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IDENTIFYING PREDICTIVE COMPONENTS OF EGG WEIGHT IN TWO LINES OF DANDARAWI CHICKEN USING PRINCIPAL COMPONENT ANALYSIS

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ABSTRACT: Two Dandarawi chicken lines (selected for high body weight at eight weeks of age and control) in the 7th generation used to unfold the impact of selection for high body weight on egg quality traits, understanding the relationship between these traits and identifying predictive components of egg weight applying principal component analysis (PCA). At 40 weeks of age, a total of 120 eggs were collected (60 egg/ line). The measured traits involved egg weight, egg length and breadth, yolk height and diameter, albumin height, weight of yolk, albumin and eggshell and eggshell thickness. Analysis of variance and descriptive statistics for the studied traits were performed using SAS program. Correlation among egg quality traits, principal component analysis, Kaiser-Meyer-Olkin (KMO), and Bartlett's test of sphericity were computed by SPSS program.

The results revealed that the selected line hens laid heavier eggs (56.38 g) than the control line hens (45.51 g), and the selected line outperformed the control line in majority of the traits. In both lines, the correlations between egg weight and most of its components were positive and highly correlated. According to KMO values and Bartlett's Test, principal component analysis (PCA) was valid for the data sets. Four principal components were identified, that accounted for 74.79 % (selected line) and 73.39 % (control line) of the cumulative variance which were more accurate than the original egg quality traits in predicting egg weight. Consequently, improving the selected Dandarawi line for high body weight in egg quality traits is critical for producing an improved Dandarawi chicken, and the four principal components can be employed effectively as selection strategy to enhance egg quality traits.

Keywords: Egg weight; Dandarawi chicken; Principal Component Analysis; Correlation.

INTRODUCTION

Egg weight and its components play a vital role in affecting the marketing process (Farooq *et al*. 2003) and incubation as a signal for predicting chick weight which is a precondition for breed improvement program (Abiola *et al.* 2008; Alabi *et al.* 2012 and Duman and Şekeroğlu, 2017). Furthermore, egg weight is one of the most important egg quality traits and can be easily predicted using these traits (Udeh *et al.* 2022 and Al-Tamimy and Shaker, 2023). Therefore, egg weight has received special attention from many poultry breeders and breeding companies as an important economic trait.

The primary goal of genetic improvement programs for chickens is to increase egg weight (Younis, 2014; Gwaza, 2016; Soliman *et al*. 2020; and Abdelhady *et al.* 2022). Several studies (Saleh *et al.* 2008; Alkan, *et al.* 2010 and Abdelhady *et al.* 2022) have reported that selection for high body weight improved and increased egg weight.

Identifying egg quality traits in local chicken breeds is of fundamental importance for conducting selection and breeding programs targeted at genetic improvement (Markos *et al.* 2017 and Liswaniso *et al.* 2020). To improve egg quality traits, breeders and researchers must first understand the relationship between these traits. To comprehend these linkages, they find themselves dealing with a huge number of interrelated traits, which can be difficult to handle this data (Björklund, 2019). More studies have been conducted on the egg quality traits of local chicken breeds and the data used was analyzed using univariate analysis. However, explaining these traits using this analysis is very complicated because each trait is examined individually, leading to an interaction in the results, and these traits are biologically correlated due to pleiotropy (Toalombo *et al.* 2019).

Moreover, they require assistance in dealing with such complex data. Principal components analysis is a multivariate technique that is primarily used to transform or reduce the original variables to a new smaller set known as principal components which are essentially a linear combination of the original variables that may describe the subject without significant loss of information and can be easily used (Khanikar *et al.* 2024). So, principal component analysis (PCA) has played a vital role in poultry science studies not only by minimizing data dimensionality, but also it has a great impact on biodiversity conservation, management and selection strategies to enhance genetic improvement (Sarma *et al.* 2022).

However, there is a scarcity of recent research on multivariate analysis of interior egg quality traits, specifically identifying egg weight from egg quality traits via principal component analysis (PCA). Consequently, the present study aimed to unfold the impact of selection for high body weight on egg quality traits, comprehend the complex relationship between these traits, and identify predictive components of egg weight in two lines of Dandarawi chicken via principal component analysis.

