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Comparative study of egg quality traits between Potchefstroom Koekoek and Hy-line silver brown layers

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Abstract

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Chicken egg is a biological structure intended by nature for reproduction and it also provides a complete diet for the developing embryo. In the current study, data on external and internal egg quality traits viz. egg weight (EW), egg length (EL), egg width (EWD), yolk weight (YW), shell weight (SW), shell surface index (SI), shell surface area (S.S.A), shell ratio (SR), albumen weight (AW), egg volume (EV), albumen ratio (AR), yolk ratio (YR), yolk/albumen (Y/A) and unit shell surface weight (USSW) were collected from Potchefstroom Koekoek and Hy-line silver brown layers to determine effect of chicken layer on egg quality traits. A total of 200 fresh eggs were randomly collected from the Potchefstroom Koekoek and Hy-line silver brown chickens at 22 weeks of age with 100 eggs per chicken layer to measure the physical egg quality traits. Pearson correlation and Analysis of variance (ANOVA) were used for data analysis. Correlation results of Potchefstroom Koekoek revealed that EW had a positively high statistical significant correlation ($P < 0.01$) with EL ($r = 0.54$), EWD ($r = 0.85$), YW ($r = 0.67$), SW ($r = 0.59$), S.S.A ($r = 1.00$), AW ($r = 0.82$) and EV ($r = 0.89$). While in Hy-line Silver Brown, EW had a positively high statistical significant correlation ($P<0.01$) with EL ($r = 0.63$), EWD ($r = 0.77$), YW ($r = 0.71$), SW ($r = 0.71$), S.S.A ($r = 1.00$) and AW ($r = 0.93$), respectively. ANOVA findings recognised that almost all the egg quality traits affected by the chicken layer favoured the Hy-line Silver Brown chicken breed when compared to Potchefstroom Koekoek chicken layer. Therefore, more studies required to improve egg quality traits of Potchefstroom Koekoek chicken layer. The study will help chicken egg farmers to improve egg quality traits to increase egg production.

Keywords: egg weight; egg length; egg width; shell weight; egg yolk weight

Introduction

Eggs are produced by laying hens, which are specialised breeds of chicken that have been selected for their high rates of egg production and are different to the breeds reared for meat (Yilmaz Dikmen et al., 2016). Chicken eggs are the best source of quality protein and serve as food for human (Tabeekh, 2011). Most commercial strains of hen can lay over 260 eggs per year and some improved genotypes can lay over 300 eggs in a year, this is almost an egg every day (Zaheer, 2015). Egg quality traits are considered as both external egg quality, focusing on the eggshell, and internal egg quality, focusing on the egg content (Ayeni et al., 2018). The Potchefstroom Koekoek is an indigenous chicken genotype which was composed in Potchefstroom Agricultural College in South Africa and it was developed through crossing of White Leghorn and Black Australorp with some barred Plymouth added (Grobbelaar et al., 2010; Tyasi et al., 2020). Hy-line silver brown layer is a commercial chicken which is a most prolific egg layer (Dessie & Gatachew, 2016; Tyasi et al., 2021). However, Potchefstroom Koekoek chicken genotype has a poor egg production, which leads to reduced egg yield and revenue of farmers (Rahman, 2013). Hy-line silver brown chicken genotype has a high egg production, which leads to increased egg yield (Okoro et al., 2017). Improvement of the egg quality traits in chickens might help to improve their egg production (Otsuka et al., 2011). Nassar et al. (2017) conducted a study on egg quality traits in Cairo L-2 strain, as a local layer strain and commercial Lohmann Brown-Lite (LBL) strain genotype, and this study indicated that Cairo L-2 strain chicken genotype performance is greater than Lohmann Brown-Lite in egg quality traits. Lado et al. (2015) conducted a comparison study of commercial and indigenous chickens and indicated that exotic Rhode Island Red produce high eggs quality traits than indigenous Baledy chicken genotype. However, based on our knowledge, there is no study that has been done to compare the egg quality traits in Potchefstroom Koekoek and Hy-line silver brown layers.

Hence, the objectives of the study were: 1). To determine the relationship between egg quality traits of Potchefstroom Koekoek and Hy-line silver brown layers. 2). To determine the effect of chicken genotype on egg quality traits. Therefore, current study will provide information on egg quality traits of Potchefstroom Koekoek and Hy-line silver brown layers. The present study will also help communal farmers, breeders, researchers, and egg production companies in determining egg quality of Potchefstroom Koekoek and Hy-line silver brown layers and to understand the egg production between indigenous and commercial chickens.

