Available online at www.worldscientificnews.com

World Scientific News

WSN 70(2) (2017) 304-311 EISSN 2392-2192

SHORT COMMUNICATION

Principal Component Analysis of Egg Quality Characteristics of Isa Brown Layer Chickens in Nigeria

H. O. Ukwu[1,*], **P. O. Abari**[1] and **D. J. Kuusu**[2]

[1]Department of Animal Breeding and Physiology, College of Animal Science, University of Agriculture Makurdi, P.M.B. 2373 Makurdi, Benue State, 234, Nigeria

[2]Federal Department of Animal Husbandry Services, Federal Ministry of Agriculture and Rural Development, P.M.B. 135 Garki Abuja, Nigeria

*E-mail address: ukwuhenry@gmail.com

ABSTRACT

This study was designed to provide an objective description of egg quality of Isa brown layer chickens in Nigeria. 104 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, oblong circumference, egg shell weight, yolk height, albumen height, albumen length, Haugh unit, albumen index and egg shell thickness. Data were subjected to principal component analysis. Egg quality traits had three principal components (factors) that contributed 85.805% of the total variability of the original eleven egg characteristics tested. The three principal components had Eigen values of 4.73 (PC1), 3.656 (PC2) and 1.069 (PC3). The first factor (PC1) accounted for 42.84% of the total variance, the second factor (PC2) accounted for 33.24% of the total variance, while the third factor (PC3) accounted for 9.72% of the total variance. The moderate to large communalities (0.583 – 0.944) observed indicate that a large number of variance has been accounted for by the factor solution. The present principal component analysis provided a means for objective description of the interdependence in the original eleven egg quality characteristics of Isa Brown layer chickens.

***Keywords*:** Egg, Principal component, Quality, Correlation, Isa brown

1. INTRODUCTION

In animal breeding and genetics, we often deal with large number of possibly correlated traits, which makes data presumably complex to handle and interpret. Such difficulty in data handling and interpretation can be quelled using principal component analysis. Principal component analysis (PCA) is a multivariate technique that analyzes a data table in which observations are described by several inter-correlated quantitative dependent variables (Abdi et al., 2010). The chicken egg which is an affordable source of protein has it quality determined by external as well as internal characteristics, and several of these egg quality traits are inter-correlated. Among the external egg quality traits are egg weight, egg length, egg width, oblong circumference, etc. Some of the internal egg quality traits are Haugh unit, albumen index, albumen height, yolk height, etc. 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), and sometimes it becomes so befuddling to interpret such relationship results due to the large number of egg traits considered. Thus, 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). This is achieved by transforming to a new set of variables, the principal components (PCs), which are uncorrelated, and which are ordered so that the first few retain most of the variation present in all of the original variables (Jolliffe, 2000). 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 had also been used by to explore the relationship among body measurements of Nigerian indigenous chickens in Niger state (Egena et al., 2014), and in broiler chickens (Ude and Ogbu, 2011). Body conformation and blood marker traits of Nigerian indigenous pigs and their crosses were studied using principal component analysis (Okoro et al., 2015). Principal component analysis had been used to explain body conformation in cow (Tolenkhomba et al., 2012). Some researchers have attempted to explain the relationships that exist among egg quality traits using principal component analysis. For example, principal component analysis was used to study egg quality characteristics of native duck breeds of China, considering only six egg quality traits (Bing-Xue et al., 2013). In addition, Sarica et al. (2012) used principal component analysis to determine the most effective variables of egg quality traits of five hen genotypes. Therefore, there is need for further study of large number of egg quality traits of the chicken using principal component analysis, in order to uncover more information that could be incorporated in a selection and breeding programme to improve egg quality of chickens. This study, therefore, was designed to provide an objective description of egg quality of Isa brown layer chickens in Nigeria from internal and external egg characteristics using principal components.

