EGG QUALITY CHARACTERISTICS OF LOCALLY-ADAPTED TURKEY STRAINS IN A HUMID TROPICAL ENVIRONMENT

***Obike, O. M., Obi, O. C., Ezea, J., Nwachukwu, E. N. and Nwokorie, A. O.**
Department of Animal Breeding and Physiology, College of Animal Science and Animal Production, Michael Okpara University of Agriculture, Umudike, PMB 7267, Umuahia, Abia State, Nigeria.
*Corresponding author's email: uceemer@yahoo.com

Abstract
The objective of this study was to determine the effect of strain on egg quality characteristics of Nigerian local turkey strains. Three hundred and three eggs comprising 71 from Black, 109 from White and 123 from Spotted were evaluated. A random sample of 18 eggs from each strain was used to determine the internal quality traits. Data collected were subjected to analysis of variance procedure. The effect of strain was significant ($P<0.05$) for the traits, except egg shape index, shell thickness, shell ratio and the yolk traits. The Spotted strain had significantly ($P<0.05$) higher egg weight, egg length and egg width compared to the Black and White strains. The mean values for egg weight ranged from 56.50 to 71.00 for Black, 55.65 to 69.59 for White and 60.67 to 72.40 for Spotted. For egg length, mean values ranged from 59.38 to 63.17 for Black, 58.25 to 60.56 for White and 61.85 to 63.67 for Spotted, while those of egg width ranged from 40.78 to 44.99 for Black, 40.60 to 43.98 for White and 40.18 to 47.20 for Spotted. The Spotted strain had significantly ($P<0.05$) higher albumen weight, albumen height, albumen index and Haugh unit when compared to others. The significant effects are suggestive of the existence of genetic variation among the local strains.

Keywords: Egg quality, tropics, strain, turkey

Introduction

In Nigeria, three varieties of turkey characterized by plumage colour (Black, White and Spotted or Lavender) are predominant (Smith, 1990). These locally-adapted turkeys are good genetic resources for improvement of important economic traits such as production and reproduction performance traits which are the most important traits considered in poultry breeding. Productive and/or reproductive adaptability is a phenomenon where an animal gives acceptable level of production and/or reproduction in a stressed or local environment (Ibe, 1990). Haque *et al*. (2001) stated that effective selection and breeding is one of the bases of successful operation in the maintenance of a satisfactory level of production and reproduction. Nwachukwu *et al*. (2006) reported that an acceptable level of reproduction is highly desirable in poultry stock. One of such most important economic productive parameters in poultry is egg traits.

Egg quality refers to those characteristics of an egg which affects its acceptability to consumers (Song *et al*., 2000). It also indicates the reproductive fitness of the parent stock which has an overall significance for an economic breeding (Metin, 2007; Egahi *et al*., 2011). Therefore, evaluation of egg quality traits is important for both layer and breeder flocks.

Egg quality characteristics are affected by various factors including genetic profile, hen's age, feeding, health, housing, storage, etc (Salahuddin and Howlider, 1991; Hurnik *et al*., 1997). It has been reported that egg quality is a breed characteristic based on significant effect of genotype of layer chickens on egg quality traits (Suto *et al*., 1997). Olawumi and Ogunlade (2009) also reported significant breed effects for egg quality traits in some exotic breeds of chickens. A significant genotype effect on internal and external egg quality traits of chicken and turkey has been reported (Yasmeen *et al*., 2008; Isidahomen *et al*., 2014). Metin (2007) also noted that egg composition of the domestic fowl showed high variation due to species, hen's age and breeding environment. Danilov (2000) also noted that the proportion of yolk, albumen and shell that contributed to egg weight increased with hen's age. Roland (1979) observed that both internal and external characteristics of the egg changed significantly with age.

Some researchers have evaluated egg quality traits of the chicken (Padhi *et al*., 1998; Yasmeen *et al*., 2008; Olawumi and Ogunlade, 2009). However, the number of studies on assessment of egg quality parameters of other poultry species, including the local turkey strains in Nigeria, has remained scanty. Such a study will boost the characterization of the local strains for improvement purposes, since phenotypic variations aid in determining the relative genetic diversity in populations (Adejoro *et al*., 2010).

This study, therefore, was conducted to evaluate the egg quality characteristics of three local turkey strains in a humid rain-forest zone of Nigeria.

