EFFECTIVENESS OF SEALING THE EGGSHELL OF CRACKED EGGS ON HATCHABILITY AND CHICK QUALITY IN BROILER CHICKENS

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ABSTRACT

The present study aimed to evaluate the effect of sealing eggshell cracks by mixing the eggshell powder with albumin on hatchability parameters and chick quality.1350 eggs were used from a 34-week-old flock of ROSS 308 broiler breeders and were distributed randomly into 3 experimental groups. The first group contained 450 intact eggs (Negative control), the second group contained 450 cracked eggs (Positive control), and the third group contained 450 cracked and treated eggs. The lowest egg weight percentage at day 18 and the highest egg weight loss percentage and embryonic mortality were noticed in the untreated cracked egg groups compared to other groups. Furthermore, the treated cracked group showed a significant improvement in egg weight percentage on day 18 and egg weight loss percentage and lowest embryonic mortality compared to the untreated cracked group. Moreover, the chick's quality in the cracked treated group was improved compared to the untreated cracked group. Consequently, results of the present study indicate that a mixture of eggshell powder with albumin can be used to seal capillary cracks to support embryo survival and chick quality.
Keywords: eggshell, hatchability, chick quality, broiler

INTRODUCTION

Intact eggshell is the main quality criterion for good hatching eggs. About 2-4% of hatching eggs are rejected due to cracked or broken shells, due to shell impacts during egg laying, in the nest, or during collection, as well as during transport, storage, and handling in the hatchery (Salahi *et al.*, 2011; Nazareno *et al.*, 2013; Butcher and Nilipour, 2005). The eggshell is the first barrier against bacterial penetration and must be defect-free to improve embryo viability. Types of eggshell cracks include complete cracks, star cracks, or hairline cracks (Perić *et al.*, 2023). Saleh *et al.*, (2011) reported that hairline cracks (0.6%) and star cracks (0.7%) accounted for about 1.3% of total cracked eggs.

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Egg hatchability rate and chick quality are greatly affected by cracked eggs inside the incubator, which leads to a significant economic loss (Rayan, 2017). Cracked hatching eggs result in greater water loss and increased microbial contamination, leading to higher embryonic mortality and deterioration in chick quality (Jabbar *et al.,* 2019; Perić *et al.,* 2023). The significant percentage of cracked eggs, which has an economic impact on the production of broiler breeders, has prompted many researchers to investigate several ways to bond these cracks (Gholami *et al.,* 2018; Perić *et al.,* 2023). Several researchers have reported that sealing cracked shells with adhesive resin, insulating tape, nail polish, cellophane tape, and melted paraffin is effective in reducing egg contamination and water loss during incubation (Narahari *et al.,* 2000; Gholami *et al.,* 2018; Perić *et al.,* 2023), which enhancing embryo survival and chick quality.

Therefore, the main objective of the present study was to evaluate the effectiveness of sealing eggshell cracks with a mixture of eggshell powder with albumin and its effect on hatchability and egg quality parameters.

MATERIALS AND METHODS

Site and the aim of the experiment

This experiment was conducted at El-Delta for Poultry Investment Company, Gharbia Governorate, Egypt. The experiment started in August 2024 and ended in September 2024. The study aimed to investigate the effects of sealing eggshells of cracked eggs on egg weight loss, hatchability, embryonic mortality, and chick quality traits.

Experimental Design and Incubator Management

Eggs were collected and distributed into three experimental groups, according to the average initial egg weight, with average weight being 61.27 g (±0.3). Each experimental group contained 450 eggs in three replicates of 150 eggs each. Group 1 included intact shell eggs (Negative control), Group 2 included untreated cracked eggs (Positive control), and Group 3 included cracked eggs treated with eggshell powder and albumin mixture. Eggs in each experimental group were randomly distributed and placed on hatching trays. The adhesive mixture was prepared as follows: fresh, clean table eggshells were brought, sterilized, ground, and dried. After obtaining the dry powdered eggshells, they were mixed with albumin as an

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adhesive (1:1). Experimental eggs were candled to determine the presence of cracks. Cracked eggs were determined then stored in a darkened egg storage room. A small flashlight was placed on the upper side of each egg, while the eggs remained in egg flats. Eggs with a crack or tear in the shell membrane, as well as those with defective shells due to calcification problems, were not considered cracked. Several normal eggs (intact, un-cracked) were collected, along with several eggs that had cracks. A distinctive mark was placed on each egg for identification.

