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Relationships between body weight and egg characteristics for konde chicken ecotype in Burkina Faso Sahel and Centre-east regions

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Abstract

In order to set up a selection program for population of local animal based on their production, it is first necessary to gather appropriate documentation on their production and breeding performance. The aim of this study was to assess the relationships between live weight and various egg quality traits for the local hen's ecotype in the Sahel and Centre-East (hen ecotype Konde) regions in Burkina Faso. Length, width, weight and external quality characteristics (shape and color) were assessed on a total of 240 eggs. Sixty-five and fifty-five hens, each producing two eggs were used in the Sahel the Centre-East regions, respectively. Candling and densitometry techniques were used to detect fresh eggs. Egg internal quantitative and qualitative characteristics of internal egg quality were assessed by measuring yolk weight, albumin weight and yolk/white pH. The average egg weight (41, 89 ±3.98 vs. 32.67 ±3.22 g), shape index (75 ±0.04 vs. 72 ±0.014 %), egg length (47.87 ±2.4 vs. 46.16 ±2.64 mm), egg width (35.69 ±1.41 vs. 33.27 ±1.38 mm), white weight (21, 45 ± 1.71 vs. 14.23 ± 2.24 g), yolk weight (14.70 vs. 12.12 ± 3.22 g) and yolk dry matter percentage (49 ± 3 vs. 40 ± 8%) were significantly higher in eggs collected in the Centre-East Region (hen ecotype Konde), while white dry matter, yolk weight and respective yolk and white pH were similar across the two regions. Correlations between egg p weight (0.43), width (0.36) and length (0.46) were significant and low in Sahelian hens. However, the correlation (0.16) was not significant between egg weight and live weight in Konde ecotype. Correlation coefficients were slightly higher, in the Centre-East region, between egg weight and width (0.87), and egg length (0.66) in the Konde hen ecotype than in the Sahel one (0.84 and 0.61 respectively). Chicken ecotype Konde showed the highest correlations between yolk weight and egg width, length and weight, in contrast to Sahel hens. Yolk dry matter weight was negatively and significantly correlated with form index, egg width and egg weight in hen ecotype Konde, but was weakly, negatively and not significantly correlated with egg length.

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Introduction

In Burkina Faso, local poultry plays an important socio-economic and cultural role in rural communities (Pousga, 2007; Kondombo, 2007). Indeed, local hens and other local poultry products are better appreciated by the population compared to products from exotic breeds (Manyelo *et al.*, 2020). The reasons for the population's preference for local poultry products have yet to be scientifically substantiated by nutritional qualities data of these products (Manyelo *et al.*, 2020). For eggs, in general, the internal and external qualities are of great importance in poultry farming, because of their effects on reproductive performance (hatchability, growth of offspring), resistance to transport, consumer appreciation and nutritional qualities (Ahmadi and Rahimi, 2011). Previous studies have shown genetic variability in the external and internal characteristics of eggs in poultry based on phenotypic and genotypic characteristics (Kul and Seker, 2004; Ahmadi and Rahimi, 2011; Inca *et al.,* 2020). Concerning local breeds chicken in Burkina Faso, there is a lack of data on both nutritional and physico-chemical characteristics of their eggs. However, these information is important not only to characterize local chicken breeds, but also offer options for their genetic improvement (Ubani *et al.*, 2012; Obike and Azu, 2012). It is important to generate data on morpho-biometric characteristics and the internal and external qualities of eggs should be made available. This would contribute to a better assessment of local hens in terms of genetics, productivity and quality of their eggs. The data collected can serve as a starting point to set up an appropriate genetic improvement program (Houndonougbo *et al.*, 2014).

The current study aimed to contribute to a better understanding of the phenotypic correlations between the various quality traits (internal, external and nutritional) of hen eggs and the biometric parameters of two local chicken ecotypes (the Sahel hen and the Konde hen) from Burkina Faso. The general objective of the present study was to assess the relationships between eggs characteristics of two local ecotypes in the (Sahel and Centre-East chicken ecotypes regions of Burkina Faso, in order to better guide breeders in their decisions.

Materials and methods

Study areas

The hens were reared in two regions of Burkina Faso, the Sahel and the Centre-East. Egg collection and measurements were carried out in these areas (Fig. 1). The Sahel region is located in the extreme north of Burkina Faso and characterized by low rainfall (less than 400 mm) and shrub steppes with thorny plants and annual grasses.

