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Research Article
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Analysis of egg quality traits and prediction of egg weight in Isa Brown laying hens

Isa Brown yumurtlayan tavuklarda yumurta kalitesi özelliklerinin analizi ve yumurta ağırlığının tahmini

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ABSTRACT

Objective: The objective of this study was to determine the best-fitted regression model for estimating egg weight of Isa Brown laying chickens using external and internal egg parameters.

Materials and Method: Data collected include: egg weight (EWT), egg length (EL), egg diameter (ED), shell thickness (ST), shell weight (SW), albumen height (AH), albumen weight (AW), yolk height (YH), yolk weight (YW) and yolk length (YL). Data were subjected to statistical analysis procedures of SPSS (version 23.0.0). Egg weight was regressed on external and internal egg parameters using forward, backward and full model regression procedures, to determine the combinations of egg parameters that explain variation in the dependent variable.

Results: Results showed that the mean (±SE) of EWT, EL, ED, ST, SW, AH, AW, YH, YW and YL were 60.49±0.47, 4.23±0.03, 2.94±0.02, 1.37±0.01, 6.04±0.05, 1.20±0.01, 36.30±0.39, 1.22±0.02, 15.29±0.15 and 2.32±0.02 respectively. The models of EWT = 30.638+0.582AW+0.571YW and EWT = -14.991+8.779EL+5.493ED+3.686SW are the best fitted regression models for predicting egg weight of Isa Brown laying chickens.

Conclusion: Conclusively, egg weight of Isa Brown laying chickens can be improved through selection for EL, ED, ST and SW trait

Keywords: Egg weight, egg quality traits, Isa Brown hen, regression

ÖZ

Amaç: Bu çalışmanın amacı, dış ve iç yumurta parametrelerini kullanarak Isa Brown yumurtlayan tavukların yumurta ağırlığını tahmin etmek için en uygun regresyon modelini belirlemektir.

Materyal ve Yöntem: Toplanan veriler şunları içerir: yumurta ağırlığı (EWT), yumurta uzunluğu (EL), yumurta çapı (ED), kabuk kalınlığı (ST), kabuk ağırlığı (SW), albümin yüksekliği (AH), albümin ağırlığı (AW), yumurta sarısı yüksekliği (YH), yumurta sarısı ağırlığı (YW) ve yumurta sarısı uzunluğu (YL). Veriler SPSS (sürüm 23.0.0) 'in istatistiksel analiz prosedürlerine tabi tutuldu. Bağımlı değişkendeki değişimi açıklayan yumurta parametrelerinin kombinasyonlarını belirlemek için yumurta ağırlığı, ileri, geri ve tam model regresyon prosedürleri kullanılarak dış ve iç yumurta parametreleri üzerinde gerilemiştir.

Bulgular: Sonuçlar EWT, EL, ED, ST, SW, AH, AW, YH, YW ve YL(±SE)'nin sırasıyla 60.49±0.47, 4.23±0.03, 2.94±0.02, 1.37±0.01, 6.04±0.05, 1.20±0.01, 36.30±0.39, 1.22±0.02, 15.29±0.15 ve 2.32±0.02 olarak belirlenmiştir. EWT = 30.638+0.582AW+0.571YW ve EWT = -14.991+8.779EL+5.493ED+3.686 modelleri, Isa Brown yumurtlayan tavukların yumurta ağırlığını tahmin etmek için en uygun regresyon modelleridir.

Sonuç: Sonuç olarak, Isa Brown yumurtlayan tavukların yumurta ağırlığı EL, ED, ST ve SW özellikleri için seçim yoluyla iyileştirilebilir.

Anahtar Kelimeler: Yumurta ağırlığı, yumurta kalitesi özellikleri, Isa Brown tavuğu, regresyon

INTRODUCTION

Egg weight is vital in egg production as it influence egg quality and the reproductive parameter in chickens (Tabinda et al., 2013). Phenotypic correlation coefficient describes the strength of the associations between any two quantitative traits. However, in multiple regression, several predictor variables are used in combination rather than just one such variable to predict the dependent variable. Additionally, multiple regression indicates the weight that each variable in the combination has added to the model.

