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RESEARCH ARTICLE

Determination of Phenotypic Correlations Between Internal and External Quality Traits of Guinea Fowl Eggs

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Summary

In this study, it was aimed to determine the internal and external quality traits of the Guinea fowl eggs as well as the phenotypic correlation among the these traits. Totally 100 Guinea fowl eggs were collected in three sequential days were used for this study. The birds were housed at Poultry Research Unit of the Department of Animal Science, Faculty of Agriculture, University of Akdeniz. Values of egg weight, egg length, egg width, eggshape index, eggshell weight, eggshell ratio, eggshell thickness, eggshell surface area, unit surface area and egg volume were determined as 40.14 g, 49.47 mm, 37.89 mm, 0.76%, 6.48 g, 16%, 0.54 mm, 65.69 cm^2, 0.11 g/cm^2 and 38.21 cm^3, respectively. In addition, values of yolk weight, yolk height, yolk width, yolk index, yolk ratio, albumen height, albumen width, albumen length, albumen weight, albumen index, yolk/albumen ratio and haugh unit were found as 13.58 g, 14.99 mm, 40.64 mm, 37%, 33%, 4.77 mm, 62.97 mm, 80.07 mm, 21.62 g, 6.7%, 68% and 74.97%, respectively. According to the results determined in this study, all most all external quality traits of the egg were changed at the significant levels depending on the change occurred in the egg weight. The results indicated that egg weight influences external egg quality traits of quinea fowl. The positive correlations obtained among the egg quality traits indicated that they can be improved phenotypically through selection.

Keywords: *Guinea fowl, Egg weight, Egg quality, Phenotypic correlation*

Beç Tavuğu Yumurtalarında İç ve Dış Kalite Özellikleri Arasındaki Fenotipik Korelasyonların Belirlenmesi

Özet

Bu çalışmada Beç tavuğu yumurtalarında iç ve dış kalite özellikleri ile bu özellikler arasındaki fenotipik korelasyonların belirlenmesi amaçlanmıştır. Bu amaçla toplam 100 adet Beç tavuğu yumurtası kullanılmıştır. Araştırma Akdeniz Üniversitesi Ziraat Fakültesi Zootekni Bölümü Hayvancılık Birimi'inde yürütülmüştür. Yumurta ağırlığı, yumurta uzunluğu, yumurta eni, şekil indeksi, kabuk ağırlığı, kabuk oranı, kabuk kalınlığı, kabuk yüzey alanı, birim yüzey alanı ve yumurta hacmi sırasıyla 40.14 g, 49.47 mm, 37.89 mm, %0.76, 6.48 g, %16, 0.54 mm, 65.69 cm^2, 0.11 g/cm^2 ve 38.21 cm^3 olarak bulunmuştur. Ayrıca, sarı ağırlığı, sarı yüksekliği, sarı genişliği, sarı indeksi, sarı oranı, ak yüksekliği, ak genişliği, ak uzunluğu, ak ağırlığı, ak indeksi, sarı/ak oranı ve haugh birimi de sırasıyla 13.58 g, 14.99 mm, 40.64 mm, %37, %33, 4.77 mm, 62.97 mm, 80.07 mm, 21.62 g, %6.7, %68 ve %74.97 olarak hesaplanmıştır. Yumurta ağırlığındaki değişmeye bağlı olarak yumurtanın dış kalite özellikleri önemli derecede değişmiş ve yumurta ağırlığı dış kalite özelliklerini etkilemiştir. Yumurta kalite özellikleri arasında ortaya çıkan önemli korelasyonlar bu özelliklerin fenotipik olarak seleksiyonla iyileştirilebileceğini göstermiştir.

