



Effect of breed and age on egg quality characteristics of two South African locally developed dual-purpose chicken breeds

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Abstract

Indigenous chickens are essential to rural livelihoods across Africa, providing meat and eggs for household nutrition and thus ensuring food security. However, information on egg quality traits of Potchefstroom Koekoek and Boschveld breeds remain limited, which is vital for identifying differences in performance, inform targeted breeding and management methods, and improve overall productivity. Hence, this study was conducted to explore the influence of breed and age on egg quality traits of Potchefstroom Koekoek and Boschveld chickens. A total of 100 chickens were randomly selected ($n = 50$ for each breed) and 800 eggs were randomly collected from the two breeds at 28, 32, 36, and 40 weeks of age, with 400 eggs collected per breed. An electronic weighing scale was used to measure egg weight (EW), shell weight (SW), and yolk weight (YW), while a digital Vernier calliper was used to measure egg width (EWD) and egg length (EL). Internal egg quality traits, including yolk ratio (YR), albumen weight (AW), albumen ratio (AR), yolk-to-albumen ratio (Y/A), and egg volume (EV), as well as external egg quality traits, including egg shape index (ESI), shell ratio (SR), shell surface area (SSA), and unit surface shell weight (USSW), were also determined. The findings revealed that Boschveld chickens had significantly higher EW (46.28 ± 0.33), SW (5.90 ± 0.03), EL (49.76 ± 0.32), EWD (36.55 ± 0.31), SSA (70.59 ± 0.39), YW (14.27 ± 0.12), EV (37939.80 ± 694.97), and Y/A (55.76 ± 0.51) than Potchefstroom Koekoek chickens. Age also had a significant effect on egg quality traits, with most traits increasing with advancing age and the highest values observed at 40 weeks. Overall, Boschveld chickens displayed superior performance in several key egg quality characteristics compared to Potchefstroom Koekoek chickens. In conclusion, both breed and age significantly influenced egg quality traits, and may assist management decisions and may provide baseline information for future breeding programmes.

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1. Introduction

Poultry eggs are affordable, widely accepted, and globally recognised as a nutritionally complete food source (Dudusola et al. 2020; Guni et al. 2021). Egg quality is a critical determinant of efficiency and profitability of egg production, processing, and breeding enterprises, as well as customer acceptance (Oleforuh-Okoleh et al. 2018). Indigenous chicken breeds are well known for their ability to adapt to tropical climates and their resilience to diseases, while the colour of their plumage serves as a means of defence against potential predators (Padhi 2016). Among these, Potchefstroom Koekoek and Boschveld are two important South African indigenously developed chicken breeds with unique genetic, physiological, and adaptive characteristics that could affect the quantity and quality of their eggs (Manyelo et al. 2020). Despite the contributions of indigenous chickens to the livelihoods of rural farmers and tolerance to harsh temperatures, their productivity is low due to factors such as poor nutrition and a high mortality rate in chicks (Maoba et al. 2022). Therefore, efforts to improve native breeds through targeted selection need to be prioritized (Okoro et al. 2017).

Consumers prefer eggs from indigenous chicken breeds due to their taste, flavour, and nutritional quality, which highlights the importance of evaluating the egg quality traits of these chickens (Sapkota et al. 2020; Lordelo et al. 2020). It has been reported that breed and age are among the most important factors influencing egg quality (Kraus and Zita 2019). Although numerous studies have examined the effect of

breed and age on egg quality traits of chickens (Kraus and Zita 2019; Kraus et al. 2020; Manyeula et al. 2021; Zita et al. 2009), limited information is available on the effects of breed and age on egg quality traits of Potchefstroom Koekoek and Boschveld chicken breeds. This gap in knowledge limits the ability to make informed decisions for selective breeding and to develop targeted methods for improving the egg quality and production efficiency of these indigenous chickens. These breeds were selected for this study because they are commonly reared dual-purpose chicken breeds that perform well and have been developed to improved productivity (Nambahu et al. 2024). They are mainly preferred by rural farmers as they are robust and well-adapted, making them valuable for assessing productivity and egg quality traits for local poultry improvement programmes (Sithole et al. 2025). The age groups of 28, 32, 36, and 40 weeks were selected to represent various stages of the laying cycle and to assess changes in egg quality traits as hens mature. Therefore, this study aimed to investigate the influence of breed and age on egg quality characteristics of Potchefstroom Koekoek and Boschveld chicken breeds. It was hypothesised that both breed and age affect external and internal egg quality traits of these chicken breeds. Evaluating these factors may help identify breed-specific and age-related trends that may inform selective breeding and management strategies aimed at improving egg quality.