Coefficient of determinations (R^2) and residual mean square errors (RMSE) are criteria employed to evaluate the suitability of model to select the relatively best-fitted model from a set of potential models (Hoang, 2019). This study therefore is aimed to evaluate egg quality traits and to determine the best-fitted models to predict egg weight in Isa Brown laying chickens.

MATERIALS and METHODS

Description of the Study Area

This study was carried out at the Poultry Unit of Livestock Teaching and Research Farm, Federal University, Dutsin-Ma. Dutsin-Ma is located between the latitude 12°27'14" N and longitude 7°29'50" E with altitude of 544 metres above the sea level (Dateandtime.info).

A total of one hundred and twenty (120) eggs were obtained from Isa Brown chickens, reared intensively in battery cage system.

Parameters measured on individual egg included, egg weight (EWT), egg length (EL), egg diameter (ED), shell thickness (ST) shell weight (SW), albumen height (AH), albumen weight (AW), yolk height (YH), yolk weight (YW) and yolk length (YL).

Data collected were subjected to statistical analysis using procedures of SPSS (23.0.0). Data were analyzed by descriptive statistics and Pearson's correlation coefficients (r) procedures of SPSS (23.0.0). Egg weight was regressed on egg parameters (external and internal traits) by forward, backward and full model regression analysis as described by Pesmen & Yardimci (2008). The accuracy of the models obtained was evaluated using the coefficient of determination (R^2) and residual mean square error (RMSE).

Statistical model

$Y = \beta + b_1X_1 + b_2X_2 + ... + b_nX_n + e$

Where,

Y = dependent variable (EWT)

β = the constant

$X_1, X_2 \ldots X_n$ = independent variables (EL, ED, ST, SW, AH, AW, YH, YW, YL)

$b_1, b_2, \ldots b_n$ = the regression coefficient associated with EL, ED, ST, SW, AH, AW, YH, YW, YL

e = residual term

RESULTS and DISCUSSION

The mean (±SE) of EWT (g), EL (cm), ED (cm), ST (mm) and SW (g) were 60.49±0.47, 4.23±0.03, 2.94±0.02, 1.37±0.01 and 6.04±0.05 respectively (Table 1). The mean (±SE) of EWT (g) observed is similar with the value (60.17+0.31) obtained on Bovan Nera Black laying chicken by Sylvia et al. (2016). However, low egg weights were reported on three genotype chickens of Tswana chickens (Kgwatalala et al., 2016) and two Sudanese genotype chickens (Yousif & Eltayeb, 2011). Low egg weights could be as the result of

the negative action of sex-linked dwarf gene (Yousif & Eltayeb, 2011). On the contrary, Dakpoganc et al. (2012) and Yousif and Eltayeb (2011), observed longer egg lengths in their reports. The mean (±SE) of SW (g) recorded is closer to the results of other researchers (Yakubu et al., 2008; Yousif & Altayeb, 2011) but higher than the values recorded (Nowaczewski et al., 2008; Tebesi et al., 2012; Alkan et al., 2015). An average shell thickness of 0.33 mm has been reported to be the minimum needed for at least a 50% chance to withstand breakage (Stadelman, 1995).

The mean (±SE) of AH (cm), AW (g), YH (cm), YW (g) and YL (cm) were 1.20±0.01, 36.30±0.39, 1.22±0.02, 15.29±0.15 and 2.32±0.02. The CV (%) for external egg quality were generally less than 10% (6.15-9.89) while those of internal egg quality traits were higher than 10% (10.48-15.85). The greatest CV (%) was observed in YH (15.85%).

The value obtained for AW (g) in this work agrees with the result of Congjiao et al. (2019). Albumen is the main content in egg, representing about 60% (Campbell et al., 2003). The value of AH recorded is however less than the value (8.41±0.04 mm) observed by Rath et al. (2015) in White Leghorns.