MATERIALS AND METHODS

The present study was done at the Poultry Research Farm and Poultry Breeding laboratory of the Poultry Production Department, Faculty of Agriculture at Assiut University. Two lines from Dandarawi chicken breed, which was line (S) that the selected line for high body weight at 8 weeks of age and line (C) that was the control line used in this study. Birds of both lines were kept and reared under the same management conditions, fed with a commercial ration and provided with clean water *ad-libitum*. In the 7^{th} generation of selection, a total of 120 fresh eggs from the two lines (60 egg/ line) were collected when the hens were 40 weeks old.

Each egg was weighed via a digital balance to the nearest 0.0001gram, then egg length (EL) and egg breadth (EB) were measured with a vernier caliper to the nearest centimeter. Each egg was broken on a table with a flat glass to measure the internal egg components. Yolk and albumin height were measured using a sensitive micrometer to the nearest 0.01 millimeter then yolk diameter was measured using vernier caliper to the nearest centimeter and transformed to millimeter. Yolk was carefully separated out the albumin and was weighed by a digital balance. The eggshell with its membranes were dried at room temperature overnight and weighed using a digital balance. Eggshell thickness was measured to the nearest 0.01 millimeter using a sensitive micrometer. Finally, albumin weight was calculated by the difference using the following equation: Albumin weight = Egg weight – (Yolk weight + Eggshell weight).

Analysis of variance and descriptive statistics for Data of egg quality traits were statistically analyzed by SAS software version 9.0 (SAS, 2002). The following General linear model (GLM) employed was: $Y_{iJ} = \mu + L_i + e_{ij}$. Where Y_{iJ} = observed value for each variable, μ = overall mean, L_i = effect of line (i = 1, 2), e_{ij} = error term. The differences between means were calculated by Duncan's new Multiple Range Test (Duncan, 1955) at 5%.

Using IBM SPSS statistics version 26.0, Pearson's correlation coefficients between egg weight and its components were calculated for each line, data suitability for principal component analysis (PCA) was also established at significance level 1% using Bartlett's test of sphericity (Jolliffe, 2002), followed by the Kaiser-Meyer-Olkin (KMO) test to measure sampling adequacy, and the validity of the principal component analysis was further evaluated by communalities which show the proportion of variance that each variable has in share with other variables (Wuensch, 2012).

RESULTS AND DISCUSSION

Means ± standard errors of egg quality traits of the two lines of Dandarawi chicken are shown in Table 1. Significant differences (P<0.05) were observed between the two lines for all egg quality traits except albumin height and yolk diameter, that were not significant. Hens in the selected line produced heavier eggs (56.38 g) than hens in the control line (45.51 g). Several studies have found that egg weight was usually positively related to hen weight (Romero *et al.* 2009 and Abdelhady *et al.* 2022), when hens in selected line had heavier body weight than hens in the control line. In general, the results reported by Saleh *et al.* (2008); Alkan, *et al.* (2010); Ashour *et al.* (2015); and Abdelhady *et al.* (2022) supported our findings that the two lines differ in egg weight, egg quality measures, and selection for high body weight improved egg quality traits as an indirect response.

The phenotypic correlations between egg weight and egg components for the two lines of Dandarawi chicken are presented in Table 2. In the selected line, there were significant (P<0.05) and highly significant (P<0.01) positive correlations between egg weight and most traits except for the relationship between egg weight and albumin height (-0.143) and between egg weight and yolk height (-0.111), where the correlations were negative. In the control line there were highly significant positive correlations (P<0.01) between egg weight and all egg components. This reveals that egg weight can be highly predictable based on egg quality traits, and it may be possible to assess egg weight using these traits. This also indicates that an increase in any of the components positively related to egg weight will result in an increase in egg weight. The results in the present study are in line with the findings of Shafey *et al.* (2014) and Ukwu *et al.* (2017); Shaker and Aziz, (2017); Shaker and Abdulla, (2018); Udeh *et al.* (2022); Kebede *et al.* (2022); and Al-Tamimy and Shaker, (2023). In contrast Shi *et al.* (2009) reported that there no significant phenotypic correlations between egg weight and egg quality traits in small, medium, and large eggs of the brown egg layer strain of Nike in China, although overall, they found significant positive correlations between egg weight and albumin weight and eggshell thickness, and there were significant negative correlations between egg weight and yolk weight and eggshell weight.