2. Materials and Methods

2.1 Ethical approval

Ethical approval for this study (project number AREC/57/2024:PG) was granted by the University of Limpopo Animal Research Ethics Committee (ULAREC) before the commencement of the study.

2.2 Study site

The study was carried out at the University of Limpopo Experimental Farm in Limpopo Province, South Africa, located approximately 10 km northwest of the University of Limpopo. Summer temperatures range between 20 °C and 36 °C, while temperatures in winter range between 5 °C and 25 °C. It is located at a latitude of 27.55 °S and a longitude of 24.77 °E, with an average annual rainfall of less than 400 mm (Hlokoe et al. 2023).

2.3 Experimental animals and management

Potchefstroom Koekoek and Boschveld chicken breeds were used in this study. The chickens were hatched at the University of Limpopo Experimental Farm and reared under an intensive management system on deep litter from day one to the point of lay. All birds were exposed to the same management, hygiene, and environmental conditions. Feeds and water were provided *ad libitum*. A continuous lighting program was used and infrared lamps (250 W) were used to maintain a brooding temperature of 32 °C during the initial brooding period. Curtain rails were used to control ventilation, and they were open during the day and closed at night.

2.4 Experimental design

A completely randomized design (CRD) was used in this study. The experiment followed a 2 x 4 factorial arrangement, with two breeds (Potchefstroom Koekoek and Boschveld) and four age groups (28, 32, 36, and 40 weeks) as the treatment factors, resulting in eight treatment combinations (P28, P32, P36, P40 and B28, B32, B36, B40). A total of 100 indigenous chickens were chosen at random, with 50 chickens from each breed. A total of 800 eggs were randomly collected from the two indigenous chicken breeds at different age points (28, 32, 36, and 40 weeks), with 400 eggs per breed. Eggs were collected at each age group, with 100 eggs collected from each breed at each age group, and various external and internal egg quality characteristics were determined. Each hen was regarded as an experimental unit within its respective treatment combination.

2.5 Measurement of external egg quality characteristics

Egg length (mm), egg width (mm), egg weight (g), shell weight (g), and egg shape index (%) were the external egg quality characteristics that were measured (Hlokoe et al. 2023). An electronic scale (Medidata®) with a precision of 0.01 g was used to measure the egg weight, and a digital Vernier calliper (Mitutoyo®) with an accuracy of 0.01 mm was used to measure the egg width and egg length. The electronic scale was also used to measure shell weight. Using the formulas described by Markos et al. (2017), other external egg quality characteristics were determined as follows:

$$\text{Shape index (\%)} = (\text{Egg width} / \text{Egg length}) \times 100$$

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

$$\text{Shell surface area (mm}^2\text{)} = 3.9782 \times \text{Egg weight}^{0.7506}$$

$$\text{Unit surface shell weight (g/mm}^2\text{)} = (\text{shell weight} / \text{Shell surface area})$$

2.6 Measurement of internal egg quality characteristics

Yolk weight (g) and albumen weight (g) were measured, following procedures of Hlokoe et al. (2023). Eggs were carefully broken, ensuring the egg yolk membrane remained intact. A yolk separator was used to separate the egg yolk and albumen, and an electronic weighing scale was used to weigh the egg yolk. Using the formulas by Ashraf et al. (2016), other internal egg quality characteristics were calculated as follows:

$$\text{Albumen ratio (\%)} = (\text{Albumen weight} / \text{Egg weight}) \times 100$$

$$\text{Albumen weight (g)} = \text{Egg weight} - (\text{Shell weight} + \text{Yolk weight})$$

$$\text{Yolk ratio (\%)} = (\text{Yolk weight} / \text{Egg weight}) \times 100$$

$$\text{Yolk / albumen} = (\text{Yolk weight} / \text{Albumen weight}) \times 100$$

$$\text{Egg volume (mm}^3\text{)} = [(0.6057 - 0.018 (\text{egg width})) \times \text{egg length} \times (\text{egg width})^2]$$