Table 2 reveals the phenotypic relationships among external egg quality trait of Isa Brown laying chickens. Highly significant (P<0.01) positive correlation coefficients of 0.535, 0.384 and 0.470, respectively were recorded between EWT against EL, ED and SW. There was a negatively and non-significant (P>0.05) phenotypic correlation values recorded between the EWT against ST (-0.136). This trend disagrees with the results of Moreki et al. (2011); Alkan et al. (2013); Stadelman (1995), who also reported a positive relationship between egg weight and shell thickness.

Table 1. Descriptive statistics of egg quality traits of Isa Brown laying chicken

Çizelge 1*. Isa Brown yumurtlayan tavukların yumurta kalitesine ilişkin istatistikleri*

Traits	N	Mean (±SE)	Coefficient of variation (%)
External egg quality			
EWT (g)	120	60.49±0.47	8.43
EL (cm)	120	4.23±0.03	6.70
ED (cm)	120	2.94±0.02	6.15
ST (mm)	120	1.37±0.01	9.06
SW (g)	120	6.04±0.05	9.89
Internal egg quality			
AH (cm)	120	1.20±0.01	12.65
AW (g)	120	36.30±0.39	11.80
YH (cm)	120	1.22±0.02	15.85
YW (g)	120	15.29±0.15	10.50
YL (cm)	120	2.32±0.02	10.48

SE = Standard error

Table 2. Phenotypic correlations of external egg qualities of Isa Brown laying chickens

Çizelge 2. Isa Brown yumurtlayan tavukların dış yumurta niteliklerinin fenotipik korelasyonları

	EWT	EL	ED	ST
EL	0.535**	1		
ED	0.384**	0.231*	1	
ST	-0.136	-0.356**	0.129	1
SW	0.470**	0.007	0.178	0.095

** Correlation is significant at *P<0.01* (2-tailed), *Correlation is significant at *P*<0.05 (2-tailed).

Phenotypic relationships of internal egg quality trait of Isa Brown laying chickens were tabulated in Table 3. There was a highly significant (P<0.01) phenotypic correlation between EWT, and AW and YW (0.534 and 0.303 respectively) in this study. Other authors also reported highly significant correlations between egg weight with albumen weight and yolk weight (Kul & Seker, 2004; Obike & Azu, 2012; Tebesi et al., 2012). These results suggest that albumen and yolk weights could significantly influence egg weight.

Table 3. Phenotypic correlations of internal egg qualities of Isa Brown laying chickens

Çizelge 3. *Isa Brown yumurtlayan tavukların iç yumurta niteliklerinin fenotipik korelasyonları*

	EWT	AH	AW	YH	YW
AH	0.111	1			
AW	0.534**	0.240**	1		
YH	0.208*	0.089	0.217*	1	
YW	0.303**	-0.071	0.253**	0.115	1
YL	0.069	0.052	0.086	-0.022	0.396**

**Correlation is significant at P<0.01 (2-tailed), *Correlation is significant at P<0.05 (2-tailed).

Table 4 presents the forward and backward methods of multiple regression equations for egg weight and external egg parameters of Isa Brown laying chickens. The forward and backward method of multiple regression for egg weight and external egg traits showed that the equation including three variables (EL, SW, ED) has highest R^2 = 0.538 and with the lowest RMSE = 12.313 which makes it the best fit model for predicting egg weight from external egg traits. The equation is; EWT = -14.991+8.779EL+3.686SW+5.493ED.