Anahtar sözcükler: *Beç tavuğu, Yumurta ağırlığı, Yumurta kalitesi, Fenotipik korelasyon*

INTRODUCTION

Avian egg is not only a tool for reproduction but is also a valuable food source for human. Moreover, avian eggs are culturally accepted worldwide and are not submitted to any religious nor traditional interdiction. Nowadays, it is widely recognized that eggs are more than a source of nutrients, numerous studies describing biological properties potentially exploitable by pharmaceutical, food-processing and cosmetic industries [1,2]. The egg size and internal quality of eggs are important for both table and hatching eggs. The nutrient content and composition

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of an egg can thus greatly influence the development of the embryo contained within as well as its success as a hatchling. Variation in the composition of avian eggs occurs among species [3-6].

Eggs from species that are more precocial at hatching tend to have a higher proportion of yolk in the egg and a corresponding lower proportion of albumen, a composition which is perhaps necessary to ensure that eggs are provisioned with enough nutrients for the prolonged incubation and development of the embryos of precocial species [6]. The major constituent of albumen is water amounting to 88% of total weight. The most important trait of egg composition, linked to egg dry matter, is the yolk/albumen ratio [7-9]. Beside the yolk/albumen ratio, eggshell resistance to shocks is an economically primordial trait as it determines the ability of eggs to withstand transportation from producers to consumers [10]. Moreover, an intact eggshell is also necessary to impede bacterial invasions of eggs and to reduce food poisining risks [10,11]. In the future egg quality studies about egg yolk, albumen and eggshell quality will continue to increase. Parcularly, most of the studies will be investigated to reduce the cholesterol level in the egg yolk [12] and to increase the yolk/albumen ratio in the eggs [7]. Although the albumen is a major indicator of internal egg quality; air cell size, albumen and yolk quality and the presence of blood or meat spots in the eggs are the parameters, which determines the internal egg quality [13,14]. Egg yolk is still an important source for nutrients, and also used in non-food purposes like leather processing and a source of biologically active substances [15].

Chicken egg has been very well studied for its internal and external qualities as well as for its compositions, however such information are not so abundantly documented in other poultry species. So, this study are conducted to investigate egg quality traits and phenotypic correlations between internal and external quality traits of Guinea fowl eggs.

MATERIAL and METHODS

Totally 100 Guinea fowl eggs were randomly selected and evaluated in this study. The Guinea birds were housed at Research Unit of Animal Science Deparment, Faculty of Agriculture, Akdeniz University. Evaluated eggs were collected from the guinea fowl hens, reared in a floor system. The hens were at about 40 weeks of age. The birds were fed a diet containing 21% crude protein and 2.900 kcal/kg metabolic energy and provided with fresh water *ad libitum* during the laying period. In order to determine egg quality traits, eggs were stored at room temperature for 24 h before quality measurement. The eggs were numbered first and then measured with an electronic balance to the nearest 0.01 g. Subsequently, egg length and width were measured by slide calipers sensitive to 0.01 mm. After this process, the eggs were broken on a table with a glass cover in order to measure the yolk height, yolk diameter, albumen height, albumen length and albumen width by a 3-legged micrometer with an accuracy of 0.01 mm. Later on, the yolk was seperated from the albumen with the help of a spoon and weighed while the albumen weight was calculated by subtracting yolk weight and shell weight from the gross egg weight. The eggshells were washed under slightly flowing water so that the albumen remains were removed. The washed eggshells were left to dry in the open air for 24 h. Then, all eggshells were balanced together with the shell membrane. Finally eggshell samples were taken from sharp region, blunt region and equatorial parts of each egg were measured with micrometer with an accuracy of 0.01 mm, and the average eggshell thickness was obtained from the average values of these three parts [16]. The other quality traits were evaluated by methods described [17-21]. Data were subjected to analysis using SPSS 17.0 [22].