2. MATERIALS AND METHODS

2. 1. Data collection

The eggs used in this study were collected from Isa brown strain of layer chicken, kept on deep litter system at Ocheposon farm located near the University of Agriculture Makurdi, Benue state, Nigeria. The birds were six months in lay and fed *ad libitum* on layers mash containing 17.0% crude protein. One hundred and five (105) eggs collected on the same day, i.e. within 24 hours of lay were used for this study. Data were collected on external and internal egg quality characteristic. The following external and internal egg quality characteristics as defined were measured:

Egg weight: The egg weight was measured using a sensitive digital weighing balance (Mettler Toledo, PL203 CE) with accuracy of 0.001g.
Egg Length: Egg length (in cm) was measured using a Venier calipers.
Egg Width: Egg width (in cm) was also measured using a Venier calipers.
Oblong Circumference: Oblong circumference (in cm) was measured using a measuring tape.
Egg Shell Weight: Egg shell weight was measured after the egg content was poured out into a separate container. The shell weight was thereafter measured using a sensitive electronic weighing balance (Mettler Toledo, PL203 CE) with accuracy of 0.001g.
Shell Thickness: Egg shell thickness (in mm) was measured using a micrometer screw gauge. Three measurements were taken at the broad end, middle and tapering end of the egg, and thereafter the average was taken as the egg shell thickness.
Yolk Height: This was also taken using a Venier calipers.
Albumen Height: This was also measured using a Venier calipers. It was taken from the thick position of albumen when placed on flat plate.
Albumen Length: This was taken using a Venier calipers. It was taken as a longitudinal section of thick albumen.
Haugh Unit: This was calculated using the expression below.

$$\text{Haugh unit (HU)} = 100 \log_{10} [H - 1.7w^{0.37} + 7.6]$$

where: H = albumen height; W = egg weight.

Albumen Index: The albumen index was calculated using the expression below.

$$\textit{Albumen index (\%)} = \frac{albumen\ height}{albumen\ length + albumen\ width/2} \times 100.$$

2. 2. Statistical Analysis of Data

Data on egg quality traits were analyzed using Statistical Package for the Social Sciences (SPSS) version 20.0 (SPSS, 2011). According to Onyeagu (2003), a fairly large number, p, of correlated random variables, Xs, can be reduced to a smaller number of random variables $Y_1, Y_2, \ldots Y_p$, so that the Ys account for a large part of the total variability of the Xs, and the Ys are independent and interpretable in terms of the original problem. The Ys are the principal components and are defined as:

$$Y_1 = L'_1X = L_{11}X_1 + \ldots + L_{p1}X_p$$

$$Y_2 = L'_2X = L_{12}X_1 + \ldots + L_{p2}X_p$$

$$Y_p = L'_p X = L_{1p}X_1 + \ldots L_{pp}X_p$$

The suitability of data to principal component analysis (PCA) was tested using Bartletts test of sphericity. The suitability of the data set to PCA was further tested by Kaiser- Meyer-Olkin (KMO) measure of sampling adequacy. A descriptive statistics of data were performed, and principal component option of factor analysis was carried out. Factor loading was based on an Eigen value of 1.00 and above, and factor-loading coefficients below 0.3 were suppressed, while the best descriptors were identified based on communality extraction factors closest to 1.00. The varimax option of orthogonal rotation was used in the rotation of the factor matrix.

3. RESULTS AND DISCUSSIONS

The descriptive statistics of egg quality characteristics of Isa Brown egg layer chickens are shown in Table 1. The Eigen values, percentage of total variance, communality extractions, and rotated component matrix after Varimax rotation of egg quality characteristics are shown in Table 2.

