Brazilian Journal of Poultry Science
Revista Brasileira de Ciência Avícola

ISSN 1516-635X Oct - Dec 2016

Special Issue 2 Incubation / 053-058

http://dx.doi.org/10.1590/1806-9061-2015-0214

The Effect of Eggshell Thickness on the Hatchability of Guinea Fowl and Pheasants

Author(s)

Yamak US[I]
Boz MA[II]
Ucar A[III]
Sarica M[I]
Onder H[I]

[I] Department of Animal Science, Agricultural Faculty, Ondokuz Mayis University, Samsun, Turkey, usyamak@omu.edu.tr, 00903623121919/1389
[II] Department of Animal Science, Agricultural and Natural Science Faculty, Bozok University, Yozgat, Turkey, m.akif.boz@bozok.edu.tr, 00903542161094/4483
[III] Department of Animal Science, Agricultural Faculty, Ankara University, Ankara, Turkey, ucara@ankara.edu.tr, 00903125961370

Mail Address

Corresponding author e-mail address
Umut Sami Yamak
Ondokuz Mayis University, Agricultural Faculty, Dep. of Animal Sci.
Samsun /TURKEY
Phone: 0090 362 3121919
Email: usyamak@omu.edu.tr

Keywords

Eggshell thickness, ultrasound, incubation, guinea fowl, pheasant.

Submitted: February/2016
Approved: April/2016

ABSTRACT

Successful incubation affects the number of healthy chicks in all poultry species. This study examined the effect of eggshell thickness on the hatching rates of guinea fowl and pheasant eggs. In total, 964 guinea fowl and 1,728 pheasant eggs were used in the study. Eggshell thickness was measured directly with an ultrasound gauge. Thicknesses ranged between 0.27-0.47 mm in guinea fowl and 0.24-0.49 mm in pheasant eggs. Incubation periods were 28 days for guinea fowl and 25 days for pheasant eggs. At the end of the incubation period, unhatched eggs were broken to identify the causes of embryonic mortality. Eggs were classified as thin-, medium- and thick-shelled, and hatching rates were calculated as a function of eggshell thickness. Differences in hatching rates of guinea fowl and pheasant eggs with different shell thicknesses were not statistically significant (p>0.05).

INTRODUCTION

Pheasant *(Phasianus colchicus)* and guinea fowl (*Numidia meleagris*) are some species used in commercial poultry production for different reasons in various parts of the world. In most countries, pheasants are bred mainly as game birds (Caglayan *et al.,* 2010), as a source of animal protein (meat) for humans (Ozbey *et al.,* 2011), or are released in the wild to prevent the depletion of species' population (Yamak, 2015). Guinea fowl, on the other hand, are raised both for meat and egg production and as a hobby. In Africa, guinea fowl production has cultural significance as a traditional activity (Konlan *et al.,* 2011), and guinea fowl meat and eggs are second to chicken eggs and meat in terms of poultry products consumed (Bernacki *et al.,* 2013).

The most important step in poultry production is incubation. In the northern hemisphere, pheasants start laying in early spring and continue until mid-summer; however, total egg production, fertility, and hatching rates vary and tend to be unsatisfactory (Ozbey *et al.,* 2011; Kozuszek *et al.,* 2009), with reported hatchability rates of fertilized eggs ranging between 41 and 79% (Ozbey *et al.,* 2011; Kontecka *et al.,* 2014). Similar variations have been observed in guinea fowl, with reported hatchability rates ranging between 45 and 86% (Yamak *et al.,* 2015a; Bernacki *et al.,* 2013; Royter & Arutyunyan, 1990). Considering the value of pheasant chicks and guinea fowl keets, together with the low egg numbers and variations in fertility and hatchability, successful incubation of all eggs is particularly desirable in these poultry species (Demirel & Kirikci, 2009; Yamak *et al.,* 2015a).