The incubator used in the study was a Petersime inspired by the nature control system, with a digital temperature and humidity system regulator. The setter was operated at 99.5 ± 0.2 ^{o} F dry–bulb temperatures and 85 ± 0.2 ^{o} F wet–bulb temperature for the first 18 d of incubation. While the hatcher (last 3 d of incubation) was divided into to the first day of hatcher, operated at 99.5 (±0.2^{o} F) dry–bulb temperatures and 85.0 (± 0.2 ^{o} F) wet–bulb temperature and the last two days in hatcher were operated at 98.5 (± 0.2 ^{o} F) dry–bulb temperatures and 90 (± 0.2 ^{o} F) wet–bulb temperatures. The incubator was maintained at a consistent 45°C and monitored using the same reference thermometers throughout the study. The eggs were also turned automatically once every hour, ensuring proper incubation conditions.

Measurements

On the first day of egg collection, the initial fresh egg weight was measured individually and then the eggs were weighed on the 18th day of incubation during the transfer to the hatcher to estimate egg weight loss ratio.

Egg weight loss (%) = (W_0-W_{18}) /W_0 x100, where W_0 is weight at setting and W_{18} is weight on the 18th of incubation (Tona et al., 2004).

To check the fertility, test was performed on the 7th, 14th, and 18th days after setting eggs in the incubator in a dark room with a bright light source using the traditional "candling" method. Before transferring the eggs to the hatchers, all eggs containing early dead embryos were removed from the trays to determine fertility, hatchability, and stage of embryonic mortality. Embryonic mortalities were classified based on embryonic period as early (0 to 7 days), intermediate (8 to 14 days, middle), and late (15 to 21 days, pipped). The overall hatchability percentage was calculated as the number of chicks hatched per total egg per replicate for each group. To check the quality of the chicks after hatching, the chicks were classified by

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individual visual inspection into the number of first and second-grade chicks, according to the method described by Tona *et al.*, (2004). The first-grade chicks were identified as having a completely closed and clean navel, a clean and dry chick, and properly developed bodies without deformities, the second-grade chicks were identified as having an unhealed navel or obvious deformities (distant legs or redbones). The body weight of 300 newborn chicks randomly assigned from each group was estimated by individual measurement on balance with an accuracy of ± 0.01 g to estimate the average chick's weight per group. Tona Score (%) is a chick quality rating system in which chicks are classified into different quality grades. Their total score ranges from 0 to 100 based on range of parameters, with a score up to 100 indicating high-quality chicks, as defined by Willemsen *et al.,* (2008).

Statistical analysis

All data were analyzed by analysis of variance (GLM), and means were compared using Duncan's multiple comparison tests (Duncan's, 1955). All analyses were performed with the SPSS procedure (SPSS for Windows Release 16, SPSS Inc. 2008). Statistical significance was considered at $p < 0.05$ for all tests.

RESULTS

Hatchability Characteristics

Table 1 shows the effect of eggshell crack closure on egg weight loss, hatchability, and embryo mortality during the incubation period. Compared to the untreated egg group, the treated cracked egg group showed higher egg weight on the 18^{th} day of incubation, as well as, a higher egg weight loss percentage. The fertility was not affected between the experimental groups, however, the fertility hatchability and total hatchability decreased in the untreated cracked group compared to the other groups. Moreover, the embryonic mortality rate increased during different stages (Early, Mid., Late, and Pip Mortality (%)) in untreated cracked eggs.

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Table (1): Effect of sealing eggshell on egg weight loss, hatchability, and embryonic mortalities of eggs (Means ± SE).