Materials and methods

Study area

This study was conducted at the Poultry Unit of the Teaching and Research Farm, Michael Okpara University of Agriculture, Umudike, Abia State lying on latitude 05° 29′ North, longitude 07° 33′ East and at an altitude of 122 m above sea level. It lies within the humid rain-forest zone of West

Africa. This area is characterized by short periods of dry season (November – March). Average rainfall is 2169.8 mm in 148 – 155 rain days. The ambient temperatures ranges from 27°C - 38°C during the dry season and18°C - 22°C during the rainy season (April – October). The day light and night (D: N) ratio is 12:12 hours. Relative humidity ranges from 50 – 95 % depending on the season of the year. This agro-ecological zone is aptly described as a warm-wet rain-forest environment. The meteorological data were obtained from the Meteorological Station of the National Root Crops Research Institute, Umudike, Abia State.

Experimental birds and their management

Forty-five breeding turkeys comprising of 36 hens and 9 toms aged 225 days were used for mating. Each strain had 12 hens mated to 3 toms. The strains – Black, White and Spotted had 71, 109 and 123 eggs, respectively collected over a period of 8 weeks.

Eighteen (18) freshly laid eggs were randomly sampled from each strain and used to evaluate the internal and shell quality traits. All birds were subjected to the same management practices throughout the experimental period. The birds reared on deep litter pens were fed *ad libitum* with a compounded layer ration containing 14 % CP and 2850 Kcal/kgME. Water was given freely. It was a Completely Randomized design experiment which had 3 replicates and a mating ratio of 1 tom: 3 hens for each strain.

The statistical model for the data is as specified below:

$Y_{ij} = \mu + S_i + e_{ij}$

where,

Y_{ij} = Single observation

μ = Overall mean

S_i = Effect of i^{th} strain

e_{ij} = Random error, independently, identically, normally distributed with zero mean and constant variance{(iind) $0,\sigma^2$}

Data collection and statistical analysis

Data were collected on egg weight taken with a 0.01 g electronic sensitive scale, egg length (longitudinal distance between the narrow and the broad ends), egg width (diameter of the widest cross-sectioned region), egg shape index (%), shell thickness (mm) and shell ratio (%). The internal egg quality traits measured were: yolk height (distance between the ends), yolk width, yolk index (%), albumen length (mm), albumen width (mm), albumen index (%) and Haugh unit.

Egg length and width, yolk height and width and albumen height and width were measured with a venier caliper sensitive to 0.01 mm. Shell thickness was determined as the average of 3 measurements taken at the pointed end, the equator and the broader end of each egg.

$$\text{Shell thickness (mm)} = \frac{point + equator + broad}{3}$$

Egg shape index, albumen index, yolk index and shell ratio were calculated as percentages.

$$\text{Egg shape index (\%)} = \frac{\text{Egg width}}{\text{Egg length}} \times 100$$

$$\text{Albumen index (\%)} = \frac{\text{Albumen height}}{\text{Albumen width}} \times 100$$

$$\text{Yolk index (\%)} = \frac{\text{Yolk height}}{\text{Yolk weight}} \times 100$$

$$\text{Shell ratio (\%)} = \frac{\text{Shell weight}}{\text{Egg weight}} \times 100$$

Haugh unit was computed as indicated below (Haugh, 1937)

$\text{Haugh unit} = 100 \log (H + 7.57 - 1.7\, W^{-37})$

where,

H = observed height of the albumen (mm)

W = weight of the egg (g)

All data collected were subjected to analysis of variance with the generalized linear model (GLM) of the Statistical Procedure of Social Sciences (2006). Significantly different means were separated using Duncan's New Multiple Range Test (Duncan, 1955).

Results

The least square means ± standard errors of mean of egg weight, egg length and egg width of the three local turkey strains from weeks 1 – 8 are presented in Tables 1, 2 and 3, respectively.

Significant ($P < 0.05$) strain effect was observed for these traits in the various weeks. The Spotted strain had significantly highest values for egg weight in all the weeks, except week 8 which had significantly similar value with the Black strain. Significant differences ($P < 0.05$) were noted in weeks 1, 2, 3, 7 and 8 for egg length, whereas for egg width significant differences were recorded in weeks 3, 5, 7 and 8. Again, the Spotted strain had significantly highest values compared to the other 2 strains except in weeks 8 where the values for the Spotted and the Black strain were statistically similar.

