The study was conducted at Dan-Alkali integrated farm to determine the influence of strains on egg quality traits of guinea fowl (Pearl and Belgium) managed intensively to generate the following parameters: egg weight (EWT), egg length (EL), egg width (EW), shell thickness (ST), shell weight (SWT), albumen height (SH), albumen weight (AWT), yolk height (YH), yolk weight (YWT) and Haugh unit (HU). Data generated were analyzed using independent sample t-test while the relationships among the traits were estimated using Pearson’s correlation analysis. The mean values of 42.26 g, 54.63 mm, 43.36 mm, 0.39 mm, 4.62 g, 5.29 mm, 26.08 g, 15.11 mm, 15.13 g and 83.49 for EWT, EL, EW, ST, SWT, AH, AWT, YH, YWT and HU were recorded in Pearl strain while the corresponding values for the Belgium type were 55.39 g, 53.56 mm, 45.90 mm, 0.52 mm, 4.95 g, 6.84 mm, 34.03 g, 15.88 mm, 17.00 g and 84.41. Except shell thickness, genotype had influence on other egg quality traits. The correlation coefficients among the egg measurements were mostly low and insignificant in Pearl while for Belgium, significantly higher values were observed. Thus, from this study, it can be concluded that Belgium strain of guinea fowl had higher values for significantly affected traits and that some parameter (egg quality traits) can indicate each other. Therefore, crossing between the Belgium strain and Pearl should be encouraged for improved egg quality characteristics in the latter.

Keywords: Correlation, Egg quality traits, Strains, Guinea fowl

Introduction

In developing nations, animal protein deficiency has remained an issue of concern. Therefore, the need to exploit any promising animal species for increased protein supply is pertinent. One of such species is guinea fowl. It is indigenous to Africa where the shortage of animal protein is most acute (Ocheja et al., 2010). The meat from this bird contributes significantly to protein availability in this region (Africa) particularly in Nigeria, the production provides sustenance to rural dwellers and their eggs serve as buffer to shortages of poultry products. According to Ayorinde (2004), guinea fowls are second to domestic chickens in term of poultry meat supply in Nigeria. They possess valuable adaptive genetic potentials and perform well under low input. Upon these, little or no attention has been paid to the conservation and improvement of this valuable species.

The distribution of this valuable species varied with a larger population found in the northern part of Nigeria. This calls for systematic effort to conserve, manage and improve this bird. In this regard, evaluation of the egg production performance, external and internal egg qualities will be useful as a selection and also enhance economic decisions for intending backyard and/or commercial producers. In domestic birds, efficiency of production and profitability depends largely on characters like fertility, egg number, hatchability and egg quality traits among others (Balvir et al., 2000; Yahaya et al., 2009).

Wolc and Olori (2009) reported that the dam was the main source of genetic variation in hatchability of fertile eggs, suggesting a huge impact of egg quality traits. These corroborated the report that many characteristics of egg have genetic basis (Stadelman, 1977). This implies that egg quality traits can be improved genetically through knowledge of their genetic variability. These traits also reflect those characteristics that determine the acceptability of eggs to consumers (Stadelman, 1977; Song et al., 2000). The eggs of domestic chicken have been widely studied for its external and internal traits whereas such information are not well documented for other poultry species including guinea fowl, particularly in their native countries like Nigeria. It is to this effect that the current study was undertaken to compare the egg quality traits of two strains of helmeted guinea fowl (Pearl and Belgium) in the sudan savannah zone of Nigeria.
Materials and Methods

Location and Climate

This study was conducted at Dan Alkali farm in Kura Local Government Area of Kano State. Kura is 27 Km away from Kano City and lies at longitude 11˚ 46' North and latitude 8˚ 25' East with a land area of 206 Km². The Local Government is semi-arid with unpredictable rainfall distribution and duration. It has four seasons: early wet season (May-July), late wet season (August-October), early dry season (November-January) and late dry season (February-April). The mean annual rainfall ranges between 134.4 mm and 140 mm (Kano Agricultural and Rural Development Agency, 2001)

Experimental Animals and Management

The animals used for this study were domesticated guinea fowls comprising of 400 Belgium (350 females and 50 males) and 200 Pearl (160 females and 40 males) strains. They were managed intensively in deep litter and fed with vital feed layer ration (18 % CP and 2800 Kcal/ME/Kg).