2.7 Statistical analysis

Data were analysed using SAS software (SAS Institute, 2025; version 9.4). A two-way Analysis of variance (ANOVA) was used to analyse the breed and age effects, and their interaction, on external and internal egg quality parameters. All statistical analyses were performed at a 5% significance level, and the Duncan Multiple Range Test was used to determine significant differences between means. The following General Linear Model (GLM) was used to achieve the objectives of this study:

$$Y_{ij} = \mu + B_i + A_j + (B \times A)_{ij} + e_{ijk}$$

Where:

Y_{ij} – the observation on egg quality characteristics for the i^{th} breed, j^{th} age, and k^{th} replicate

μ – overall mean

B_i – effect of the i^{th} breed

A_j – effect of the j^{th} age group

$(B \times A)_{ij}$ – the interaction effect between breed and age

e_{ijk} – Random residual error

3. Results and Discussion

Breed and age are the key factors affecting the quality of eggs in poultry (Kraus and Zita 2019). Table 1 and Table 2 show the effects of breed, age, and their interaction on external and internal egg quality traits of Boschveld and Potchefstroom Koekoek chicken breeds. The results indicated that the Boschveld chicken breed had significantly higher values of egg length, egg width, egg volume ($P < 0.01$), as well as egg weight, shell weight, shell surface area, yolk weight, and yolk/albumen ratio ($P < 0.05$), compared to the Potchefstroom Koekoek chicken breed. However, no significant ($P > 0.05$) breed differences were found in egg shape index, shell ratio, unit surface shell weight, yolk ratio, albumen weight, and albumen ratio. Overall, the present study revealed the superiority of the Boschveld chicken breed in most studied parameters over the Potchefstroom Koekoek chicken breed. These findings agree with those reported by Tyasi et al. (2022), who found that breed affected external egg quality characteristics including egg weight, egg length, egg width, shell weight, and shell surface area but had no effect on the shell ratio and unit surface shell weight of Potchefstroom Koekoek chickens. However, in contrast Guni et al. (2021) reported no breed effects on egg width and shell weight of Kuroiler and Sasso chickens

Table 1. Effect of breed, age, and their interaction on the external egg quality traits (Mean $\pm$ SE)