Table 1: Means (±SE) of egg weight (g) of the three local turkey strains (1 – 8 weeks)

	Strain		
Week	Black	White	Spotted
1	56.50 ± 2.20[b]	55.65 ± 0.87[b]	60.67 ± 1.69[a]
2	58.75 ± 1.31[b]	57.46 ± 2.80[b]	63.90 ± 1.06[a]
3	62.44 ± 0.73[b]	60.85 ± 1.52[b]	67.56 ± 1.30[a]
4	63.89 ± 1.30[b]	62.46 ± 1.56[b]	69.29 ± 0.78[a]
5	66.17 ± 1.92[b]	65.65 ± 0.95[b]	71.64 ± 1.51[a]
6	68.44 ± 0.73[b]	68.00 ± 0.62[b]	71.78 ± 1.26[a]
7	69.85 ± 1.52[b]	69.56 ± 1.02[b]	72.13 ± 0.87[a]
8	71.00 ± 2.20[a]	69.59 ± 0.88[b]	72.40 ± 1.48[a]

[a-b] Means with different superscripts in the same row are significantly different (P =.05).
SE = standard error of mean

Table 2: Means (±SE) of egg length (mm) of the three local turkey strains (1 – 8 weeks)

	Strain		
Week	Black	White	Spotted
1	59.38 ± 1.65[b]	58.25 ± 0.66[c]	61.85 ± 0.89[a]
2	61.00 ± 0.60[b]	60.83 ± 0.75[b]	62.40 ± 0.44[a]
3	61.13 ± 1.01[b]	60.85 ± 0.82[b]	62.47 ± 0.41[a]
4	61.92 ± 0.40[a]	61.58 ± 0.66[a]	62.76 ± 0.55[a]
5	62.16 ± 0.64[a]	62.15 ± 0.43[a]	62.83 ± 0.69[a]
6	62.43 ± 0.55[a]	62.15 ± 1.00[a]	63.06 ± 0.69[a]
7	62.58 ± 0.52[b]	61.92 ± 0.40[b]	63.58 ± 0.45[a]
8	63.17 ± 0.39[a]	60.56 ± 0.65[b]	63.67 ± 0.45[a]

[a-c] Means with different superscripts in the same row are significantly different (P =.05).
SE = standard error of mean

Least square means and standard errors of means for average egg shape index, egg shell and internal egg quality traits of the three local turkey strains are shown in Table 4. Significant ($P < 0.05$) strain effect was observed only for albumen width, albumen height, albumen index and
Haugh unit. The Haugh unit obtained in this study ranged between 93.03 ± 0.51 and 97.79 ± 0.38. The Spotted strain again recorded significantly ($P < 0.05$) highest values for these traits. Although no significant strain effect was observed, the Spotted strain still recorded numerically higher values for egg shape index, shell ratio, shell thickness, yolk width, yolk height and yolk index. The Spotted strain significantly ($P < 0.05$) had higher albumen width, albumen height, albumen index and Haugh unit compared to the Black and White strains.

Discussion

Effect of strain on external egg quality traits

The result of this study (Table 1) indicates significant difference ($P < 0.05$) of egg weight among the three strains in all the weeks. Egg weight variations in different genetic groups were reported by some authors (Padhi *et al*., 1998; Chatterjee *et al*., 2007; Isidahomen *et al*., 2014). Pandey *et al*. (1986) reported that egg weight is a direct proportion of the albumen, yolk and shell and that it varies significantly between strains of hen. In general, the egg of the Spotted strain weighed highest compared to those of the Black and White strains. The values recorded in this study compared favourably with values reported for local (65.85 ± 0.87) and crossbred (70.98 ± 0.92) turkeys (Isidahomen *et al*., 2014). However, the values were below 76.10 ± 1.71 and 85 g documented for Indian and exotic turkeys (Majood *et al*., 2004; Isidahomen *et al*., 2014), respectively.

Table 3: Means (±SE) of egg width (mm) of the three local turkey strains (1 – 8 weeks)

Strain			
Week			Spotted
	Black	White	
1	40.78 ± 0.43[a]	40.60 ± 0.67[a]	40.18 ± 0.32[a]
2	41.13 ± 0.43[a]	42.00 ± 0.56[a]	42.50 ± 0.26[a]
3	42.25 ± 0.21[b]	42.10 ± 0.33[b]	43.65 ± 0.37[a]
4	43.00 ± 0.49[a]	42.57 ± 0.26[a]	43.85 ± 0.33[a]
5	43.28 ± 0.40[b]	42.66 ± 0.33[b]	44.00 ± 0.36[a]
6	43.80 ± 0.44	42.90 ± 0.18	44.75 ± 0.22
7	44.37 ± 0.38[b]	43.99 ± 0.27[b]	45.19 ± 0.52[a]
8	44.99 ± 0.56[a]	43.98 ± 0.41[b]	47.20 ± 0.21[a]