Kaiser Meyer Olkin (KMO) and Bartlett's Test for egg quality traits of the two lines of Dandarawi chicken were presented in Table 3. The selected and control lines had KMO values of 0.511 and 0.501, respectively. These results indicated that the sample size was acceptable for principal component analysis. The KMO values in this study were lower than the results of Ukwu *et al.* (2017), when found that the KMO was 0.77 in ISA brown layer chicken. Also, Shaker *et al.* (2019) reported that KMO values were 0.68 and 0.72 for chicken and Guinea Fowl, respectively. Furthermore, Udeh *et al.* (2022) found that KMO in Bovan Nera (0.66), ISA Brown (0.74) and FU-NAAB Alpha. The viability of PCA was tested by Bartlett's sphericity test, which was a highly significant result (p-value = 0.001) for the two lines, showing that PCA was viable for the data sets. This result agreed with the findings of (Kebede *et al.* 2022).

Factor loadings and communality values, eigenvalues and variance percentage of egg quality traits for the two lines of Dandarawi chicken are shown in Table 4. The communalities show variance estimates of the variance for calculated variable, which ranged from 0.56 to 0.91 in the selected line and 0.49 to 0.89 in the control line. The lowest communality value was for yolk height in both lines, whereas the highest communality values were for albumin weight and in the selected line and for egg breadth and eggshell weight in the control line. This indicated that larger proportions of the variance were shared between the variables and the communalities differed by lines. These results were consistent with those reported by Udeh *et al.* (2022), who found that communalities ranged from 0.40 to 0.90 in Bovan Nera and 0.57 to 0.92 in ISA Brown. Also, Kebede *et al.* (2022) found that the highest communality values were for albumin weight in Fayoumi and Koekoek chicken breeds.

Factor loadings represent the relationship between original variables and principal components. As presented in Table 4, PC1 is strongly correlated with egg length and breadth, weight and thickness of eggshell and albumin weight, PC2 with yolk diameter and weight, PC3 with egg length and yolk height, and PC4 with eggshell weight and thickness in the selected line. As for the control line, PC1 was strongly associated with egg length, albumin height, yolk weight and height, eggshell weight and thickness, PC2 and PC3 with albumin weight, and PC4 with egg breadth and yolk diameter. It was observed that the variables strongly related to each principal component differed between the two lines, revealing that their egg quality traits are genetically different. Although the factor loading pattern in both lines of Dandarawi chicken revealed that PC1 was mostly correlated with egg length and eggshell weight and thickness. As a result, PC1 will refer to egg length and eggshell weight and thickness. In contrast to the hypothetical meaning of PC1 in this study, Goto *et al.* (2015) reported that PC1 of Onagadori chicken breed loaded on albumen and yolk size, albumen height, and yolk weight. Udeh *et al.* (2022) revealed that PC1 included egg width, egg surface area and albumen weight in Bovan Nera, ISA Brown and FUNAAB Alpha chicken strains.

Four principal components with eigenvalue greater than one were identified via principal component analysis which accounted for 74.79 % and 73.39 % of the cumulative variance in the selected line and control line, respectively (Table 4). PC1, PC2, PC3, and PC4 have eigenvalues of 2.71, 1.69, 1.29, and 1.04, respectively in the selected line as shown in Figure 1. The eigenvalues of PC1, PC2, PC3, and PC4 in the control line were 2.59, 1.51, 1.31, and 1.20, respectively as shown in Figure 2. PC1, PC2, PC3, and PC4 interpreted (30.07%, 18.79%, 14.35%, and 11.58%) in the selected line and (28.78%, 16.77%, 14.50%, and 13.34%) in the control line of the cumulative variance.

The first principal component in the selected line and control lines had the greatest eigenvalues (2.71 and 2.59) which explained (30.07% and 28.78%), respectively. Similarly, Kebede *et al.* (2022) identified three factors of 6 egg quality parameters which accounted 65.5% in Fayoumi and 69% in Koekoek chicken of the overall variance and they found that PC1 had the highest eigenvalue and interrupted most of the total variance in the two chickens. Also, Udeh *et al.* (2022) extracted three factors of ten egg quality traits which explained 67.93%, 72.64% and 70.40% of the total variance in Bovan Nera, ISA Brown and FUNAAB Alpha chicken strains, respectively, and they found that PC1 had the highest eigenvalue and explained most of the total variance in the three chicken strains.