3. 1. Egg quality characteristics

Among the egg quality characteristic studied, albumen index and albumen height were more variable than other egg quality characteristics, with coefficient of variation values of 31.25 and 24.49% for albumen index and albumen height respectively. The coefficients of variation for egg weight, egg length, egg width, oblong circumference and eggshell weight were low and ranged from 3.05 to 12.48%. The coefficients of variation for shell thickness, Haugh unit, yolk height and albumen length were also low and ranged from 7.75 to 15.12%. Egg weight ranged from 43.55g to 64.51g with a mean of 52.75±0.46g. Mean egg length, egg width and oblong circumference for Isa brown eggs recorded in this study were 5.09±0.02, 3.86±0.01 and 15.08±0.04cm respectively. Mean shell weight and shell thickness for Isa brown eggs recorded in this study were 5.13±0.06g and 0.34±0.00mm respectively. Mean Haugh unit was 70.30±1.04, while mean albumen index was 7.21%. Mean yolk height and albumen length were 1.42±0.01 and 7.51±0.07cm respectively, while mean albumen height was 4.90±0.01mm. The mean egg weight (52.75±g) observed in this study was lower than the value (58.06g) reported by Kabir et al. (2014) for Isa brown strain of layer chickens. This variation in egg weight could be because of age of the birds used in the study.

3. 2. Principal Component Matrix.

Bartlett’s test was highly significant (0.000) indicating that the data was suitable for PCA. Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was 0.77. Eyduran et al. (2010) reported that a KMO measure of 0.60 and above is considered adequate. A scree plot of Eigen values against their principal components is shown in figure I. Egg quality traits had three principal components (factors) that contributed 85.805% of the total variability of the original eleven egg characteristics tested. The three principal components had Eigen values of 4.73 (PC1), 3.656 (PC2) and 1.069 (PC3). The Eigen values showed the amount of variance explained by each of the principal components out of the total variance. The first factor (PC1) accounted for 42.84% of the total variance, the second factor (PC2) accounted for 33.24% of the total variance, while the third factor (PC3) accounted for 9.72% of the total variance. The first factor (PC1) was characterized by high positive loadings on albumen index (0.964), Haugh unit (0.946), albumen height (0.935) and moderate loading on yolk height (0.571), while albumen length showed negative loading (-0.856). The first factor is a description of the internal quality of egg. The second factor (PC2) was characterized by high positive loadings on oblong circumference (0.935), egg weight (0.915), egg length (0.878), egg width (0.798) and low positive loadings on albumen length (0.307), eggshell weight (0.474) and yolk height (0.500). The second factor is a description of external egg quality as they relate with albumen length and yolk height. The third factor (PC3) was characterized by high positive loadings on shell thickness (0.949) and eggshell weight (0.831). The third factor is a description of eggshell quality. The moderate to large communalities (0.583 – 0.944) observed indicate that a large number of variance has been accounted for by the factor solution.

In a study on egg quality characteristics of native duck breeds of China, Bin-Xue et al. (2013) extracted two principal components that accounted for 65.32% of total variance, with first factor accounting for 40.49% and second factor accounting for 24.83% of total variance. Sarica et al. (2012) used principal component analysis to study egg quality traits of five hen genotypes and concluded that breaking strength and shell thickness (external qualities), albumen height, albumen index and Haugh unit (internal qualities) are the most effective parameters of egg quality. However, the present study extracted three principal components (PC). The first factor (PC1), which is a description of internal egg quality had albumen index, Haugh unit, albumen height and yolk height as best descriptors of internal egg quality. The second factor (PC2), which is a description of external egg quality had oblong circumference, egg weight, egg length and egg width as best descriptors of external egg quality. The third factor (PC3), which is a description of eggshell quality, had eggshell thickness and shell weight as best descriptors of egg shell quality.

Table 1. Descriptive statistics of egg quality characteristics of commercial layer chickens.

Egg quality traits	N	Min	Max	Mean ± SEM	CV %
Egg weight (g)	105	43.55	64.51	52.75±0.46	8.85
Egg length (cm)	105	4.58	5.70	5.09±0.02	3.54
Egg width (cm)	105	3.51	4.24	3.86±0.01	3.63
Oblong circumference (cm)	105	14.20	16.30	15.08±0.04	3.05
Egg shell weight (g)	105	3.02	6.44	5.13±0.06	12.48
Shell thickness (mm)	105	0.25	0.41	0.34±0.00	11.76
Haugh unit	105	43.06	98.67	70.30±1.04	15.12
Albumen index (%)	105	2.71	14.08	7.21±0.22	31.25
Yolk height (cm)	105	1.10	1.65	1.42±0.01	7.75
Albumen height (mm)	105	2.60	8.30	4.90±0.01	24.49
Albumen length (cm)	105	5.85	10.47	7.51±0.07	9.72

CV = coefficient of variation; Min = minimum; Max = maximum; SEM = standard error of the mean; N = sample size

Table 2. Eigen values, percentage of total variance, rotated component matrix and communalities of egg quality characteristics of commercial layer chickens.