Shape Index (%)=100(Egg width/Egg height)*

*Shell Surface Area (cm^2)=3.9782*Egg weight$^{0.75056}$*

Unit Surface Shell Weight (g/cm^2)=Shell weight/Shell surface area

Shell Ratio (%)=100(Shell weight/Egg weight)*

Albumen Index (%)=100{Albumen height/[(Albumen length+Albumen width)/2]}*

Albumen Weight (g)=Egg weight-(Yolk weight+Shell weight)

Albumen Ratio (%)=100(Albumen weight/Egg weight)*

Yolk Index (%)=100(Yolk height/Yolk diameter)*

Yolk Ratio (%)=100(Yolk weight/Egg weight)*

Yolk/Albumen Ratio (%)=100(Yolk weight/Albumen weight)*

*Haugh Unit=100 log [Albumen height-(1.7*Egg weight$^{0.37}$)+7.57]*

*Egg Volume (cm^3)=[0.6057-(0.0018*Egg width)]*Egg length*(Egg width)^2*

RESULTS

Descriptive statistics of internal and external egg qualities and phenotypic correlations among the internal and external egg traits are presented in *Table 1, 2* and *3*, respectively. There was found significant correlations among the internal and external egg quality traits.

DISCUSSION

The egg weights were ranged from 34.03 g to 45.7 g and average egg weight was determined as 40.14±0.235g. The average egg weight determined in this study was similar to that found in studies carried out by Oke et al.[23,24]; Singh et al.[25]; Nahashon et al.[26,27]. But, the egg weight was found lower than those of reported by Tebesi et al.[28]; Dudusola [29];

Table 3. *The phenotypic correlations between internal and external quality traits of guinea fowl*
Tablo 3. *Beç tavuğu yumurtalarının iç ve dış kalite özellikleri arasındaki fenotipik korelasyonlar*

Traits	SW	YW	YH	YWDT	AH	AWDT	AL	EWDT	EL	ST	AI	SI	SI	SFA	SR	HU	EWL	AW	Y/A	YR	AR
EW	.658**	.569**	.292**	.329**	.243*	-.119	.082	.859**	.569**	.462**	.223*	.064	.311**	1.000**	.212*	.043	.890**	.201*	-.188	-.260*	.075
SW		.568**	.101	.360**	.078	.023	-.091	.501**	.236*	.867**	.102	-.085	.247*	.657**	.861**	-.048	.488**	.078	.274**	.049	-.498**
YW			.223*	.574**	.051	.176	.183	.469**	.236*	.430**	.005	-.092	.220*	.568**	.388**	-.064	.461**	-.064	.670**	.638**	-.669**
YH				-.255*	.677**	-.130	-.173	.219*	.098	.073	.624**	.889**	.135	.289**	-.030	.641**	.213*	.225*	-.030	-.012	.045
YW					-.087	.081	.187	.345**	.048	.274**	-.108	-.656**	.260*	.329**	.258*	-.150	.291**	-.050	.398**	.371**	-.410**
AH						-.267*	-.222*	.223*	.143	.077	.933**	.570**	.101	.240*	-.045	.976**	.233*	.269*	-.173	-.146	.161
AWDT							.510**	-.146	-.101	-.003	-.484**	-.145	-.057	-.117	.132	-.242*	-.155	-.277**	.310**	.303**	-.319**
AL								.096	-.026	-.248*	-.452**	-.247*	.117	.088	-.152	-.246*	.058	.049	.075	.131	-.023
EWDT									.404**	.331**	.202	-.007	.592**	.857**	.108	.052	.937**	.245*	-.207	-.249*	.134
EL										.143	.145	.048	-.487**	.568**	-.044	.027	.698**	.086	-.215*	-.247*	.190
ST											.115	-.066	.166	.460**	.795**	-.003	.318**	.009	.294**	.081	-.486**
AI												.543**	.077	.219*	-.008	.913**	.219*	.257*	-.193	-.181	.171
YI													-.024	.062	-.134	.573**	.015	.182	-.196	-.169	.212*
SI														.310**	.130	.043	.278**	.156	-.019	-.030	-.028
SFA															.212*	.039	.888**	.201*	-.189	-.262*	.075
SR																-.077	.071	-.092	.493**	.251*	-.704**
HU																	.055	.118	-.134	-.095	.143
EWL																		.223*	-.242*	-.288**	.175
AW																			-.778**	-.753**	.724**
Y/A																				.955**	-.955**
YR																					-.848**