Data Collection

Egg quality traits

About ten egg quality traits were measured in animal science laboratory, Ahmadu Bello University, Zaria. The traits were egg weight, egg length, egg width, shell thickness, shell weight, yolk weight, yolk height, albumen weight, albumen height and Haugh unit. Egg weight, shell weight, yolk weight and albumen weight were determined using electronic scale with an accuracy of 0.01 g while egg length and width, yolk and albumen heights were recorded using digital venier caliper (0.01mm accuracy). Shell thickness was recorded using digital micrometer screw gauge (0.01mm accuracy). Haugh unit was calculated using the following formula:

$\text{HU} = 100 \log (h - 1.7w + 7.6)$

Where

$\text{HU} = \text{Haugh unit}$

$h = \text{observed albumin height (mm)}$

$w = \text{observed weight of egg (g)}$

Data analysis

Data generated were analyzed using descriptive statistics and independent sample t-test was employed to determine the effect of strains on egg quality traits (egg measurements) all using SPSS version 25 (2017). The model utilized was as follows:

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

Where:

$Y_{ij} = \text{Egg quality traits}$

$\mu = \text{Overall mean}$

$B_i = \text{the effect of } i\text{th strains (i = 1, 2)}$

$e_{ij} = \text{residual error}$

The relationships among egg quality traits were determined using Pearson’s product moment correlation

Results

Effect of strain on egg quality parameters are presented in Table 1. Significant ($P<0.001$) effect of strain on EWT, EL, EW, SWT, AH, AWT, YH, YWT and HU was observed. Belgium strain had higher values on all significantly affected traits than Pearl (55.39±0.23 g, 45.90±0.43 mm, 4.95±0.09 g, 6.84±0.35 mm, 34.03±0.19 g, 15.88±0.10 mm, 17.00±0.88 g and 84.41±0.11 vs 42.26±0.26 g, 43.36±0.33 mm, 4.62±0.06 g, 5.29±0.05 mm, 26.08±0.46 g, 15.11±0.23 mm, 15.13±0.16 g and 83.49±0.27). The correlation coefficients among the egg quality traits in Pearl and Belgium strains, and in their pooled data are presented in Tables 2, 3 and 4, respectively. The coefficients observed in Pearl were generally low and non-significant except between yolk height and haugh unit and shell weight and shell thickness in which strong, negative and significant value was detected (-0.660 and -0.580, respectively). The relationship observed among the egg quality traits of Belgium strain were mostly significant varied widely the association varied widely from positively low and non-significant value between EWT and AWT (0.005) to strong, negative and significant between ST and AWT (-0.875).
Table 2: Effects of breed on egg quality traits

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Overall mean ±S.E</th>
<th>Pearl (mean± S.E)</th>
<th>Belgium(mean± S.E)</th>
<th>LOS</th>
</tr>
</thead>
<tbody>
<tr>
<td>EWT (g)</td>
<td>48.83±0.37</td>
<td>42.26±0.26</td>
<td>55.39±0.23</td>
<td>***</td>
</tr>
<tr>
<td>EL (mm)</td>
<td>54.10±0.32</td>
<td>53.56±0.41</td>
<td>54.63±0.48</td>
<td>***</td>
</tr>
<tr>
<td>EW (mm)</td>
<td>44.63±0.28</td>
<td>43.36±0.33</td>
<td>45.90±0.43</td>
<td>***</td>
</tr>
<tr>
<td>ST (mm)</td>
<td>0.45±0.09</td>
<td>0.39±0.00</td>
<td>0.51±0.17</td>
<td>NS</td>
</tr>
<tr>
<td>SWT (g)</td>
<td>4.79±0.06</td>
<td>4.62±0.06</td>
<td>4.95±0.09</td>
<td>***</td>
</tr>
<tr>
<td>AH (mm)</td>
<td>6.07±0.18</td>
<td>5.29±0.05</td>
<td>6.84±0.35</td>
<td>***</td>
</tr>
<tr>
<td>AWT (g)</td>
<td>30.05±0.22</td>
<td>26.08±0.46</td>
<td>34.03±0.19</td>
<td>***</td>
</tr>
<tr>
<td>YH (mm)</td>
<td>15.50±0.12</td>
<td>15.11±0.23</td>
<td>15.88±0.10</td>
<td>***</td>
</tr>
<tr>
<td>YWT (g)</td>
<td>16.07±0.45</td>
<td>15.13±0.16</td>
<td>17.00±0.88</td>
<td>***</td>
</tr>
<tr>
<td>HU</td>
<td>83.95±0.15</td>
<td>83.49±0.27</td>
<td>84.41±0.11</td>
<td>***</td>
</tr>
</tbody>
</table>

