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The influence of egg shell crack types on hatchability and chick quality

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Abstract: Fertile eggs were obtained from a commercial flock of Ross broiler breeders (51 weeks old) and candled to determine the presence of hairline or star cracks. Eggs (5400 total) were assigned in equal numbers to 3 treatments (hairline-cracked, star-cracked, and normal eggs) and incubated for 21 days. Upon hatching, 10 chicks per treatment were euthanized, and organ weights were measured. Compared with normal eggs, the presence of egg shell cracks (regardless of type) resulted in higher egg weight loss at the time of transfer; a decrease in hatchability, hatch of fertile eggs, chick length, yolk-free body mass ($P < 0.01$), and percentage of hatchling breast and liver weight ($P < 0.05$); and an increase in the contamination rate of eggs ($P < 0.01$). Weight loss in hairline-cracked eggs was significantly higher than in star-cracked eggs ($P < 0.001$). Percentage hatchability and body weight of chicks hatched from star-cracked eggs was higher than in chicks from hairline-cracked eggs ($P < 0.001$). Crack type did not have a significant effect on chick length and body weight uniformity; however, the Pasgar score as a quality indicator was higher in chicks hatched from star-cracked eggs than those from hairline-cracked eggs ($P < 0.05$). There were no significant differences among treatments in terms of heart and small intestine weight. The contamination rate of hairline-cracked eggs was higher than that of star-cracked ($P < 0.01$). A higher incidence of embryonic mortality was observed during days 1-8 of incubation for shell-cracked eggs ($P < 0.001$). Total embryonic mortality in hairline-cracked, star-cracked, and normal eggs was 51.1%, 36.6%, and 13.3%, respectively. This study showed that egg shell cracks reduced incubation parameters and chick quality. The negative effects of hairline cracks were more pronounced than those of star cracks.

Key words: Egg shell, hairline crack, star crack, hatchability, chick quality, embryonic mortality

Introduction

Physical characteristics of hatching eggs play an important role in embryonic development and hatchability (1). Eggshell quality is considered one of the most important physical properties (2). The eggshell has 2 important roles in embryonic development: the shell must be thick and strong enough to protect the developing embryo against adverse environmental conditions and physical damage, and the shell must have sufficient pores to exchange O_2/CO_2 and moisture while preventing disease-causing microorganisms from entering the egg (1).

Many factors can affect eggshell quality and shell breakage, including genetics, bird age, nutrition, viral diseases, environmental conditions, egg collection and handling, and proper storage of eggs (3-7). When flocks get older, eggshell quality parameters

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including egg shell thickness and breaking strength decrease (8,9); about 5% of eggs received by the studied hatchery had shell-related problems. Major eggshell damages include complete eggshell breakage, hairline cracks, and star cracks (8,9). In completely broken eggshells, the external shell as well as the shell membranes are damaged. Eggshell cracks may be created in uterus during eggshell formation, during transportation, or when eggs are transferred from setter to hatcher. About 50% of eggshell breakage in the body included hairline cracks with no damage to shell membranes (10).

Singh et al. (11) demonstrated that most eggshell damage at the studied farm consisted of straight cracks and star cracks. The incidence of complete breakage, hairline cracks, and star cracks may vary between 1-5%, 1-3% and 1-2%, respectively (7). Eggs with completely broken shells are often removed from incubation because of the high possibility of egg dehydration and to prevent the introduction of disease microorganisms (12). However, due to difficulty of diagnosis or economic conditions, eggs with hairline cracks and star cracks are usually not removed from the incubation process. Detection of hairline cracks usually requires candling before setting the eggs (13). Little research has been done on the impact of shell breakage, especially microcracks (hairline cracks and star cracks), in hatchery eggs. Barnett et al. (13) reported that hatchability and hatched chick weight from hairline-cracked eggs were lower than in normal eggs. In addition, the mortality rate in chicks hatched from hairline-cracked eggs was higher at day 14 after hatching.

