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Full Length Research

Effect of egg weight on external and internal egg quality traits of Isa Brown egg layer chickens in Nigeria

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ABSTRACT: This study was designed to determine the effect of egg weight on internal and external egg quality characteristics of Isa brown egg layer chickens. A total number of 105 eggs collected within 24 hours of lay were used for the study. Eggs were numbered, weighed and classified into three egg weight groups: Light (less than 49.99 g), medium (50 to 55 g) and heavy (greater than 55 g) egg weight groups. Data were collected on internal egg quality characteristics (yolk height, albumen height, albumen length, albumen width, Haugh unit, yolk index, albumen index and yolk diameter) and external egg quality characteristics (egg length, egg width, oblong circumference, egg shell weight, egg shape index and egg shell thickness). Data were analyzed using Statistical Package for the Social Sciences (SPSS) version 20.0. Egg weight had significant ($P < 0.05$) effect on egg length, egg width, oblong circumference, eggshell weight, and eggshell thickness. Egg weight did not significantly ($P > 0.05$) affect Haugh Unit, yolk index, albumen index, and albumen length of the three egg weight groups. However, significant differences ($P < 0.05$) were observed among the light, medium and heavy egg weight groups in terms of yolk height, yolk diameter, and albumen height and albumen width. Positive correlations ($P < 0.05$) were observed between egg weight and egg length, egg width, oblong circumference, eggshell weight and eggshell thickness. Egg weight also correlated positively ($P < 0.05$) with yolk height, yolk diameter, albumen height and width.

Key words: Egg characteristics, chicken, correlation, Isa Brown, weight.

INTRODUCTION

The chicken egg, which is naturally designed for reproduction, is a veritable source of protein affordable to all classes of people whether rich or poor. In addition to protein, the chicken egg also contains carbohydrate, vitamins and other nutrients. Among the economically important traits in egg production enterprise are egg size, shell thickness and internal qualities of egg. The size of chicken egg, which is an important factor in marketing, is influenced by age, breed or strain of the chicken, as well as nutrition, and the colour varies from white to brown. Notably, consumers prefer jumbo size eggs to small-size eggs. Transportability of egg is dependent on its shell thickness since eggs with thin shells are liable to break on transit and hence constitute a great loss to the poultry farmer. Thus, the internal and external egg quality traits are of major importance to the egg industry worldwide (Ahmadi and Rahimi, 2011). Some researchers have studied the chicken egg quality from different perspectives. It has been reported that the quality of the chicken egg is influenced by genetic and non-genetic factors such as season, environment and feed intake (Ahmadi and Rahimi, 2011; Ojedapo, 2013; Burra, 2014). Egg quality traits had been reported to influence embryo development, hatchability, and growth performance of chicks (Khan et al., 2004; Onagbesan et al., 2007; Huwaida et al., 2015). Alabi et al. (2012) reported that medium-sized eggs could be considered for better hatchability, while large-sized eggs could be considered if growth performance is of primary importance. There are also reports on the relationship between egg size and egg quality characteristics (Abanikaanda et al., 2007; Olawumi and Ogunlade, 2008; Sarica et al., 2012). There is need to, further, investigate the influence of egg weight on its quality traits (internal and external), as such information could be useful in a selection programme to improve the quality of chicken egg as table egg, and for reproduction. This study, therefore, was designed to determine the effect of egg weight on internal and external egg quality traits of commercial Isa brown egg layer chickens.

MATERIALS AND METHODS

Experimental location

The research was conducted at the University of Agriculture Makurdi, Benue state. The state is located within the lower river Benue trough in the middle belt region of Nigeria. Its geographical coordinates are Longitude 7˚ 47ˈ and 10˚ 0ˈ East and Latitude 6˚ 25ˈ and 8˚ 8ˈ North. The area is characterized by a period of dry season between October to March and a period of rainy season from April to September. Annual rainfall ranges from 973 to 1324 mm.