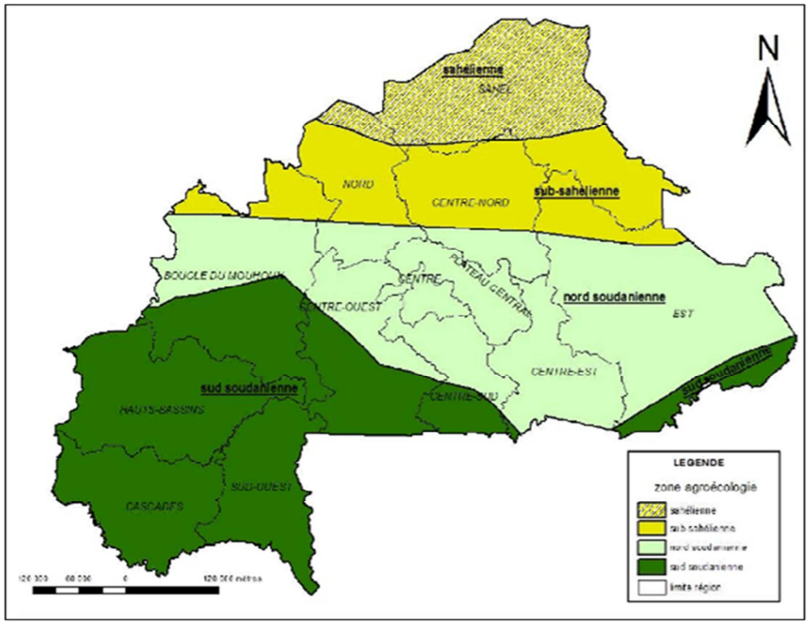

Fig. 1. Geographical location of studies sites

The Centre-East region is characterized by two climate types: the North-Sudanese climate (Kouritenga, Koulpélogo and a large part of Boulgou) with an average rainfall varying between 600 and 1000 mm per year and the South-Sudanese climate (a small part of the rural commune of Zoaga [Boulgou] with average rainfall more than 1000 mm per year). The vegetation consists of shrub savannahs, wooded savannahs and gallery forests or clear forests.

Area of laboratories analyses

Laboratory analyses of the eggs were carried out in the Animal Production and Health Research Laboratory LARePSA) of the Animal Productions Department of the Agricultural and environment research Institute (INERA)/Centre National Center of Scientific and Technical Research (CNRST) based at the Center of Environmental, Agricultural and Formations Research (CREAF) in Kamboinsé located in the North Sudanese zone. It is located 18 km from the center of Ouagadougou, in a northerly position.

Biological and field data collection

Measurements were taken on 240 eggs (130 eggs in the Sahel and 110 eggs in the Centre-East) with two eggs per hen: 65 hens from the Sahel region and 55 Konde ecotype hens from the Centre-East region of Burkina Faso. A survey sheets had been used to collect data. Plastic trays were used to store and transport the eggs. A cold room with a constant temperature of 8°C was used to store the eggs.

Laboratory equipment and measurements

Laboratory equipment consisted mainly of tools used to determine dry matter (an oven, a kiln), small laboratory equipment (a desiccator, pH-meter paper) and consumables. The weight of the hens was measured on an electronic scale with a capacity of 5,000 g and a precision of 1 g. Measurements of the large and small diameters of the eggs were taken with a caliper with a maximum length of 150 mm precision. Egg weights were measured on a DENVER electronic balance with a capacity of 5,000 g and a precision of 0.000 1 g, used in the laboratory.

Before data collection, local chicken producers were identified and interviewed. The interview consisted in explaining the purpose of the study and the survey procedures as well as to ensure that their birds are from the target ecotypes.

Site selection and sampling

Sites were selected by considering the agro-ecological zones of Burkina Faso and the existing sub-populations of local hens in the targeted region (Zare *et al.*, 2021; Yacouba *et al.*, 2022). Sites were chosen in consultation with agriculture and animal extension services agents. The following criteria were considered for the practical determination of sites: number of animals in the area, optimal distance between sites to avoid sampling related individuals, and the existence of family farms of sufficient size. A maximum of two (2) eggs were collected per hen.

Egg freshness

Candling and densitometry techniques were used to detect fresh eggs. The former involves candling the egg using a light source. An egg is considered fresh if the egg surface is clear with a reduced air chamber, whereas it is considered not fresh if the egg air chamber is large and altered and if the egg remains dark. Secondly, the eggs were immersed in a 10% concentrated NaCl solution. The egg is considered extra fresh if it stays vertically on the bottom of the container, fresh if it is slightly detached from the bottom of the container, and not fresh if it floats on the surface of the solution. Non-fresh eggs are systematically excluded from further analysis.