Breed	EW (g)	SW (g)	EL (mm)	EWD (mm)	ESI (%)	SR (%)	USSW (g/mm ²)	SSA (mm ²)
BV	46.28 $\pm$ 0.33 ^a	5.90 $\pm$ 0.03 ^a	49.76 $\pm$ 0.32 ^a	36.55 $\pm$ 0.31 ^a	73.16 $\pm$ 0.28 ^a	12.86 $\pm$ 0.06 ^a	0.08 $\pm$ 0.00 ^a	70.59 $\pm$ 0.39 ^a
PK	45.07 $\pm$ 0.40 ^b	5.76 $\pm$ 0.05 ^b	47.06 $\pm$ 0.33 ^b	34.40 $\pm$ 0.30 ^b	72.73 $\pm$ 0.23 ^a	12.84 $\pm$ 0.06 ^a	0.08 $\pm$ 0.00 ^a	69.15 $\pm$ 0.46 ^b
P-value	0.02 [*]	0.02 [*]	0.00 ^{**}	0.00 ^{**}	0.23 ^{ns}	0.83 ^{ns}	0.17 ^{ns}	0.02 [*]
Age								
28	40.48 $\pm$ 0.51 ^c	5.29 $\pm$ 0.07 ^d	41.24 $\pm$ 0.45 ^d	29.13 $\pm$ 0.44 ^c	70.15 $\pm$ 0.43 ^d	13.11 $\pm$ 0.07 ^b	0.08 $\pm$ 0.00 ^b	63.81 $\pm$ 0.59 ^c
32	44.16 $\pm$ 0.39 ^b	5.94 $\pm$ 0.04 ^b	49.36 $\pm$ 0.36 ^c	36.78 $\pm$ 0.34 ^b	74.38 $\pm$ 0.30 ^b	13.53 $\pm$ 0.08 ^a	0.09 $\pm$ 0.00 ^a	68.19 $\pm$ 0.45 ^b
36	44.44 $\pm$ 0.36 ^b	5.66 $\pm$ 0.05 ^c	52.26 $\pm$ 0.18 ^a	39.33 $\pm$ 0.12 ^a	75.37 $\pm$ 0.25 ^a	12.78 $\pm$ 0.08 ^c	0.08 $\pm$ 0.00 ^b	68.54 $\pm$ 0.42 ^b
40	53.60 $\pm$ 0.29 ^a	6.43 $\pm$ 0.05 ^a	50.80 $\pm$ 0.39 ^b	36.65 $\pm$ 0.39 ^b	71.87 $\pm$ 0.31 ^c	12.00 $\pm$ 0.07 ^d	0.08 $\pm$ 0.00 ^c	78.94 $\pm$ 0.32 ^a
P-value	0.00 ^{**}	0.00 ^{**}	0.00 ^{**}	0.00 ^{**}	0.00 ^{**}	0.00 ^{**}	0.00 ^{**}	0.00 ^{**}
Breed by age								
BV, 28 Weeks	45.53 $\pm$ 0.71 ^c	5.94 $\pm$ 0.09 ^b	42.56 $\pm$ 0.66 ^e	29.14 $\pm$ 0.63 ^e	68.10 $\pm$ 0.61 ^e	13.12 $\pm$ 0.10 ^b	0.09 $\pm$ 0.00 ^b	69.72 $\pm$ 0.81 ^c
PK, 28 Weeks	35.45 $\pm$ 0.17 ^e	4.64 $\pm$ 0.04 ^e	39.93 $\pm$ 0.59 ^f	29.12 $\pm$ 0.63 ^e	72.21 $\pm$ 0.53 ^c	13.09 $\pm$ 0.10 ^b	0.08 $\pm$ 0.00 ^e	57.89 $\pm$ 0.21 ^e
BV, 32 Weeks	43.88 $\pm$ 0.67 ^d	5.89 $\pm$ 0.06 ^b	48.99 $\pm$ 0.51 ^c	36.83 $\pm$ 0.49 ^c	75.08 $\pm$ 0.50 ^a	13.57 $\pm$ 0.12 ^b	0.09 $\pm$ 0.00 ^a	67.82 $\pm$ 0.78 ^d
PK, 32 Weeks	44.44 $\pm$ 0.41 ^c	5.99 $\pm$ 0.06 ^b	49.72 $\pm$ 0.51 ^c	36.73 $\pm$ 0.46 ^c	73.70 $\pm$ 0.30 ^b	13.48 $\pm$ 0.09 ^a	0.09 $\pm$ 0.00 ^a	68.56 $\pm$ 0.47 ^c
BV, 36 Weeks	44.49 $\pm$ 0.64 ^c	5.74 $\pm$ 0.09 ^c	52.44 $\pm$ 0.33 ^b	39.34 $\pm$ 0.21 ^b	75.19 $\pm$ 0.42 ^a	12.95 $\pm$ 0.12 ^b	0.08 $\pm$ 0.00 ^c	68.54 $\pm$ 0.75 ^c
PK, 36 Weeks	44.40 $\pm$ 0.34 ^c	5.59 $\pm$ 0.05 ^d	52.07 $\pm$ 0.13 ^b	39.32 $\pm$ 0.11 ^b	75.55 $\pm$ 0.29 ^a	12.61 $\pm$ 0.10 ^c	0.08 $\pm$ 0.00 ^d	68.53 $\pm$ 0.39 ^c
BV, 40 Weeks	51.21 $\pm$ 0.35 ^b	6.04 $\pm$ 0.05 ^b	55.07 $\pm$ 0.13 ^a	40.88 $\pm$ 0.14 ^a	74.27 $\pm$ 0.31 ^b	11.81 $\pm$ 0.08 ^e	0.08 $\pm$ 0.00 ^e	76.29 $\pm$ 0.40 ^b
PK, 40 Weeks	56.00 $\pm$ 0.29 ^a	6.82 $\pm$ 0.07 ^a	46.52 $\pm$ 0.49 ^d	32.43 $\pm$ 0.49 ^d	69.46 $\pm$ 0.41 ^d	12.18 $\pm$ 0.11 ^d	0.08 $\pm$ 0.00 ^c	81.60 $\pm$ 0.32 ^a
P-value	0.00 ^{**}	0.00 ^{**}	0.00 ^{**}	0.00 ^{**}	0.00 ^{**}	0.00 ^{**}	0.00 ^{**}	0.00 ^{**}

