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The Effect of Storage Period and Temperature on Weight Loss in Quail Eggs and the Hatching Weight of Quail Chicks

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Abstract: The present study was aimed at the determination of the effects of storage period and temperature on weight loss in quail eggs, hatchability results and hatching weight of quail chicks. Total 6,000 eggs obtained from a quail flock composed of 250 male and 750 female animals which were of the same age, provided with the same feed, exposed to the same management conditions and raised in cages and 2004 quail chicks which hatched from these eggs constituted the material of the study. Eggs of hatching quality, weighing 12-15 g were allocated to 3 groups and were stored at temperature of 11°C (10-12), 21°C (20-22) and 27°C (26-28), respectively. Each of the 3 temperature groups were divided into 4 sub-groups such that they were stored at the indicated temperature for a period of 1, 5, 10 and 15 days, respectively thus, resulting in a total number of 12 groups. Throughout the storage period, all eggs were kept in 3 storage compartments which had the same features and of which the humidity was adjusted to 75±5%. Throughout the storage period, eggs were neither subjected to pre-storage incubation nor were their position altered. Throughout the trial period, the humidity rate of the storage compartments was reduced at the following rates for the sub-groups which were stored for periods of 1, 5, 10 and 15 days, respectively; in the group subjected to a storage temperature of 11°C 0.2, 0.6, 1.3 and 1.8%, in the group exposed to a storage temperature of 21°C 0.6, 1.5, 3.1 and 5.3% and in the group stored at a temperature of 27°C 1.1, 2.0, 3.7 and 6.10%, respectively. In the same sub-groups, the hatching weight of the chicks were as follows; in the group subjected to a storage temperature of 11°C 9.47, 9.18, 9.50 and 9.13 g, in the group exposed to a storage temperature of 21°C 9.38, 9.42, 9.41 and 9.30 g and finally, in the group stored at a temperature of 27°C 9.67, 9.49 and 9.071 g for the 1st three sub-groups, respectively. The sub-group of eggs which was stored at 27°C for 15 days did not hatch. The differences between the calculated percentages were statistically significant ($p<0.05$). When evaluated together with hatchability results and embryonic death, it was determined that egg weight losses above a rate of 3% affected hatching weight and hatchability adversely. Moreover, in the group of eggs determined to have suffered a weight loss percentage of 6.1% no hatching was observed.

Key words: Egg, quail, storage, weight loss, chick, Turkey

INTRODUCTION

In a previously conducted similar study, Narahari *et al.* (1988) stored the hatching eggs of Japanese quails for a period of 1-7 days and determined that the highest rates of fertility and hatchability of fertile eggs were obtained in the eggs stored for 1-3 days. In chicks which hatch from eggs stored for a period exceeding the normal storage length, it is observed that quality and hatching weight decrease, the number of second-quality chicks increases and most important of all, hatchability and hatchability of fertile eggs decrease. The reason for the decrease in hatchability is the increase in embryonic deaths, observed particularly in the early embryonic stage. If stored without being cooled to a temperature range of 23-33°C, quail eggs loose approximately 2-3% of their weight within a period of 1 week. When compared to hen's eggs, the rate of water loss observed in quail eggs is rather high. The underlying reason is the shell of quail eggs being thinner and having a greater number of pores.

The adverse effect of prolonged storage periods on hatchability is related to the loss in moisture and pH change that occur in eggs. In eggs that have become lighter either hatching is not observed at all or chicks smaller than the normal size hatch. It has been observed that in these smaller chicks, occasionally the survival rate decreases and growth disorders develop. After an egg is

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laid, water and gas (CO_2) release occurs from the shell as a result of cooling. Gas release leads to an increase in the pH value of the egg white (albumen). The severity of these adverse effects varies with several factors including the temperature and humidity of the environment, air circulation and the porosity of the egg shell (Becker *et al*., 1968; Mayes and Takeballi, 1984).