Studies investigating methods of improving pheasant and guinea fowl egg production have focused on nutrition (Jones *et al.,* 2010; Nahashon *et al.,* 2007) and on the effects of housing system on egg production and hatching (Kontecka *et al.,* 2013; Avornyo *et al.,* 2007). Egg storage prior to incubation – a common practice in these species due to their relatively low egg production – has been shown to have a negative effect on hatchability (Moreki & Ditshupo, 2012; Demirel & Kirikci, 2009).

Hatchability may also be affected by eggshell thickness; however, most studies examining the relationship between eggshell thickness and hatchability have focused on chickens (Tsarenko, 1988; Bennet, 1992; Yamak *et al*., 2015b), with only limited studies evaluated other poultry species, namely turkeys, geese, ostriches, and partridges (Koneva, 1968; Tsarenko *et al*., 1978; Gonzalez *et al*., 1999; Yamak *et al*., 2015c). Therefore, the present study aimed at evaluating the relationship between eggshell thickness and hatchability of pheasant and guinea fowl eggs using an ultrasound gauge to measure thickness.

MATERIAL AND METHODS

Within the framework of this study, two separate experiments were conducted in June 2015. Experiment 1 was conducted at the Yozgat Guinea Fowl Breeding Station of the Turkish Ministry of Forest and Water Affairs. In total, 964 guinea-fowl eggs laid by a flock of 46-wk-old breeders were collected. The breeding flock consisted of 350 female and 150 male guinea fowls. Breeders were fed *ad libitum* a commercial corn- and-soybean-based chicken layer feed (145g CP, 11.5 MJ ME, 10g Ca, 4g P, 6.5g lysine, 3g methionine per kg).

Eggs were placed in a storage machine and kept at 18°C and 70-80% relative humidity for up to 7 days. All eggs were numbered, and eggshell thickness was measured on the blunted edge with an eggshell thickness gauge (ORKA Tech. Ltd., Israel) that uses precision ultrasound to measure thickness without breaking the egg and is accurate to within 0.01 mm.

The total incubation period was 28 days. Eggs were incubated for 25 days in an incubator set at 37.5°C and 60% relative humidity and then transferred to a hatcher set at 36.5°C and 70% relative humidity. After the 28-day incubation period, all unhatched eggs were broken and opened, and infertile eggs and embryonic deaths were identified. Infertile eggs (n=227) were not used in the calculation of hatching rates.

Experiment 2 was conducted at the Samsun Pheasant Breeding Station of the Turkish Ministry of Forest and Water Affairs. In total, 1,728 pheasant laid by a flock of 52-wk-old breeders were collected. The breeding flock consisted of 900 female and 128 male pheasants. Breeders were fed *ad libitum* a commercial corn- and-soybean-based chicken layer feed (145g CP, 11.5 MJ ME, 10g Ca, 4g P, 6.5g lysine, 3g methionine per kg).

Eggs were placed in a storage machine and kept at 18°C and 70-80% relative humidity for up to four days. All eggs were numbered, and eggshell thickness was measured on the blunted edge with an eggshell thickness gauge (ORKA Tech. Ltd., Israel) that uses precision ultrasound to gauge thickness without breaking the egg and is accurate to within 0.01 mm.

The total incubation period was 25 days. Eggs were incubated for 21 days in an incubator set at 37.7°C and 62% relative humidity and then transferred to a hatcher set at 37.7°C and 85% relative humidity. After the 25-day incubation period, all unhatched eggs were broken open, and infertile eggs and embryonic deaths were identified. Infertile eggs (n=237) were not used in the calculation of hatching rates.

Statistical analysis

All statistical analyses were performed using SPSS Software Version 20.0 licensed to Ondokuz Mayis University. Frequency analysis was performed using Tukey's Hinges test, and eggshell thickness groups were formed according to percentiles. Kruskal-Wallis tests were used to examine the effects of eggshell thickness (by percentile group as well as by thickness value) on hatchability. Kendal's Tau Correlation Analysis was used to assess relationships between eggshell thickness and hatchability. The effect of eggshell thickness value on hatchability was analyzed using the Chi-square test. A difference of $p<0.05$ was considered statistically significant.

