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A Study on the Relationship Between Eggshell Color and Eggshell Quality in Commercial Broiler Breeders

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Abstract: In this experiment, two trials were conducted to determine whether broiler breeder eggshell color could be used as an easy means of predicted eggshell quality. In Trial 1, 4320 commercial broiler breeder eggs were obtained. Specific gravity (SG) was measured and color determined on the eggs on the day of lay. The results showed that eggshell color was significantly affected by age and strain. L was found to be the most closely related to total color, E. Eggshell color was highly significantly but lowly correlated to SG. In Trial 2, 360 commercial broiler breeder eggs were acquired. SG and color were determined on the day of lay. Shell thickness without the membranes was then measured. In this trial, eggshell color was found to also be highly significantly but lowly correlated to shell thickness. It was determined that, while eggshell color is significantly correlated to shell quality, it is not as accurate a measure of eggshell quality as is SG or shell thickness.

Key words: Broiler breeders, eggshell color, eggshell quality

Introduction

Eggshell quality is a major concern of commercial egg producers and breeder managers. The loss of eggs due to poor shell quality results in a loss of revenue for these producers. Improving overall eggshell quality would have a significant economic impact on the industry. Eggshell quality is largely based on two characteristics of the shell, its thickness and its weight. It is generally accepted that the specific gravity of the egg is a sufficient estimator of eggshell quality. McNally (1965) showed that the incidence of cracked eggs increased as the shell weight decreased. It has been shown that thicker shelled eggs have higher hatchability (Axelsson, 1932; McDaniel *et al.,* 1979; Bennett, 1992) and Mussehl and Halbersleben, (1923) observed that the specific gravity and hatchability of chicken eggs were positively correlated. Eggs with low specific gravities have been reported to have higher early embryonic death rates (Coleman and McDaniel, 1975). These observations indicate that it is very important for eggs to have good eggshell quality. Therefore, an easy and accurate method of predicting eggshell quality of hens would be very beneficial. Determining whether eggshell color is an accurate estimator of eggshell quality is the focus of the work presented in this paper.

Materials and Methods

Trial 1: A total of 4320 eggs were obtained from a commercial hatchery. Half of the eggs came from each of two crosses, Hubbard X Avian (HXA) and Ross X Avian (RXA). The Avian crosses were Avian 24 in the HXA and Avian 34 in the RXA cross. Within each cross, 720 eggs were obtained at approximately 30, 40 and 50 weeks of age.

Specific gravity and color determination: The eggs were measured on the day of lay at room temperature. Egg specific gravity (SG) was determined by Archimedes' method. The eggs were weighed in air on a Mettler scale (model # BD601). The weight of the water displaced by the eggs was determined by submerging the eggs in a beaker of room temperature water on the same tared scale. Due to the fact that the specific gravity of water is temperature dependent, a correction factor based on the temperature of the water must be multiplied by the weight of displaced water before the specific gravity of the egg can be determined (Kell, 1975). Egg specific gravity was then determined using the equation, specific gravity = egg weight in air/ (displaced water weight X temperature correction). The color of the eggshells was determined using a Hunter Labs Labscan II Colorimeter. Color was based on three indices: L, degree of white to black; a, degree of red to green and b, degree of yellow to blue. A fourth value, E, was calculated to be the total color difference from the standard by the equation, E = [square root of (L^2) + (a^2) + (b^2)]. The lower the *E* value the darker the color. The eggs were placed on a 0.5 inch aperture on the colorimeter and measured at three different locations on the equator and the average was used to calculate E.

Trial 2: Three hundred sixty eggs from 50 week old Hubbard X Avian broiler breeders were obtained from a commercial hatchery. The eggs were measured the day of lay at room temperature. All specific gravity and color measurements were obtained by the same methods as in Trial 1. Eggshell thickness without the membranes was determined using a Sargent-Welch caliper (Superior, Cranston, RI). Two pieces of eggshell were taken from opposite sides of the equator of the egg and their thickness measured. The average of these was used for data analysis.

Data analysis: Pearson correlation coefficients were calculated according to the procedures of the Statistical Analysis System (SAS Institute, 1993). SAS was also used to analyze all data by ANOVA using a nested design and when significant effects were found, the means were separated with Duncan's Multiple Range test.