Depending on the length of the storage period, the completion of embryonic development can be prolonged and the incubation period can be delayed. Previously conducted studies have demonstrated that every single day of storage results in an average delay of 0.5-1 h in the hatching time (Mayes and Takebali, 1984). Eggs stored for a period of 15 days loose approximately 3% of their weight. It has been proven that storage prolongs the incubation period. This prolongation is clearly evident in eggs stored for 7 days or more. As the incubation period exceeds the normal length which is 390±1.2 h for quails results begin to deteriorate. For this reason when the storage period exceeds 7 days, 30-40 min should be added to the incubation period for each day, the egg has been stored. The deterioration of results is associated with reduced chick quality.

MATERIALS AND METHODS

Japanese quails (Coturnix coturnix japonica) bred at the Alternative Poultry Unit of the Research and Practice Farm of Selcuk University, Faculty of Veterinary Medicine were used in the present study. Total 750 female and 250 male quails, subjected to the same environmental and management conditions were allocated as breeders. The animals were exposed to a lighting period of 24 h during the 1st week after hatching, 8 h during days 8-40 post-hatching and 16 h, starting from day 40 post-hatching until sexual maturity. Eggs laid by 12 weeks old quails on the same day were used in the trial. During the laying period, the breeder quails were housed in five-storey cages with 20 compartments on each storey. The cages were equipped with automatic water systems and bedding dispensers (Woodard and Abplanalp, 1967).

The animals were fed on rations prepared at the feed preparation unit of the farm. During the growth period, the chicks were provided with a diet of 24% crude protein and 2800 kcal kg^{-1} metabolic energy, whilst during the laying period the animals were fed on a diet of 20% crude protein and 2800 kcal kg^{-1} metabolic energy, *ad libitum* (Marks, 1980; Wiseman, 1985; Fraser *et al*., 1991).

Of the two incubators of the Gostyn C82 model with a capacity of 2000 quail eggs which were available at the poultry unit, one was used as a setter and the other as a hatching machine. The incubator used as a setter was adjusted to a temperature of 37.5°C and a humidity of 55-60% for embryonic development whilst the incubator used as a hatching machine was adjusted to a temperature of 37.2°C and a humidity of 75-80% for hatching. Eggs were stored in 3 egg storage cabinets available in the poultry unit which were of different sizes and could be adjusted to the desired temperature and humidity. In order to ensure that the groups were subjected to the same conditions, the two different machines were used alternately for different replicates. The humidity of the three compartments was adjusted to 75±5% and remained stable throughout the trial period. Thermometers and hygrometers of varying size and brand were used to control the temperature and humidity of the egg storage cabinets, incubators and brooders. The eggs were placed into viols and transferred as such. Furthermore, wooden bedsteads were used for the transfer and keeping of eggs during storage and incubation. The eggs were fumigated in a PVC cabinet measuring 1×1×1 m which was equipped with operable partitions. The weighing of the eggs, chicks and potassium permanganate used for fumigation was performed using a scale sensitive to ±0.01 g and of a capacity of 620 g whilst feed and leftover feed were weighed on a scale sensitive to ±0.1 g and of a capacity of 7200 g. Both scales were electronic and of the scaltec SBA brand.

A five-storey five-block apartment-type cage with 10 compartments on each storey was used. Cages were equipped with an automatic watering system and automatic bedding dispensers. Each compartment, measuring 30×25×25 cm, housed 4 quails, 3 of which were females and 1 was male. In order to prevent the eggs and the chicks that hatched from these eggs from being mixed with each other, 600 tulle bags (15×5 cm) were used such that one egg was placed into each bag.