Experimental birds and data collection

The eggs used in this study were collected from Isa brown strain, kept on deep litter system at a reputable farm located in Makurdi, Benue state, Nigeria. The birds were six months in lay and fed *ad libitum* on layers mash containing 16.0% crude protein. One hundred and five (105) eggs were collected on the same day, i.e. within 24 hours of lay. The eggs were weighed and further grouped into light weight (< 49.9 g), medium weight (50 to 55 g) and heavy weight (> 55 g) groups. Egg weight was measured using a sensitive digital weighing balance (Mettler Toledo, PL203 CE) with accuracy of 0.001 g. Egg length and egg width were taken using a vernier caliper. Oblong circumference of each egg was taken using the measuring tape. The eggshell weight was taken after breaking the egg, and the content poured into a separate container. The eggshells were dried at room temperature and thereafter weighed using a digital electronic weighing balance (Mettler Toledo, PL203 CE). Eggshell 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 eggshell thickness. Yolk height and yolk diameter for each egg were measured using vernier caliper. Albumen height, albumen width and albumen length were also measured with vernier caliper. Haugh unit, yolk index, albumen index and egg shape index were calculated using the equations below.

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

Where H= albumen height (in mm) and W= egg weight (in g).

$$\text{Yolk index (\%)} = \frac{\text{yolk height}}{\text{yolk diameter}} x100$$

$$\text{Albumen index (\%)} = \frac{\text{albumen height}}{\text{albumen length} + \text{albumen width}/2} x100$$

$$\text{Egg shape index (\%)} = \frac{\text{egg width}}{\text{egg length}} \text{x}100$$

Statistical analysis

Data collected from the study were subjected to one-way Analysis of Variance and Pearson’s product moment correlation using Statistical Package for the Social Sciences (SPSS, 2011) version 20.0. The following model was used for ANOVA.

$$\boldsymbol{Yij} = \mu + \boldsymbol{Wi} + \boldsymbol{eij}$$

Where; Y_{ij} = j^th^ observation in the i^th^ egg weight group, µ = population mean, Wi = effect of the i^th^ egg weight (i=1, 2, 3); light, medium and heavy egg weight groups and e_{ij} = error term with the usual properties.

RESULTS AND DISCUSSION

The descriptive statistics of external egg quality traits and internal egg quality characteristics in different egg weight groups were shown in Tables 1 and 2 respectively. The effect of egg weight on external egg quality traits were shown in Table 3, while the effects of egg weight on internal egg quality traits were shown in Table 4. The phenotypic correlations among egg weight and external egg quality traits were shown in Table 5, while correlations among egg weight and internal egg quality traits were shown in Table 6.

Effect of egg weight on external egg quality traits

Egg length

The egg length of light, medium and heavy egg weight groups were significantly (P < 0.05) different. Numerically,

Table 1. Descriptive statistics of external egg quality traits in different egg weight groups.

Egg trait	Egg weight group	N	Min	Max	Mean	SD	CV (%)
	Light	34	4.58	5.32	4.94	0.145	2.94
Egg length (cm)	Medium	35	4.87	5.22	5.07	0.096	1.89
	Heavy	36	4.95	5.70	5.25	0.142	2.70
	Light	34	3.51	3.97	3.73	0.084	2.25
Egg width (cm)	Medium	35	3.73	4.00	3.87	0.065	1.68
	Heavy	36	3.78	4.24	3.99	0.099	2.48
	Light	34	14.20	15.90	14.62	0.357	2.44
Oblong circumference (cm)	Medium	35	14.70	15.30	15.06	0.165	1.10
	Heavy	36	15.00	16.30	15.53	0.271	1.75
	Light	34	3.02	5.50	4.51	0.612	13.57
Egg shell weight (g)	Medium	35	4.23	6.44	5.29	0.424	8.02
	Heavy	36	4.65	6.23	5.56	0.345	6.21
	Light	34	68.23	95.80	76.03	4.376	5.76
Egg shape index (%)	Medium	35	72.57	81.93	76.36	2.130	2.79
	Heavy	36	69.57	81.25	75.98	2.926	3.85
	Light	34	0.25	0.38	0.32	0.038	11.88
Shell thickness (mm)	Medium	35	0.30	0.41	0.36	0.029	8.06
	Heavy	36	0.28	0.41	0.36	0.031	8.61

N = sample size; Max = maximum; Min = minimum; SD = standard deviation, CV= coefficient of variation.

heavy weight egg group had highest egg length (5.25 cm) while light weight egg groups had the least egg length (4.94 cm). It could be observed from this study that egg length increased with egg weight. The mean egg lengths observed in this study were slightly lower than the value (5.63 cm) reported by Abanikannda et al. (2007) for eggs from Harco heavy breed layers.

Egg width

The egg width of light, medium and heavy egg weight groups were significantly ($P < 0.05$) different. Numerically, the heavy egg weight group had the highest egg width (3.99 cm) while light weight egg had the lowest egg weight (3.73 cm). The result suggests that egg width increased with egg weight. The mean egg widths observed in this study were also slightly lower than the value (4.25 cm) reported by Abanikannda et al. (2007) for eggs from Harco heavy breed layers.