Results and Discussion

In Trial 1, all age within strain correlations between SG and the color measurements were highly significant (P<0.01) except for the measurement b (Table 1). The correlation of *b* to SG was highly significant in the 50 week Ross X Avian (RXA) group and significant (P<0.05) in the 40 week RXA group but was not significant in the 30 week RXA group or any of the Hubbard X Avian (HXA) groups (Table 1). When the correlation of *b* to SG was significant, it was very low (0.09 and 0.18) (Table 1). The range of correlations for SG with *a* was 0.14 to 0.25. The correlation of SG with L ranged from -0.1 to -0.21. These correlations were very similar to those found for E (-0.11 to -0.21). This suggests that L is the most similar measurement to total color, E and the usefulness of calculating the other color measurements is questionable. When correlations were calculated within strain cross, the HXA strain did not show a significant correlation between b and SG (Table 2). All other correlations of SG with the color measurements were highly significant (P<0.01) (Table 2). The correlation of SG with *a* was low in both strain crosses (0.14 and 0.22) (Table 2). The correlations with SG were also low for the measurement L (-0.11 and -0.15) which were very similar to the correlations of SG with E (-0.12 and -0.15) (Table 2). When the eggs were analyzed by age group, correlations of SG to the color measurements were highly significant (P<0.01) in all three age groups (Table 3). Once again the correlations of L (-0.26 to -0.42) and E (-0.27 to -0.44) with SG were very similar (Table 3). Low to moderate correlations between SG and *a* were found (0.22 to 0.38) (Table 3). The measurement b was very lowly correlated with SG with correlations ranging from 0.07 to 0.28 (Table 3). The high significance of all of these correlations suggests that age is a more important factor on eggshell color and eggshell quality than is strain cross. The highly significant (P<0.01) negative correlation between E and SG agrees with several previous studies. Godfrey and Jaap (1949) and Grover *et al.* (1980) separated eggs into visually determined color groups, while Joseph *et al.* (1999) used a color measuring computer program to separate eggs. All found that eggs with darker eggshells had higher specific gravities. When Moyle *et al.* (2008) used a colorimeter to place eggs into 5 groups based on eggshell color, they also found that darker eggs had higher specific gravity values. The low correlation of SG and *a* and the lack of significance of correlation between

Table 1: The correlation of specific gravity with various color measurements (L,a,b,E) of broiler breeder eggs from three age groups within two commercial strain crosses (Trial 1)

	Strain					
	Hubbard X Avian			Ross X Avian		
	Weeks of Age			Weeks of Age		
	30	40	50	30	40	50
L	-0.17**	-0.10**	-0.12**	-0.16**	-0.16**	-0.21**
a	0.16**	0.15**	0.14**	0.18**	0.20**	0.25**
b	0.01ns	-0.01ns	0.05ns	0.04ns	0.09*	0.18**
E	-0.18**	-0.11**	-0.13**	-0.17**	-0.17**	-0.21**

**: highly significant (P<0.01), *: significant (P<0.05), ns: not significant

Table 2: The correlation of specific gravity with various color measurements (L,a,b,E) of broiler breeder eggs from two commercial strain crosses (Trial 1)

	Strain	
	Hubbard X Avian	Ross X Avian
L	-0.11**	-0.15**
a	0.14**	0.22**
b	0.01ns	0.11**
E	-0.12**	-0.15**

**: highly significant (P<0.01), *: significant (P<0.05), ns: not significant

Table 3: The correlation of specific gravity with various color measurements (L,a,b,E) of commercial broiler breeder eggs obtained from three age groups (Trial 1)

	Age (wks)		
	30	40	50
L	-0.26**	-0.42**	-0.28**
a	0.26**	0.22**	0.38**
b	0.07**	0.08**	0.28**
E	-0.27**	-0.44**	-0.27**

**: highly significant (P<0.01)

Table 4: The means of various color measurements (L, a, b, E) and specific gravity (SG) of eggs from two commercial broiler breeder strain crosses (Trial 1)

	Strain		
	Hubbard X Avian	Ross X Avian	P > F
L	67.98±0.10 B	72.29±0.12 A	0.0001
a	6.71±0.05 A	5.30±0.05 B	0.0001
b	14.45±0.04 A	13.60±0.05 B	0.0001
E	69.93±0.09 B	73.86±0.11 A	0.0001
SG	1.0803±0.0001 A	1.0739±0.0001 B	0.0001

A, B means within a row with different letters are significantly different (P<0.05).

Table 5: The means of various color measurements (L,a,b,E) and specific gravity (SG) of eggs obtained from three age groups of commercial broiler breeders (Trial 1)

	Age (wks)			
	30	40	50	P > F
L	72.31±0.15 A	68.84±0.15 B	69.16±0.13 B	0.0001
a	5.96±0.06 A	6.11±0.06 A	5.96±0.06 A	0.08
b	14.02±0.05 AB	13.91±0.06 A	14.17±0.06 B	0.0001
E	73.99±0.13 A	70.61±0.13 C	70.96±0.11 B	0.0001
SG	1.0777±0.0002 A	1.0775±0.0002 A	1.0764±0.0002 B	0.0001

A, B, C means within a row with different letters are significantly different (P<0.05).

Table 6: The correlation of shell thickness with various color measurements (L,a,b,E) and specific gravity (SG) of eggs from a commercial broiler breeder flock (Trial 2)

	Shell Thickness
L	-0.14**
a	0.17**
b	0.08*
E	-0.15**
SG	0.76**

** - highly significant (P<0.01), * - significant (P<0.05)

SG and b in several group suggests that the level of red to green and yellow to blue in the eggshell may not be as influential in the determination of total color as the degree of white to black. A highly significant difference (P<0.01) was found between strains for the means of all four color measurements and SG (Table 4). The HXA group had significantly lower L and E and higher SG than the RXA group (Table 4). This agrees with the idea that darker eggs have better shell quality as well as the finding of Joseph *et al.* (1999), who found that strain had a significant effect on shell color and shell quality.