Throughout the trial, eggs were collected three times a day, in the morning at noon and in the evening from a flock composed of 250 male and 750 female quails of the same age and subjected to the same environmental and management conditions. In order to ensure that the hatching time and thereby, the age of the animals were the same, starting with the group of eggs stored for the longest period, the eggs were collected and weighed for storage periods of 15, 10 and 5 and 1 day, respectively. When weighed each egg was marked with a colour pen to identify the particular group and sub-group it belonged to. The eggs were randomly placed in 3 egg storage cabinets which were adjusted to the following temperatures; A:10-12°C (11±1); B:20-22°C (21±1) and C: 26-28°C (27±1) such that each cabinet contained an equal number of eggs. The date and time the eggs had begun to be stored were recorded. The eggs of which the storage period ended were weighed as follows according to their sub-group; a (1 day), b (5 days), c (10 days), d (15 days). Before loaded, the eggs were fumigated for 20 min with formalin gas, produced by dissolving 20 g of potassium permanganate in 40 cc of 40% formol. Subsequently, the fumigated eggs were placed into the setter for incubation. Prior to their use, the incubators were also fumigated and disinfected. At the end of the 14th day, the eggs which completed their pre-development were placed onto transfer trays according to their identifying numbers such that each egg was put into a separate tulle bag accompanied by a piece of paper marked with a specific number. At the end of the 3 days hatching period, the hatched chicks were weighed, identified with a wing number and transferred to the brooder. The eggs which did not hatch by the 18th day were broken out and examined for fertility.

The data obtained in the present study (fertility rate, hatchability, machine efficiency, mortality rate and egg weight loss rate) were analysed (Chi-square (χ^2) test) statistically after angle transformation (Arc sin $\sqrt{}$ % P). The findings were tabularized using real values.

The effect of the investigated factors and the interaction between the different factors were determined using the General Linear Model (GLM) whilst differences between the groups swere determined using Duncan's multiple range test.

RESULTS

Egg weight loss and hatching weight of chicks variance analysis results (GLM) for egg weight, egg weight loss and hatching weight are shown in Table 1. The evaluation of the variance analysis results suggests that the factors do not have any influence on Pre-Storage Egg Weights (PrSEW) ($p>0.05$) but have significant effect on Post-Storage Egg Weights (PoSEW) ($p<0.01$). The interaction between storage period and storage temperature affected post-storage egg weight and Egg Weight Loss (EWL) significantly whilst Hatching Weight (HW) was ascertained to be affected significantly only by storage period ($p<0.05$).

Pre-Storage Egg Weight (PrSEW), Post-Storage Egg Weight (PoSEW) and Egg Weight Loss (EWL) data are shown in Table 2 and 3. The assessment of Table 1-3 demonstrate that while egg weights did not differ prior to storage, differences were observed due to varying conditions after storage.

It was ascertained that prolonged storage periods led to decreased egg weight and increased egg weight loss. While post-storage egg weights did not differ between eggs stored for 1 day as regards egg weight loss, it was observed that the 3 temperature groups differed from each other with the greatest losses being observed in the eggs stored at 27°C. In the case of storage for 5 days, post-storage egg weights were similar in the groups stored at 21 and 27°C and were greater than the values of the group stored at 11°C. The 3 groups differed for egg weight loss and as a result of the trend of increased weight loss with increased temperature, the highest percentage of EWL was determined in the group stored at 27°C. In the case of storage for a period of 10 days, the post-storage egg weights of the group stored at 11°C were lower than the values of the other 2 groups. On the contrary, the lowest egg weight loss was determined in the group subjected to a storage temperature of 11°C. In the case of storage for 15 days which was the longest storage period tested in the study. The 3 groups stored at different temperature differed from each other and in general, displayed decreased post-storage egg weights and increased egg weight losses ($p<0.05$). The evaluation of the data showed in Table 3 demonstrated that pre-storage egg weights did not differ between either the 3 groups exposed to different storage temperatures or the sub-groups stored for different length of time ($p>0.05$). On the other hand, it was observed that post-storage egg weights differed with storage period and temperature. The differences observed between the groups exposed to storage temperature of 21 and 27°C for post-storage egg weight and egg weight loss were statistically significant. In other word, in the group of eggs stored at 11°C, smaller egg weight loss was observed under the same storage conditions, resulting in this group displaying the greatest post-storage egg weights.