Egg traits	Factor 1	Factor 2	Factor 3	Communalities
Albumen index	0.964			0.944
Haugh unit	0.946			0.896
Albumen height	0.935			0.941
Albumen length	-0.856	0.307		0.838
Yolk height	0.571	0.500		0.583
Oblong circumference		0.935		0.909
Egg weight		0.915		0.928
Egg length		0.878		0.805
Egg width		0.798		0.743
Shell thickness			0.949	0.935
Egg shell weight		0.474	0.831	0.917
Eigen values	4.713	3.656	1.069	
Percentage of total variance	42.84	33.24	9.72	

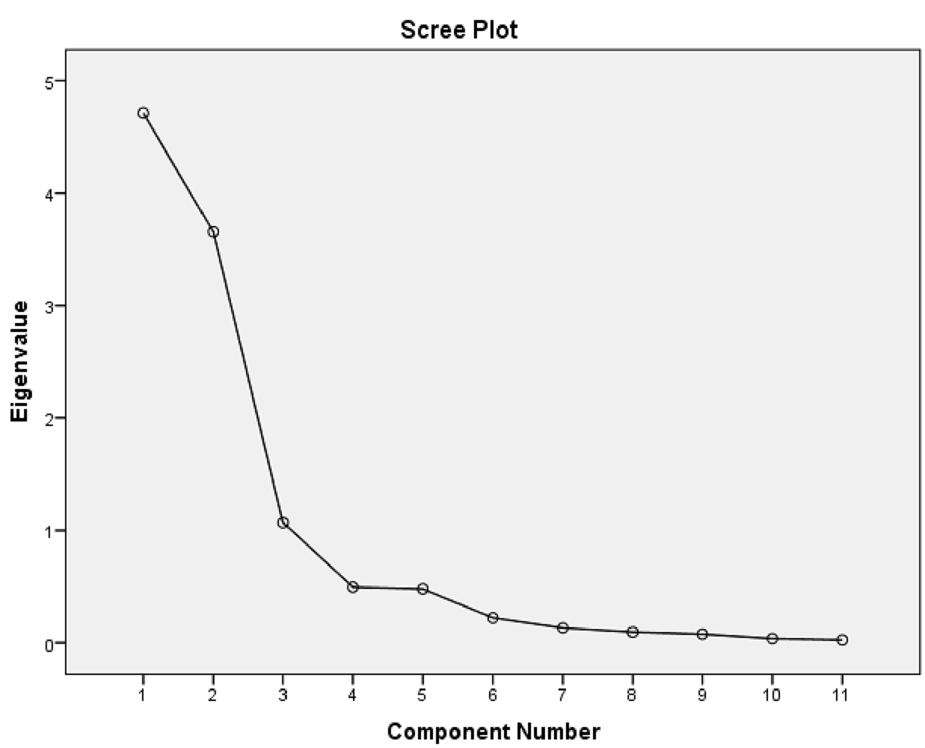

Figure 1. Scree Plot

4. CONCLUSION

The result of principal component analysis of egg traits extracted three factors that can objectively be used to describe the interdependence in the original eleven egg quality characteristics of Isa brown layer chickens. Therefore, the use of the three orthogonal egg quality factors (PC1, PC2 and PC3) extracted from the principal component analysis could be more reliable in predicting egg quality compared to the use of the original inter-correlated egg quality characteristics. The three principal factors could be used in a breeding programme for the improvement of egg quality traits.