EWT = Egg weight, EL = Egg Length, EW = Egg width, ST = Shell thickness, SWT = Shell weight, AH = Albumen height AWT = Albumen weight, YH = Yolk height, YWT = Yolk weight, HU = Haugh Unit, LOS = Level of significant, *** = P< 0.001, ** = P< 0.01, * = P< 0.05 and NS = Non-Significant
Table 3: Correlation coefficients among egg measurements in Pearl guinea fowl

<table>
<thead>
<tr>
<th>Parameters</th>
<th>1</th>
<th>2</th>
<th>3</th>
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<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>EWT(1)</td>
<td>1</td>
<td>0.041&lt;ns</td>
<td>-0.176&lt;ns</td>
<td>0.031&lt;ns</td>
<td>0.001&lt;ns</td>
<td>0.087&lt;ns</td>
<td>-0.035&lt;ns</td>
<td>-0.066&lt;ns</td>
<td>-0.105&lt;ns</td>
<td>0.006&lt;ns</td>
</tr>
<tr>
<td>ST (2)</td>
<td>1</td>
<td>-0.580&lt;**</td>
<td>-0.020&lt;ns</td>
<td>-0.001&lt;ns</td>
<td>-0.124&lt;ns</td>
<td>-0.007&lt;ns</td>
<td>0.004&lt;ns</td>
<td>0.026&lt;ns</td>
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<td></td>
</tr>
<tr>
<td>SWT(3)</td>
<td>1</td>
<td>0.092&lt;ns</td>
<td>0.028&lt;ns</td>
<td>0.020&lt;ns</td>
<td>0.189&lt;ns</td>
<td>0.094&lt;ns</td>
<td>0.125&lt;ns</td>
<td>0.101&lt;ns</td>
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<tr>
<td>EL (4)</td>
<td>1</td>
<td>0.113&lt;ns</td>
<td>0.094&lt;ns</td>
<td>0.051&lt;ns</td>
<td>0.032&lt;ns</td>
<td>0.024&lt;ns</td>
<td>-0.014&lt;ns</td>
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<tr>
<td>EW (5)</td>
<td>1</td>
<td>0.087&lt;ns</td>
<td>0.035&lt;ns</td>
<td>0.066&lt;ns</td>
<td>0.105&lt;ns</td>
<td>-0.006&lt;ns</td>
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<tr>
<td>AH (6)</td>
<td>1</td>
<td>-0.124&lt;ns</td>
<td>0.007&lt;ns</td>
<td>0.004&lt;ns</td>
<td>0.026&lt;ns</td>
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<tr>
<td>AWT(7)</td>
<td>1</td>
<td>0.094&lt;ns</td>
<td>0.125&lt;ns</td>
<td>-0.101&lt;ns</td>
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<tr>
<td>YH (8)</td>
<td>1</td>
<td>0.024&lt;ns</td>
<td>-0.014&lt;ns</td>
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<tr>
<td>YWT(9)</td>
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<td>-0.660&lt;**</td>
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<tr>
<td>HU(10)</td>
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</tbody>
</table>

EWT = Egg weight, ST = Shell thickness, SWT = Shell weight, EL = Egg Length, EW = Egg width, AH = Albumen height, AWT = Albumen weight, YH = Yolk height, YWT = Yolk weight, HU = Haugh Unit, ns = non-significant, * = P<0.05 and ** = P< 0.01

