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PRINCIPAL COMPONENT ANALYSIS OF EGG QUALITY TRAITS OF INDIGENOUS CHICKEN GENOTYPES IN EDO STATE

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ABSTRACT
This study was conducted to provide an unbiased description of egg quality traits of four indigenous chicken genotypes in Edo, Nigeria. 180 eggs were used for the study. The eggs were initially weighed individually using a sensitive electronic weighing balance with accuracy of 0.001g. Data were collected on egg weight, egg length, egg width, egg shell weight, egg shape index and egg shell thickness. Mean computational values of the data were taken using Statistical Procedure for Social Sciences (SPSS) and data were subjected to principal component analysis. Egg quality traits had three principal components (PC) that contributed 91.27% of the total variability of the original six egg characteristics tested. The three principal components had Eigen values of 2.59 (PC1), 1.66 (PC2) and 1.24 (PC3). Egg weight accounted for 43.08% of the total variance, Egg length accounted for 27.58% of the total variance, while egg width accounted for 20.62% of the total variance. The present principal component analysis provided a means for objective description of the interdependence in the six egg quality characteristics of naked neck, frizzle feathered, normal feather and the short flight feathered indigenous chicken genotypes.

KEYWORDS: *Chickens genotypes, principal component, Egg, quality traits, Eigen values, Indigenous chickens*

INTRODUCTION

The difficulty often encountered in breeding and genetics with regards to large number of correlated traits that are seemingly complex to handle and interpret can be crushed using principal component analysis. Principal component analysis is a multivariate technique that analyzes a data table in which the observations are described by several interrelated quantity dependent variable (Abdi *et al.,* 2010).

Principal component analysis had been used to predict body weight of Nigerian indigenous chickens from their orthogonal body shape characters (Yakubu *et al.,* 2009), and in quantifying size and morphological indices of domestic rabbits (Yakubu and Ayoade, 2009). It has also been used to explore the relationship among body measurements in broiler chickens (Ude and Ogbu, 2011) and in Nigerian indigenous chickens in Niger state

(Egena *et al.,* 2014). Some researchers have attempted to explain the relationship that exist among egg quality traits using principal component analysis as in the case of egg quality characteristics of native duck breeds of China when only six egg quality traits were considered (Bing-Xue *et al.,* 2013). Sarica *et al.* (2012) also used principal component analysis to determine the most effective variables of egg quality traits of five hen genotypes.

Eggs from poultry have been known to play an important nutritional role to human and also a nutritional reservoir for the developing embryo (Liswaniso *et al.,* 2020). Egg being the chief product of poultry is made up of albumen (58%), yolk (31%), and egg shell (11%) (Abanikannda and Leigh, 2007). The chicken egg which is an inexpensive source of protein has its quality determined by properties such as egg weight, egg length, egg width, egg shape index, egg radius, egg surface area, shell weight, and shell ratio as well as internal characteristics such as Haugh unit, albumen index, albumen height, albumen weight, albumen ratio, yolk height, yolk weight, yolk width, yolk ratio, yolk index and several of these egg quality traits are inter-correlated. Egg quality traits are known to be influenced by genetic as well as non-genetic factors. The associations among the chicken egg quality traits have been studied and reported (Abanikannda *et al.,* 2007; Sekereglu and Altuntas, 2009; Kabir *et al.,* 2014), especially with regards to data handling and the confusing interpretational relationship of large number of egg traits measured. Therefore, the central idea of principal component analysis (PCA) is to reduce the dimensionality of a data set consisting of a large number of interrelated variables, while retaining as much as possible of the variation present in the data set (Jolliffe, 2000). Understanding egg quality traits of local chicken breeds in the ordinary breeding environment has a principal importance in designing and implementing selection and breeding strategies that are holistic for genetic improvement (Markos *et al.,* 2017). In order to breed towards improving egg quality, there is need to understand the relationship that exists between these traits and to further study large number of egg quality traits of chicken using principal component analysis. This will help to uncover more information that could be incorporated in a selection and breeding strategies to improve egg quality of chickens. This study, therefore, was conducted to provide an unbiased description of egg quality traits of indigenous chicken genotypes in Edo state using principal components.