[a-b] Means with different superscripts in the same row are significantly different (P =.05).
SE = standard error of mean

The effect of strain on egg length (Table 2) and egg width (Table 3) were also significantly (P < 0.05) from each other in some weeks. Genotypic differences with regard to egg length and egg width have been reported for chicken (Anderson *et al*., 2004) and turkey (Isidahomen *et al*., 2014). Egg length and width are important traits with respect to mechanical handling of eggs. The values of both traits noted in this study are slightly higher compared to reports of Anderson *et al*. (2004) for chicken (49.00 – 69.98 mm and 38.49 – 48.99 mm) and turkey (5. 85 – 6.27 cm and 4.04 – 4.32 cm) eggs, respectively.

Within the strains, the values of egg weight, length and width increased with increase in age (weeks). This is in agreement with the findings of Yannakopoulos and Tserveni (1986), Hurnik *et al*. (1997) and Fikret *et al*. (2010) who observed that egg weight increased significantly with quail, chicken and pheasant age.

Effect of strain on shape index, shell and internal egg quality characteristics

Egg shape index (%), shell ratio (%) and shell thickness (mm) did not vary significantly (P > 0.05) among the three strains. This result is in contrast with the work of Fikret *et al*. (2010) and Isidahomen *et al*. (2014) who reported significant differences for shape index and shell thickness in pheasants and turkeys, respectively. However, it agreed with the report of Obike *et al*. (2011) who observed no significant difference for egg shape index and shell thickness between the Black and Pearl strains of guinea fowl. Although not significantly different, the high values obtained for these traits may indicate high shell strength of eggs of the strains which could aid good hatchability and resistance to fracture. Hunto (1995) reported that the ability of eggs to resist fracture damage depends on shell structure and shape. In corroboration, shape index was reported to have a significant effect on the variation of crushing strength (Richards and Staley, 1967). Eggs of normal shape have been reported to hatch better than those that are abnormally shaped (Narushin and Romanov, 2002). Shell ratio values were 10.26 ± 0.31 (Spotted), 10.47 ± 0.37 (Black) and 10.51 ± 0.32 (White), which indicates high shell stiffness. These values are in line with the report (10.81 %) of Egahi *et al*. (2011). Abdallah *et al*. (1993) reported that shell ratio is a more sensitive estimate of shell quality traits. It was reported that percentage of shell is related to total egg weight, with larger eggs frequently having proportionately less shell (Metin, 2007).

Table 4: Means (±SE) of internal and shell egg quality traits of the three local turkey strains (1 – 8 weeks)

	Strain		
Trait	Black	White	Spotted
YW (mm)	42.69 ± 0.52[a]	42.23 ± 0.48[a]	43.47 ± 0.56[a]
YH (mm)	16.63 ± 0.49[a]	16.36 ± 0.54[a]	17.50 ± 0.39[a]
YI (%)	38.67 ± 1.22[a]	38.36 ± 1.24[a]	40.36 ± 0.93[a]
AW (mm)	87.28 ± 1.10[b]	82.96 ± 1.20[c]	92.19 ± 1.21[a]
AH (mm)	6.50 ± 0.11[b]	5.92 ± 0.14[b]	7.56 ± 0.15[a]
AI (%)	7.37 ± 0.19[b]	6.98 ± 0.17[b]	8.23 ± 0.92[a]
HU	94.89 ± 0.34[b]	93.03 ± 0.51[c]	97.79 ± 0.38[a]
ST (mm)	0.79 ± 0.11[a]	0.77 ± 0.01[a]	0.79 ± 0.01[a]
SR (%)	10.47 ± 0.37[a]	10.26 ± 0.31[a]	10.51 ± 0.32[a]
ESI (%)	70.76 ± 0.62[a]	70.04 ± 0.24[a]	71.38 ± 0.79[a]

[a-c] Means with different superscripts in the same row are significantly different (P =.05).
SE = standard error of mean.
YW = yolk width, YH = yolk height, YI = yolk index, AW = albumen weight, AH = albumen height, AI = albumen index, HU = haugh unit, ST = shell thickness, SR = shell ratio, ESI = egg shape index.