Table 4: Correlation coefficients among egg measurements in Belgium guinea fowl

<table>
<thead>
<tr>
<th>Parameters</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
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<th>6</th>
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<tbody>
<tr>
<td>EWT(1)</td>
<td>1</td>
<td>0.025&lt;ns</td>
<td>-0.014&lt;ns</td>
<td>-0.018&lt;ns</td>
<td>0.038&lt;ns</td>
<td>0.005&lt;ns</td>
<td>-0.099&lt;ns</td>
<td>-0.037&lt;ns</td>
<td>-0.053&lt;ns</td>
<td>0.035&lt;ns</td>
</tr>
<tr>
<td>ST (2)</td>
<td>1</td>
<td>0.535&lt;**</td>
<td>-0.413&lt;**</td>
<td>0.466&lt;**</td>
<td>0.716&lt;**</td>
<td>-0.875&lt;**</td>
<td>-0.613&lt;**</td>
<td>-0.075&lt;**</td>
<td>0.111&lt;ns</td>
<td></td>
</tr>
<tr>
<td>SWT(3)</td>
<td>1</td>
<td>-0.175&lt;*</td>
<td>0.405&lt;**</td>
<td>0.329&lt;**</td>
<td>0.479&lt;**</td>
<td>-0.350&lt;**</td>
<td>-0.012&lt;ns</td>
<td>-0.021&lt;ns</td>
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<tr>
<td>EL (4)</td>
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<td>0.349&lt;**</td>
<td>0.232&lt;**</td>
<td>0.010&lt;ns</td>
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<td>-0.014&lt;ns</td>
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<tr>
<td>EW (5)</td>
<td>1</td>
<td>0.347&lt;**</td>
<td>-0.412&lt;**</td>
<td>-0.233&lt;**</td>
<td>-0.132&lt;ns</td>
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<td></td>
<td>0.137&lt;ns</td>
</tr>
<tr>
<td>AH (6)</td>
<td>1</td>
<td>-0.637&lt;**</td>
<td>-0.504&lt;**</td>
<td>0.199&lt;**</td>
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<tr>
<td>AWT(7)</td>
<td>1</td>
<td>0.580&lt;**</td>
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<td>-0.158&lt;*</td>
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<tr>
<td>YH (8)</td>
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<td>0.650&lt;**</td>
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<tr>
<td>YWT(9)</td>
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<td>0.109&lt;ns</td>
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<tr>
<td>HU(10)</td>
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</tbody>
</table>

EWT = Egg weight, ST = Shell thickness, SWT = Shell weight, EL = Egg Length, EW = Egg width, AH = Albumen height, AWT = Albumen weight, YH = Yolk height, YWT = Yolk weight, HU = Haugh Unit, ns = non-significant, * = P<0.05 and ** = P< 0.01
Table 5: Correlation coefficients among the egg quality parameters in both strain

<table>
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<tr>
<th>Parameters</th>
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</tr>
</thead>
<tbody>
<tr>
<td>EWT(1)</td>
<td>1</td>
<td>0.040**</td>
<td>0.092ns</td>
<td>-0.077ns</td>
<td>0.211**</td>
<td>0.196**</td>
<td>0.780**</td>
<td>0.155**</td>
<td>0.083ns</td>
<td>-0.136**</td>
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<tr>
<td>S T (2)</td>
<td>1</td>
<td>0.453**</td>
<td>-0.315**</td>
<td>0.369**</td>
<td>0.679**</td>
<td>-0.347**</td>
<td>-0.245**</td>
<td>-0.070ns</td>
<td>0.035ns</td>
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</tr>
<tr>
<td>SWT(3)</td>
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<td>-0.092ns</td>
<td>0.304**</td>
<td>0.299**</td>
<td>-0.032ns</td>
<td>-0.053ns</td>
<td>0.017ns</td>
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<tr>
<td>E L (4)</td>
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<td>-0.029ns</td>
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<td>0.043ns</td>
<td>0.077ns</td>
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<tr>
<td>E W (5)</td>
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<td>0.310**</td>
<td>0.062**</td>
<td>-0.025ns</td>
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<td>-0.004ns</td>
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<tr>
<td>A H(6)</td>
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<td>0.067**</td>
<td>-0.162**</td>
<td>0.211**</td>
<td>0.015ns</td>
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<td>-0.072ns</td>
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<td>-0.175**</td>
</tr>
<tr>
<td>Y H (8)</td>
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<td>0.174**</td>
<td>-0.625**</td>
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</tbody>
</table>

EWT = Egg weight, ST = Shell thickness, SWT = Shell weight, EL = Egg Length, EW = Egg width, AH = Albumen height, AWT = Albumen weight, YH = Yolk height, YWT = Yolk weight, HU = Haugh Unit, ns = non-significant, * = P<0.05 and ** = P<0.01