The purpose of this study was to investigate the effects of eggshell crack types on incubation parameters and the quality and organ weight of hatched chicks.

Material and methods

Fertile eggs were collected from a 51-week-old broiler breeder flock (Ross 308). After delivering the eggs to the hatchery, eggshell cracks were detected and classified as hairline or star cracks. In order to ensure the accuracy of this process, all cracked eggs were candled in a dark room. A total of 5400 eggs were weighed individually and assigned to 3 treatments: hairline-cracked, star-cracked, and normal eggs. Eggs from each treatment (1800 total) were randomly assigned to 5 replicates per treatment. All eggs were stored under similar conditions for 4 days at 18 °C and 75% RH and then incubated in a forced-draft incubator (Multistage Petersime Model 576, Petersime, Zulte, Belgium). At 19 days of incubation, the treatment groups were weighed and transferred to the hatcher (14). Each hatcher basket was divided into 3 parts; after the transfer of eggs, baskets were covered by wire mesh in order to prevent possible admix of the chickens.

Between 472 h and 510 h of incubation, the number of hatched chicks was checked every 2 h, and spread of hatching was calculated as the dispersion around the average incubation duration. Upon hatching, all chicks from each experimental unit were individually weighed and chick length was measured (15). Breakout analysis of unhatched eggs was performed for embryonic mortality evaluation (16), and the Pasgar score as a chick quality parameter was assessed considering chick activity, navel status, and feet and beak conditions (17).

At the end of the experiment, 2 chicks from each treatment were randomly selected and weighed. The chicks were then euthanized by carbon dioxide, and the weight of the yolk sac, yolk-free body mass (YFBM), breast muscle, small intestine, liver, and heart were measured. The length of the small intestine was also measured (18). Data were analyzed by the GLM procedure of SAS (SAS Institute, Cary, NC, USA, 1999). Mean separation was accomplished using Duncan's multiple range tests, and values were considered statistically different at $P < 0.05$ (19).

Results

Hatchability percentage, egg weight at transfer, fertility, and hatching of fertile eggs in the control group (without cracks) were 83.9%, 62 g, 97.8%, and 85.8%, respectively. These values were higher than the values from groups with eggshell cracks. These values were also significantly higher in star-cracked eggs than in hairline-cracked eggs ($P < 0.001$). Egg weight loss during transfer in hairline-cracked eggs was higher than in star-cracked eggs and the

control ($P < 0.001$). As shown in Table 1, there were significant differences in incubation times between the control, star-cracked eggs, and hairline-cracked eggs ($P < 0.001$).

Chick weight, chick yield or chick weight to egg weight ratio, and Pasgar scores were significantly lower for hairline cracks than in the other groups ($P < 0.01$). However, no differences were found between the star-cracked eggs and the control group. Cracks decreased chick length compared to the control eggs ($P < 0.001$), but there were no significant differences between the eggshell crack groups in terms of chick length. As presented in Table 2, the effects of the 3 treatments on body weight uniformity of chicks and percentage of culled chicks was not significant.

The effects of egg shell crack types on hatchability, hatching weight, and organ weights are shown in Table 3. Both star and hairline cracks reduced the YFBM ($P < 0.001$). YFBM in star-cracked eggs was significantly higher than in the hairline group. There was no significant difference in yolk sac weight, small intestine length, small intestine weight, or heart weights among the treatments. However, liver weight and breast muscle weights were higher in the control group compared to the other groups. The type of crack did not have any effect on breast muscle or liver weights.

As shown in Table 4, the results of egg breakout showed the significant effect of eggshell cracks types on infertility, embryonic mortality at 1-8 days and 9-18 days of incubation, and percentage of total embryonic mortality ($P < 0.001$). However, embryonic mortality in the control group was lower than in the other groups. Embryonic mortality during days 1-8 of incubation and total embryonic mortality were higher with hairline cracks than star

Table 1. Effect of eggshell crack type on egg weight at transfer, egg weight loss, incubation time, hatchability, fertility, and hatching of fertile eggs.