Materials and Methods

Study area

The current study was conducted at the University of Limpopo Experimental farm, South Africa. The farm is situated 10km north-west of the university. Temperature in summer ranges from 10°C to 36°C and in winter temperature ranges from 5°C to 28°C. University of Limpopo lies at latitude 27.55ºS and longitude 24.77ºE and the mean annual rainfall is less than 400 mm (Kutu and Asiwe, 2010).

Experimental animals and managements

Potchefstroom Koekoek and Hy-line silver brown chicken breed were used in this study. The chickens were purchased and raised under intensive managed system in a closed space on deep litter from day old until they were pullets (22 weeks). They were medicated similarly, and they were also subjected to the same managerial, hygienic, and climatic conditions. During the brooding and rearing periods, all chicks were fed *ad libitum* using standard commercial starter (21% crude protein (CP) and 3000 kcal metabolize able energy (ME)/kg) from hatching time to 4 weeks of age, followed by a grower diet (18% CP and 2900 kcal ME/kg) to 10 weeks of age. At the age of 22 weeks, the chickens were separated per breed. The layers were fed with 16.10% crude protein diet 11.97 MJkg/DM. The diet consisted with ingredients like: maize (64%), maize gluten meal (11.67%), soya Hipro (4.37%), fish meal (5%), full fat soya (4.91%), Di sodium phosphate (1.33%), L-lysine (0.20%), $CaCO_3$ (8.17), DL-methionine (0.20%) and vitamin trace element premix (0.15%). The chickens were vaccinated against Newcastle disease, Gumboro, Marek's and Fowl Pox disease. Artificial heat (32°C) using infrared lights and continuous light program was provided. Ventilation was controlled using curtain rails. The standard normal management actions were exactly obeyed as explained by Alabi et al. (2012).

Experimental design

Completely randomized design was used in the current study. A total of 100 chickens were randomly selected with 50 per breed at the age of 22 weeks. A total of 200 fresh eggs were randomly collected from the Potchefstroom Koekoek and Hy-line silver brown chicken breeds when they were 22 weeks of age with 100 eggs per breed to measure egg quality traits.

Measurement of external egg quality traits

External egg quality traits that were measured are, egg weight (g), egg length (cm), egg width (cm), egg shape index (%) and shell weight (g). External egg quality traits were measured as described by Kgwatalala et al. (2013). Briefly, egg weight was determined using an electronic scale, while egg length and width were determined with a Vernier calliper. Shell weight was determined by weighing the shell on the electronic scale. Other external egg quality traits such as egg shape index, shell surface area, unit surface shell weight and shell ratio were calculated using the following formulas by Markos et al. (2017).

Shape index (%) = x 100

Shell surface area (cm^2) = 3.9782 x egg weight$^{0.75056}$

Unit surface shell weight (g/cm^2) =

Shell ratio (%) = x 100

Egg volume (cm^3) = [0.6057 – (0.018- egg width)] x egg length x (egg width)^2

Measurement of internal egg quality traits

Internal egg quality traits that were measured are egg yolk weight (g) and albumen weight (g). Internal egg quality traits were measured following the procedure of Kgwatalala et al. (2013). Briefly, the individual eggs were carefully broken out being cautious not to break the membranes that enclose the egg yolk and albumen. The egg yolk and albumen were carefully separated, and the weight of the egg yolk was determined using an electronic scale. Albumen weight was calculated by subtracting the yolk weight and the shell weight from the whole egg weight. Other internal egg quality traits like albumen ratio, yolk ratio, and yolk/albumen and egg volume were calculated using the formulas as indicated by Ashraf et al. (2016).

Albumen weight (g) = egg weight – (yolk weight + shell weight)

Albumen ratio (%) = x100

Yolk ratio (%) = x 100

Yolk / albumen = x 100

Statistical analysis

Statistical Analysis System (SAS, 2019) software program version 9.4 was used to analyse the data. One-way analysis of variance (ANOVA) was used to determine effect of breed on egg quality traits. All the statistical analysis was performed at the 5% significance level. Duncan Multiple Range Test was used for significant differences among means. The following model was used to achieve the objectives of this study:

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

Where, Y_{ij}: The j^{th} observation of the i^{th} egg quality traits.

μ: The overall mean.

S_i: The fixed effect of the i^{th} breed.

e_{ij}: Residual error.