Yolk parameters (height, width and index) did not also differ significantly ($P > 0.05$) among the strains. This is similar to the observations of Obike *et al*. (2011) and Hayirhi *et al*. (2005) but disagrees with that of Isidahomen *et al*. (2014). The yolk index values obtained in this study fell within the standard range of 33.0 – 50.0 mm reported for fresh eggs (Ihekoronye and Ngoddy, 1985). It then implies that the eggs of these strains could have appreciable hatchability since yolk index determines an egg's freshness and large index makes for good hatchability.

It has been reported that a Haugh unit of 90 and above is considered excellent depending on the breed type (USDA, 2012). The result of this study is in line with the report of Wang *et al*. (2009) who noted mean value range of 99.15 – 102.64 for chicken eggs. Fikret *et al*. (2010) gave values of 95.27 and 90.38 for one and two year old pheasant eggs. The higher value is an indication of eggs with better albumen quality (North, 1984).

Conclusion

The significant strain effect noted for egg weight, egg length, egg width, albumen weight, albumen height, albumen index and Haugh unit is indicative of the existence of genetic variations among the local turkey types. With regard to these significant traits mentioned, the Spotted strain had statistically highest values except in week 8 for egg weight, egg length and egg width where it compared favorably with the Black strain. The Spotted strain also had higher numerical values for the non-significant traits – egg shape index, shell ratio, shell thickness, yolk weight, yolk height and yolk index, when compared to Black and White strains. The implication is that the Spotted strain may be best suited for improvement of egg quality traits of local turkeys in the study zone.

Acknowledgement

The authors are grateful to Michael Okpara University of Agriculture, Umudike for providing facilities for the study.

References

Abdallah, A.G., Harms, R.H. and Husseiny, E.L. (1993). Various methods of measuring shell quality in relation to percentage of cracked eggs. Poult. Sci. 72: 2038 - 2043.

Adejoro, F.A., Salako, A.E. and Ogundere, A.A. (2010). Phenotypic characterization of the Balami sheep of Nigeria. In: Proceeding 15th Animal Science Association of Nigeria conference, Akpan, I.P. and Ebeso, I.E. (eds.), Uyo, Nigeria, pp. 10 - 12.

Anderson, K.E., Curtis, P.A. and Jones, F.T. (2004). Shell characteristics of egg from historic strains of single comb White Leghorn chicken and relationship of egg shape with shell strength. Poult. Sci. 3: 17 - 18.

Chatterjee, R.N., Rai, R.B., Kundu, A., Senani, S. and Sundar, J. (2007). Egg quality traits in indigenous breeds of chicken of Andaman. Indian Vet. J. 84: 206 - 208.

Danilov, R.V. (2000). Effect of hens' age on quality of hatching eggs and embryonic development. In: Proceeding 21st World Poultry Congress, Montreal, Canada.

Duncan, B.E. (1955). Multiple ranges and multiple F-test. Biometrics. 11: 1 – 42.

Egahi, J.O., Loyue, E.T. and Dim, N.T. (2011). Effect of age on egg quality characteristics of Lohmen Brown layers in Makurdi. In: Proceeding 36th Nigerian Society for Animal Production conference, Adeniji, A.A., Olatunji, E.A. and Gana, E.S. (eds.), Abuja, Nigeria, pp. 59 - 60.

Fikret, E., Orhan, O. and Feride, G. (2010). The effect of age on egg production, hatchability and egg quality characteristics in Pheasant (*Phasianus colchicus*). J. Anim. Vet. Adv. 9: 1237 - 1241.

Haque, M.N., Islam, A.B.M.N., Bhuiyan, A.K.F.H., Aziz, S.A. and Kibria, M.G. (2001). Phenotypic variation and repeatability of semen characteristics of bull. Pakist. J. Biol. Sci. 4: 1418 - 1420.

Haugh, R.R. (1937). The haugh unit for measuring egg quality. United States Egg Poult. Mag. 43: 552 – 555, 572 – 573.

Hayirhi, N., Esenbuga, M., Lacin, E., Karaoglu, M. and Yildiz, L. (2005). Nutrition practice to alleviate the adverse effect of stress on laying performance, metabolic profile and egg quality in peak producing hens. Asian J. Anim. Sci. 18: 13 - 19.

Hunto, P. (1995). Understanding the architecture of the egg shell. World's Poult. Sci. J. 51: 141 - 147.

Hurnik, J.F., Summer, J.D., Reinhard, B.S. and Sweirczewks, A. (1997). Effect of age in the performance of laying hens during the first year of production. Poult. Sci. 226 - 228.