MATERIALS AND METHODS

Study Location

The experiment was carried out in the poultry unit of the Department of Animal Science and Animal Technology Teaching and Research Farm of Benson Idahosa University, Benin City, Edo State. The climate is tropical with an average annual temperature of 26.2°C and an average rainfall of 2075mm. the area lies within the geographical coordinate of longitude 5°37′59.99″ E and latitude 6° 19′60.00″ N of the Greenwich, in the south-south geo-political zone of Nigeria.

Experimental Animals and their Management

Forty-five (45) eggs were collected from each experimental genotype of naked neck, frizzle feathered, normal feathered and the short flight feathered chicken with each replicated thrice, fifteen (15) eggs were collected from each of the three replicates of the four genotypes used, making a total of one hundred and eighty (180) eggs. The egg quality analysis was carried out at the 6^{th} week of lay when the birds were about thirty (30) weeks old. The external and internal parameters; egg weight, egg length, egg width, egg shape index were measured on each egg, after which the eggs were broken, content emptied, the egg shell and egg shell thickness were measured individually.

Traits Measured

Egg Weight: The egg weight was obtained by weighing individual eggs using a sensitive weighing scale to the nearest 0.01g. (Digital Analytical Balance (PA 313 Ohaus Corporation 310g capacity with readability 0.001g).

Egg Length: This was determined by measuring the distance between the broad end and the narrow end of the egg using a venier caliper (cm).

Egg Width: This was determined by measuring the diameter of the egg at the widest cross-sectional region using a venier caliper (cm).

Egg Shape Index: This was measured as a ratio of the length and that of the width of an egg.

$$\text{Egg Shape Index} = \frac{Egg\ lenght}{Egg\ width}$$

Egg Shell Thickness: This was determined by measuring the individual dry egg shell at three different locations of the shell (narrow, middle and broad portions) to the nearest 0.01mm using a micrometre screw gauge.

Shell thickness (mm) = (sharp point thickness + equator thickness + stubby thickness)/3

Data Analysis

Pearson's coefficient of correlation was first estimated for all the traits measured in the study. This was followed by principal component (PC) analysis. Principal Component Analysis (PCA), a multivariate statistical technique was used to analyze the data table representing observations described by several dependent variables, which were in general, inter-correlated. The PCA was then used to extract the most important information from the data table, compress the size of the data set by keeping only the important information, simplify the description of the data set, analyze the structure of the observations and the variables and to express this information as a set of new orthogonal variables by displaying them as points in maps.

In achieving these goals, the mean, standard errors and coefficient of variation of egg weights and egg measurement of the different indigenous chickens were obtained using Microsoft Excel package. Data from the correlation matrix was used for principal component analysis (PCA). Bartlett's test of sphericity was used to test whether the correlation matrix was an identity matrix or a correlation matrix full of zeros. The PCA data set were further tested using the Kaiser Meyer-olkin (KMO) measure of sampling adequacy. A KMO measure of 0.60 and above is considered adequate (Eyduran *et al.*, 2010). Everitt *et al.* (2001) defined principal component analysis as a method of transforming variables in a multivariate data set, x1, x2, ……..xp into new uncorrelated variables y1, y2,………yp which account for decreasing proportions of the total variance in the original variables defined as:

$y_1 = a_{11}x_1 + a_{12}x_2 \ldots\ldots + a_{1p}x_p$

$y_2 = a_{21}x_1 + a_{22}x_2 \ldots\ldots + a_{2p}x_p$

$Yp = a_{p1}x_1 + ap_2x_2 + \ldots\ldots + a_{pp}x_p$

The principal components y1, y2……yp account for decreasing proportions of the total variance in the original variables x1, x2,……xp. Variance maximizing orthogonal rotation was used in the linear transformation of the factor pattern matrix in order to make the interpretation of the extracted principal components easier. The principal components analyses were performed using the factor program of SPSS 22 statistical package (SPSS, 2012)