* $P<0.05$, ** $P<0.01$; ***EW***=*Egg weight*, ***SW***=*Shell weight*, ***YW***=*Yolk weight*, ***YH***=*Yolk height*, ***YWDT***=*Yolk width*, ***AH***=*Albumen height*, ***AWDT***=*Albumen width*, ***AL***=*Albumen length*, ***EWDT***=*Egg width*, ***EL***=*Egg length*, ***ST***=*Shell thickness*, ***AI***=*Albumen index*, ***YI***=*Yolk index*, ***SI***=*Shape index*, ***SFA***=*Shell surface area*, ***SR***=*Shell ratio*, ***HU***=*Haugh unit*, ***EVL***=*Egg volume;* ***AW***=*Albumen weight*, ***Y/A***= *Yolk/albumen*, ***YR***=*Yolk ration*

Table 1. *External quality traits of Guinea fowl eggs* ***Tablo 1.*** *Beç tavuğu yumurtalarının dış kalite özellikleri*				
Traits	**N**	**Min**	**Max**	**Mean±SE**
Egg weight (g)	100	34.03	45.70	40.14±0.235
Egg length (mm)	100	46.44	52.68	49.47±0.107
Egg width (mm)	100	36.40	40.02	37.89±0.087
Shell weight (g)	97	3.01	8.97	6.48±0.080
Shell ratio (%)	97	9.00	20.00	16.10±0.162
Sharp region thickness (mm)	95	0.44	0.71	0.55±0.005
Blunt region thickness (mm)	95	0.41	0.69	0.53±0.004
Equatorial region thickness (mm)	95	0.43	0.69	0.54±0.004
Average shell thickness (mm)	95	0.43	0.70	0.54±0.004
Shell surface area (cm^2)	100	49.94	60.71	55.69±0.216
Unit surface shell weight (g/cm^2)	97	0.06	0.15	0.11±0.001
Shape index (%)	100	72.00	81.00	76.60±0.191
Egg volume (cm^3)	100	34.26	43.25	38.21±0.214

Table 2. *Internal quality traits of Guinea fowl eggs* ***Tablo 2.*** *Beç tavuğu yumurtalarının iç kalite özellikleri*				
Traits	**N**	**Min**	**Max**	**Mean±SE**
Yolk weight (g)	90	11.69	15.87	13.58±0.107
Yolk height (mm)	90	12.04	17.09	14.99±0.110
Yolk width (mm)	90	36.51	45.13	40.64±0.170
Yolk index (%)	90	28.00	44.00	37.02±0.347
Yolk ratio (%)	90	30.00	38.00	33.81±0.235
Albumen height (mm)	90	3.09	6.93	4.77±0.086
Albumen width (mm)	90	51.54	71.54	62.97±0.480
Albumen length (mm)	90	65.23	91.34	80.07±0.563
Albumen weight (g)	100	16.67	41.89	21.62±0.491
Albumen index (%)	90	4.00	10.00	6.79±0.143
Albumen ratio (%)	90	44.00	57.00	50.03±0.315
Yolk/Albumen ratio (%)	90	54.00	85.00	68.10±0.858
Haugh unit	90	60.57	87.80	74.97±0.651