RESULTS

The distribution and hatching rates of guinea fowl eggs by shell thickness value are given in Table 1. Eggshell thickness value did not influence guinea fowl hatching rates (p=0.107). Eggshell thickness of fertilized guinea fowl eggs (n=737) ranged between 0.27-0.47 mm. Eggs were classified into groups according to shell thickness, and 124 eggs were classified as thin-shelled (<0.31 mm), 468 as medium-shelled (0.31-0.35 mm) and 145 as thick-shelled (>0.35). Hatching rates for thin-, medium- and thick-shelled guinea fowl eggs were 86.3%, 89.1% and 85.5%, respectively (Table 2). The differences in hatching rates among groups were not significant (p=0.425).

The distribution and hatching rates of pheasant eggs by shell thickness value are given in Table 3. Eggshell thickness value had no effect on pheasant hatching rates (p=0.236). Eggshell thicknesses of fertilized pheasant eggs (n=1474 eggs) ranged between 0.24 and 0.49

Table 1 – Hatching rates of guinea fowl eggs according to eggshell thickness value.

Thickness value	Number of hatched eggs	Number of dead in the shell	Hatching rate (%)
0.27	6	0	100.0
0.28	1	2	33.3
0.29	17	0	100.0
0,30	83	15	84.7
0.31	108	10	91.5
0.32	77	15	83.7
0.33	92	9	91.1
0.34	81	8	91.0
0.35	59	9	86.8
0.36	40	9	81.6
0.37	25	5	83.3
0.38	8	1	88.9
039	8	1	88.9
0.40	8	3	72.7
0.41	5	0	100.0
0.42	6	0	100.0
0.43	6	0	100.0
0.44	6	0	100.0
0.45	8	1	88.9
0.46	1	1	50.0
0.47	3	0	100.0
Total	648	89	87.9

p=0.107

mm. Eggs were classified into groups according to shell thickness, with 279 eggs classified as thin-shelled (<0.31 mm), 865 as medium-shelled (0.31-0.35 mm) and 330 as thick-shelled (>0.35). Hatching rates for thin-, medium- and thick-shelled pheasant eggs were 78.5%, 78.7% and 80.0%, respectively (Table 4). Differences in hatching rates among groups were not significant (p=0.390).

DISCUSSION

Poultry eggshell quality and thickness are affected by numerous factors such as nutrition, stress, disease, and production system (Roberts, 2004). Eggshell thickness has been reported to range between 0.30 and 0.45 mm in guinea fowl eggs (Adeyemo & Oyejola, 2004; Bernacki *et al.*, 2013) and between 0.253 and 0.343 mm in pheasant eggs (Nowaczewski *et al.,* 2013; Kozuszek *et al.*, 2009). The average eggshell thickness of guinea fowl and pheasant eggs determined in this study were 0.33 mm and 0.36 mm, respectively. In order to determine the effect of eggshell thickness on hatchability, this study grouped eggs into thin-shelled, medium-shelled and thick-shelled groups based on calculations made using fertilized eggs only. Accordingly, 16.83% of guinea fowl eggs were classified as thin-shelled, 63.5% as medium-shelled and 19.67% as thick-shelled, whereas 18.93% of pheasant eggs were classified as thin-shelled, 58.68% as medium-shelled and 22.39% as thick-shelled.

Table 2 – Hatching rates of guinea fowl eggs according to eggshell thickness group.

	Eggshell Thickness Group		
	Thin	Medium	Thick
Number of hatched eggs	107	417	124
Number of dead in the shell	17	51	21
Hatching rate (%)	86.3	89.1	85,5

p=0.536

Table 3 – Hatching rates of pheasant eggs according to eggshell thickness value.