Oblong circumference

The oblong circumference of the egg weight groups were significantly different ($P< 0.05$), with numerical values of 14.62, 15.06 and 15.53 cm for light, medium and heavy weight groups respectively. The heavy weight egg group had the highest mean oblong circumference (15.53 cm) while the light weight egg group had the lowest mean oblong circumference (14.62 cm). Oblong circumference increased with egg weight as observed in this study. The mean oblong circumference values obtained in this study were lower than the value (16.39 cm) reported by Esonu et al. (2004) for Shikka brown layers 10 months in lay. This could be an indication that age of the birds has an influence on the oblong circumference of the eggs.

Eggshell weight

The eggshell weights of light, medium and heavy weight groups were significantly ($P < 0.05$) different and were observed to be 4.51, 5.29 and 5.56 g respectively. Eggshell weight increased as the egg weight increased as revealed in this study. Mean eggshell weight recorded in this study were lower than the values (6.36, 7.6, and 7.81 g) reported by John-Jaja et al. (2016) for Bovan Nera black layer chickens at 25, 51 and 72 weeks of age respectively.

Egg shape index

The egg shape indices of light, medium and heavy weight groups were not significantly ($P > 0.05$) different. The medium egg weight group had the highest egg shape index (76.36%) while the heavy weight group had the lowest egg shape index (75.98%), but were statistically insignificant. Mean egg shape indices observed in this study were comparable to the values reported by Sarica et al. (2012) for white (75.58±0.11%) and brown (76.71±0.09%) egg layer that were within the range 28 to 72 weeks of age. Egg shape indices obtained in this

Table 2. Descriptive statistics of internal egg quality traits in different egg weight groups.

Egg trait	Egg weight group	N	Min	Max	Mean	SD	CV(%)
	Light	34	50.97	88.44	69.98	9.062	12.95
Haugh unit (Hu)	Medium	35	50.71	98.67	69.40	12.310	17.74
	Heavy	36	43,06	91.14	71.49	10.442	14.61
	Light	34	29.89	47.81	39.55	3.514	8.88
Yolk index (%)	Medium	35	32.06	46.53	39.24	4.006	10.21
	Heavy	36	24.70	75.32	41.45	6.943	16.75
	Light	34	3.76	12.22	7.11	2.237	31.46
Albumen Index (%)	Medium	35	3.69	11.98	6.87	2,295	33.41
	Heavy	36	2.71	14.08	7.65	2.215	28.95
	Light	34	1.10	1.53	1.37	0.098	7.15
Yolk height(cm)	Medium	35	1.19	1.61	1.40	0.114	8.14
	Heavy	36	1.31	1.65	1.38	0.071	4.80
	Light	34	3.20	3.75	3.46	0.152	4.39
Yolk diameter (cm)	Medium	35	3.13	3.93	3.56	0.176	4.92
	Heavy	36	3.12	3.93	3.60	0.178	4.94
	Light	34	2.60	7.20	4.59	1.110	24.18
Albumen height (mm)	Medium	35	3.00	7.20	4.71	1.267	26.90
	Heavy	36	2.60	8.30	5.34	1.193	22.34
	Light	34	5.85	8.49	7.28	0.695	9.55
Albumen length (cm)	Medium	35	6.29	9.34	7.56	0.670	8.86
	Heavy	36	6.25	10.47	7.68	0.773	10.07

N = sample size; Max = maximum; Min = minimum; SD = standard deviation, CV= coefficient of variation.

study showed that the eggs had normal shape.

Eggshell thickness

Mean eggshell thickness of light, medium and heavy egg weight groups were significantly ($P < 0.05$) different. However, the light egg weight group had the lowest egg shell thickness (0.32 mm) while, both the medium and heavy egg weight groups had the highest egg shell thickness (0.36 mm) each. The mean egg shell thickness observed in this study was in agreement with the finding of Sarica et al. (2012) who reported mean egg shell thickness of 0.349 and 0.355 mm for brown and white egg layers respectively. In addition, comparable eggshell thickness value (0.34 mm) was also reported by Tadesse et al. (2015) for Isa brown egg layers.