ITEMS	MAIN TREATMENT EFFECTS:				
	Control	**Non-sealed**	**Sealed**	**SEM**	**Sig.***
Fresh egg weight (g)	61.4	61.3	61.1	0.27	NS
Egg weight at d 18 (g)	54.8 [a]	50.5 [c]	52.6 [b]	2.13	*
Egg weight Loss (%)	10.8 [c]	17.7 [a]	13.9 [b]	3.33	*
Fertility (%)	95.1	94.2	94.0	0.65	NS
Total Hatchability (%)	89.1 [a]	53.1 [c]	78.4 [b]	15.56	*
Fertility Hatchability (%)	93.69 [a]	56.36 [c]	83.46 [b]	15.53	*
Early Mortality (%)	1.78 [b]	2.89 [a]	2.27 [ab]	0.34	*
Mid. Mortality (%)	0.22 [c]	6.22 [a]	1.56 [b]	0.01	*
Late Mortality (%)	5.34 [c]	24.90 [a]	11.77 [b]	3.21	*
Pip Mortality (%)	3.56 [c]	12.89 [a]	6.00 [b]	3.42	*
Total Mortality (%)	10.90 [c]	46.90 [a]	21.60 [b]	21.1	*

[a-b] Means, within a row, that don't share common superscript differ significantly (P≤0.05). * = significant at P≤0.05

Chick quality traits

Table 2 shows the effect of eggshell crack closure on chick quality, which includes: chick weight (g), relative weight (%), Tona score (%), and chick grade (A and B). The weight of chicks decreased, and their quality deteriorated in the group of untreated cracked eggs compared to the other experimental groups, as the score of chicks B increased and the score of chicks A decreased. Furthermore, chick weight and quality improved significantly in the cracked-treated egg group, which was quite similar to the negative control group.

Table (2): Effect of sealing eggshell on chick quality traits (Means ± SE).

ITEMS	MAIN TREATMENT EFFECTS:				
	Control	**Non-sealed**	**Sealed**	**SEM**	**Sig.**
Chick weight (g)	41.3 [a]	37.1 [b]	40.6 [a]	2.4	*
Relative weight (%)	68.2 [a]	60.4[c]	66.5 [b]	2.5	*
Tona score (%)	95 [a]	79.7 [c]	90.4 [b]	5.7	*
Chick grade A (%)	98.8 [a]	90.3 [c]	97.2 [b]	3.1	*
Chick grade B (%)	1.2 [c]	9.7 [a]	2.8 [b]	5.6	*

[a-b] Means, within a row, that don't share common superscript differ significantly (P≤0.05).

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DISCUSSION

The primary criterion for the quality of hatching eggs is eggshell integrity. Shell cracks or breakages cause significant economic losses to the poultry industry. Therefore, the current study aims to study possible solutions for treating cracked eggs to improve embryo viability.

The results of the current study showed a higher total hatchability and fertile eggs and lower egg weight on the 18th day of incubation, as well as a lower egg weight loss percentage in the treated cracked egg group compared to the untreated cracked egg group. Moreover, the embryonic mortality rate increased during different stages in untreated cracked eggs, which is consistent with other published results (Barnett et al., 2004). In agreement with these results, previous studies reported that the overall mortality rate during different embryonic stages is significantly higher in cracked eggs compared to intact eggs (Salahi *et al.,* 2011; Khabisi *et al.*, 2012; Rayan, 2017; Gholami *et al.,* 2018). As expected, the hatchability of total and fertile eggs, egg weight on the 18th day of incubation, egg weight loss, and embryonic mortalities were improved in the treated egg group compared to the untreated cracked eggs group. Consistent with the results of the current study, Gholami *et al.,* (2018) found a significant increase in hatchability and egg weight at 18 days of incubation with a decrease in egg weight loss in the uncolored nail varnish-treated egg group. Hair-cracked eggs are more susceptible to bacterial contamination and increased eggshell cracks, resulting in poor eggshell quality. Once bacteria penetrate the eggshell membrane, they secrete protein enzymes that further digest the membrane, thus increasing incidence of embryonic death and reducing hatchability (Narushin and Romanov, 2002). It can be assumed that eggshell powder-albumin paste was able to control evaporative water losses and reduce microbial contamination within normal range. Our results are consistent with those of Narahari et al. (2000) and Gholami et al. (2018), who applied different eggshell treatments to cracked eggs. This result demonstrates the positive role of eggshell powder with albumin paste in maintaining water evaporation and embryo safety. Similarly, our results are consistent with several reports that applied different treatments to cracked eggshells, which enhanced hatchability and reduced embryonic mortality (Christensen, 2001; Narahari *et al.*, 2000; Simsek and Gurses, 2009; Gholami *et al.,* 2018). From the above,

it can be concluded that the mixture of eggshell powder with albumin enhanced the hatching rate and embryo safety and reduced the embryonic mortality rate.