There were highly significant differences (P<0.01) in color indices, except for in the *a* measurement and SG when compared between age groups (Table 5). The *L* value was significantly higher at 30 weeks than 40 or 50 weeks, which where not different from one another (Table 5). These data agree with those reported by Odabasi *et al.* (2007). E was significantly different for each age group (Table 5). The SG was significantly lower in the 50 week age group than the two younger age groups, which agrees with several workers who found that eggshell quality declined as the age of the hen increases (Pfost, 1960; Roland *et al.*, 1975; Nys, 1986). In Trial 2, eggshell thickness was found to be significantly, but lowly, correlated to all color measurements and highly correlated to SG (Table 6). These findings agree with Olsson (1934) and Holder and Bradford (1979) that egg specific gravity increases as shell thickness increases. The increased thickness of darker eggs may be due to a possible relationship between the processes of eggshell pigmentation and eggshell calcification, with great pigment deposition leading to greater deposition of calcium. It was determined from these data that eggshell color is significantly but lowly correlated to SG. L is the most similar color index to total color, E. Eggshell color is significantly affected by age and strain. It was also determined that shell thickness is not better correlated to eggshell color than egg SG. Therefore, it can be concluded that eggshell color alone would not be a sufficient estimator of eggshell quality. However, eggshell color could possibly be used in conjunction with SG in order to provide a more accurate estimator of eggshell quality.

References

Axelsson, J., 1932. Variation and heredity of some characters in White Leghorns, Rhode Island Reds and Barnvelders. Part I. Lunds Univ. Arsskr. N.R. Aud 2 Med. Mat. Dch. Naturvet, 28: 1-196.

Bennett, C.D., 1992. The Influence of Shell Thickness on Hatchability in Commercial Broiler Breeder Flocks. J. Appl. Poult. Res., 1: 61-65.

Coleman, M.A. and G.R. Mc Daniel, 1975. The effect of light and specific gravity on embryo weight and embryonic mortality. Poult. Sci., 54: 1415-1421.

Godfrey, G.F. and R.G. Jaap, 1949. The relationship of specific gravity, 14-day incubation weight loss and egg shell color to hatchability and egg shell quality. Poult. Sci. 28: 874-889.

Grover, R.M., D.L. Anderson and R.A. Damon, Jr., 1980. The correlation between egg shell color and specific gravity as a measure of shell strength. Poult. Sci., 59: 1335-1336.

Holder, D.P. and M.V. Bradford, 1979. Relationship of specific gravity of chicken eggs to number of cracked eggs observed and percent shell. Poult. Sci., 58: 250-251.

Joseph, N.S., N.A. Robinson, R.A. Renema and F.E. Robinson, 1999. Shell quality and color variation in broiler breeder eggs. J. Appl. Poult. Res., 8: 70-74.

Kell, G.S., 1975. Density, thermal expansivity, and compressibility of liquid water from 0°C to 150°C: Correlations and tables for atmospheric pressure and saturation reviewed and expressed on 1968 temperature scale. J. Chem. Eng. Data, 20: 97-105.

Obadasi, A.Z., R.D. Miles, M.O. Balaban and K.M. Portier, 2007. Changes in Brown Eggshell Color as the Hen Ages. Poult. Sci., 86: 356-363.

Olsson, N., 1934. Studies on specific gravity of hen's eggs. A new method for determining the percentage of shell on hen's eggs. Otto Harrassowitz, Leipzig.

McDaniel, G.R., D.A. Roland, Sr. and M.A. Coleman, 1979. The Effect of Egg Shell Quality on Hatchability and Embryonic Mortality. Poult. Sci., 58: 10-13.

McNally, E.H., 1965. The relationship of egg shell weight to cracked eggs. Poult. Sci., 44: 1513-1518.

Moyle, J.R., D.E. Yoho, R.S. Harper, A.D. Swaffar, R.K. Branwell and D.J. Elfick, 2008. Egg shell color, specific gravity and hatchability in eggs from broiler breeders. Poult. Sci., 7 (In press).

Mussehl, F.E. and D.L. Halbersleben, 1923. Influence of the specific gravity of hen's egg on fertility, hatching power and growth of chicks. J. Agric. Res., 23: 717-720.

Nys, Y., 1986. Relationships between age, shell quality and individual rate and duration of shell formation in domestic hens. Br. Poult. Sci., 27: 253-259.

Pfost, R.E., 1960. Decline of interior egg quality as affected by season of the year and the age of the hen. Poult. Sci., 39: 1284 (abst).

Roland, D.A., Sr., D.R. Sloan and R.H. Harms, 1975. The ability of hens to maintain calcium deposition in the eggshell and egg yolk as the hen ages. Poult. Sci., 54: 1720-1723.

SAS Institute, 1993. SAS® Applications Guide, 1993 ed. SAS Institute Inc., Cary, NC.