RESULTS AND DISCUSSION

Presented in Table 1, are the egg quality traits for the four genetic groups of indigenous chickens of the same age and diet. The eggs laid by naked neck, frizzle and short wing chickens were significantly (P<0.05) larger (36.76 ± 0.66g, 37.32±41g and 36.75±61g) compared to the eggs size of 33.77 ± 0.42g laid by the normal feathered chickens. There was no significant difference (P>0.05) in egg length between the eggs laid by naked neck and the frizzle feathered chickens but the eggs were significantly different (P<0.05) from the normal chicken eggs, short wings feather chickens eggs showed no difference. Frizzle feather chickens laid longer eggs (4.64 ± 0.03cm) compare to normal feathered chicken (4.41±0.03cm). The eggs laid by short wing chicken had the highest egg width value (3.39±0.03cm) and was significantly different (P<0.05) from the egg width of frizzle (3.28±0.04cm) and that of the normal feathered chickens with the least value (3.24±0.02cm). Frizzle feather chickens had the highest egg shape index value (1.42±0.02cm) and was significantly different (P<0.05) from the least egg shape index value of 1.36±0.02cm obtained from normal feathered chicken. The naked neck and the short wing feathered chickens showed no difference. There was no significance difference (P>0.05) in egg shell weight and egg shell thickness among the eggs laid by naked neck, frizzle feathered and the short wing genotype but the eggs were significant difference (P<0.05) from the eggs laid by the normal feathered chickens.

The descriptive statistics for the egg weight and measurement traits of the indigenous chickens used in this study are shown in Table 2. The mean weight was 36.15g and egg shell weight was 3.62g while the egg measurements were 4.55cm (Egg length), 3.31cm (Egg width), 1.38cm (Egg shape index) and 0.28mm (Egg shell thickness) respectively. The egg shell thickness varied more with coefficient of variation of 14.29 % while the egg width recorded the least value with coefficient of variation of 3.32 %

The coefficient of correlation among egg measurements of indigenous Nigeria chickens are presented in Table 3. The correlation coefficients ranged from 0.64 to 0.75. The relationship between egg weight and egg measurement was positive and highly significant (P<0.01). The correlation was highest between egg shape index and egg length while the least correlation was observed between egg shell thickness and egg shape index. Kaiser-Meyer Olkin (KMO) measure of sampling adequacy was 0.65 while the results of the Bartlett's test of sphericality was significant (P = 0.000). The result was in agreement with the report of Eyduran *et al*. (2010) reported that a KMO measure of 0.6 and above is considered adequate. The physical egg quality characteristics remain an important factor in the embryonic development and subsequent hatching Ayeni *et al.* (2018). There are a number of these quality traits, according to Mohammed *et al.* (2019), the most influential ones are egg weight, shell thickness, albumen weight and egg yolk. The results from this study are comparable with the documented egg quality traits of indigenous chicken genotype in south Africa (Kayo, 2019) and Botswana indigenous chickens (Kgwatalala *et al.,* 2016) but differs from the documented results of the egg laying leghorn breed (Kgwatalala *et al.,* 2016) when compared with that of indigenous chickens. The differences in external egg traits could be attributed to Genetic variability as well as the changes in nutrition in the sampled chickens (Liswaniso *et al.,* 2020).

The Eigen value of the total variance of the component matrix of egg weights and egg measurement are presented in table 4, the scree plot of Eigen values against their principal component is shown in figure 1, while figure 2 showed the component plot of egg traits on the principal component of the indigenous chicken genotypes. The Eigen value showed the amount of variance explained by each of the factors out of the total variance. The egg quality traits had three principal components (factors) that accounted for 91.27 % of the total variability in the parameters measured. The three principal components had Eigen values of 2.59(PC1), 1.66(PC2) and 1.24(PC3). The Eigen values showed the amount of variance explained by each of the principal components in the total variance. The first factor (PC1) accounted for 43.08% of the total variance, the second factor (PC2) accounted for 27.58% of the total variance while the third factor (PC3) accounted for 20.62% for the total variance.