In the current study, all hatched chicks were recorded, and their wings were marked individually for each group after the entire batch had hatched. As described by Abdelazeem (2016), all chicks were examined and weighed to assess their quality. Our results showed that the weight of chicks hatched from eggs with hairline cracks was lower than that of eggs in the control and treated groups. Like obtained results, Khabisi *et al.,* (2012) found that the chicks' weight that were hatched from eggs with hairline cracks was significantly lower compared to eggs of the control group. Good quality is graded into two categories: A and B. Grade A is for saleable chicks that are clean, free from deformities, dry, and have a completely closed navel. Grade B is for non-saleable chicks that are unclean, have an unclosed unhealed, and have many deformities, including lesion or deformities in the beak or legs. In agreement with our data, Salahi *et al.,* (2011) and Ryan and Badri, (2017) found significantly lower chick quality in groups with cracked shell eggs. Based on the results of the current study, data showed a decrease in the chick's weight and deterioration in the chick's quality, as chick degree B increased and chick degree A decreased in the untreated cracked egg group. Despite that, there was a significant improvement in chick weight and quality in the treated crack egg group, which was very similar to the Negative control group.

The increase in the percentage of grades A chick in the treated group indicates that sealing the cracks with a mixture of eggshell powder with albumin has a positive effect on the classification of first grade chicks. This was confirmed by Gholami *et al.,* (2018) who found that sealing the eggshell of cracked eggs increases the percentage of first-grade chicks. In support of the results of the present study, Narahari *et al.,* (2000) reported that sealing cracked eggshells with adhesive tapes and epoxy glue had a positive effect on chick weight. Similarly, Gholami *et al.,* (2018) reported no difference in chick weight hatched from cracked sealed eggs compared to intact eggs.

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CONCLUSION

We conclude from the present results that the mixture of eggshell powder with albumin can be used to seal the cracks in the eggshell, which had positive effects on the embryo survival rate and the overall hatchability rate by preventing water loss during incubation and reducing embryo contamination. Sealing the cracks in the eggshell with the mixture of eggshell powder with albumin also reduces the likelihood of reducing the hatching chick's weight and enhancing the chick's quality.

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فعالية سد قشر البيض المتشقق على قابلية الفقس وجودة الكتكوت في دجاج التسمين

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المستخلص

كان الهدف من الدراسة الحالية هو تقييم تأثير سد شقوق قشر البيض من خلال خلط مسحوق قشر البيض مع الألبومين على معايير الفقس وجودة الكتاكيت. تم استخدام ١٣٥٠ بيضة من قطيع امهات دجاج اللحم بعمر ٣٤ أسبوعًا وتم توزيعها عشوائيًا على ٣ مجموعات تجريبية. المجموعة الأولى تحتوي على ٤٥٠ بيضة سليمة (مجموعة مقارنة سلبي)، المجموعة الثانية تحتوي على ٤٥٠ بيضة متشققة (مجموعة مقارنة إيجابي)، والمجموعة الثالثة تحتوي على ٤٥٠ بيضة متشققة وتمت معاملتها. كانت أقل نسبة وزن للبيض في اليوم ١٨ من التفريخ وأعلى نسبة فقدان لوزن البيض والنفوق الجنيني في مجموعات البيض المتشققة غير المعالجة مقارنة بالمجموعات الأخرى. علاوة على ذلك، أظهرت المجموعة المتشققة المعالجة تحسنًا كبيرًا في نسبة وزن البيض في اليوم ١٨ من التفريخ ونسبة فقدان وزن البيض وأقل نفوق جنيني مقارنة بالمجموعة غير المعالجة المتشققة. علاوة على ذلك، تحسنت جودة الكتاكيت في المجموعة المتشققة المعالجة مقارنة بالمجموعة المتشقق غير المعالجة. وبذلك تشير نتائج الدراسة الحالية إلى أنه يمكن استخدام خليط من مسحوق قشر البيض مع الألبومين لسد الشقوق الشعرية بهدف دعم بقاء حيوية الجنين وجودة الكتاكيت.

الكلمات الدالة: قشر البيض، قابلية الفقس، جودة الكتاكيت، دجاج التسمين

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