Results and Discussion

Phenotypic correlation among measured traits

The correlation is the common and useful statistics that describes the degree of relationship between two variables. Table 1 displays Pearson's correlation results of Potchefstroom Koekoek chicken breed. Pearson's correlation results of Potchefstroom Koekoek revealed that EW had a positively high statistical significant correlation (P < 0.01) with EL (r = 0.54), EWD (r = 0.85), YW (r = 0.67), SW (r = 0.59), S.S.A (r = 1.00), AW (r = 0.82) and EV (r = 0.89) but had no statistical significant correlation with SI (r = -0.09), SR (r = -0.17), USSW (r = 0.02), AR (r = 0.08), YR (r = -0.03) and Y/A (r = -0.05). The results further showed that EL had a positively high statistical significant association (P < 0.01) with EV (r = 0.71) and S.S.A (r = 0.54), a positive statistical significant association (P < 0.05) with AW (r = 0.47), EWD (r = 0.32) and YW (r = 0.36) and a negatively high statistical significant association (P < 0.01) with SI (r = -0.86) but had no statistical significant association with SW (r = 0.20), SR (r = -0.23).

Table 1. Phenotypic correlation among egg quality traits of Potchefstroom Koekoek chicken breed

Traits	EW, g	EL, mm	EWD, mm	YW, g	SW, g	SI, %	S.S.A, cm²	USSW, g/cm²	SR, %	AW, g	AR, %	YR (%)	Y/A (%)	EV (cm³)
EW, g														
EL, mm	0.54^{**}													
EWD, mm	0.85^{**}	0.32^{*}												
YW, g	0.67^{**}	0.36^{*}	0.61^{**}											
SW, g	0.59^{**}	0.20^{ns}	0.56^{**}	0.48^{*}										
SI, %	-0.09^{ns}	-0.86^{**}	0.20^{ns}	-0.03^{ns}	0.09^{ns}									
S.S.A, cm²	1.00^{**}	0.54^{**}	0.85^{**}	0.67^{**}	0.59^{**}	-0.09^{ns}								
USSW, g/cm²	0.02^{ns}	-0.12^{ns}	0.10^{ns}	0.15^{ns}	0.77^{**}	0.18^{ns}	0.02^{ns}							
SR, %	-0.17^{ns}	-0.23^{ns}	-0.08^{ns}	-0.02^{ns}	0.69^{**}	0.18^{ns}	-0.18^{ns}	0.92						
AW, g	0.82^{**}	0.47^{*}	0.65^{**}	0.15^{ns}	0.25^{*}	-0.13^{ns}	0.82^{**}	-0.28^{*}	-0.42^{*}					
AR, %	0.08^{ns}	0.09^{ns}	-0.01^{ns}	-0.64	-0.34	-0.10^{ns}	0.09^{ns}	-0.49^{*}	-0.47^{*}	0.64^{**}				
YR, %	-0.03^{ns}	-0.01^{ns}	0.04^{ns}	0.73	0.09^{ns}	0.04^{ns}	-0.03^{ns}	0.16^{ns}	0.11^{ns}	-0.55^{**}	-0.92^{**}			
Y/A, %	-0.05^{ns}	-0.02^{ns}	0.03^{ns}	0.71^{**}	0.18^{ns}	0.05^{ns}	-0.05^{ns}	0.28^{*}	0.24^{ns}	-0.59^{**}	-0.96^{**}	0.99^{**}		
EV, cm³	0.89^{**}	0.71^{**}	0.89^{**}	0.62^{**}	0.51^{**}	-0.26^{*}	0.89^{**}	0.02^{ns}	-0.17^{ns}	0.71^{**}	0.05^{ns}	0.02^{ns}	0.00^{ns}	

EW= egg weight, EL= egg length, EWD= egg width, YW= yolk weight, SW= shell weight, SI= shell surface index, S.S.A= shell surface area, SR= shell ratio, AW= albumen weight, EV= egg volume, AR= albumen ratio, YR= yolk ratio, Y/A= yolk/albumen, USSW= unit shell surface weight, ns= not significant, * Significant ($p < 0.05$) and **Significant ($p < 0.01$)

Table 2. Phenotypic correlation among egg quality traits of Hy-line Silver brown chicken breed