Treatment	Egg weight at transfer (g)	Egg weight loss (%)	Incubation time (h)	Hatchability (%)	Fertility (%)	Hatchability of fertile eggs (%)
Normal	62.0[a]	11.4[c]	497.0[b]	83.9[a]	97.76[a]	85.78[a]
Star cracks	55.6[b]	20.7[b]	501.8[ab]	49.4[b]	89.44[b]	55.64[b]
Hairline cracks	53.1[c]	24.0[a]	503.0[a]	30.0[c]	83.34[c]	35.78[c]
SEM	0.42	0.6	1.54	3.89	1.73	4.83
P-value	0.0001	0.0001	0.0301	0.0001	0.0003	0.0001

[a-c]: Means within a column without a common superscript differ significantly ($P \leq 0.05$).

Table 2. Effect of eggshell crack type on chick weight, chick length, uniformity, Pasgar score, chick yield, chick weight uniformity, and culls. .

Treatment	Chick weight (g)	Chick yield (%)	Chick length (cm)	Pasgar score	Weight uniformity (%)	Culls (%)
Normal	48.9[a]	69.9[a]	19.96[a]	99.52[a]	82.56	1.12
Star cracks	48.2[a]	68.7[a]	19.42[b]	99.3[a]	70.34	1.68
Hairline cracks	45.6[b]	65.3[b]	19.40[b]	98.6[b]	70.16	2.24
SEM	0.51	0.72	0.11	0.18	5.79	0.85
P-value	0.0056	0.0058	0.0091	0.0227	0.2667	0.780

[a-b]: Means within a column without a common superscript differ significantly ($P \leq 0.05$).

Table 3. Effect of eggshell crack type on yolk sac weight, yolk-free body mass (YFBM), small intestine length, and weights of small intestine, liver, heart, and breast as percentages of live body weight.

Treatment	YFBM (g)	Yolk sac weight (g)	Small intestine length (cm)	Percentage of live body weight (%)			
				Small intestine weight	Liver weight	Heart weight	Breast weight
Normal	42.0[a]	5.78	40.5	3.34	3.47[a]	0.79	6.29[a]
Star cracks	38. 7[b]	6.89	38.5	3.46	2.89[b]	0.81	4.99[b]
Hairline cracks	35.9[c]	7.19	37.6	3.25	2.91[b]	0.69	5.062[b]
SEM	0.70	0.71	0.91	0.19	0.14	0.05	0.35
P-value	0.0003	0.3318	0.3506	0.6269	0.0278	0.3809	0.0439

[a-c]: Means within a column without a common superscript differ significantly (P ≤ 0.05).

Table 4. Effect of eggshell crack type on infertility, embryo mortality, and contamination.

Treatment	Infertility (%)	Embryo mortality					
		1-8 days (%)	9-17 days (%)	18-19 days (%)	20-21 days (%)	Total embryo mortality (%)	Contamination (%)
Normal	2.22[c]	10.55[c]	0.55[b]	0.55[b]	1.66	13.32[c]	2.77[c]
Star cracks	10.55[b]	23.32[b]	9.44[a]	2.77[ab]	1.1	36.65[b]	6.66[b]
Hairline cracks	16.66[a]	33.88[a]	8.32[a]	5.55[a]	3.32	51.09[a]	10.55[a]
SEM	1.88	2.93	1.68	1.28	0.81	3.14	1.242
P-value	0.0006	0.0004	0.0055	0.0522	0.177	0.0001	0.003

[a-c]: Means within a column without a common superscript differ significantly (P ≤ 0.05).

cracks. The type of crack also had a significant effect on the percentage of contamination (P < 0.01); the percentage of contamination with hairline cracks was higher than in the other groups.