Thickness value	Number of hatched eggs	Number of dead in the shell	Hatching rate (%)
0.24	0	1	0.0
0.25	5	1	83.3
0.26	6	1	85.7
0.27	19	0	100.0
0.28	38	20	65.5
0.29	67	17	79.8
0,30	84	20	80.8
0.31	103	31	76.9
0.32	129	41	75.9
0.33	170	52	76.5
0.34	143	34	80.8
0.35	136	26	84.0
0.36	82	19	81.2
0.37	67	16	80.7
0.38	61	12	83.6
0.39	20	8	71.4
0.40	15	6	71.4
0.41	11	2	84.6
0.42	1	0	100
0.43	4	1	80.0
0.44	1	1	50
0.45	1	1	50
0.49	1	0	100
Total	1164	310	79.0

p=0.236

Table 4 – Hatching rates of pheasant eggs according to eggshell thickness group.

	Eggshell Thickness Group		
	Thin	Medium	Thick
Number of hatched eggs	219	681	264
Number of dead in the shell	60	184	66
Hatching rate (%)	78.5	78.7	80.0

p=0,390

Fertility rates of guinea fowl and pheasant eggs were 76.45% and 86.28%, respectively. Fertility may be affected by various factors, including the general condition of the parents, mating rate, age, egg-storage duration and condition, weather conditions, and geographical location (Yamak *et al.,* 2015a; Agbolosu *et al.,* 2012). Given that previous studies reported fertility rates of between 43 and 91.7% for guinea fowl eggs (Yamak *et al*., 2015a; Bernacki *et al*., 2013; Agbolosu *et al.,* 2012) and 55.3 and 95.8% for pheasant eggs (Ozbey *et al.,* 2011; Caglayan *et al.,* 2010; Kozuszek *et al.,* 2009), the fertility rates found in the current study should be considered to be within acceptable ranges.

Hatchability rates were assessed as the ratio of hatched chicks to fertilized eggs. Overall hatching rates were 87.9% for guinea fowl eggs (Table 1) and 79.0% for pheasant eggs (Table 3). Reported hatchability rates of guinea fowl and pheasant eggs widely vary, with rates of between 45 and88% reported for guinea fowl (Royter & Arutyunyan, 1990; Saina, 2005; Moreki & Mothei, 2013; Yamak *et al.,* 2015a) and between 41.54 and 96.7% for pheasant eggs (Esen *et al.,* 2010; Demirel & Kirikci, 2009; Kozuszek *et al.,* 2009). Factors that affect hatchability have been well described in previous studies and include male-female ratio and nutrition of parents, as well as egg-storage conditions (Yamak *et al.,* 2015a; Kozuszek *et al.,* 2009). Moreover, any abnormalities in egg physical characteristics can cause a collapse in embryo development and prevent successful hatching (Narushin & Romanov, 2002). This study calculated hatching rates separately for each shell thickness value of both guinea fowl and pheasant eggs. Hatching rate differences were not statistically influenced by eggshell thickness values neither for guinea fowl eggs (Table 1, p=0.107) or pheasant eggs (Table 3, p=0.236).

The present study grouped both guinea fowl and pheasant eggs according to eggshell thickness as either thin-, medium-, or thick-shelled eggs (Tables 2 and Table 4). Whereas hatching rates of thin-shelled pheasant eggs were 1.5% lower than hatching rates of thick-shelled pheasant eggs, hatching rates of thin-shelled guinea fowl eggs were 1% higher than hatching rates of thick-shelled guinea fowl eggs. In both cases, the differences in hatching rates among eggshell thickness groups were not statistically significant (p>0.05). Bennet (1992) also reported hatchability rates of thin-shelled chicken eggs to be 3 to 9% lower than those of thick-shelled eggs. However, most previous studies have shown significant hatching rates differences between thin- and thick-shelled egg, with some studies reporting higher hatching rates in thin-shelled eggs while others in thick-shelled eggs. Tsarenko (1988) reported hatchability rates of thin-shelled eggs to be 30% higher than those of thick-shelled eggs. Tsarenko *et al.* (1978) found hatchability rates of thin-shelled goose eggs to be 20-40% lower than those of thick-shelled goose eggs. Koneva (1968) reported similar findings in turkey eggs, whereas Andrews (1972), in contrast, reported higher hatchability rates in thin-shelled than in thick-shelled turkey eggs, and Gonzalez *et al.* (1999) found hatchability rates of thin-shelled ostrich eggs to be higher than those of thick-shelled ostrich eggs.