Effect of egg weight on internal egg quality traits

Haugh unit (HU)

The mean Haugh unit of the different egg weight groups were not significantly ($P>0.05$) affected by egg weight, although eggs from heavy weight group had numerically better Haugh unit than eggs in light and medium weight groups. The mean Haugh unit values for light, medium and heavy egg weight groups were 69.98, 69.40 and 71.49 respectively. The Haugh unit values obtained in this study were lower than the value (85.34) reported by Tadesse et al. (2015) for Isa brown egg layers on intensive system.

Yolk index

Yolk indices for light, medium and heavy egg groups were 39.55, 39.24 and 41.45% respectively. Eggs from the three egg weight groups did not differ significantly ($P > 0.05$) in their yolk indices, although eggs in heavy weight group had better yolk index (41.45) than eggs in the other groups. The yolk indices observed in this study were higher than the yolk index (38.0%) reported by Esonu et al. (2004) for Shikka brown layers already in 10 months of lay. However, mean yolk indices recorded in this study were lower than the values reported by Sarica et al. (2012) for white (44.65%) and brown (44.74%) egg layer within the range of 28 to 72 week of age.

Albumen index

Mean albumen indices were 7.11, 6.87 and 7.65% for light, medium and heavy egg weight groups respectively. Albumen indices among the different egg weight groups

Table 3. Effect of egg weight on external egg quality traits.

Egg traits	Egg weight groups			SEM
	Light	Medium	Heavy	
Egg length (cm)	4.94^{a}	5.07^{b}	5.25^{c}	0.018
Egg width (cm)	3.73^{a}	3.87^{b}	3.99^{c}	0.013
Oblong circumference (cm)	14.62^{a}	15.06^{b}	15.53^{c}	0.045
Egg shell weight (g)	4.51^{a}	5.29^{b}	5.56^{c}	0.063
Egg shape index (%)	76.03	76.36	75.98	0.316
Shell thickness (mm)	0.32^{a}	0.36^{b}	0.36^{b}	0.004

a, b, c: means in the same row with different superscripts are significantly (P < 0.05) different. SEM: standard error of the mean.

Table 4. Effect of egg weight on internal egg quality traits.

Egg traits\Egg weight group	Light	Medium	Heavy	SEM
Haugh unit (Hu)	69.98	69.40	71.49	1.038
Yolk index (%)	39.55	39.24	41.45	0.501
Albumen index (%)	7.11	6.87	7.65	0.220
Yolk height (cm)	1.37^{a}	1.40^{a}	1.48^{b}	0.010
Yolk diameter (cm)	3.46^{a}	3.58^{b}	3.60^{b}	0.017
Albumen height (mm)	4.59^{a}	4.71^{a}	5.34^{b}	0.120
Albumen length (cm)	7.28	7.56	7.68	0.071

ab=means in the same row with different superscript differ significantly (P<0.05). SEM= Standard Error of the Mean.

did not differ significantly (P> 0.05). However, the heavy egg weight group still had a better albumen index (7.65) than eggs in the other groups. Mean albumen indices observed in this study were lower than the values reported by Sarica et al. (2012) for white (9.95%) and brown (8.08%) egg layers within the range of 28 to 72 weeks of age.

Yolk height

Yolk height of the three egg weight groups were significantly (P < 0.05) different, with eggs in the heavy egg weight group having the highest value of 1.48 cm. The change in yolk height observed among the egg weight groups in this study showed that yolk height increased as egg weight increased. This is in line with the findings of Sekeroglu and Altuntas (2009) who observed a positive change in yolk height among medium, large, extra- large and jumbo size eggs. However, mean yolk height values observed in this study were lower than the value (1.78 cm) reported by Tadesse et al. (2015) for Isa brown layers. The values were also lower than the values reported by Sarica et al. (2012) for white (1.87 cm) and brown (1.85 cm) egg layer within age range of 28 to 72 weeks.

Yolk diameter

Yolk diameter of the different egg weight groups differ significantly (P<0.05). The heavy and the medium egg weight group had the highest numerical values of 3.60 and 3.58 cm of yolk diameter respectively, while the light egg weight group had the least value of 3.46 cm. It could be observed from this study that yolk diameter increased as egg weight increased. This result was in agreement with the report of Alkan et al. (2015) who reported that yolk width (diameter) increased as the egg weight increased.

Albumen height

Significant (P < 0.05) differences were observed in the albumen height of the different egg weight groups. The heavy egg weight group had the highest albumen height (5.34mm). The change in albumen height observed among the egg weight groups in this study showed that albumen height increased as the egg weight increased. This result is in agreement with the findings of Seleroglu and Altuntas (2009) who observed a positive change in albumen height among medium, large, extra-large and jumbo size eggs. However, mean albumen heights recorded in this study were lower than values (6.34 mm)

Table 5. Correlations among egg weight and external egg quality traits.