Traits	EW, g	EL, mm	EWD, mm	YW, g	SW, g	SI, %	S.S.A, cm^2	USSW, g/cm^2	SR, %	AW, g	AR, %	YR (%)	Y/A (%)	EV (cm^3)
EW, g														
EL, mm	0.63^{**}													
EWD, mm	0.77^{**}	0.30^{*}												
YW, g	0.71^{**}	0.50^{*}	0.62^{**}											
SW, g	0.71^{**}	0.54^{**}	0.60^{**}	0.56^{**}										
SI, %	-0.17^{ns}	-0.83^{**}	0.29^{*}	-0.14^{ns}	-0.20^{ns}									
S.S.A, cm^2	1.00^{**}	0.63^{**}	0.78^{**}	0.71^{**}	0.71^{**}	-0.17^{ns}								
USSW, g/cm^2	0.15^{ns}	0.20^{ns}	0.17^{ns}	0.21^{ns}	0.74^{**}	-0.12^{ns}	0.15^{ns}							
SR, %	-0.20^{ns}	-0.02^{ns}	-0.09^{ns}	-0.05^{ns}	0.54^{**}	-0.05^{ns}	-0.20^{ns}	0.85^{**}						
AW, g	0.93^{**}	0.54^{**}	0.68^{**}	0.42^{*}	0.52^{**}	-0.14^{ns}	0.93^{**}	-0.05^{ns}	-0.37^{*}					
AR, %	0.30^{*}	0.09^{ns}	0.11^{ns}	-0.40^{*}	-0.16^{ns}	-0.01^{ns}	0.30^{*}	-0.45^{*}	-0.57^{**}	0.62^{**}				
YR, %	-0.28^{*}	-0.11^{ns}	-0.11^{ns}	0.48^{*}	-0.11^{ns}	0.04^{ns}	-0.28^{*}	0.11^{ns}	0.18^{ns}	-0.58^{**}	-0.91^{**}			
Y/A, %	-0.29^{*}	-0.12^{ns}	-0.11^{ns}	0.46^{*}	-0.02^{ns}	0.05^{ns}	-0.29^{*}	0.33^{*}	0.33^{*}	-0.61^{**}	-0.96^{**}	0.99^{**}		
EV, cm^3	0.17^{ns}	-0.34^{*}	0.25^{*}	-0.06^{ns}	-0.13^{ns}	0.52^{**}	0.17^{ns}	-0.33^{*}	-0.34^{*}	0.29^{*}	0.38^{*}	-0.28^{*}	-0.31^{*}	

EW= egg weight, EL= egg length, EWD= egg width, YW= yolk weight, SW= shell weight, SI= shell surface index, S.S.A= shell surface area, SR= shell ratio, AW= albumen weight, EV= egg volume, AR= albumen ratio, YR= yolk ratio, Y/A= yolk/albumen, USSW= unit shell surface weight, ns= not significant, * Significant ($p < 0.05$) and **Significant ($p < 0.01$)

Pearson's correlation results of Hy-line Silver Brown chicken breed are shown in Table 2. The results showed that EW had a positively high statistical significant correlation ($P<0.01$) with EL (r = 0.63), EWD (r = 0.77), YW (r = 0.71), SW (r = 0.71), S.S.A (r = 1.00), and AW (r = 0.93), a positive statistical significant association ($P < 0.05$) with AR (r = 0.30), and a negative statistical significant correlation ($P < 0.05$) with YR (r = -0.28) and Y/A (r = -0.29) but had no statistical significant correlation with SI (r = -0.17), SR (r = -0.20), USSW (r = 0.15) and EV (r = 0.17).

Again, the results indicated that EL had a positively high statistical significant association ($P < 0.01$) with SW (r = 0.54), S.S.A (r = 0.63), AW (r = 0.54), a positive statistical significant association ($P < 0.05$) with YW (r = 0.50) and EWD (r = 0.30), a negatively high statistical significant correlation ($P < 0.01$) with SI (r = -0.83) and a negative statistical significant correlation ($P < 0.05$) with EV (r = -0.34) but had no statistical significant correlation with SR (r = -0.02), USSW (r = 0.20), AR (r = 0.09), YR (r = 0.11) and Y/A (r = 0.12). Kejela et al. (2019) study on Native, Sasso and Bovans brown breeds is in agreement with the current study with the results showed more correlation between internal and external egg quality traits of local and exotic chickens. Current study findings are dissimilar to the findings of Rajkumar et al. (2009) who found dissimilar correlation results on Naked neck breed. The variation might be due to different breeds. The results of the current study suggest that EL, EWD, YW, SW, S.S.A, AW and EV might be used to improve egg weight of Potchefstroom Koekoek. Whereas, EL, EWD, YW, SW, S.S.A and AR might be used to improve egg weight of Hy-line Silver Brown during breeding.