The huge differences in the reported findings regarding the relationship between eggshell thickness and hatchability may be related to the methodology used to determine eggshell thickness. Voisey & Hamilton (1976) showed that eggshell thickness is closely related to egg specific gravity, and most studies since then have assessed eggshell thickness according to egg specific gravity. However, other studies determined eggshell thickness using logarithms that rely mainly on egg weight to calculate eggshell thickness (Tyler & Geake, 1961; Ar *et al.,* 1974; Shafey, 2002). In contrast with the direct measurement by ultrasound used in the present study, calculations based on specific gravity or egg weight all rely on indirect methods of measurement. In a study comparing various indirect methods for measuring eggshell thickness, Yamak *et al. (*2014) showed that the same chicken egg could be identified as thin-shelled by one indirect method and as thick-shelled by another indirect method. These findings highlight the importance of direct measurement. Previous studies conducted using the same direct ultrasound measurement method used in the present study, but with different poultry species, namely chickens (Yamak *et al.,* 2015b) and partridges (Yamak *et al.,* 2016), also found hatching rates to be unaffected by eggshell thickness. Moreover, the hatching time of partridge eggs was not affected by eggshell thickness (Yamak *et al.,* 2016).

CONCLUSION

This study measured eggshell thickness directly using an ultrasound gauge and found no significant differences in hatching rates as a function of eggshell thickness. Although these findings differ from those obtained in some previous studies using indirect measurement methods, direct measurement with an ultrasound gauge has been shown to provide more accurate results (Yamak *et al.,* 2014). Accordingly, it may be stated that once the embryo has completed its development, even thick-shelled guinea fowl and pheasant eggs may hatch successfully. New studies need to be conducted with other poultry species, including egg weight loss during incubation, to verify these results.

REFERENCES

Adeyemo AI, Oyejola O. Performance of guinea fowl (*Numida meleagris*) fed varying levels of poultry droppings. International Journal of Poultry Science 2004;3:357-360.

Agbolosu AA, Teye GA, Jebuni SN, Ansah T, Naandam J. Comparative study of growth and laying performance of indigenous layer guinea fowls (*Numida meleagris*) from Upper East, Upper West and Northern Regions of Ghana. Agriculture and Biology Journal of North America 2012;3(9):354-359.

Andrews LD. Phenotypic correlation of certain turkey egg parameters. Poultry Science 1972;51:2010- 2014.

Ar A, Paganelli CV, Reeves RB, Greene DG, Rahn H. The avian egg: water vapor conductance, shell thickness, and functional pore area. Condor 1974;76:153-158.

Avornyo FK, Karbo N, Munkaila L, Mbii P, Abukari A, Allegye, C. Towards reducing Guinea Fowl mortality in Northern Ghana: Research and development experiences. Savanna Farmer 2007;8:3-5.

Bennet CD. The influence of shell thickness on hatchability in commercial broiler breeder flocks. Journal of Applied Poultry Research 1992;1:61-65.

Bernacki Z, Kokoszynski D, Bawej. Laying performance, egg quality and hatching results in two guinea fowl genotypes, Archiv fur Geflugelkunde 2013;77(2):109–115.

Caglayan T, Alasahan S, Cetin O, Kirikci K, Gunlu A. Effects of egg weight and length of storage period on chick weight and hatchability performance of pheasants (*Phasianus colchicus*). Journal of Food, Agriculture & Environment 2010;8(3&4):407-410.

Demirel S, Kirikci K. Effect of different egg storage times on some egg quality characteristics and hatchability of pheasants (*Phasianus colchicus*), Poultry Science 2009;88:440–444. doi: 10.3382/ps.2008-00131.

Gonzalez A, Satterlee DG, Moharer F, Cadd GG. Factors affecting ostrich egg hatchability. Poultry Science 1999;78:1257- 1262.