Discussion

Egg weight

The mean egg weight (48.83±0.37 g) observed in the present study fall within the range values of 40-58 g reported by Taye and Gyawu (2002), but higher than 35.80 g (Ayorinde, 1991), 38.4g (Oke et al., 2004), 24.7g (Saina et al., 2005), 35.7 g (Sanfo, 2009), 35.4g (Adeyeye, 2010), 32.8 g (Nandaam and Issah, 2012) and 43.16 g (Tebesi et al., 2012). The result obtained for Pearl strains is similar to 40 g (Bell and Smith, 2003; Apiiga, 2004; Matina Nickolova, 2009; Moreki, 2009). However, Obike et al. (2011) and Nahashon et al. (2006) reported values of 29.01and 39.50 g, respectively in the same strain. The mean egg weight of 55.39±0.23 g observed in Belgium strain is similar to the value (55.40 g) reported by Adeyemo et al. (2006). The fact that genotype had effect on egg weight as observed in the present study agrees with the report of some investigators (Ayorinde et al., 1989; Nahashon et al., 2006). In their separate findings, the authors detected significant variation in egg morphometric of different varieties of guinea fowl. The superiority of Belgium strain observed over the Pearl could be due to varied live weight of the two genotypes. The former was significantly heavier than the latter and many studies have shown that egg measurements had positive correlation with this trait (body weight), this is in line with the finding of Obike et al. (2011) who recorded heavier eggs in black than Pearl guinea fowl and attributed this fact to the varied live weight of the two strains. Similar assertion was also made by Oke et al. (2004) and the authors reported strong correlation (0.85) between these traits (egg and live weights). Earlier reports of Ayorinde et al. (1989) showed slight differences in egg weight among four varieties of guinea fowl; Ash (37.2 g), Black (36.8 g), Pearl (37.8 g) and White (36.4 g). In addition, Nowaczewski et al. (2008) also detected significant influence of genotype on egg weight among Polish and French breeds and recorded higher value in the latter than the former. However, Nwachukwu et al. (2005) reported non-significant influence of genotype on egg weight among two strains of Japanese quail (panda white and cinnamon brown). In Hyderabad of India, Rajkumar et al. (2009) similarly reported non-significant variation in egg weight of naked neck (NaNa and Nana) and normal feather (nana) strains of chickens which buttress the finding of Ahmadu et al. (2018) in two strains of Shika brown layer.
**Egg length**

The mean egg length observed in the current study agrees with the values of 50.34±3.87, 51.13±0.40, 49.47±0.11 and 50.34±3.87 g as reported by Wilkanowska and Kokoszynski (2010), Kgwatalala et al. (2013), Alkan et al. (2013) and Abdullahi et al. (2018), respectively. However, Sogunle et al. (2017) reported lower mean among the Pearl strain of guinea fowl. The influence of genotype on egg length observed in the present study was significant and is in accordance with the reports of Obike et al. (2011) among local stocks of black and Pearl guinea fowls. Similarly, Wilkanowska and Kokoszynski (2010) also detected considerable variation in egg length of White and Pearl varieties of guinea fowl. The significantly lengthier egg observed in Belgium strain as compared to pearl study confirm the finding of Abdullahi et al. (2018). The authors recorded higher length in Belgy guinea fowl strain than Pearl variety and attributed this fact to differences in the genetic constitution of the studied strains. The work of Kgwatalala et al. (2013) similarly showed that the performance of exotic strain of guinea fowl in term of egg parameters supercede that of local varieties. Royal purple breed of guinea fowl was observed to had the highest for egg length than lavender, Pearl and white strains. Working on nine strains of local chickens, Bobbo et al. (2013) observed significant effect of genotype on egg length in Adamawa state of Nigeria. Similarly, Kgwatalala et al. (2016) and Rajkumar et al. (2009) also detected significant difference on this trait among local chicken strains and recorded higher values in naked neck than normal feather and dwarf types. Contrary to the present work, Toye et al. (2012) observed the absence of genotype influence on egg lengths of Black Harco and Lohman Brown chicken. Nwachukwu et al. (2015) also observed the absence of genotype influence on egg length in two strains of quail (Panda white and Cinnamon brown).