Effect of breed on egg quality traits

The results of external egg quality traits of the two chicken breeds namely, Potchefstroom Koekoek and Hy-line Sil-

Table 3. Effect of breed on external egg quality traits

Egg quality traits	Potchefstroom Koekoek (Mean ± SE)	Hy-line Silver Brown (Mean ± SE)
EW, g	54.79 ± 0.67^{b}	63.10 ± 0.95^{a}
EL, mm	54.82 ± 0.47^{b}	57.65 ± 0.50^{a}
EWD, mm	42.04 ± 0.19^{b}	44.03 ± 0.22^{a}
SW, g	7.33 ± 0.13^{b}	8.22 ± 0.15^{a}
SI, %	76.79 ± 0.64^{a}	76.52 ± 0.67^{a}
SSA, cm^2	80.26 ± 0.74^{b}	89.21 ± 1.01^{a}
SR, %	13.38 ± 0.19^{a}	13.00 ± 0.18^{a}
USSW	0.09 ± 0.00^{a}	0.09 ± 0.00^{a}

EW= egg weight, EL= egg length, EWD= egg width, SW= shell weight, SI= shell surface index, S.S.A = shell surface area, SR= shell ratio, USSW= unit shell surface weight. a, b means in the same row with different superscripts are significantly different ($P < 0.05$)

ver Brown are shown in Table 3. The findings revealed that EW was significantly ($P < 0.05$) affected by the breed. The results further showed that EL, EWD, SW and SSA were significantly ($P < 0.05$) affected by the breed, and SI, SR and USSW were not significantly ($P > 0.05$) affected by the breed.

The results of internal egg quality traits of the two chicken breeds Potchefstroom Koekoek and Hy-line Silver Brown are displayed in Table 4.

Table 4. Effect of breed on internal egg quality traits

Egg quality traits	Potchefstroom Koekoek (Mean ± SE)	Hy-line Silver Brown (Mean ± SE)
YW, g	17.84 ± 0.32^{a}	18.31 ± 0.30^{a}
AW, g	29.62 ± 0.48^{b}	36.57 ± 0.68^{a}
AR, %	54.10 ± 0.50^{b}	57.91 ± 0.42^{a}
YR, %	32.57 ± 0.44^{a}	29.06 ± 0.35^{b}
Y/A, %	60.65 ± 1.33^{a}	50.35 ± 0.97^{b}

YW= yolk weight, AW= albumen weight, AR= albumen ratio, YR= yolk ratio, Y/A= yolk/albumen. a, b means in the same row with different superscripts are significantly different ($P < 0.05$)

The study revealed that AW, AR, YR and Y/A were significantly ($P < 0.05$) affected by the breed. Furthermore, the results showed that YW was not significantly ($P > 0.05$) affected by the breed. Oleforuh-Okoleh (2016) study on Black Olympia and the Nigerian local chicken is in agreement with the current study which results showed that egg quality traits measured include egg weight, egg shape index, shell weight and shell thickness were significantly affected by the breed. However, the current study findings are dissimilar to the findings of Islam and Dutta (2010) study on indigenous (Deshi), three exotics (Cobb 500 of Broiler, Fayoumi, and RIR) and a crossbred (Sonali derived from RIR Fayoumi) chicken breeds, with their results showed that highly significant differences exist for both external and internal egg quality traits between the genetic groups of chicken. The variation might be due to different breeds. The findings of the current study suggest that Hy-line Silver Brown chicken breed is the better than Potchefstroom Koekoek chicken breed in most egg quality traits. Therefore, genetic improvement of egg quality traits in Potchefstroom Koekoek is required.

Conclusion

The study was conducted to investigate the relationship between egg quality traits and also to compare egg quality traits between Potchefstroom Koekoek and Hy-line silver Brown chicken breed. Pearson correlation was used to determine the relationship between the measured trait, the results suggest that EL, EWD, YW, SW, S.S.A, AW and EV had a high positive statistical significant correlation with EW in both chicken breeds. Analysis of variance was used to examine the effect of chicken breed on egg quality traits, the findings suggest that egg quality traits affected by the breed favoured the Hy-line silver Brown genotype compared to Potchefstroom Koekoek. Therefore, egg quality traits of Potchefstroom Koekoek chicken breed might be require a genetic improvement.

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