Table 1: Variance analysis results for egg weight loss and the hatching weight of chicks

		PrSEW		PoSEW		EWL		HW	
Groups	SD	SE	p-value	SE	p-value	SE	p-value	SE	p-value
Storage	3	1.7	0.527	1.10	0.000	92.1	0.193	9409.0	0.036
Temperature	2	1.2	0.594	0.20	0.003	489.9	0.000	0.3	0.124
Storage x temperature	6	8.3	0.899	0.50	0.000	317.6	0.000	0.2	0.098
SEM	n = 108	2.3	-	0.03	-	57.5	-	0.2	-

PrSEW: Pre-Storage Egg Weight (g); PoSEW: Post-Storage Egg Weight (g); EWL: Percentage of Egg Weight Loss (PrSEW-PoSEW)/PrSEW x 100), HW: Hatching Weight

Table 2: Pre-storage and post-storage egg weights (g), egg weight losses (%) and egg weight loss (%) for varying storage periods in the different temperature groups

Storage (days)	Temperature (°C)	PrSEW	PoSEW	EWL
1	11	$13.2\pm0.05^{*}$	$13.2\pm0.05^{*}$	0.2 ± 0.02^{c}
	21	$13.3\pm0.04^{*}$	$13.2\pm0.04^{*}$	0.6 ± 0.06^{b}
	27	$13.3\pm0.07^{*}$	$13.1\pm0.07^{*}$	1.1 ± 0.18^{a}
5	11	$13.3\pm0.05^{*}$	13.2 ± 0.05^{a}	0.6 ± 0.05^{c}
	21	$13.2\pm0.04^{*}$	13.0 ± 0.05^{b}	1.5 ± 0.19^{b}
	27	$13.2\pm0.04^{*}$	13.0 ± 0.03^{b}	2.0 ± 0.19^{a}
10	11	$13.2\pm0.06^{*}$	13.0 ± 0.06^{a}	1.3 ± 0.04^{b}
	21	$13.3\pm0.05^{*}$	12.8 ± 0.04^{b}	3.1 ± 0.11^{a}
	27	$13.2\pm0.07^{*}$	12.7 ± 0.07^{b}	3.7 ± 0.03^{a}
15	11	$13.3\pm0.05^{*}$	13.1 ± 0.05^{a}	1.8 ± 0.04^{c}
	21	$13.3\pm0.04^{*}$	12.6 ± 0.03^{b}	5.3 ± 0.36^{b}
	27	$13.2\pm0.04^{*}$	12.4 ± 0.05^{c}	6.1 ± 0.13^{a}

$^{a-c}$Differences between the mean values shown with different superscripts in the same column were statistically significant ($p<0.05$); *Differences between the groups were statistically insignificant ($p>0.05$)

Table 3: Total embriyonic death and hatchabilty (%) and chick weight (g) at different temperature in the sub-groups exposed to different storage periods

Temperature (°C)	Storage (days)	TED (%)	Hatchabilty (%)	EWL (%)	CW (g)
11	1	$7.8\pm1.13^{*}$	84.2 ± 2.24	0.2 ± 0.02^{d}	$9.47\pm0.06^{*}$
	5	$9.0\pm1.23^{*}$	83.4 ± 1.86	0.6 ± 0.05^{c}	$9.18\pm0.15^{*}$
	10	$12.4\pm1.34^{*}$	80.8 ± 1.67	1.3 ± 0.04^{b}	$9.50\pm0.12^{*}$
	15	$11.8\pm1.95^{*}$	79.4 ± 2.11	1.8 ± 0.04^{a}	$9.13\pm0.16^{*}$
21	1	12.2 ± 2.86^{b}	77.0 ± 2.57^{a}	0.6 ± 0.06^{d}	9.38 ± 0.04^{ab}
	5	11.6 ± 1.88^{b}	78.4 ± 1.95^{a}	1.5 ± 0.19^{c}	9.42 ± 0.04^{a}
	10	13.3 ± 1.22^{b}	78.4 ± 1.86^{a}	3.1 ± 0.11^{b}	9.41 ± 0.07^{ab}
	15	55.5 ± 5.10^{a}	35.4 ± 4.57^{b}	5.3 ± 0.36^{a}	9.30 ± 0.08^{c}
27	1	10.4 ± 1.35^{c}	79.2 ± 2.00^{a}	1.1 ± 0.18^{d}	9.67 ± 0.07^{a}
	5	13.3 ± 2.96^{c}	77.8 ± 3.93^{a}	2.0 ± 0.19^{c}	9.49 ± 0.09^{b}
	10	34.4 ± 6.14^{b}	54.2 ± 5.91^{b}	3.7 ± 0.03^{b}	9.07 ± 0.07^{c}
	15	100.0 ± 0.00^{a}	0.0 ± 0.00^{c}	6.1 ± 0.13^{a}	-