CONCLUSION

The selected Dandarawi chicken line outperformed the control line in majority of egg quality traits. Consequently, improving the selected Dandarawi chicken line in egg quality traits is critical for producing an improved Dandarawi chicken. Furthermore, due to the highly significant positive correlation between egg weight and its components, egg weight may be predicted from egg quality traits. The principal component analysis (PCA) of nine egg quality traits was useful in minimizing their dimensionality and utilizing the four components in predicting egg weight were more accurate than the original egg quality traits. Finally, the four principal components (PC1, PC2, PC3, and PC4) can be employed effectively as selection criteria to improve egg quality traits.

Table (1): Means ± SE of egg quality traits for the two Dandarawi chicken lines at 40 weeks of age

Traits	Selected Line	Control Line	P-value
Egg Weight (g)	56.38±0.27[a]	45.51±0.24[b]	**
Egg Length (cm)	5.13±0.02[a]	4.80±0.03[b]	**
Egg Breadth (cm)	3.96±0.01[a]	3.70±0.01[b]	**
Albumin Height (mm)	17.41±0.11	17.21±0.14	N.S.
Yolk Height (mm)	20.45±0.13[a]	19.08±0.15[b]	**
Yolk Diameter (mm)	38.28±0.17	37.88±0.20	N.S.
Yolk Weight (g)	17.26±0.18[a]	14.85±0.14[b]	**
Eggshell Weight (g)	5.64±0.06[a]	4.76±0.06[b]	**
Eggshell Thickness (mm)	0.40±0.00[a]	0.35±0.00[b]	**
Albumin Weight (g)	32.86±0.35[a]	25.90±0.21[b]	**

Means within the same row for each line with different superscript letters are significantly different ($p<0.05$). N.S: not significantly different.

Table (2): Phenotypic correlation coefficients between egg weight and egg quality traits for the two Dandarawi chicken lines at 40 weeks of age

Traits	EW	EL	EB	A H	YH	YD	YW	ESW	EST	AW
EW	1	0.45**	0.50**	-0.14	-0.11	0.28*	0.26*	0.15	0.28*	0.70**
EL	0.48**	1	0.23*	0.02	0.06	0.05	0.02	0.18	0.29*	0.60**
EB	0.18	-0.29*	1	-0.27*	-0.24*	0.05	0.12	0.32**	0.25*	0.62**
AH	0.35**	0.39**	-0.12	1	0.26*	0.02	0.00	-0.24*	-0.16	-0.30*
YH	0.28*	0.23*	-0.11	0.46**	1	0.16	0.10	-0.26*	-0.17	-0.18
YD	0.25*	0.31**	0.13	0.23*	0.24*	1	0.59**	-0.13	0.07	-0.06
YW	0.39**	0.37**	0.09	0.08	0.24*	0.23*	1	0.08	0.12	-0.22*
ESW	0.53**	0.26*	0.10	0.30*	0.10	0.09	0.28*	1	0.58**	0.24*
EST	0.31**	0.20	-0.05	0.24*	0.10	0.01	0.24*	0.77**	1	0.35**
AW	0.72**	0.22*	0.11	0.26*	0.12	0.10	-0.32**	0.13	-0.03	1

EW: Egg Weight, EL: Egg Length, EB: Egg Breadth, AH: Albumin Height, YH: Yolk Height, YD: Yolk Diameter, YW: Yolk Weight, ESW: Eggshell Weight, EST: Eggshell Thickness, AW: Albumin Weight.

*Values above the diagonal are the correlation coefficients of selected line while values below the diagonal are the correlation coefficients of the control line.

*: significant at 5%; **: highly significant at 1%.

