64.71%; Fanoor et al., 2001). However, Murad et al. (2001) and Miazi et al. (2012), who reported higher fertility (95.5% and 88.6%, respectively) in Fayoumi chicken than the present findings. The fertility depends on various factors such as storage conditions, moisture content, and storage time. The percentages of fertile eggs, according to their storage time before incubation; embryonic mortality and hatching weight are shown in Table 5. The average fertility of the eggs recorded in this study (85.7%) was higher than in previous report on Fayoumi under farming conditions (64.71%; Fanoor et al., 2001). However, Murad et al. (2001) and Miazi et al. (2012), who reported higher fertility (95.5% and 88.6%, respectively) in Fayoumi chicken than the present findings. The fertility depends on various factors such as storage conditions, moisture content, and storage time.

Table 3. Egg weight and egg weight losses during storage periods in Fayoumi fertile eggs according to the length of the storage period (mean ± SEM).

| Storage period, d | Number of eggs | Egg weight after storage, g | Egg weight loss during storage, % |
|------------------|---------------|-----------------------------|----------------------------------|
| 0                | 990           | 39.46±2.21                  | 0.00±0.00*                      |
| 2                | 990           | 39.54±2.10                  | 0.41±0.07*                      |
| 3                | 990           | 39.35±2.19                  | 1.00±0.12                       |
| 4                | 990           | 39.25±2.20                  | 1.41±0.28*                     |
| 6                | 990           | 39.46±2.08                  | 2.01±0.55*                     |
| 8                | 990           | 39.62±1.96                  | 2.60±0.76*                     |
| Total            | 5940          | 39.45±2.11                  | 1.25±0.25                      |

*Values are expressed as a percentage of egg weight at the beginning of storage period. **Values in the same column with different superscripts are significantly different (P<0.05).

Table 4. Internal quality characteristics of Fayoumi eggs according to storage time (mean ± SE).

| Storage period, d | Yolk weight, g | Albumen weight, g | Albumen index | Yolk index | Haugh unit |
|------------------|----------------|------------------|---------------|------------|------------|
| 0                | 14.87±0.20    | 23.80±0.50       | 6.80±0.32     | 44.10±1.03*| 83.10±1.40*|
| 2                | 15.13±0.24    | 23.85±0.39       | 6.60±0.25     | 43.90±0.77*| 81.05±1.32*|
| 3                | 15.20±0.29    | 23.39±0.45       | 6.57±0.23     | 43.70±0.80*| 82.00±1.03*|
| 4                | 15.31±0.21    | 23.35±0.40       | 6.50±0.18     | 39.99±0.64*| 82.51±0.56*|
| 6                | 16.06±0.20    | 23.24±0.46       | 6.12±0.10     | 39.65±0.56*| 75.81±1.05*|
| 8                | 16.24±0.23    | 23.13±0.36       | 6.02±0.15     | 39.16±0.69*| 75.99±0.96*|

*The differences among values with different superscript letters in the same column are significant at P<0.05.
The main effects of egg storage on embryonic mortality are presented in Table 4. Differences in embryonic mortality were found to be significant due to the main effect of egg storage duration (P<0.01). Most of the deaths were in eggs stored for 8 d. The embryos of eggs stored for 8 d showed noticeably lower hatchability and higher mortality during incubation. Similar findings were obtained by Petek and Dikmen (2006), who reported that most embryonic deaths were noticed in broiler breeder eggs stored for 15 d as compared to 5 d storage period. Some researchers (Yoo and Wientjes, 1991; Scott and Mackenzie, 1993; Elibol et al., 1991; Scott and Mackenzie, 1993; Giladi and Kochav, 1976; Giladi and Kochav, 1976; EG12 or EG13). (2012) also noted that the best hatchability of guinea fowl eggs was recorded at 0 d storage time (88%) followed by 4 d (76%) at 20°C that indicated storing guinea fowl eggs beyond 4 d contributes to a decline in hatchability. These hatchability values are very close to the results of the present study. Some embryos of eggs stored for a long period could not begin developing instantly after normal incubation temperatures were provided. Another prospect is that the development of embryos from eggs stored for a long time proceeds at a slower rate in the first period of incubation.

