

## THE RELATIONSHIP BETWEEN EGGSHELL COLOUR AND EGG QUALITY TRAITS IN TABLE EGGS

Ali Aygun

Department of Animal Science,  
Faculty of Agriculture, Selcuk University, 42075, Konya, Turkey.

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### ABSTRACT

**Variations in egg quality and yolk colour in relation to eggshell colour in commercial brown layer eggs were studied using 734 eggs. The traits of interest were eggshell colour, yolk colour, egg weight, Haugh unit value and shell strength. The results showed that egg weight and shell strength increased as the darkness of the shell increased, whereas the Haugh score decreased. A highly significant positive correlation was found between yolk a\* (redness) and yolk colour (DSM) (0.655) ( $p < 0.001$ ) and could be used to indicate the darkness of the egg yolk. No correlation was observed between shell colour and egg yolk colour. The shell L\* (lightness) value could be used to measure the dark or light colour of the eggshell and could possibly be accepted as a colour criterion for eggshells. Some egg quality traits varied with the colour of the eggshell.**

**Key words:** Egg quality, Haugh unit, Shell colour, Shell strength, Yolk colour.

### INTRODUCTION

The intensity of eggshell pigment varies substantially (Romanoff and Romanoff, 1949; Shafey *et al.*, 2001). The three chief colour pigments in the eggshell are biliverdin-IX, zinc biliverdin chelate and protoporphyrin-IX (Kennedy and Vevers, 1976). Brown-shelled eggs contain relatively large amounts of protoporphyrin-IX and relatively small amounts of biliverdin-IX (Kennedy and Vevers, 1976; Schwartz *et al.*, 1980; Wang *et al.*, 2009).

Consumer preferences for shell colour vary worldwide. Consumers in Italy, the UK, Portugal and Ireland buy only brown eggs. However, almost equal numbers of brown and white eggs are sold in the markets of Germany, Holland and Spain (Arthur and O'sullivan, 2005). The relative proportions of brown eggs sold vary in China and South Korea (approximately 80%) and in Puerto Rico (nearly 100%) (Hooge, 2007).

The colour of the eggshell is determined by stress, by the age of the hen and by disease. Odabasi *et al.*, (2007) showed that the tendency of hens to lay eggs with coloured shells increased as the flock aged, as indicated by an increase in the lightness (L\*) values over time. Previous studies showed that eggs with darker eggshells had a higher specific

gravity (Godfrey and Jaap, 1949; Grower *et al.*, 1980; Ingram *et al.*, 2008). Joseph *et al.*, (1999) reported that strain had a greater influence on shell colour variation than feed and that shell colour in broiler breeder eggs was correlated with specific gravity and relative shell weight.

The purpose of this study was to evaluate variations in egg quality and yolk colour in relation to variations in eggshell colour in commercial brown laying eggs.

### MATERIALS AND METHODS

A total of 734 eggs (unwashed, feces-free) were obtained from H&N Brown Nick hens (60 weeks of age) in the Research and Application Farm at the Faculty of Agriculture at Selcuk University Konya. The hens were housed three per cage (800 cm<sup>2</sup>/hen) and fed a layer ration (Table 1). Feed and water were provided *ad libitum*. All eggs were collected over a 24-h period. Prior to the measurement of egg quality, the eggs were stored for 1 day at room temperature (20± 2 °C).

Colour measurement was performed using a Minolta Chroma Meter CR-400 (Minolta, Osaka, Japan). The L\*, a\* and b\* colour measurements were determined according to the CIELab colour space system, where L\* corresponds to dark/light

chromaticity (measured on a scale of 0 %, dark, to 100%, light),  $a^*$  to green/red chromaticity (on a scale of -60 %, green, to 60 %, red) and  $b^*$  to blue/yellow chromaticity (on a scale of -60 %, blue, to 60 %, yellow). The instrument was calibrated with a white reference tile ( $L^* = 97.10$ ,  $a^* = -4.88$ ,  $b^* = 7.04$ ) before the measurements were made (Francis, 1998). The eggshell colour was measured at the large pole of the egg.