Table (3): Kaiser Meyer Olkin (KMO) and Bartlett's Test for egg quality traits of the two Dandarawi chicken lines

		Selected Line	Control Line
KMO		0.511	0.501
Bartlett's Test	Chi-Square P-value	155.14 **	142.23 **

**: highly significant at 1%.

Table (4): Factor loadings, communality values, Eigenvalues and total variance (%) of egg quality traits for the two Dandarawi chicken lines

Traits	Selected Line					Control Line				
	PC1	**PC2**	**PC3**	**PC4**	**Com**	**PC1**	**PC2**	**PC3**	**PC4**	**Com**
Egg Length	**0.54**	0.15	**0.67**	0.12	0.78	**0.68**	0.24	-0.20	-0.19	0.60
Egg Breadth	**0.72**	0.12	0.03	-0.39	0.68	-0.11	-0.21	0.22	**0.88**	0.89
Albumin Height	-0.46	0.09	0.43	0.46	0.61	**0.68**	0.38	0.14	-0.09	0.63
Yolk Height	-0.41	0.30	**0.53**	0.16	0.56	**0.54**	0.39	-0.23	0.02	0.49
Yolk Diameter	-0.07	**0.86**	-0.01	-0.22	0.79	0.43	0.30	-0.29	**0.53**	0.63
Yolk Weight	-0.02	**0.87**	-0.24	-0.03	0.82	**0.50**	-0.37	-0.61	0.21	0.81
Eggshell Weight	**0.66**	0.02	-0.35	**0.50**	0.81	**0.70**	-0.50	0.40	0.02	0.89
Eggshell Thickness	**0.66**	0.22	-0.13	**0.53**	0.78	**0.64**	-0.58	0.31	-0.17	0.86
Albumin Weight	**0.81**	-0.11	0.43	-0.26	0.91	0.21	**0.55**	**0.66**	0.16	0.81
Eigenvalues	2.71	1.69	1.29	1.04		2.59	1.51	1.31	1.20	
Variance %	30.07	18.79	14.35	11.58		28.78	16.77	14.50	13.34	
Cumulative Variance %	30.07	48.86	63.21	74.79		28.78	45.55	60.05	73.39	

PC: Principal component, Com: communality.
* Variables strongly correlated with each component are in bold.

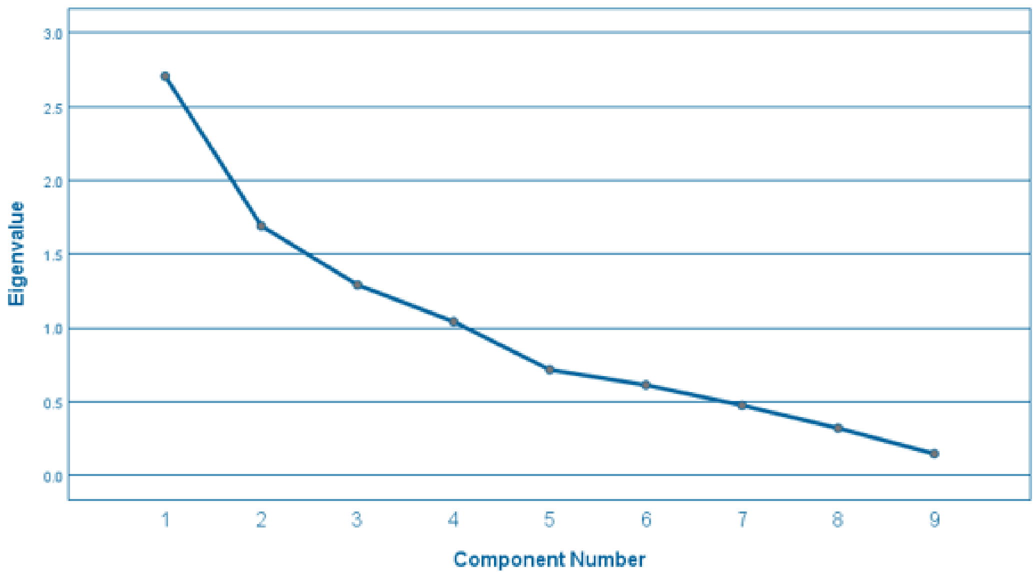

Figure (1): Principal component numbers with Eigenvalues for selected Dandarawi chicken line.