Ibe, S.N. 1990. Utilizing local poultry genetic resources in Nigeria. In: Proceeding 4th World congress on genetics applied to livestock production, Hill, W.G., Thompson, R. and Woolliams, J. (eds.), Edinburgh, Scotland.

Ihekoronye, A.I. and Ngoddy, P.O. (1985). Integrated food science and technology for the tropics. Macmillian Publishers, Nigeria.

Isidahomen, C.E., Njidda, A.A. and Adeniji, A.A. (2014). The effects of genotype on internal

and external egg quality traits, egg proximate composition and lipid profile characteristics of three strains of layer turkeys. Inter. J. Agri. Biosci. 3: 65-69.

Metin, S. (2007). Heritability of exterior egg quality traits in Japanese quail. J. Appl. Biol. Sci. 1: 37 - 40.

Majood, A., Rajeshwara Rao, M.V., Mashesh, P.S., Ravikumar, K., Sayeed, A. and Nallappa, P. (2004). Turkey farming – Indian Development Gataway. Central Poultry Development, Hesserghatta, Bungalore. Http://www.cpdosrbng.karnicin

Narushin, V.G. and Romanov, M.N. 2002. Egg physical characteristics and hachability. World's Poult. Sci. J. 58: 297 - 303.

North, O.M. (1984). Commercial chicken production manual 3rd edition AVT Publishing company, California. P: 291.

Nwachukwu, E.N., Ibe, S.N., Ejekwu, K. and Oke, U.K. (2006). Evaluation of the growth parameters of main and reciprocal normal, naked neck and frizzle chicken in a humid tropical environment. J. Anim. Vet. Adv. 5: 542 - 546.

Obike, O.M, Oke, U.K. and Azu, K.E. (2011). Comparison of egg production performance and egg quality traits of Pearl and Black strains of Guinea fowl in a humid rain-forest zone of Nigeria. Inter. J. Poult. Sci. 10: 547 - 551.

Olawumi, S.O. and Ogunlade, J.T. (2009). The effect of genotype and age of layer breeders on egg quality traits. Nig. J. Anim. Prod. 38: 228 - 236.

Oluyemi, J.A. and Roberts, F.A. (2000). Poultry Production in warm – wet climate. Spectrum Books Ltd., Ibadan, Nigeria.

Padhi, M.K., Rai, R.B., Senani, S. and Saha, S.K. (1998). Assessment of egg quality characteristics in White Leghorn layers. Indian J. Poult. Sci. 33: 113 - 115.

Pandey, N.K., Mahapalra, C.M., Verma, S.S. and Johari, D.C. (1986). Effect of strain on physical egg quality characteristics of White Leghorn chicken. J. Poult. Sci. 21: 304 - 307.

Richards, J.F., and Staley, L.M. (1967). The relationship between crushing strength, deformation and other physical measurements of the hen's egg. Poult. Sci. 46: 430 - 437.

Roland, D.A. (1979). Factors influencing shell quality of aging hens. Poult. Sci. 58: 774 - 777.

Salahuddin, M. and Howlider, MA. (1991). Effect of breed and season on egg quality traits of fowl. J. Anim. Sci. 61: 859 - 863.

Smith, A.J. (1990). Poultry. The Tropical Agriculturist. CTA, Macmillan.

Song, K.T., Choi, S.H. and Ho, H.R. (2000). A comparison of egg quality of Pheasant, Chuker, Quail and Guinea fowl. Asian-Austr. J. Anim. Sci. 13: 986 - 990.

Social procedure for social sciences and facilities for release (2006). Version 15.0, Mcgraw-Hill Book Company, New York.

Suto, P., Horn, P. and Ujvari, J. (1997). The effect of different housing systems on production and egg quality traits of brown and white leghorn layers. Acta Agraria Kaposv. 1: 29 - 35.

United States Department of Agriculture (2012). Standard grades and weight classes for shell egg values of turkey. 8th edition, Clay Irving, Panixcom, Manhattan Beach, CA, USA.

Wang, K.H., Doui, T.C. and Yangz, H.M. (2009). Haugh unit of high value. Int. J. Agric. Biol. 14: 235 - 240.

Yannakopoulos, A.L. and Tserveni-Gousi, A.S. (1986). Quality characteristics of quail eggs. Br. Poult. Sci. 27: 171 - 176.

Yasmeen, F., Mahmood, S., Hassan, M., Akhtar, N. and Yaseen, M. (2008). Comparative productive performance and egg quality characteristics of pullets and spent layers. Pakist. Vet. J. 28: 5 - 8.