Egg weight was measured using an electronic digital balance and was recorded to the nearest 0.01 g. Specific gravity was estimated by Archimedes' method (Wells, 1968). The height of the albumen and yolk colour (1 - 15 according to the DSM (formerly Roche) yolk colour fan) was measured using an Egg Analyzer (05-UM-001, Version B, Orka Food Tech. Ltd.). Shell strength (kg) was measured with an Egg Force Reader (06-UM-001, Version B, Orka Food Tech. Ltd.). The Haugh unit value was calculated from albumen height and egg weight using the Equation (1):

$$\text{Haugh Unit} = 100 \log (H + 7.57 - 1.7W^{0.37}) \quad (1)$$

where,  $H$  is the albumen height (mm) and  $W$  is the weight of the egg (g) (Haugh, 1937).

**Statistical analyses** Before statistical analysis, the data were checked for normality and were found not to be normally distributed. Furthermore, data transformation was not helpful. Therefore, Spearman's rank correlation was used to analyze the relationships between phenotypes. All analyses were performed using Genstat (Payne *et al.*, 2003).

## RESULTS AND DISCUSSION

The Spearman rank correlations between shell  $L^*$ , shell  $a^*$ , shell  $b^*$ , yolk  $L^*$ , yolk  $a^*$ , yolk  $b^*$  and yolk colour are shown in Table 2. The Spearman rank correlations of shell  $L^*$  with shell  $a^*$  and shell  $b^*$  were negative ( $r = -0.852$  and  $-0.261$ , respectively;  $p < 0.001$ ). Similarly, Odabasi *et al.*, (2007) found a significant ( $p < 0.05$ ) negative correlation between shell  $L^*$  and shell  $a^*$ , between shell  $L^*$  and shell  $b^*$  ( $r = -0.92$  and  $-0.19$ , respectively). This indicated that the lighter the shell colour (higher  $L^*$ ), the less redness of shell colour. Aygun (2013) stated that the shell  $L^*$  value might be used to express whether the colour of the eggshell was dark or light and could be considered as a discriminative colour criterion: more the shell  $L^*$  value decreases, more darker is the egg shell colour.

The Spearman rank correlation of shell  $L^*$  with yolk  $L^*$  was positive ( $r = 0.198$ ,  $p < 0.001$ ). These results indicate that eggs with lighter shells had lighter yolk colour. However, shell  $L^*$  was not correlated with yolk  $a^*$ , yolk  $b^*$  or yolk colour. The result of this study was consistent with the results of Yang *et al.* (2009), who found no significant correlation between shell colour and yolk colour.

Significant ( $p < 0.001$ ) positive correlations were found between shell  $a^*$  and shell  $b^*$  ( $r = 0.409$ ). This finding is similar to results reported by Odabasi *et al.*, (2007) who stated that there was significant ( $p < 0.05$ ) positive correlation between shell  $a^*$  and shell  $b^*$  ( $r = 0.41$ ).

Negative correlations were found between shell  $a^*$  and yolk  $a^*$  ( $r = -0.133$ ,  $p < 0.001$ ). Significant ( $p < 0.001$ ) negative correlations were found between yolk  $L^*$  and yolk  $a^*$  and between yolk  $L^*$  and yolk colour ( $r = -0.508$  and  $-0.300$ , respectively). However, a significant ( $p < 0.001$ )

TABLE 1: Composition of the diet

Item (g kg <sup>-1</sup> unless noted)	Amount
<b>Ingredient</b>	
Corn, yellow	537.0
Barley	100.0
Soybean meal, 48%	183.0
Sunflower meal, 31%	40.0
Vegetable oil	33.0
Limestone	82.5
Dicalcium phosphate	16.5
Salt	3.5
Vitamin premix <sup>1</sup>	1.5
Mineral premix <sup>2</sup>	1.0
Lysine	0.2
Methionine	1.8
Total	1000
<b>Calculated value</b>	
CP	160.0
ME (kcal kg <sup>-1</sup> )	2799.0
Ca	36.0
Available P	4.2
Lysine	7.6
Methionine	4.1
Methionine + cystine	7.2
<sup>1</sup> Vitamin premix supplied kg <sup>-1</sup> diet: Vitamin A, 8 000 IU; vitamin D3, 2 200 IU; vitamin E, 13 IU; vitamin K3, 3 mg; vitamin B1, 2 mg; vitamin B2, 5 mg; vitamin B6, 3 mg; vitamin C, 50 mg; calcium D-pantothenate, 7 mg; nicotine acid, 17 mg; D-biotin, 0.3 mg; folic acid, 0.67 mg; vitamin B12, 10 mg.	
<sup>2</sup> Mineral premix supplied kg <sup>-1</sup> diet: Copper, 5 mg; iron, 60 mg; manganese, 100 mg; zinc, 60 mg; selenium, 0.15 mg; cobalt, 0.50 mg; choline, 125 mg.	