External egg quality

The following egg quality parameters were measured using the method described by Sauveur (1988).

Height or length (L) of the egg, which is the distance between the large end and the small end of the egg.

Width (LD), which is measured at the large diameter of the egg.

Each egg was weighed individually on a precision electronic balance.

The shape index (SI) of the eggs was calculated as a ratio between the length (L) and width or large diameter (LD) of the egg.

$$SI = \frac{LD}{L}$$

Egg internal and nutritional quality/chemical composition

Quantitative and qualitative internal characteristics were assessed by measuring yolk weight, albumin weight and yolk and white pH. The chemical composition of the eggs included pH and dry matter. Eggs were broken at the inner tube using a scalpel blade. Their content was carefully collected in sterile petri dishes, with the yolk and white separated. The weights of yellow and white were taken. Their pH was measured with a pH meter. The weight of the hens was measured using a 5,000 g capacity scale accurate to 1 g, and the weight of the eggs, white and yolk was measured individually using a 500 g capacity scale accurate to 0.000 1 g. The following measurements were calculated:

Weight of white or yolk (g) = (Proportion of white or yolk × 100)/(Egg weight (g))

Dry matter and organic matter content were determined by oven calcination. Moisture content was determined by the difference in mass of a sample before and after oven drying, in accordance with French standard NF V 03-707 (July 2000). The result obtained was subtracted from 100 to give the dry matter content. Five grams (5 g) of test sample (TS) were weighed into a pre-weighed and tared weight of empty basket (WEB), and then placed in an oven at 105 °C for 24 hours. The sample carriers/crucibles were then cooled in a desiccator for 30 to 40 minutes and weighed (FW). The mass percentage of water was obtained using the following formula:

% H= (TS - [FW-WEB])/TS×100
% H = percent humidity
TS = test sample
FW = final weight
WEB = weight of empty basket

Data processing and analysis

Survey data was processed using Excel. The stored data was analyzed using R software (R.4.3.2). Statistical analyses included descriptive summaries (mean, and standard deviation), and correlations analyses. Parametric data was then compared by performing a student's t test between the means of the parameters of the two groups. Non-parametric data was analyzed using the Wilcoxon test.

Results

Egg quality characteristics

Significant differences ($p \leq 0.001$) were observed for all traits except for yolk pH (acidic) and white pH (basic) between the two ecotypes (Table 1).

However, no significant differences were observed for the percentage dry matter of the egg white between the two ecotypes as indicated in Table 1.

Table 1. Mean and standard deviation of egg characteristics in the two ecotypes

	Ecotypes		Signification
Average	Centre-East	Sahel	
External quality			
Egg weight (g)	41.89 ±3.98 [a]	32.67 ±3.22 [b]	***
Egg length (mm)	47.87 ±2.4 [a]	46.16 ±2.64 [b]	***
Egg width (mm)	35.69 ±1.41 [a]	33.27 ±1.38 [b]	***
Shape index (%)	75 ±4 [a]	72 ±1.4 [b]	**
Internal quality			
Egg yolk weight (g)	14.70 ±2.48 (35.09 %) [a]	12.12 ±3. 22(37.88 %) [b]	***
Egg white weight (g)	21.45 ±1.71 (51.21 %) [a]	14.23 ±2.24 (43.56 %) [a]	***
Yolk pH	5.47 ±0.51 [a]	5.34 ±0.48 [a]	NS
White pH	8.17 ±0.38 [a]	8.34 ±0.86 [a]	NS
Yolk dry matter (%)	49 ±3 [a]	40 ±8 [b]	***
White dry matter (%)	14 ±2 [a]	15 ±7 [a]	NS

Values in a row bearing the same letters are not significantly different; NS = Not significant ($p > 0.05$); ***: $p < 0.001$; **: $p < 0.01$.