BV: Boschveld, PK: Potchefstroom Koekoek; EW: Egg weight, SW: Shell weight, EL: Egg length, EWD: Egg width, ESI: Egg shape index, SR: Shell ratio, USSW: Unit surface shell weight, SSA: Shell surface area, SE: Standard error; **: significant ($P < 0.01$), *: significant ($P < 0.05$), ns: non-significant; Mean values bearing different superscripts within the column differ significantly

and breed effect on albumen weight was reported in Siciliana and Livorno chickens (Di Rosa et al. 2020) and Oravka and Rhode Island Red breeds (Hanusová et al. 2015). These variations may be due to breed differences, nutrition, and the environment. The findings of this study imply that the Boschveld chickens performed better in terms of egg quality, compared to the Potchefstroom Koekoek chicken breed. Breed differences in body size as well as mature body weight may contribute to the observed superiority of Boschveld in most egg quality characteristics. Additionally, differences in the efficiency of feed utilisation, particularly protein and calcium metabolism, may explain why Boschveld chickens have a higher shell weight and shell surface area, compared to the Potchefstroom Koekoek.

The second objective of the study was to evaluate the effect of age on egg quality characteristics of the Boschveld and Potchefstroom Koekoek chicken breeds. The age of birds significantly ($P < 0.01$) affected all the studied egg quality traits, with egg weight, albumen weight, albumen ratio, and shell surface area increasing with advancing age, while shell ratio decreased as age increased. It was also found that the egg length, egg width, egg shape index and egg volume showed an increase until 36 weeks of age and declined at 40 weeks. However, shell weight, yolk weight, yolk ratio, yolk/albumen, and unit surface shell weight showed a decrease at 36 weeks of age but increased at 40 weeks

of age. It was found that egg weight, shell weight, shell surface area, yolk weight, albumen weight, and albumen ratio were higher at 40 weeks of age. The results of the present study are in agreement with those of Kraus et al. (2020), who found that age significantly influenced egg weight, egg shape index, shell weight, yolk weight, and albumen weight. The findings are further supported by Aminami et al. (2022), who reported that age significantly affected egg weight, length, width, and egg shape index of Marshall and Abor Acre broiler breeding stocks. It was found that the chickens showed better egg quality characteristics after 40 weeks of age. Rajaravindra et al. (2015) reported that age significantly influenced egg weight, egg length, egg width, albumen ratio, yolk weight, yolk ratio, shell weight, and shell ratio. The study found that PB-2 breeders had optimum egg quality characteristics at 40 weeks of age. The findings of the present study differ from those reported by Dinesh et al. (2022) and Ogunshola et al. (2018), who found that age did not affect the shell weight of Dahlem Red chickens and Fulani ecotype hens, respectively. This might be due to nutrition and breed differences. The findings also differ with those of Dudusola et al. (2020), who found that age had no effect on egg shape index in Noiler chickens. It has been reported that egg weight showed an increase with age; however, the egg shape index was higher in younger chickens than in older ones. The significant decline in eggshell quality found in older chickens might be due to a decrease in calcium absorption by the