Discussion

In this study, egg weight loss in control eggs (11.38%) was in agreement with the guidelines of Aviagen and Cobb-Vantress (16,20). According to Aviagen, appropriate egg weight loss in normal eggs is 12% from the time the eggs are set until they are transferred to the hatcher. These conditions are considered ideal for optimum hatchability and chick quality (16). However, the Cobb-Vantress management guide indicates that egg weight loss up to day 18 of incubation is 12%; as altitude increases, egg weight loss will increase (20).

Percentage of egg weight loss between days 1 and 19 of incubation in the Cobb 500 strain was 10.9%; this loss was 12.9% in Ross 308. The broiler breeder flock age (younger than 44 weeks old) had no effect on egg weight loss, whereas the impact of strain on egg weight loss was significant (21). In the present study, eggshell cracks caused an egg weight loss of 23.96%, which was significantly higher than in the control group (11.4%).

Barnett et al. (13) reported that egg weight loss in good quality eggs and eggs with hairline cracks was 13.4% and 17.02%, respectively. Differences in egg weight loss in our study (24%) and in that of

Barnett et al. (17.02%) may be related to the extent of hairline crack length; the length of cracks in our study were between 0.93 and 6.6 cm with a mean of 3.39 cm. We also found that egg weight loss with star cracks (20.7%) was lower than with hairline cracks (24%). In the study by Barnett et al. (13), eggs were selected from 5 broiler breeder flocks 48 to 56 weeks old; we used only 1 flock of 51-week-old broiler breeders. We also observed that egg weight loss in the hairline group was 2.22 g more than in the star-crack group. Because of this difference, we expected better hatchability in the star crack group.

Hatchability percentage and hatching of fertile eggs in a 36-week-old Ross 308 strain were 80.8% and 85.9%, respectively (21). In the current study, the hatchability of eggs with cracks significantly decreased, and this finding is consistent with the results of other researchers (13,22). In our study, the decrease in hatchability percentage was 53.88% with hairline cracks and 34.46% with star cracks. The decrease in the hatchability rate in the study by Barnett et al. (13) was 23.9%; this decline in the current study was 30%. Based on this observation, the star-crack group had a higher hatchability rate than eggs with hairline cracks.

We observed significant differences in fertility among control eggs, star-cracked eggs, and hairline-cracked eggs. In the study by Barnett et al. (13), mean fertility was 77.5% to 100%, and initial egg weights in normal and hairline-cracked eggs were 64.40 g and 64.69 g. Our data on fertility are different from those of Barnett et al. Our initial egg weights were 69.98 g, 70.06 g, and 69.78 g in the control, star-crack, and hairline groups, respectively, which were again different from the values reported by Barnett et al.

Chick weight is affected by egg weight (14,23). The initial egg weight rate is normally between 66% and 68% (20). Chick yield in fresh eggs stored for a short period was between 67% and 67.5% (16). This rate in a 36-week-old flock was 73.1% (21). In the current experiment, chick weight and chick yield in the hairline-crack group were lower than in the other groups. These results are in agreement with those of Barnett et al. (13). Most egg weight loss (23.96%) was seen with hairline cracks, and this loss reduced chicken weight. In the study by Barnett et al. (13), chick weight was 45 g and 43.5 g in the normal and hairline-cracked eggs, respectively, and the difference between the 2 groups was 1.5 g. In our study, this difference was 3.3 g, and this may explain the lower performance.

At the time of transfer, different levels of cracks had significant effects on the percentage of culled chicks in a study by Lovell (22). While the average percentage of culls in the control, star-crack, and hairline groups were 1.12%, 1.68%, and 2.24%, respectively, there were no significant differences between the treatments. In the current experiment, the type of eggshell crack negatively impacted the quality of the growing embryo by increasing the cull rate, but did not result in embryonic mortality.