Table 2. Egg qualitative characteristics in two ecotypes

		Ecotypes		Total
		Centre-East	Sahel	
Egg color (%)	White	78.38	86.67	84.25
	Dirty white	21.62	13.33	15.75
	Total	100	100	100
Egg shapes (%)	Oval	91.89	97.78	96.07
	Round	8.11	2.22	3.93
	Total	100	100	100
Egg freshness (%)		60.32	60.56	

Table 3. Correlations between live weight and external egg quality in the Centre-East hen (Konde ecotype) on the upper diagonal and the Sahel hen (lower diagonal)

	Shape index	Egg width	Egg length	Egg weight	Body weight
Shape index		0.40*	-0.68***	0.04 ns	0.36*
Egg width	0.35*		0.40*	0.87***	0.16 ns
Egg length	-0.75***	0.36*		0.66***	-0.19 ns
Egg weight	-0.01 ns	0.84***	0.61***		0.16 ns
Body weight	-0.16 ns	0.36*	0.41**	0.43**	

*** = p<0.001; ** = p<0.01; * =p<0.05; ns = Non-significant.

Table 4. Correlations between internal egg quality traits for the Centre-East hen (Konde ecotype) on the upper diagonal and the Sahel hen (lower diagonal)

	Egg white weight	Egg yolk weight	White dry matter	Yolk dry matter
Egg white weight		-0.38 ns	-0.50 ns	0.22 ns
Egg yolk weight	-0.42*		0.36 ns	-0.79***
White dry matter	-0.08 ns	0.36ns		-0.29 ns
Yolk dry matter	0.21 ns	-0.21 ns	-0.08 ns	

*** = p<0.001; * = p<0.005; ns = Non-significant.

Table 5. Correlations between body weight and external and internal egg quality traits of the Centre-East hen (ecotype Konde) and the Sahel hen

Sahel region	Shape index	Egg width	Egg length	Egg weight	Body weight
Egg white weight	-0.11 ns	0.55**	0.35 ns	0.54**	0.03 ns
Egg yolk weight	-0.12 ns	0.04 ns	0.14 ns	0.18 ns	0.18 ns
White dry matter	-0.02 ns	0.15 ns	0.12 ns	0.11 ns	0.02 ns
Yolk dry matter	0.07 ns	-0.02 ns	-0.07 ns	-0.001 ns	0.06 ns

*** =p<0.001; ** = p<0.01; * =p<0.005; ns = non-significant.

Egg qualitative characteristics are presented in Table 2. Over 60% of the eggs collected were fresh. The eggs were predominantly white (84.25%) or dirty white (15.75%), with oval shape predominating (96%).

Correlations between the phenotype and egg characteristic's

Table 3 presents the correlations between egg external characteristics and hen live weigh. Egg weight was, as expected positive correlated with egg length (0.61) and width (0.84). Significant positive correlations ranging from 0.36 to 0.40 were obtained between egg width and egg length (Table 3). Similarly, significant positive correlations ranging between 0.36 and 0.44 were obtained between hen live weight and egg width, and between egg weight and length. Highly negative correlations ranging from -0.75 to -0.68 were only found between egg shape index and egg length in the two regions. Egg weight, yolk weight, egg white weight and hen live weight are moderately correlated with correlation ranging between 0.35 and 0.43 (Table 3). A moderate correlation was also observed between egg mass and yolk weight.

The correlations between egg internal characteristics are presented in Table 4. Significant negative correlate on were observed between yolk weight and egg white weight (-0.42 in the Sahel region and

between yolk weight and yolk dry matter mass (-0.79) in the Centre East region (Table 4). Table 5 presents the correlations of egg internal traits with the external egg characteristics and hen live weight. In the Sahel region hen, egg white weight was significantly correlated with egg width (0.55) and egg weight (0.54). However, in the centre-east region (Konde ecotype) positive and significant correlations of 0.77, 0.50, and 0.83 were observed between yolk weight egg width, egg length, and egg weight, respectively (Table 5). Additionally, significant and negative correlations were obtained between yolk dry matter and shape index (-0.47), egg width (-0.73), and egg weight (-0.64).

Discussion

Average egg weight, shape index, egg length, egg width and white weight were significantly higher in eggs collected in the Centre-East Region (Konde hen ecotype), while white dry matter, yolk weight and yolk/white pH were similar between the two hen ecotypes. Indeed, the average egg weight (32.67 ±3.22 g) of local hens from the Sahel region was lower than the results found in this study for the Konde ecotype (41,89±3.98 g) and previously reported weights ranging from 37.95 to 44.9 g on local eggs from West and Central Africa (Fotsa, 2009). However the average egg weight of Konde hens (41.89 ±3.98 g) corroborates the values mentioned above. Moula *et al.* (2012) reported average egg weights ranging between 50.23 and 54.32 g for local hens in Basse Kabylie, Algeria. The average weight of Sahelian hen eggs is close to that (33.86 g) found by Samandoulougou *et al.* (2016) in the peri-urban area of Ouagadougou in Burkina Faso. These differences in weight could be explained by genetic divergence between chicken ecotypes (Egahi *et al.*, 2013), availability of feeding resources, environmental conditions and vegetation. Thus, depending on genetic variability, the average egg weight of local breed hens falls within the weight range of 27 to 54.7 g (Alkan, 2013).