Jones LR, Black HL, White CM, Johnston NP, Mcgee ME, Donahue SW, Egget DL. Effects of calcium-loading on egg production in ring-necked pheasants, Journal of Wildlife Management, 2010;74(6):1295–1300. doi:10.2193/2008-367.

Koneva A. Relationship of morphological traits of turkey eggs with hatching of chicks. Ptitsevodstvo 1968;11:32-33.

Konlan SP, Avornyo F, Karbo N, Sulleyman A. Increasing guinea fowl eggs availability and hatchability in the dry season, Journal of World's Poultry Research 2011;1(1):1-3.

Kozuszek R, Kontecka H, Nowaczewski S, Rosinski A. Storage time and eggshell colour of pheasant eggs vs. the number of blastodermal cells and hatchability results. Folia Biologica 2009;57:121–130.

Moreki JC, Ditshupo T. Effect of storage time on hatchability of guinea fowl eggs. Journal of Animal Science Advances 2012;2(7):631-636.

Nahashon SN, Adefope N, Amenyenu A, Wright D. Effect of varying metabolizable energy and crude protein concentrations in diets of pearl gray guinea fowl pullets. 2. Egg production performance. Poultry Science 2007;86:973–982.

Narushin VG, Romanov MN. Egg physical characteristics and hatchability. World's Poulry Science Journal 2002;69:297-303.

Nowaczewski S, Szablewski T, Cegielska-Radziejewska R, Kontecka H. Egg morphometry and eggshell quality in ring-necked pheasants kept in cages, Annals of animal Science 2013;13(3):531–541.

Ozbey O, Esen F, Aysondu MH. Effect of hatch weight on egg production, hatchability and egg quality characteristics in Pheasant (*Phasianus colchicus*). Journal of Animal and Veterinary Advances 2011;10(24):3201-3206.

Roberts JR. Factors affecting egg internal quality and shell quality in laying hens. Journal of Poultry Science 2004;41:161-177.

Royter Y, Arutyunyan W. Selection of guinea fowl for parental flock (in Russian). Ptisevodstvo 1990 ;12:16-18.

Saina H. Guinea fowl (*Numida meleagris*) production under smallholder farmer management in Guruve district, Zimbabwe [thesis]. Harare (ZW): Department of Animal Science, Faculty of Agriculture, University of Zimbabwe; 2005. p.108.

Shafey TM. Effects of egg size and eggshell conductance on hatchability traits of meat and layer breeder flocks. Asian-Australian Journal of Animal Science 2002;15(1):1-6.

Tsarenko PP. Increasing the quality of poultry products: Table and hatching eggs. Leningrad: Agropromizdat; 1988.

Tsarenko R, Tsarenko P, Belko A. Quality of goose eggs and their selection for incubation. Ptitsevodstvo 1978;(1):28-30.

Tyler C, Geake FH. Studies on egg shells. XV. Critical appraisal of various methods of assessing shell thickness. Journal of the Science of Food and Agriculture 1961;281-288.

Voisey PW, Hamilton RMG. Notes on the measurement of egg specific gravity to estimate shell quality. Ontário: Engineering Research Service Agriculture Canada; 1976.

Yamak US. Artificial breeding of wild birds in Turkey: Partridge breeding case. Indian Journal of Animal Research 2015;49(2):258-261.

Yamak US, Sarica M, Boz MA. Egg shell thickness and hatchability. Incubation and fertility Research Group Meeting; 2014 Sep 29-30; Lunteren. Netherlands.

Yamak US, Boz MA, Sarica M. Changes in guinea fowl fertility and hatching traits over a 4-month laying season with long-term egg storage conditions. Indian Journal of Animal Research 2015a;49(4):532-536.

Yamak US, Sarica M, Boz MA, Onder H. The effect of egg shell thickness on some hatching traits of broiler breeders. Kafkas Universitesi Veteriner Fakultesi Dergisi 2015b;21(3):421-424.

Yamak US, Sarica M, Boz MA, Ucar A. The effect of eggshell thickness on hatching traits of partridges. Brazilian journal of Poultry Science 2016; 18(nesp):13-16.