Chick length was greater in the control group, and because of their high quality scores, these chicks exhibited better growth and development. Hairline cracks increased the hatch spread, which probably resulted in lower scores and activity in hairline-crack chicks compared to chicks from other treatments. In the present study, there were no significant differences in the uniformity of body weight and chick length among the treatments. The possible reason for this observation is that weak embryos or chicks died during the incubation process; the remaining chicks were uniform in both weight and length. Chick weight with hairline cracks was lower than in the other treatments. This is related to higher egg weight loss during the incubation period and is consistent with the findings of Barnett et al. (13), who reported that the YFBM was lower in hairline-cracked eggs.

Low chick weight or YFBM in the hairline group maybe related to a higher contamination rate and the inability of chicks to consume the yolk sac. Incubation times in normal, star-cracked, and hairline-cracked eggs were 497 h, 501.8 h, and 503 h, respectively; chicks hatched from eggs with hairline cracks stayed in the hatcher 6 h longer than chicks from normal eggs. According to Khan et al. (24), yolk retention and yolk sac infection are the most important factors in chicken mortality in many domestic birds. Increased incubation time (staying in the hatcher for a longer period) affects the yolk sac infection rate and retention. A yolk sac size increase indicates that the chick is unable to use it (24), and this condition may affect organ development.

In this study, liver weight in the control group was greater than in the other treatments. This was related to better metabolism and lower contamination rates in the control group. One benefit of the Ross 308 strain is that these birds have good breast muscle yield. Based on our observations, the breast muscle weight in the control group was higher than in the other treatments. However, the weights of other organs were not significantly different from those of the control.

In addition, the infertility percentage with hairline cracks was higher than in the other treatments. The high percentage of embryonic mortality in the early stages was related to the higher contamination with hairline cracks as compared to the control. Eggshells are the first defense barrier; a break facilitates the entry of microorganisms into the eggs, resulting in an increase in the percentage of total embryonic mortality and contamination. The mortality and contamination results from the current study are in agreement with those of Barnett et al. (13). According to Wilson (23), eggshell cracks or low eggshell quality increases the percentage of chicks stuck in the shell; this leads to chick dehydration. Hussein et al. (25) reported that yolk sac infection occurs mainly due to bacterial contamination of the eggshell at the broiler breeder farms; this can lead to decreased hatchability and an increased mortality and cull rate (26,27).

In conclusion, setting eggs with hairline or star cracks significantly reduced hatchability and increased chick weight and incubation time. Performance and incubation parameters in eggs with hairline cracks were poorer than in eggs with star cracks. Chick quality was affected by cracks; chick yield, Pasgar scores, and chick weight were more acceptable with star cracks than hairline cracks. YFBM and breast muscle weight were higher in normal eggs than in star- and hairline-cracked eggs. Early embryonic mortality (days 1-8) and contamination rates were higher with hairline cracks than in eggs with star cracks and in normal eggs.