Nowaczewski et al.[30]; Song et al.[31] whereas was found higher than those reported by Obike et al.[32]. The difference between the egg weights reported in the various studies, it might be due to variations in strain, stocking density, seasonal factors, feeding system and age of birds Nagarajan et al.[33]; Tanabe and Ogawa [34]. Generally eggs of birds have oval shape with small differences among the species. Despite its small differences, egg shape is considered as an important factor in characterizing bird species. In this study egg shape index ranged from 0.72 to 0.81% and average egg shape index was calculated as 0.76%, indicating that the eggs had normal shape. The average egg shape in in this study was similar to that reported in studies carried out by Tebesi et al.[28]; Nowaczewski et al.[30], whereas was found lower than those reported by Dudusola [29]; Oke et al.[24] and Singh et al.[25]. The results of investigations concerning the relationship of egg weight with egg shape index are ambiguous. However, in many studies carried out on chickens researchers reported a negative, although not always significant, correlation between the egg shape index and its weight Rozycka and Wezyk [35]; Kul and Seker [36]; Tebesi et al.[28]; Nowaczewski et al.[30]; Begli et al.[37] which would mean that heavier eggs are more elongated. In contrast, in their experiments on quinea fowls Bernacki and Heller [38] found that heavier eggs were characterized by greater shape index, these eggs were more ball-shaped. These results are further corroborated by research result obtained by Kuzniacka et al.[39] in Guinea fowls, who found a significant positive correlation between the shape of eggs and their weight (0.317).

In this study average egg length and width was found as 49.47 and 37.89 mm, respectively. The egg length and width values in this study were similar to that found in studies carried out by Tebesi et al.[28]; Singh et al.[25] and Song et al.[31]. The egg weight showed significant and positive correlation with egg length and egg width, and the values of correlations was determines as 0.569 and 0.859 for egg length and egg width, respectively. The significant and positive correlation indicates that the longer length of the egg, the higher the egg weight. Egg length had also been reported to significantly affect egg weight Momira et al.[40]. However, the association between egg weight and egg width was significant. This may be attributed to the fact that the yolk of the egg occupies the width area, thereby translating to heavier weight for eggs. This result corroborated the report of Abanikannda et al.[41]. These authors reported a phenotypic correlation of 0.78 and 0.84 between egg weight with egg length and egg width, respectively. Based on the correlations, they concluded that egg length and egg width were beter predictors of egg weight when compared to egg shape index. The findings determined in this study are also in agrement with the reports of Nwagu et al.[42]; Obike and Azu [32]; Tebesi et al.[28] they found highly significant correlations between the egg weight with egg length and egg width. Also, Apuno et al.[43] reported that significant correlations between the egg weight with egg length and egg width.

The eggshell weights were ranged from 3.01 to 8.97 g, and and average eggshell weight was calculated as 6.48 g. The averege eggshell weight of quinea fowls in this study was similar to that reported by Bernacki and Heller [38]; Kuzniacka et al.[39]; Dudusola [29]; Nowaczewski et al.[30]; Oke et al.[24]. The greater eggshell weight of the quinea fowls could have been affected not only by their greater surface area resulting from the egg size but also its thickness. The authors found a significant positive correlation between the egg weight and the thickness of its eggshell Nowaczewski et al.[30]; Tebesi et al.[28]. In this research, also found a significant positive correlation between the egg weight and eggshell weight (0,658). According to Nordstrom and Ousterhout [44], eggshell weight was significantly influenced by egg weight. These workers found that 47% of variation in eggshell weight was due egg weight. On the other hand, no such correlations were reported by Kuzniacka et al.[39]; Oke et al.[24] and Nahashon et al.[26,27] in quinea fowls.

The eggshell thickness was ranged from 0.43 to 0.70 mm, and average eggshell thickness was determined as 0.54mm. Also, average eggshell thickness was found higher at sharp region (0.55mm) and lower at the blunt region (0.53mm) implying that mineralizion was higher at sharp region. The finding on eggshell thickness was in disagrement with Song et al.[31], Dudusola [29]; Tebesi et al.[28] and Nowaczewski et al.[30] and the average eggshell value in this study was higher than the reported by these authors. The egg weight has an indirect relation with the shell quality of the egg. Thus, it has been stated by most of the researchers that the eggshell thickness has direct relation with the egg weight Choi et al.[45]; Stadelman [46]. Some researchers have mentioned a positive correlations between the egg weight and the eggshell thickness Stadelman [46]; Nowaczewski et al.[30]; Kul and Seker [36]. Also, Moreki et al.[47] who found a positive correlation between egg weight and eggshell thickness of Ross broiler breeder eggs. This implies that eggshell thickness increases with increased egg weight of broiler chicken. In this study, there was found significant correlation between the egg weight and eggshell thickness (0.462). In this study, eggshell surface area was ranged from 49.94 to 60.71 cm^2 and average eggshell surface area was calculated as 65,69 cm^2. The average eggshell surface area was lower than those of reported by Dudusola [29] and Nowaczewski et al.[30]. Also, eggshell ratio was ranged from 0.09 to 0.20% and average eggshell ratio was determined as 16%. The average eggshell ratio determined in this study was similar to that found in studies carried out by Nowaczewski et al.[30] but, was found higher than those of reported by Tebesi et al.[28] and Song et al.[31].