According to Fasenko et al. (2001), the effect of presorage incubation on hatchability when storage time is prolonged depends on the developmental stage of the embryo after presorage incubation. They 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 mini mal (Reijrink et al., 2009). These embryos, therefore, contain more cells than embryos less advanced and are in a more inactive 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. Steinke (1972) reported that the developmental stage of the embryo at oviposition is related to hatchability. He showed that embryos in a pregastrula stage of development at oviposition (<EG10) were common in eggs of hens with hatchability lower than 55%, whereas eggs of hens with moderate and very good hatchability contained embryos at an advanced gastrula stage of development (>EG10).

Table 5. Fertility, hatchability, embryonic mortality and hatchling weight of Fayoumi eggs according to the length of the storage period.

| Storage period, d | Number of eggs | Fertility | Hatchability | Embryonic mortality | Hatchling weight, g |
|------------------|---------------|-----------|--------------|-------------------|-------------------|
|                  | Incubated     | Fertile   | Hatched      | 1st wk 2nd wk 3rd wk |                   |
| 0                | 990           | 852       | 750          | 86.00 75.75 88.03   | 2.0 2.3 3.7      |
| 2                | 990           | 852       | 706          | 86.00 71.31 82.87   | 2.7 2.8 5.9      |
| 3                | 990           | 855       | 658          | 86.37 66.46 76.96   | 5.2 5.1 7.5      |
| 4                | 990           | 854       | 493          | 86.27 49.79 57.73   | 10.9 10.5 9.9    |
| 6                | 990           | 838       | 103          | 84.65 10.40 12.30   | 36.3 13.7 9.8    |
| 8                | 990           | 843       | 90           | 85.16 9.09 10.67    | 47.4 16.6 16.7   |
| Total            | 5940          | 5004      | 2800         | 85.76 47.16 54.76   | 20.34 9.04 9.23  |

*Percentage of incubated eggs that were fertile; †percentage of incubated eggs that hatched; ‡percentage of fertile eggs that hatched. *Values in the same column with different superscripts are significantly different (P<0.05).
It has been suggested that the decrease in viability of the embryo may be caused by changes in the embryo or by changes in certain physical aspects of the egg, namely albumen pH (Lapao et al., 1999). After oviposition, carbon dioxide is released from the egg, resulting in an increase in albumen pH from about 7.6 to 9.5 within a short period of time, whereas the yolk remains slightly acid, at a pH around 6.5. Therefore, a 1,000-fold hydrogen ion concentration gradient (3 pH units) may exist across the blastoderm (Stern, 1991), in its intermediary position between albumen and yolk. Excess carbon dioxide loss causes the albumen to have an excessively high pH and this is negatively affects the initiation of embryo development. If the loss of carbon dioxide is too low, the pH of the albumen will also be too low resulting in eggs which are too fresh and not hatch as well as those stored for 3-4 d. This process of carbon dioxide loss is also temperature-dependent and may be stimulated by cooling after oviposition (Lapao et al., 1999). Literature showed that the rise in albumen pH with storage time is related with a decrease in albumen index. Albumen liquefaction probably facilitates the movement of nutrients from the albumen to the blastoderm and may reduce resistance to gaseous diffusion (Lapao et al., 1999). The above cited effect of storage upon albumen viscosity would also explain why short-term storage may have beneficial effects on hatchability, as these flocks generally lay eggs that have albumens of good quality and that are quite resistant to degradation. However, extended periods of egg storage allow the albumen to degrade excessively. This degradation causes the blastoderm to move into close proximity to the eggshell, so that early embryonic mortality results from dehydration during the early stages of incubation (Brake et al., 1993).

Significant differences were found in hatching weight at different egg storage time (P=0.038; Table 4). In the current study, higher hatching weight (26.33 g) was recorded than findings of Rashid et al. (2011), who reported that hatching weight in Fayoumi breed was 23.55 g. These results of the present study are in line with the findings of Garip and Dere (2011), who reported that hatching weight of quail decreased from 1d (9.47 g) to 15d (9.13 g) of egg storage periods at 11°C. Our results are in contradiction with the findings of other workers (Petek et al., 2003; Garip and Dere, 2006; Garip et al., 2005), who reported that hatching weight was not affected by storage period. This may be due to shortage storage period employed, different breeds, different storage temperature and weight of the eggs used in the above studies.

Conclusions

In conclusion, after d 8 of storage period there is a decrease in hatchability and hatchability of fertile eggs. Changing in some interior quality (Haugh unit, albumen and yolk indices), with the effect of storage time might indirectly affect the fertility, hatchability and hatchability of fertile eggs. Storage time of Fayoumi eggs can be extended until 3 d, but longer storage can negatively affect hatchability.

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