Table 1: Some Egg Quality Traits of Indigenous Chickens in Edo

Parameters	Naked neck	Frizzle	Normal	Short wings	SEM
Egg weight (g)	36.76 ± 0.66^{a}	37.32 ± 0.41^{a}	33.77 ± 0.42^{b}	36.75 ± 0.61^{a}	0.33
Egg length (cm)	4.60 ± 0.65^{a}	4.64 ± 0.03^{a}	4.41 ± 0.03^{b}	4.54 ± 0.07^{ab}	0.28
Egg width (cm)	3.34 ± 0.02^{ab}	3.28 ± 0.04^{bc}	3.24 ± 0.02^{c}	3.39 ± 0.03^{a}	0.16
Egg shape index	1.38 ± 0.02^{ab}	1.42 ± 0.02^{a}	1.36 ± 0.02^{c}	1.38 ± 0.01^{ab}	0.10
Egg shell weight (g)	3.66 ± 0.08^{a}	3.86 ± 0.05^{a}	3.19 ± 0.03^{b}	3.77 ± 0.10^{a}	0.05
Egg shell thickness (mm)	0.29 ± 0.01^{a}	0.30 ± 0.01^{a}	0.23 ± 0.01^{b}	0.30 ± 0.01^{a}	0.01

$^{a,\,b.}$ Within rows carrying different superscripts differ significantly (P<0.05)

Table 2: Mean, Standard Deviation (SD) and Coefficient of Variation (CV %) for Indigenous Chicken Egg Quality Traits in Edo

Parameters	N	Mean	SD	CV (%)
Egg weight	180	36.15	2.29	6.33
Egg length	180	4.55	0.19	4.18
Egg width	180	3.31	0.11	3.32
Egg shape index	180	1.38	0.07	5.07
Egg shell weight	180	3.62	0.35	9.69
Egg shell thickness	180	0.28	0.04	14.29

Table 3: Correlation Coefficient Matrix of Egg Quality Trait of Nigeria Indigenous Chickens in Edo

	Egg weight	Egg length	Egg width	Egg shape index	Egg shell weight	Egg shell thickness
Egg weight	1					
Egg length	0.75	1				
Egg width	0.48	0.13	1			
Egg shape index	0.31	0.75	-52	1		
Egg shell weight	0.38	0.23	0.33	0.22	1	
Egg shell thickness	0.31	0.16	0.17	0.07	0.64	1

Table 4: Component Eigen Values of Egg Quality Traits of Nigeria Indigenous Chickens in Edo

Component	EIGEN VALUES		
	Total	% of Variance	Cumulative %
Egg weight	2.59	43.08	43.08
Egg length	1.66	27.58	70.66
Egg width	1.24	20.62	91.27
Egg shape index	0.35	5.81	97.08
Egg shell weight	0.15	2.55	99.63
Egg shell thickness	0.02	0.37	100