Table 2. Effect of breed, age, and their interaction on internal egg quality traits (Mean $\pm$ SE)

Breed	YW (g)	YR (%)	AW (g)	AR (%)	Y/A (%)	EV (mm ³)
BV	14.27 $\pm$ 0.12 ^a	30.95 $\pm$ 0.18 ^a	26.10 $\pm$ 0.23 ^a	56.18 $\pm$ 0.19 ^a	55.76 $\pm$ 0.51 ^a	37939.8 $\pm$ 694.97 ^a
PK	13.79 $\pm$ 0.15 ^b	30.55 $\pm$ 0.15 ^a	25.52 $\pm$ 0.24 ^a	56.60 $\pm$ 0.15 ^a	54.42 $\pm$ 0.41 ^b	32279.5 $\pm$ 655.47 ^b
P-value	0.01*	0.09 ^{ns}	0.08 ^{ns}	0.09 ^{ns}	0.04*	0.00**
Age						
28	12.26 $\pm$ 0.19 ^c	30.21 $\pm$ 0.24 ^b	22.94 $\pm$ 0.30 ^d	56.68 $\pm$ 0.24 ^a	53.80 $\pm$ 0.62 ^b	21282.3 $\pm$ 858.97 ^c
32	13.72 $\pm$ 0.12 ^b	31.25 $\pm$ 0.21 ^a	24.49 $\pm$ 0.28 ^c	55.23 $\pm$ 0.25 ^b	57.15 $\pm$ 0.67 ^a	37267.5 $\pm$ 807.26 ^b
36	13.45 $\pm$ 0.13 ^b	30.46 $\pm$ 0.27 ^b	25.33 $\pm$ 0.28 ^b	56.76 $\pm$ 0.28 ^a	54.39 $\pm$ 0.76 ^b	43361.5 $\pm$ 329.16 ^a
40	16.69 $\pm$ 0.15 ^a	31.11 $\pm$ 0.20 ^a	30.48 $\pm$ 0.18 ^a	56.90 $\pm$ 0.18 ^a	55.01 $\pm$ 0.54 ^b	38527.3 $\pm$ 967.23 ^b
P-value	0.00**	0.00**	0.00**	0.00**	0.00**	0.00**
Breed by age						
BV, 28 Weeks	13.61 $\pm$ 0.31 ^d	29.68 $\pm$ 0.34 ^c	25.97 $\pm$ 0.38 ^c	57.19 $\pm$ 0.34 ^b	52.38 $\pm$ 0.85 ^c	21980.1 $\pm$ 1327.59 ^e
PK, 28 Weeks	10.90 $\pm$ 0.12 ^f	30.74 $\pm$ 0.32 ^b	19.91 $\pm$ 0.15 ^f	56.17 $\pm$ 0.33 ^c	55.22 $\pm$ 0.88 ^b	20584.6 $\pm$ 1092.65 ^e
BV, 32 Weeks	13.97 $\pm$ 0.22 ^c	32.04 $\pm$ 0.35 ^a	24.02 $\pm$ 0.47 ^a	54.40 $\pm$ 0.40 ^e	59.69 $\pm$ 1.12 ^a	37122.8 $\pm$ 1177.61 ^c
PK, 32 Weeks	13.48 $\pm$ 0.11 ^d	30.46 $\pm$ 0.23 ^b	24.97 $\pm$ 0.31 ^d	56.06 $\pm$ 0.26 ^c	54.61 $\pm$ 0.64 ^b	37412.3 $\pm$ 1110.24 ^c
BV, 36 Weeks	14.09 $\pm$ 0.21 ^c	31.98 $\pm$ 0.41 ^a	24.66 $\pm$ 0.48 ^d	55.07 $\pm$ 0.41 ^d	58.91 $\pm$ 1.17 ^a	43638.9 $\pm$ 609.26 ^b
PK, 36 Weeks	12.80 $\pm$ 0.12 ^e	28.93 $\pm$ 0.28 ^d	26.01 $\pm$ 0.30 ^c	58.45 $\pm$ 0.30 ^a	49.87 $\pm$ 0.74 ^d	43084.1 $\pm$ 250.63 ^b
BV, 40 Weeks	15.42 $\pm$ 0.15 ^b	30.12 $\pm$ 0.22 ^b	29.75 $\pm$ 0.25 ^b	58.07 $\pm$ 0.20 ^a	52.05 $\pm$ 0.56 ^c	49017.5 $\pm$ 331.14 ^a
PK, 40 Weeks	17.96 $\pm$ 0.19 ^a	32.09 $\pm$ 0.31 ^a	31.21 $\pm$ 0.23 ^a	55.72 $\pm$ 0.26 ^c	57.96 $\pm$ 0.82 ^a	28037.2 $\pm$ 1195.12 ^d
P-value	0.00**	0.00**	0.00**	0.00**	0.00**	0.00**