**Egg width**

The mean egg width recorded in this study is closer to the value of 46.22±0.28 mm reported by Sogunle et al. (2017). Slightly similar values of 38.52±3.96, 37.89±0.09, 39.00±0.04 and 37.80±0.20 mm were reported by Wilkanowska and Kokoszynski (2010), Alkan et al. (2013), Abdullahi et al. (2018) and Kgwatalala et al. (2013), respectively in different strains of guinea fowls. The significant difference observed in egg width as a result of varied genotype is well documented (Abdullahi et al., 2018). The fact that exotic breed of guinea fowl surpassed their local counterpart in most egg quality traits agrees with the works of some investigators (Nowaczewski et al., 2008; Abdullahi et al., 2018). In their separate studies, the authors compared two exotic strain (French and Belgy types) with a local variety (Pearl) in term and observed higher width in the former than the latter. Kgwatalala et al. (2013) also recorded wider egg in Royal purple breeds of guinea fowl than Lavender, Pearl and White varieties and attributed this result to differences in the genetic architecture of these strains. However, the non-significant effect of strain on egg width was evident among the Black and Pearl varieties of guinea fowl (Obike et al., 2011). Nwachukwu et al. (2015) made similar assertion and concluded that genotype had no influence on egg widths of two strains of Japanese quails (Panda white and Cinnamon brown).

**Shell thickness**

The overall mean shell thickness recorded in the present observation is similar to respective values of 0.46 and 0.42±0.13, 0.52, 0.54±0.02 and 0.50 mm reported by Dudusola (2010) and Obike et al. (2011), Nowaczewski et al. (2008), Sangilimadan et al. (2009) and Kgwatalala et al. (2013). However, Oke et al. (2002), Singh et al. (2009) and Tebesi et al. (2012) recorded lower values of 0.39, 0.38±0.01 and 0.32 mm, respectively. The non-significant effect of genotype on shell thickness detected in the present finding is in-line with the report of Obike et al. (2011). Similarly, Bobbo et al. (2013) observed non-significant influence of strain on shell thickness among nine genotypes of local fowls in Adamawa state of Nigeria. Working on Japanese quail, Hrncar et al. (2014) noticed absence of significant variation in shell thickness of Panda white and Cinnamon brown strains Furthermore, Abdullahi et al. (2018) also detected non-significant variation in shell thickness of Shika brown layer chickens strain (A and B). However, the present observation contradicts the report of Nowaczewski et al. (2008) that meat type guinea fowls (518 µm) had thinner shell than Pearl strain (522 µm). Similar reports in chickens also showed varied shell thickness across different genotypes (Khalil et al., 2013; Wambui et al., 2018). In their study, they recorded thicker shells in exotic commercial layers than indigenous chickens.

**Shell weight**

The mean shell weight of 4.79±0.06 g observed in the present study is lower than those reported by Obike et al. (2011), Kgwatalala et al. (2013), Nowaczewski et al. (2013) and Alkan et al. (2013) (7.20±0.31, 6.03±0.10, 7.35±0.21 and 6.48±0.08 g, respectively). Similarly, Songule et al. (2017) and earlier work of
Abdullahi et al. (2018) reported lower means of 5.68±0.11 and 6.10±0.09 g, respectively. The superiority of Belgium guinea fowl over pearl in term of shell weight as observed in the current study conform with the work of Nowaczewski et al. (2008). In their report, French meat variety was favoured over the Pearl strain and correlated this fact to larger egg size observed in the former. Abdullahi et al. in 2018 also made similar assertion in which the authors reported heavier shell in Belgy strain of guinea fowls than local Pearl variety and concluded that most egg parameters are positively correlated to body size, this might the reason why the exotic strains surpassed the local varieties in term of this trait. Among the local stocks, Wilkanowska and Kokoszyński (2010) detected a considerable variation in shell weights of Pearl and White strains with the latter having larger value than the former. Similar report of Hrnčar et al. (2014) on Japanese quail (Coturnix coturnix japonica) pointed out the influence of genotype on shell weight. Working on indigenous local chickens, Bobbo et al. (2013) observed higher shell weight in frizzled strain than naked neck, normal feather and their crosses and attributed this result to feather morphology and distribution genes. This also buttress the work of Alamu (2017) among four genotypes of chickens (NV, DRB, LB and KK) at different WOA (25, 27, 29, 31 and 33) managed in battery cage. Khalil et al. (2013) and Wambui et al. (2018) compared local fowls native to Egypt and Kenya, respective with exotic commercial laying hen and observed heavier shell in the latter. They further explained that eggs from this hen were larger and heavier than those from the local chickens. Further reports of Hanusová et al. (2015) revealed a significant difference in shell weights of Oravka and Rhode Ireland Red chickens. On the other hand, Obike et al. (2011) noticed absence of significant variation in shell weights of Black and Pearl guinea fowls. Similarly report of Ahmad et al. (2018) among strain A and B of Shika brown layers confirm this finding. Although the authors reported numerically higher shell weight in A than B, the difference was however, not statistically significant. Working on local chicken and Japanese quail, Rajkumar et al. (2009) and Nwachukwu et al. (2015), respectively reported non-significant effect of strain on shell weight of these two species.