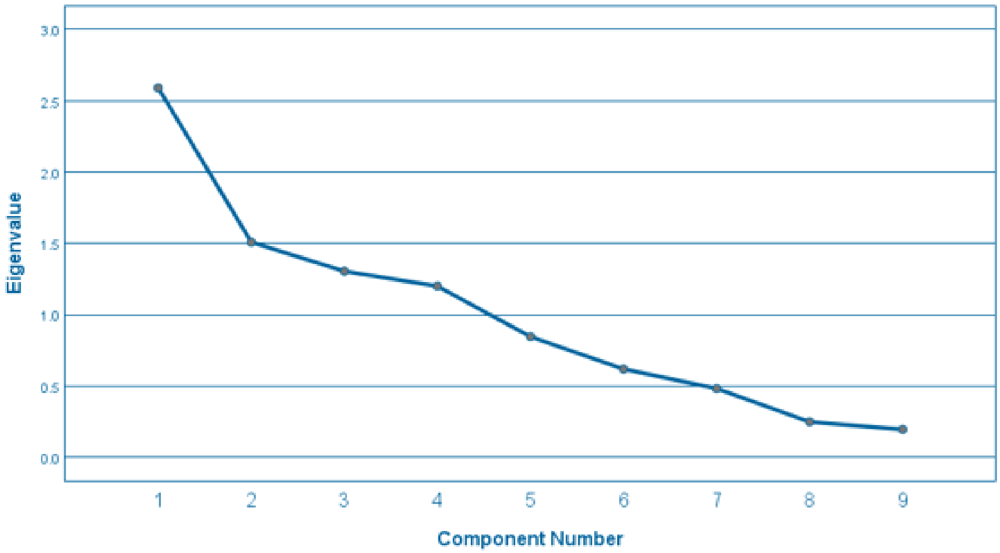

Figure (2): Principal component numbers with Eigenvalues for control Dandarawi chicken line.

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الملخص العربي

تحديد مكونات التنبؤ بوزن البيضة في خطين من دجاج الدندراوي باستخدام تحليل المكونات الأساسية

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تم استخدام خطين من دجاج الدندراوي (المنتخب لوزن الجسم العالي في عمر ثمانية أسابيع والكنترول) في الجيل السابع لتحديد تأثير الانتخاب لوزن الجسم العالي علي صفات جودة البيض، فهم العلاقة بين هذه الصفات، وتحديد مكونات التنبؤ بوزن البيضة في الخطين باستخدام تحليل المكونات الأساسية. في عمر 40 أسبوع تم استخدام اجمالي 120 بيضة (60 بيضة/ خط). اشتملت الصفات المدروسة كلا من وزن البيضة، طول وعرض البيضة، ارتفاع وقطر الصفار، ارتفاع البياض، وزن كلا من الصفار، البياض والقشرة، سمك القشرة. تم تحليل التباين والاحصاء الوصفي للصفات المدروسة باستخدام برنامج SAS. تم حساب معامل الارتباط بين وزن البيضة ومكوناتها، تحليل المكونات الأساسية واختبار KMO وBartlett's باستخدام برنامج SPSS.

أظهرت النتائج ان دجاجات الخط المنتخب وضعت بيض اثقل وزناً (56.38 جرام) عن دجاجات خط الكنترول (45.51 جرام) وان الخط المنتخب تفوق علي خط الكنترول في معظم الصفات المدروسة. في كلا الخطين، كانت الارتباطات بين وزن البيضة ومعظم مكوناتها موجبة وذات دلالة إحصائية معنوية. استناداً علي قيم KMO واختبار Bartlett's، كان تحليل المكونات الأساسية مناسبا للبيانات المستخدمة. تم تحديد أربع مكونات أساسية والتي فسرت 74.79 % للخط المنتخب و73.39 % لخط الكنترول من التباين الكلي وان هذه المكونات كانت اكثر دقة في التنبؤ بوزن البيضة عن استخدام الصفات الأصلية. وبالتالي، فإن تحسين خط الدجاج الدندراوي المنتخب لوزن الجسم العالي في صفات جودة البيض امر هام لإنتاج الدجاج الدندراوي المحسن وان المكونات الأساسية الأربعة يمكن أن تستخدم بفاعلية كاستراتيجية للانتخاب لتحسين صفات جودة البيض.

الكلمات الدالة: وزن البيضة، دجاج الدندراوي، تحليل المكونات الأساسية، الارتباط.