BV: Boschveld, PK: Potchefstroom Koekoek; YW: Yolk weight, YR: Yolk ratio, AW: Albumen weight, AR: Albumen ratio, Y/A: Yolk-to-albumen ratio, EV: Egg volume; SE: Standard error; **: significant ($P < 0.01$), *: significant ($P < 0.05$), ns: non-significant; Mean values bearing different superscripts within the column differ significantly

intestines and an increase in egg size with hen age (Nys 2017). The findings of the study imply that egg quality characteristics, including egg weight, albumen weight, albumen ratio, and shell surface area, improve with age, while the shell ratio declines with an increase in age. This may be due to the decline in skeletal calcium available for shell calcification as age increases (Dudusola et al. 2020).

The interaction effect of breed and age on egg quality traits revealed a highly significant ($P < 0.01$) difference on all the investigated traits, including egg weight, shell weight, shell surface area, egg length, egg width, egg shape index, shell ratio, unit surface shell weight, yolk weight, yolk-to-albumen ratio, yolk ratio, albumen weight, albumen ratio, and egg volume. It was revealed that the Boschveld and Potchefstroom Koekoek chicken breeds have better egg quality characteristics at 40 weeks of age, which indicates that the egg quality characteristics improve as the chickens mature. It was also found that the shell weight, shell surface area, yolk weight, and albumen weight improved with age in the Potchefstroom Koekoek chicken breed while the egg length, egg width, and egg volume improved with age in the Boschveld chicken breed. The results of the present study align with those reported by Zita et al. (2009), who found that the interaction effect of breed and age influenced egg weight, egg shape index, yolk weight, and shell weight. It was reported that egg weight and yolk quality

improved with age, with Moravia Black Shell Layer having the highest egg weight and yolk quality. The findings are not in agreement with those of Kraus et al. (2020), who reported that the interaction effect of breed and age did not affect shell weight and yolk weight. This could be due to nutrition and the environment. The findings of the study imply that the egg quality characteristics, including egg weight, shell weight, shell surface area, yolk weight, and albumen weight, improved with age and were higher in the Potchefstroom Koekoek chickens at 40 weeks. It was also found that egg length, egg width, and egg volume improved with age and were higher in the Boschveld chickens at 40 weeks of age.

4. Conclusions and Recommendations

The present study revealed that both breed and age significantly influenced egg quality traits of indigenous chickens. Boschveld chickens displayed superior egg quality traits compared to Potchefstroom Koekoek chickens, highlighting their potential use in breeding programmes focused on improving egg quality. Increasing age was associated with higher egg weight, albumen weight, albumen ratio, and shell surface area, while shell ratio declined as the hens matured. The improved egg quality traits observed at 40 weeks of age indicate that egg quality improves as hens mature. These results emphasize the importance of considering both breed and age in the development of

management, breeding, and production practices to improve the productivity of South African indigenous chicken breeds. Further research is recommended to evaluate egg quality traits in other South African indigenous chicken breeds across different regions of the country and to investigate the influence of other factors, including nutrition, environment, and genetics, on egg quality.

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