TABLE 2: Phenotypic correlations between eggshell and egg yolk colour

	Shell a*	Shell b*	Yolk L*	Yolk a*	Yolk b*	Yolk Colour (DSM) <sup>1</sup>
Shell L*	-0.852***	-0.261***	0.198***	0.051 <sup>NS</sup>	-0.044 <sup>NS</sup>	-0.037 <sup>NS</sup>
Shell a*		0.409***	-0.116**	-0.133***	0.030 <sup>NS</sup>	0.036 <sup>NS</sup>
Shell b*			0.082*	-0.122***	0.066 <sup>NS</sup>	0.045 <sup>NS</sup>
Yolk L*				-0.508***	0.444***	-0.300***
Yolk a*					-0.186***	0.655***
Yolk b*						-0.005 <sup>NS</sup>

<sup>1</sup>DSM yolk colour fan, \* Significant at  $p < 0.05$ , \*\* Significant at  $p < 0.01$ , \*\*\* Significant at  $p < 0.001$ , <sup>NS</sup> Not significant

positive correlation was found between yolk colour (DSM) and yolk a\* ( $r = 0.655$ ). The yolk a\* value tends to indicate a dark yolk colour. Higher values of yolk a\* correspond to darker yolks.

The Spearman rank correlation coefficients between shell L\*, shell a\*, shell b\*, yolk L\*, yolk a\*, yolk b\*, yolk colour and selected egg quality traits are shown in Table 3. Negative correlations were found between shell L\* and egg weight ( $r = -0.132$ ,  $p < 0.001$ ), whereas a positive relationship was observed between shell L\* and Haugh unit ( $r = 0.127$ ,  $p < 0.001$ ). Negative correlations were found between shell L\* and specific gravity and between shell L\* and shell strength ( $r = -0.286$  and  $-0.299$ , respectively;  $p < 0.001$ ). The results of present study for shell colour and shell strength agreed with the findings of Yang *et al.* (2009) ( $r = -0.262$ ,  $p < 0.05$ ), whereas these authors found no significant correlation between shell colour and the Haugh unit value ( $0.191$ ,  $p > 0.05$ ). However, the results of present study disagree with the findings of Zita *et al.* (2009), who reported no significant correlation between shell colour and shell strength ( $r = -0.026$ ,  $p > 0.05$ ). Ingram *et al.* (2008) reported a significant negative correlation between shell L\* and specific gravity in 50-wk-old commercial broiler breeders. Similarly, Joseph *et al.* (1999) found a significant negative correlation between specific gravity and shell colour ( $r = -0.236$ ). In contrast, Campo and Escudero (1984) reported a significant positive

correlation coefficient between eggshell colour and specific gravity ( $r = 0.250$ ).

Positive correlations were found between shell a\* and egg weight, specific gravity ( $r = 0.190$  and  $0.190$ ,  $p < 0.001$ , respectively). Also moderate positive correlation was found between shell a\* and shell strength ( $r = 0.297$ ,  $p < 0.001$ ). This finding indicates that eggs with redness (higher a\*) shells had higher values of shell strength. No significant correlation was observed between egg weight and yolk L\*, yolk b\*, yolk colour (DSM). Sekeroglu and Altuntas (2009) reported no significant correlation between egg weight and yolk colour in extra-large eggs (average weight 64.17 g).