Albumen height

The mean albumen height of 6.07±0.18 mm observed in this study is within the range values of 6.26±0.10-5.74±0.10 mm reported by Kgwatalala et al. (2013) among five strains of guinea fowl (Pearl grey, Lavender, Royal purple and White). Slightly higher value of 7.35±0.25 mm was reported by Obike et al. (2011). However, respective values of 4.77±0.09 and 4.28±0.16 mm were reported by Alkan et al. (2013) and Sogunle et al. (2017). The value observed among the Pearl strain is slightly similar to those obtained by Wilkanowska and Kokoszyński (2010) and Abdullahi et al. (2018): 4.70±0.01 and 4.7 mm, respectively. The mean values recorded by these authors in Belgy and White strains of guinea fowl is closer to the one obtained in Belgium breed. The fact that this trait was significantly affected by genotype as observed in the

Albumen weight

The mean albumen weight of 30.05±0.22 kg observed in the present study is higher than 26.40±0.48 g (Nowaczewski et al., 2008), 17.43±0.25 g (Obike et al., 2011), 21.62±0.49 g (Alkan et al., 2013), 21.47±0.35 g (Kgwatalala et al., 2013) and 18.91±0.38 g (Sogunle et al., 2017). The fact that albumen weight varied according to genotype differences as observed in the present finding is well documented (Nowaczewski et al., 2008). The author recorded higher value in exotic type (French meat breed) than the pearl varieties and correlated this fact to differences in egg sizes of both strains. This corroborate the work of Kgwatalala et al. (2013) among the local stocks (Pearl, Lavender and White strains) and exotic Royal purple and. They similarly observed heavier albumen in the latter than the former. Abdullahi et al. (2018) also proved that the exotic strains (Belgy) are superior to the local varieties (Pearl) in all egg measurements. Among the local stains, White guinea fowls were observed to have significantly higher albumen weight than the Pearl type (Wilkanowska and Kokoszyński, 2010). Hrnčar et al. (2014) compared the egg measurements of layer and broiler quails (Japanese type) and noticed significantly higher values in the meat type (broiler) on all traits recorded (including albumin weight). Kgwatalala et al. (2016) detected considerable variation on albumin weight among naked neck, normal feather and dwarf strains of chicken. They reported higher mean in naked neck than other strains (normal and dwarf). Further explanation of these authors showed that this variation (in albumen weight) was due to genes controlling the distribution of feather and growth. In addition, Hanusova et al. (2015) reported significantly higher albumen weight in Oravka layers than Rhode Ireland Red chicken. However, Obike et al. (2011) reported non-significant difference in albumen weight of Pearl and Black guinea fowl strains. Similar observation was also made by Nwachukwu et al. (2015) in Panda white and cinnamon brown strains of Japanese quails.
current observation agrees with the finding of Kgwatalala et al. (2013). The author observed varied height among eggs obtained from Pearl grey, Lavender, Royal purple and white strains of guinea fowl and attributed this to differences in the genetic make-up of the experimental birds. Similar observation was also made by Abdullahi et al. (2018) in Belgy and Pearl varieties. Further report of Wilkanowska and Kokoszynski (2010) showed significant variation in albumen height of Pearl and White guinea fowls. Contrary to the current finding, Obike et al. (2011) detected non-significant effect of genotype on albumen height. Several investigators (Rajkumar et al., 2009; Hrncar et al., 2014; Kgwatalala et al., 2016; Ahmad et al., 2018) also made similar assertion in chicken.