The mean egg length (47.87 and 46.16 mm) and width (35.69 and 33.27 mm) found in the Centre-East and Sahel region hens respectively were higher than the values of 35.24 mm (length) and 23.59 mm width reported by Faye *et al.* (2005).

However, they were lower than those reported by Samandoulougou *et al.* (2016). The average shape index of 75 and 72% in the Centre-East and Sahel regions were very similar to those found by Keambou *et al.* (2009) who reported shape indices ranging between 72.67 and 73.04% for local eggs in Cameroon. Regarding egg shape (96% oval and 4% round) and color (84.25% white eggs and 15.75% salle white eggs) they were substantially different for the results reported by Samandoulougou *et al.* (2016) where only 83% and 65% of the eggs were oval and of white color, respectively. White weight (21.45 g and 14.23 g), yolk weight (14.70 and 12.12 g) and yolk dry matter percentage (49 and 40 %) were significantly higher in local hens of the Konde ecotype than in local hens from the Sahel region, while no difference was found for white dry matter percentage (14 and 15 %). The proportions of egg whites (51.21 and 43.56%) and yolk (35.09 and 37.88%) in both ecotypes were lower than those reported by Samandoulougou *et al.* (2016). However, these results corroborate those of other authors (Moula *et al.*, 2010; Sreenivas *et al.*, 2013) who reported low proportions of egg whites or yolk below 50%. The egg yolk (5.47 and 5.34) and white (8.17 and 8.34) pH found in this study were similar to those reported by Samandoulougou *et al.* (2016). According to Benabdeljelil and Mérat (1995), yolk proportion correlates with the matter content in the egg and the intake of essential fatty acids. Thus, a higher yolk proportion can be considered favorable from the point of view of the egg's nutritional value. The proportion of yolk is the criterion most often taken into consideration in commercial breeding (Beaumont *et al.,* 2010).

Correlation between hen weight and egg weight (0.43), width (0.36), and length (0.46) were significant in Sahelian hens. However, no significant correlations were found between egg characteristics and live weight in Konde hens. Correlation coefficients were slightly higher between egg weight

and width (0.87), and egg length (0.66) in the Konde ecotype than in the Sahel region (0.84 and 0.61, respectively). Significant positive correlations between weight and egg length and width in the different ecotypes in our studies were in concordance with the results reported by Kgwatalala *et al.* (2016), Yousif and Eltayeb (2011) and Yakubu *et al.* (2008). The correlation coefficients between egg weight and egg width in the different Tswana chicken strains reported in the present study were higher than the correlation coefficient between the same traits reported by Yousif and Eltayeb (2011) in dwarfs and naked-neck strains of Sudanese chickens (0.45 and 0.53, respectively). The correlation between egg weight and width and length in the two local hen ecotypes in our studies were almost identical to those found by Samandoulougou *et al.* (2016) and Kgwatalala *et al.* (2016) using local chicken ecotypes.

Our correlation estimated is also higher than those reported between the two traits in Nigerian bare-neck and normal chickens (Yakubu *et al.*, 2008).

The significant correlations between weight and egg length and width were expected due to the fact that egg length and width determine the volume and holding capacity of an egg, giving an indication of egg surface area and weight (Obike and Azu, 2012). Direct selection for egg length and width will therefore result in a simultaneous improvement in egg volume, surface area and weight. Egg length was positively ($p < 0.05$) correlated with egg width in the centre-area (0.40) and Sahel (0.36) regions. These results confirm those of Kgwatalala *et al.* (2016) using Tswana chickens. However, there were slightly lower than those reported by Samandoulougou *et al.* (2016) who found a moderate correlation of 0.53 using local hens from the peri-urban area of the city of Ouagadougou. Yakubu *et al.* (2008) reported a strong, positive correlation between egg length and width (0.71) in free-range naked chickens and native Nigerian chickens with normal feathers. Obike and Azu (2012) also reported moderate and positive correlation coefficients between egg length and width in pearl grey and royal purple guinea fowl varieties.