Table 4. Forward and backward methods of multiple regression equations of egg weight and external egg parameters of Isa Brown laying chickens

Çizelge 4. *Isa Brown yumurtlayan tavukların yumurta ağırlığı ve dış yumurta parametrelerinin çoklu regresyon denklemlerinin ileri ve geri yöntemleri*

Model	Equation	R^2	RMSE	Sig
FORWARD				
1	EWT = 19.732+9.648EL	0.287	18.705	0.000
2	EWT = -4.032+9.586EL+3.979SW	0.504	13.124	0.000
3	EWT = -14.991+8.779EL+3.686SW+5.493ED	0.538	12.313	0.000
BACKWARD				
1	EWT = -12.705+8.528EL+5.699ED – 1.415ST+3.703SW	0.539	12.394	0.000
2	EWT = -14.991+8.779EL+3.686SW+5.493ED	0.538	12.313	0.000

Table 5 shows the forward and backward methods of multiple regression for egg weight and internal egg parameters. The equations for backward multiple regression method involving three variables (AW, YH, YW), recorded high R^2 = 0.323 but the lowest RMSE = 18.067 which made it most suitable to predict egg weight in Isa Brown laying chickens, thus; EWT = 28.904+0.562AW+2.248YH+0.554YW.

Table 5. Forward and backward methods of multiple regression equations of egg weight and internal egg parameters of Isa Brown laying chickens

Çizelge 5. *Isa Brown yumurtacı tavukların yumurta ağırlığı ve iç yumurta parametrelerinin çoklu regresyon denklemlerinin ileri ve geri yöntemleri*

Model	Equation	R^2	RMSE	Sig
FORWARD				
1	EWT = 37.401+0.636AW	0.285	18.735	0.000
2	EWT = 30.638+0.582AW+0.571YW	0.316	18.094	0.000
BACKWARD				
1	EWT = 30.123+0.230AH+0.559AW+2.155YH+0.616YW - 0.973YL	0.324	18.335	0.000
2	EWT = 30.335+0.561AW+2.165YH+0.612YW – 0.958YL	0.324	18.177	0.000
3	EWT = 28.904+0.562AW+2.248YH+0.554YW	0.323	18.067	0.000
4	EWT = 30.638+0.582AW+0.571YW	0.316	18.094	0.000

Table 6 shows the full method of multiple regression of EWT on external and internal egg parameters of Isa Brown laying chickens. The equation for external egg traits has four variables with R^2 = 0.539 and RMSE = 200.718 while the equation for internal egg traits has five variables with R^2 = 0.324 and RMSE = 18.335. The criteria for suitability of the model show that the equations for full models are less suitable to predict egg weight.

Table 6. Full method of multiple regression equations of egg weight and egg quality parameters of Isa Brown laying chickens

Table 6. *Isa Brown yumurtlayan tavukların yumurta ağırlığı ve yumurta kalitesi parametrelerinin çoklu regresyon denklemlerinin tam yöntemi*

Equation	R^2	RMSE	Sig
EXTERNAL			
EWT = -12.705+8.528EL+5.699ED – 1.415ST+3.703SW	0.539	200.718	0.000
INTERNAL			
EWT = 30.123+0.230AH+0.559AW+2.155YH+0.616YW – 0.973YL	0.324	18.335	0.000

The outcome of the study showed that EWT = 30.638+0.582AW+0.571YW and EWT = -14.991+8.779EL+5.493ED+3.686SW are the best fitted regression models for predicting egg weight of Isa Brown laying chickens, using external and internal egg traits respectively. Topal (2003) also opined that R^2 or RMSE may be confidently applied to determine the best-fitted regression models for predicting body weights in livestock. The higher and significant ($P<0.001$) R^2 value with lower RMSE obtained in this study showed that (EL, ED, SW) and internal egg parameters (AW, YW) could be used to estimate egg weight of Isa Brown laying chickens with high degree of precision.

CONCLUSION

This study revealed that EL, ED and SW were strongly and positively correlated with EWT as 0.535, 0.384 and 0.470 respectively. Hence, selection for these traits will invariably lead to the improvement of egg weight in Isa Brown laying chickens. The outcome of the regression analysis showed that EWT = 30.638+0.582AW+0.571YW and EWT = -14.991+8.779EL+5.493ED+3.686SW are the best fitted regression models for predicting egg weight of Isa Brown laying chickens, using external and internal egg parameters respectively.

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