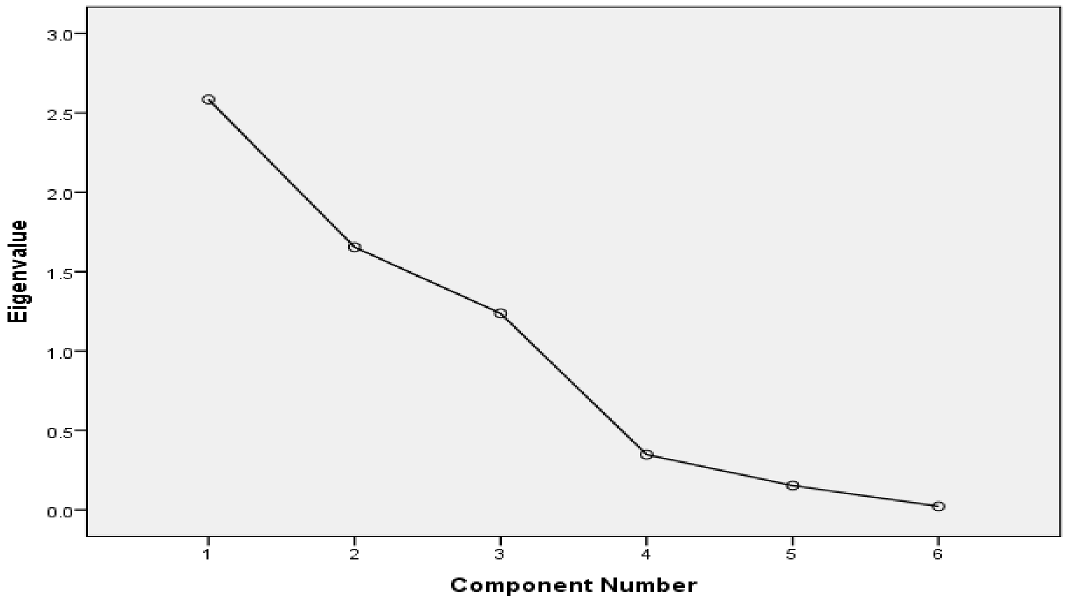

Fig. 1: Scree plot

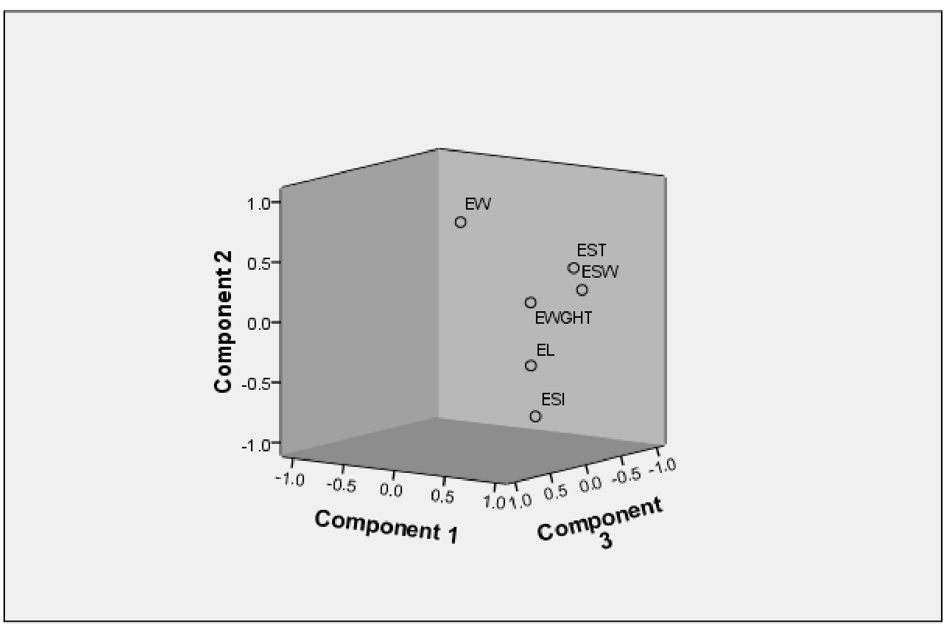

Fig. 2: Component plot

Apart from the normal feather indigenous chickens, the larger eggs and longer eggs found in naked neck, frizzle as well as in short wings hens may be attributed to the morphological structure of the chicken in relation to temperature regulation in hot humid environment. This is in agreement with Peters *et al.* (2007). The frizzling condition is caused by a major gene responsible for the action manifested in the follicle of the chicken feather disrupting the smooth feather emergence thereby making it ruffled. This helps in temperature regulation, reducing stress and increasing egg weight and length. Similar reason may have probably accounted for the significant (P<0.05) increase in the eggs weight when compared with the normal feather indigenous chicken. This observation was in agreement with the report of Peters *et al.* (2002) who that frizzle and naked neck hens laid heavier eggs when compared to their normal counterpart.

CONCLUSION

The result of principal component analysis of indigenous chicken egg traits extracted three factors, egg weight, egg length and width that can be used to describe the interdependence in the six egg quality characteristics of four indigenous chicken genotypes. Apart from the usefulness of the three principal factors in breeding strategy for the improvement of egg quality traits, the use of the three orthogonal egg quality factors (PC1, PC2 and PC3) extracted from the principal component analysis could be more dependable in predicting egg quality compared to the use of the original inter-correlated egg quality characteristics.

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