References

[1] Abanikaanda, O. T. F., Olutogun, O., Leigh, A. O. and Ajayi, L. A. (2007). Statistical modeling of egg weight and egg dimensions in commercial layers. *International Journal of Poultry Science*, 6(1): 59-63

[2] Abdi, H. and Williams, L. J. (2010). Principal Component Analysis. John Wiley and Sons, Inc. *WIREs Comp. Stat.* 2: 433-457

[3] Bing-Xue, D., Jian-Zhou, S., Jin-Bing, Z., Wan-Li, G., Yun, W. and Xue-Ying, C. (2013). Principal component analysis of egg quality characteristics of native duck breeds in China. *Journal of Animal and Veterinary Advances*, 12(15): 1286-1288

[4] Egena, S. S. A., Ijaiya, A. T., Ogah, D. M. and Aya, V. E. (2014). Principal Component Analysis of Body Measurements in a Population of Indigenous Nigerian Chickens Raised Under Extensive Management System. *Slovakian Journal of Animal Science*, 47 (2): 77-82

[5] Everitt, B. S., Landau, S. and Leese, M. (2001). Cluster Analysis. 4th edn. Arnold Publisher, London.

[6] Eyduran, E., Topal, M. and Sonmez, A. Y. (2010). Use of factor scores in multiple regression analysis for estimation of body weight by several body measurements in brown trouts (Salmo trutta fario). *International Journal of Agriculture & Biology*, 12: 611-615.

[7] Jolliffe, I. T. (2002). Principal Component Analysis. 2nd ed. Springer series in Statistics. Pp. 1-6

[8] Kabir, M., Sulaiman, R. O., Idris, R. K., Abdu, S. B., Daudu, O. M., Yashim, S. A., Hassan, M. R., Adamu, H. Y., Eche, N. M., Olugbemi, T. S. and Adedibu, I. I. (2014). Effects of Strain, Age and the Interrelationships between External and Internal Qualities of Eggs in Two Strains of Layer Chickens in Northern Guinea Savannah Zone of Nigeria. *Iranian Journal of Applied Animal Science*, 4(1): 179-184

[9] Okoro, V. M., Ogundu, U. E., Okani, M., Oziri, I., Eneowo, O., Olisenekwu, O. T., Kadurumba, O., Ogbuewu, I. P., Onyemauwa, S., Ukwu, H. O. and Ibe, S. N. (2015). Principal Component Analysis of Conformation and Blood Marker Traits at Pre- and Post-Weaning Stages of Growth in F2 Crossbred Nigerian Indigenous X Landrace Pigs. *Animal Biotechnology*, 26: 243-250

[10] Onyeagu, S. I. (2003). A First Course in Multivariate Statistical Analysis. Mega Concept. Pub. Pp. 146-148

[11] Sarica, M. H., Onder, H. and Yamak, U. S. (2012). Determining the most effective variables for egg quality traits of five different hen genotypes. *International Journal of Agriculture and Biology*, 14: 235-240

[12] Sekeroglu, A. and Altuntas, E. (2009). Effects of egg weight on egg quality characteristics. *Journal of Science of Food and Agriculture*, 89(3): 379-383.

[13] SPSS (IBM) (2011). Statistics for windows, version 20.0. Armonk, NY: IBM Corp.

[14] Tolenkhomba, T. C., Konsam, D. S., Singh, N. S., Prava M., Singh, Y. D., Ali, M. A. and Motina, E. (2012). Factor analysis of body measurements of local cows of Manipur, India. *International Multidisciplinary Research Journal*, 2(2): 77-82

[15] Ude, I. and Ogbu, C. C. (2011). Principal component analysis of body measurements in three strains of broiler chickens. *Science World Journal*, 6(2): 11-14

[16] Yakubu, A. and Ayoade, J. A. (2009). Application of Principal Component Factor Analysis in Quantifying Size and Morphological Indices of Domestic Rabbits. *International Journal of Morphology*, 27(4): 1013-1017

[17] Yakubu, A., Kuje, D. and Okpeku, M. (2009). Principal components as measure of size and shape in Nigerian indigenous chickens, *Thailand Journal of Agricultural Science*, 42(3): 167-176

(Received 18 April 2017; accepted 01 May 2017)