There was found a moderate phenotypic correlation between egg weight and albumen weight (0.201) and a highly significant corelation between egg weight and yolk weight (0.569) in this study. The findings determined in this study are in agrement with the reports of Obike and Azu [32]; Tebesi et al.[28]; Kul and Seker [36] they found highly significant correlations between the egg weight with albumen weight and yolk weight. These results suggest that the heavier weight of the albumen and the yolk, the larger egg weight which in turn leads to increase in egg weight. So, selecting for egg weight will invariably select eggs with larger albumen and yolk weight, which is needed for embryo development.

Yolk weight had a significant correlation with yolk width (0.574). The yolk width possibly constitutes the yolk portion which may have influenced the yolk weight positively. Non-significant and negative correlation was found between yolk weight and yolk index. This result is in consonance with the report of Obike and Azu [32] and Nwagu et al.[42]. There was found a negative but significant relationship (-0.656) between yolk index and yolk diameter. This result is an expected situation, because yolk diameter is the very important factor in the determination of yolk index. Inversely, the association between yolk index and yolk height was highly significant (0.889). Also, yolk index was found positively and significant correlated with albumen height (0.570). This means that improvement of yolk diameter, yolk height and albumen height will result to a beter yolk index. Depending on the this result, egg freshness will be improved since yolk index determines egg freshness.

Highly significant and positive correlation was determined between albumen index with albumen height (0.933), albumen weight (0.257) and albumen ratio (0.724), but there was found significant and negatively correlation between albumen index and albumen width (-0.484) in this study. According to Ozcelik [48], albumen index, albumen height, albumen weight and albumen ratio gives indication of the dense albumen quality anda are used in the estimation of haugh unit, which is an important factor the internal quality of the egg.

The correlation between albumen height and yolk height was found positive and significant (0.677). This observation implies that as albumen height increased, yolk height increased and albumen quality becomes beter. Similar result was determined by Obike and Azu [32]; Nwagu et al.[42]. Similarly, there was found positive and significant relationship between albumen index and yolk index (0.543). This result is in corformity with the research findings of Obike and Azu [32]; Ozcelik [48]; Kul and Seker [36]. In this study, haugh unit was not significant, but negatively correlated with eggshell thickness (-0.003), eggshell weight (-0.048) and eggshell ratio (-0.077). However, also non-significant and positive correlation was found between haugh unit with egg weight (0.043), egg width (0.052), egg length (0.027) and egg shape index (0.043). Similar result reported by Zhang et al.[49].

As a result, the study revealed that egg weight of quinea fowl is an important factor that influences external egg quality characteristics. Thus, it was possible to use egg weight in determining the eggshell weight, eggshell thickness and eggshell ratio instead of using these traits that are the determinants of the eggshell quality of the quinea fowl. It should therefore be considered in any breeding and management programme aimed at improving these traits. In additon, egg length and egg width were stronly and positively correlated with egg weight as 0.569 and 0.859, respectively. Hence, selection for egg length and egg width will invariably select eggs with heavier phenotypic weight. Based on this result, the traits should be employed as selection criteria to improve egg weight. Also, the correlations determined among the internal egg quality traits indicate that the parameters can be improved through selection. Poultry researchers will study on egg quality traits as well as the activities of the breeders who deal with the Guinea fowl eggs breeding and improvement.

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