The effect of storage temperature on post-storage egg weight was greatest in the eggs stored for 1 day and lowest in the eggs stored for 10 days in the group stored at 11°C whilst storage for 5 and 15 days resulted in similar weights which fell between the values pertaining to the eggs stored for 1 and 10 days. At a storage temperature of 21°C, the same effect differed between the 4 sub-groups with the greatest impact being observed in the eggs stored for 1 day. In the group of eggs stored at 27°C, the effect of storage temperature was similar in the sub-groups stored for 1 and 5 days, lower in the sub-group stored for 10 days and lowest in the sub-group stored for 15 days. Egg weight losses increase with both increased storage temperature and prolonged storage period. The lowest weight loss was determined in eggs stored at 11°C for 1 day (0.2%) whilst the greatest weight loss was observed in eggs stored at 27°C for 15 days (6.1%). The differences between the groups were found to be statistically significant ($p<0.01$).

DISCUSSION

Pre-storage egg weights having not differed between the different groups demonstrated that the random allocation of the eggs to the different groups resulted in an even distribution of eggs and that differences observed between the groups for post-storage egg weights arose from the experimental conditions employed (Table 2 and 3). Weight losses in eggs result from losses in moisture and gas. 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. Data obtained in the present study demonstrated that egg weight loss increased with prolonged storage period in all temperature groups. This finding is in agreement with the report of Sachdev *et al.* (1985) indicating that in eggs stored at 24°C, weight loss increased with prolonged storage period yet is in contradiction with the report of Akman and Yildirim indicating that weight loss percentage in eggs stored for 15 days was 3%. In the present study, egg weight losses in eggs stored for the same time length were determined to be 1.8% at 11°C, 5.3% at 21°C and 6.1% at 27°C. This shows that egg weight loss increases with prolonged storage time and increased storage temperature. Weight losses which occur at levels exceeding 2% during storage, adversely affect hatchability results is in agreement with the report of Dere *et al.* (2009). As a matter of fact in the present study, hatchability results deteriorated as from the 10th day of storage in eggs stored at 21°C with an egg weight loss of 3.1% and as from the 5th day of storage in eggs stored at 27°C with an egg weight loss of 2.0%. It was also observed that embryonic mortality rates had also increased in these groups similar as Garip *et al.* (2009).

The differences observed between the different storage time sub-groups for hatching weights are in contradiction with the literature report of Petek *et al.* (2003) as these researchers reported that hatching weight was not affected by storage period. This conclusion may have arisen from the shorter storage period employed and from the variances in the breeds and storage temperatures as well as the weights of the eggs used in the study conducted by the researchers (Garip and Dere, 2006; Garip *et al.*, 2005).

CONCLUSION

In the present study, it was determined that quail eggs could be stored at 11°C for 15 days at 21°C for 10 days and at 27°C for 5 days without any significant decrease in hatchability. On the other hand, prolonged storage at temperatures of 21 and 27°C resulted in significant decrease in hatchability. Similarly, the results obtained in the present study showed that the effect of storage temperature was dependent on the length of the storage period. Thus, short-term storage for 1-5 days did not result in any adverse effect even at the highest storage temperature (27°C). The storage-induced decrease observed in hatchability resulted from early embryonic death caused by prolonged storage period and increased storage temperature. Furthermore, none of the eggs stored at 27°C for 15 days hatched. It was also ascertained that egg weight losses exceeding a percentage of 2% adversely affected hatchability results and increased embryonic death rates.

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