The correlation coefficients among egg weight, specific gravity, shell strength and Haugh unit value are shown in Table 4. Negative correlation ( $r = -0.148$ ) was found between egg weight and specific gravity. This finding is similar to results reported by other researchers (Durmus, 2006; Aygun and Yetisir 2010). However, Frank *et al.*, (1964) reported that there was no significant correlation between egg weight and specific gravity. It was observed that a moderate positive correlation ( $r = 0.585$ ) between specific gravity and shell strength. Godfrey (1949) found a correlation coefficient of 0.748 between specific gravity and breaking strength. It is generally accepted that the specific gravity of an egg is a sufficient estimator of eggshell quality (Ingram *et al.*, 2008). Higher specific

TABLE 3: Phenotypic correlations among eggshell colour, yolk colour and egg quality characteristics

	Egg weight	Specific gravity	Shell strength	Haugh Unit
Shell L*	-0.132***	-0.286***	-0.299***	0.127***
Shell a*	0.190***	0.190***	0.297***	-0.117*
Shell b*	0.032 <sup>NS</sup>	0.118**	0.174***	-0.084*
Yolk L*	-0.046 <sup>NS</sup>	0.045 <sup>NS</sup>	0.028 <sup>NS</sup>	-0.064 <sup>NS</sup>
Yolk a*	-0.132***	0.005 <sup>NS</sup>	-0.029 <sup>NS</sup>	0.152***
Yolk b*	-0.064 <sup>NS</sup>	0.132***	0.066 <sup>NS</sup>	-0.006 <sup>NS</sup>
Yolk colour (DSM)	0.062 <sup>NS</sup>	0.082*	0.052 <sup>NS</sup>	0.072*

\* Significant at  $p < 0.05$ , \*\* Significant at  $p < 0.01$ , \*\*\* Significant at  $p < 0.001$ , <sup>NS</sup> Not significant

TABLE 4: Phenotypic correlations among egg weight, specific gravity and shell strength

	Specific gravity	Haugh Unit	Shell strength
Egg weight	-0.148***	-0.018 <sup>NS</sup>	-0.038 <sup>NS</sup>
Specific gravity		-0.024 <sup>NS</sup>	0.585***
Haugh Unit			-0.150***

\* Significant at  $p < 0.05$ , \*\* Significant at  $p < 0.01$

\*\*\* Significant at  $p < 0.001$ , <sup>NS</sup> Not significant

gravity values were related to thicker eggshells, a desirable characteristic for the egg industry (De Ketelaere *et al.*, 2002; Keshavarz and Quimby 2002).

It was found in this study that a correlation ( $r = -0.150$ ,  $p < 0.001$ ) between the Haugh unit value and shell strength. No significant relationships were found between egg weight and the Haugh unit value or between egg weight and shell strength. The present findings were similar to the results reported by Aygun and Yetisir (2010), who found no significant correlation between egg weight and the Haugh unit value in molted brown laying hens. Consistent with the results of this study Kul and Seker (2004), Olawumi and Ogunlade (2008), Sekeroglu and Altuntas (2009) reported no significant relationship between egg weight and the Haugh unit value. Akbas *et al.*, (1996) and Zita *et al.*, (2009) reported negative correlations ( $r = -0.198$ ,  $-0.100$ , respectively) between egg weight and shell strength.

It was found that no significant correlation between specific gravity and the Haugh unit value. In contrast, Aygun and Yetisir (2010) reported a weak positive correlation between specific gravity

and the Haugh unit value ( $r = 0.113$ ) in molted brown laying hens ( $p < 0.01$ ).

## CONCLUSIONS

The shell L\* value could be used to measure the dark or light colour of the eggshell and could possibly be accepted as a colour criterion for eggshells. This result might be useful for scientists who wish to identify an easily applied method of classifying eggshell colour for their research.

Some egg quality traits vary with the colour of the eggshell. The classification of eggs according to eggshell colour may be commercially important.

If the eggshell L\* value decreases (i.e., darkness increases), the Haugh unit value also decreases, but the shell strength increases. If the egg producers reported the L\* value on egg cartons, consumers could easily predict the Haugh unit value and shell strength of the eggs sold in the market. Furthermore, these findings might offer important information to scientists interested in selection for high shell strength.

The yolk a\* value can be used to indicate the darkness of the egg yolk.

No significant correlation was observed between eggshell colour and yolk colour. The eggshell colour is not useful to consumers who wish to estimate the yolk colour without opening the egg.

The relationship between eggshell colour and egg cholesterol, other nutrients and the microbial load of the egg is a suggested topic for further research.

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