Positive and moderate correlations between egg width and egg shape index were observed in both local hen ecotypes. Moderate correlation coefficients between egg width and shape index were also reported in quail and chicken (Abanikannda *et al.*, 2007). Obike and Azu (2012) also reported moderate correlation between egg length and width in pearl grey and royal purple guinea fowl varieties. Positive and moderate correlations between egg width and egg shape index were observed in both local hen ecotypes. Moderate correlation coefficients between egg width and shape index were also reported in quail and chicken (Abanikannda *et al.*, 2007). Higher positive correlation (0.70 to 0.76) between egg width and shape index were reported in pearl grey and black varieties of helmeted guinea fowl (Obike and Azu, 2012). Positive correlations between egg width and egg form index are to be expected in different poultry species, as egg width is the numerator in the calculation of egg form index (Obike and Azu, 2012). Strong negative correlations between egg length and shape index were observed in Konde and Sahel hens (-0.68 and -0.75, respectively) in contrast to the results of Kgwatalala *et al.* (2016), who found moderate correlations.

The correlation between albumen and yolk weights was -0.38 ($p > 0.05$) in and -0.42 ($p < 0.05$) in the Cente-East and Sahel regions, respectively. The results although of similar magnitude to those reported by Kgwatalala *et al.* (2016); they are in different direction. Additionally, these results are substantially different from those obtained by Samandoulougou *et al.* (2016) who reported strong positive correlation (0.95). Yousif and Eltayeb (2011) also reported weak, positive and negative correlations between albumen weight and yolk weight (0.25 and -0.11 in dwarf and naked-neck strains, respectively) in chickens of Sudanese origin. This indicates that selection for improved albumen weight could lead to an improvement in the total edible portion of the egg, which is consistent with Nonga *et al.* (2010) results, who stated that albumen had a major influence on overall egg quality.

Strong positive correlations were observed between egg weight and other internal egg quality characteristics such as albumen weight, yolk weight, yolk dry matter content and egg white dry matter content in both chicken ecotypes used in this study.

These estimates were similar to those observed between egg weight and albumen weight (0.88 and 0.79 in dwarf and naked-neck hens, respectively) and the moderate positive correlations between egg weight and yolk weight in dwarf (0.66) and naked-neck chicken (0.50) reported by Kgwatalala *et al.* (2016) and Yousif and Eltayeb (2011). The local Kondé ecotype hen showed the highest correlations between yolk weight and egg width, length, and weight compared to the local ecotype in the Sahel region. There were moderate positive correlations between egg length, albumen weight and yolk weight in the two local hen ecotypes used in this study. The moderate correlations between egg length and albumen weight observed in the present study are consistent with those reported by Yakubu *et al.* (2008), who also found moderate correlation coefficients between the two traits in bare-neck and normal-feathered chickens from Nigeria (0.52). Yolk dry matter weight is negatively correlated with form index, width, egg weight in the Konde hen, but was only weakly correlated with egg length. The weak positive correlations observed between egg width, albumen weight and yolk weight in both chicken ecotypes were similar to those reported between egg width and albumen weight (0.37 and 0.36) and yolk weight (0.32 and 0.350) in Sudanese dwarf and naked-neck hens by Yousif and Eltayeb (2011).

Conclusion

Based on the results of this study on hen weight is an important factor influencing egg quality characteristics. It must therefore be taken into account in any selection and management program aimed at improving these traits. Egg length and width are strongly and positively correlated with egg weight and hen weight. Consequently, selection for egg length and width will invariably results in heavier eggs and heavier hens. Consequently, these traits could be used as selection criteria to improve egg weight. Both traits can also be considered as good estimators of egg weight compared to egg shape index. The correlations observed between internal egg qualities traits indicate that these parameters can be improved by selection. In general, estimates of phenotypic correlations show that hen ecotypes could be used to improve egg quality characteristics in the studied regions. For protein-rich egg production for consumption and marketing based on live weight alone, the Centre-East chicken (the ecotype Konde) would be the more advantageous. This great diversity can serve as a basis for the development of more efficient strains through crossbreeding or/and selection. Furthermore, the information can be supplemented by studies on the nutritional quality of meat and eggs, as well as a better understanding of their productivity and the biodiversity of hens in Burkina Faso. Knowledge of egg quality and the correlations between these parameters of local hen ecotypes in the Sahel and Centre-East is a step in the conservation and selection of animal genetic resources in Burkina Faso.

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