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References

1. Narushin, V.G., Romanov, M.N.: Egg physical characteristics and hatchability. World's Poult. Sci. J., 2002; 58: 297-303.
2. Narushin, V.G., van Kempen, T.A., Wineland, M.J., Christensen, V.L.: Comparing infrared spectroscopy and egg size measurements for predicting eggshell quality. Bio. Sys. Eng., 2004; 87: 367-373.
3. Butcher, G.D., Miles, R.: Concepts of Eggshell Quality. University of Florida, Gainesville, Florida. 2009.
4. Etches, R.J.: Calcium logistics in the laying hen. Proceedings of the 69th Annual Meeting of the Federation of American Societies for Experimental Biology. 1987; 619-628.
5. Roberts, R., Juliet, R.: Egg quality and food safety. 18th Annual American Soybean Association International Marketing, Asian Feed Technology and Nutrition Workshop, Cambodia. 2010; 24-27.
6. Michalak, K., Mroze, E.: Ultra structure of the turkey hatching egg shell. Polish J. Nat. Sci., 2006; 21: 671-689.
7. Coutts, J.A., Wilson, G.C.: Optimum Egg Quality: A Practical Approach. Revised Version. 5M Publishing, Sheffield, UK. 2007.
8. Elaroussi, M.A., Forte, L.R., Eber, S.L., Biellier, H.V.: Calcium homeostasis in the the laying hen. 1. Age and calcium effects. Poultry Science, 1994; 73: 2590-1595.
9. Rayan, G.N., Gala, A., Fathi, M.M., El-Attar, A.H.: Impact of layer breeder flock age and strain on mechanical and ultrastructural properties of eggshell in chicken. Int. J. of Poul. Sci., 2010; 9: 139-147.
10. Narahari, D., Rajini, R.A., Srinivasan, G., Ramamurthy, N.: Methods to improve the hatchability of checked chicken eggs. Brit. Poult. Sci., 2000; 41: 178-181.
11. Singh, R.P., Beura, C.K., Mahapatra, A.S., Bathla, H.V.L., Jha, G.K., Singh, P.K., Kumar, D.: Assessment of quantitative losses of eggs between farm and household consumer. Ind. J. Poult. Sci., 2009; 44: 239-242.
12. Mertens, K., Bamelis, F., Kemps, B., Kamers, B., Verhoelst, E., De Ketelaere, B., Bain, M., Decuypere, E., De Baerdemaeker, J.: Monitoring of eggshell breakage and eggshell strength in different production chains of consumption eggs. Poult. Sci., 2006; 85: 1670-1677.
13. Barnett, D.M., Kumpula, B.L., Petryk, R.L., Robinson, N.A.: Hatchability and early chick growth potential of broiler breeder eggs with hairline cracks. J. of Appl. Poult. Res., 2004; 13: 65-70.

14. Tona, K., Bamelis, F., Coucke, W., Bruggeman, V., Decuypere, E.: Relationship between broiler breeder age and egg weight loss and embryonic mortality during incubation in large-scale condition. J. of Appl. Poult. Res., 2001; 10: 221-227.

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

16. Tullett, S.: Investigating Hatchery Practice. Aviagen, Newbridge, UK. 2009.

17. Pas Reform: Incubation Guide, Broiler. Pas Reform Hatchery Technologies, Zeddam, the Netherlands. 2008.

18. Molenaar, R.: Evaluation of Chick Quality: Which Method Do You Choose? HatchTech Incubation Technology, Veenendaal, the Netherlands. 2009. 19.
SAS Institute. SAS Procedure Guide, Version 8. SAS Institute, Cary, North Carolina. 1999.

20. Cobb-Vantress Inc: Cobb Breeder Management Guide, Revised. Cobb-Vantress, Siloam Springs, Arkansas. 2008.

21. Abudabos, A.: The effect of broiler breeder strain and parent flock age on hatchability and fertile hatchability. Int. J. Poult. Sci., 2010; 9: 231-235.

22. Lovell, E.J: The effect of transfer cracks on chick quality and hatchability. Proceedings of the Western Poultry Disease Conference (Lohmann Animal Health International), 1998; 47: 55-59.

23. Wilson, H.R.: Hatchability Problem Analysis, CIR1112. University of Florida, Gainesville, Florida. 2004.

24. Khan, K.A., Khan, S.A., Aslam, A., Rabbani, M., Tipu, M.Y.: Factors contributing to yolk retention in poultry (a review). Pakistan Vet. J., 2004; 24: 46-50.

25. Hussein, S.A., Hassan, A.H., Sulaiman, R.R.: Bacteriological and pathological study of yolk sac infection in broiler chicks in Sulaimani district. J. of Dohuk University, 2008; 11: 48-55.

26. Coutts, G.S.: Poultry Diseases under Modern Management. 2nd ed. Saiga Publishing Company Limited, London. 1981.

27. Mosqueda, T.A., Lucio, M.B.: Enfermedades communes de la saves domesticas. National Autonomous University of Mexico, Mexico City. 1985; 377-381.