**Yolk height**

The average yolk height obtained in this study (15.50±0.12 mm) is similar to 14.44±0.11 and 16.70 mm as reported by Alkan et al. (2013) and Kgwatalala et al. (2009). However, Sogunle et al. (2017) reported mean value of 11.03±0.31 mm among local strains of guinea fowl. The result obtained for Pearl in this study (15.11±0.23 mm) was higher than those reported by Wilkanowska and Kokoszynski (2010), Obike et al. (2011) and Abdullahi et al. (2018) in the same strain of guinea fowl; 14.54, 13.02±0.39, 13.30±0.03 mm, respectively. The mean yolk height obtained in Belgium breed (15.88±0.10 mm) is similar to 15.88±0.03 mm as observed by Abdullahi et al. (2018). Similar value was also reported by Wilkanowska and Kokoszynski (2010) among White strain of guinea fowl. The significantly higher yolk observed in Belgium strain than the Pearl variety agrees with the finding of Abdullahi et al. (2018) in the same strains. The authors reported higher values for Belgy breeds than Pearl strains and related to heavier egg observed in the former than the latter. Wilkanowska and Kokoszynski (2010) also noticed higher yolk in White variety of helmeted guinea fowl than the Pearl indicating that qualitative trait (plumage colour) had significant effect on quantitative characters which opposed the work of some authors that most productive and reproductive traits among local guinea fowl did not differ statistically. Sogunle et al. (2017) observed significant difference among eggs of various species of poultry (domestic chicken, ducks and guinea fowl). Working on local chickens of different genotypes, Rajkumar et al. (2009) and Kgwatalala et al. (2016) detected significant effect of strain on yolk height. However, the same author in 2013 reported the absence of significant variation in yolk height of different genotypes of guinea fowl (Pearl grey, Lavender, Royal purple and White). Obike et al. (2011) also noticed the same result among Pearl and Black strains of guinea fowls.

**Yolk weight**

The overall mean yolk weight observed in the present work is above the range values of 12.81±0.14-14.51±0.20 g reported by Kgwatalala et al. (2013) among the local stocks (Pearl grey, Lavender and white) and exotic strain of guinea fowl (Royal purple). Also, the mean value obtained from Pearl strain was higher than 9.68±0.36, 12.42±0.28 and 12.70±0.00 g as reported by Abdullahi et al. (2018), Obike et al. (2011) and Nowaczewski et al. (2008), respectively. Similarly, Alkan et al. (2013) and Sogunle et al. (2017) reported respective values of 13.58±0.11 and 11.86±0.12 g in the same strain. The mean yolk weight recorded among the Belgium breed is higher than those reported by Abdullahi et al. (2018) and Nowaczewski et al. (2008) in exotic strains: Belgy (14.83±0.36 g) and French meat type (15.9 g), respectively. The significantly heavier yolk observed in the Belgium breed conform the finding of Nowaczewski et al. (2008) who reported higher value for this trait in French meat type than the local varieties (Pearl strain). Similarly, Abdullahi et al. (2018) and Kgwatalala et al. (2013) recorded higher yolk weight in exotic strains (Belgy and French meat type, respectively) than the local stocks and related this variation to differences in the genetic constitution of these genotypes. However, Obike et al. (2011) reported non-significant effect of genotype on yolk weight.

**Haugh unit**

The mean obtained for Haugh unit in the present study fall within the range values of 81.40±1.00-86.46±1.45 as reported by Kgwatalala et al. (2013). However, Alkan et al. (2013) and Sogunle et al. (2017) reported lower values of 74.97±0.65 and 71.55±1.29, respectively in Pearl guinea fowl strain. The significantly higher Haugh unit observed in Belgium breed showed that eggs obtained from this strain had higher protein content. This is attributable to the fact that, this strain produced the heaviest egg with higher albumen. Working on local chickens, Kgwatalala et al. (2016) detected significant variation in Haugh units of naked, normal and dwarf strains. Similarly, Bobbo et al. (2013) reported significant differences in Haugh unit of normal feathered chicken, naked neck, frizzled and their crosses. Furthermore, the work of Khalil et al. (2013) showed significant variation in Haugh unit of Golden...
Montazah, White Leghorn and their crosses and related this fact to genetic variability among these genotypes.

**Phenotypic correlation**

The mostly non-significant coefficients observed in Pearl strain is in line with the work of Abdullahi et al. (2018) who reported lower and insignificant relationship on most egg quality traits of the same strain. This could be as a result of absence of pleiotropics gene action and linkage. Is a well-known fact that phenotypic relationship among traits indicates genetic correlation, therefore, poor association observed in this study showed that the latter (genetic correlation) is weak and cannot be predicted from the former (phenotypic relationship). The fact that there was significant relationship among egg quality parameters as observed in Belgium strain showed that some traits can indicate themselves.

**Conclusions and Recommendation**

- Belgium strain had significantly higher value than the Pearl on most egg traits observed.
- The correlation coefficients observed in Pearl strain were low while for the Belgium type, significantly higher values were detected.
- Crossing between Belgium strain and Pearl variety should be encouraged for improved egg quality traits in the latter.

**References**