Egg traits	EWT	EL	EWIDTH	OBC	ESW	ESI	ST
EWT	1						
EL	0.773**	1					
EWIDTH	0.888**	0.513**	1				
OBC	0.876**	0.880**	0.726**	1			
ESW	0.680**	0.513**	0.561**	0.572**	1		
ESI	0.048	-0.430**	0.426**	-0.176	-0.105	1	
ST	0.395**	0.326**	0.271**	0.353**	0.803**	-0.183	1

**= Correlation is significant at the 0.01 level, EWT= Egg weight; EL = Egg length; EWIDTH= Egg width; OBC= Oblong circumference; ESW= Egg shell weight; ESI = Egg shape index; ST= Shell thickness, N = 105.

reported by Tadesse et al. (2015) for Isa brown egg layers and Sarica et al. (2012) for white (8.24 cm) and brown (7.22 cm) egg layers.

Albumen length

Albumen length of the different egg weight groups did not differ significantly (P > 0.05), although eggs in the heavy weight groups had longer albumen length (7.68 cm) than other egg weight groups. Although there was no significant effect of egg weight on albumen length, it could be observed from this study that albumen length numerically increased as egg weight increased. This result agreed with the report of Alkan et al. (2015) who reported that albumen length increased with egg weight.

Correlation between egg weight and external egg quality traits

The correlations between egg weight and egg length, egg width, oblong circumference, egg shell weight were highly positive and significant (P < 0.01), while moderate positive and significant (P < 0.01) correlation was found between egg weight and shell thickness. This implies that as egg weight increases, egg length, egg width, oblong circumference, eggshell weight and shell thickness also increase. The positive correlations observed in this study, between egg weight and egg length, egg width, eggshell weight, and egg shape index were in agreement with the results of Alkan et al. (2015). However, moderate positive correlation observed in this study, between egg weight and shell thickness (0.395) disagreed with the result (-0.425) reported by Alkan et al. (2015). In addition, the association among the external egg measurements varied from positive to negative. The relationship between egg length and oblong circumference was highly positive (0.88) and significant (P < 0.01), which is an indication that egg length increases with oblong circumference. Moderate correlation was found between egg length and egg width, and eggshell weight, while low positive association was found between egg length and shell thickness (P < 0.01). However, low negative correlation was found between egg length and egg shape index (P < 0.01), which suggests that egg shape index decreases as egg length increases. Positive correlations were also observed between egg width and oblong circumference, eggshell weight, egg shape index, and shell thickness (P < 0.01). Low to moderate positive correlations were observed between oblong circumference and egg shell weight and shell thickness, while highly positive correlation was observed between egg shell weight and shell thickness.

Correlation between egg weight and internal egg quality traits

Positive correlations were found between egg weight and albumin index, yolk height, yolk diameter, albumin height (P < 0.01) and albumin length (P < 0.05), which implies that increase in egg weight results to corresponding increase in albumen index, yolk height, yolk diameter, albumen height and albumen length. However, non-significant (P > 0.05), low and positive correlations were observed between egg weight and Haugh unit, yolk index and albumin index. The low to moderate positive correlations observed in this study, between egg weight and Haugh unit, albumin index, yolk height, yolk diameter, albumin height, and albumin length were in agreement with the findings of Alkan et al. (2015). In addition, correlations among internal egg quality parameters varied from positive to negative. Haugh unit was positively associated with yolk index, albumin index, yolk height and albumin height, but negatively associated with yolk diameter, and albumin length (P < 0.01). Yolk index was positively associated with albumin index, yolk height, and albumin height, but negatively associated with yolk diameter, and albumin length (P < 0.01). Albumin index showed positive association with yolk height, and albumin height, but negative association with yolk diameter, and albumin length (P < 0.01). Yolk height showed positive association with albumin height, but negative association with albumin length (P < 0.01). Yolk diameter had positive association with albumin length

Table 6. Correlations among egg weight and internal egg quality traits.

Egg traits	EWT	HU	YI	AI	YH	YD	AH	AL
EWT	1							
HU	0.100	1						
YI	0.129	0.357**	1					
AI	0.164	0.897**	0.369**	1				
YH	0.476**	0.488**	0.587**	0.551**	1			
YD	0.358**	-0.293**	-0.456**	-0.237*	-0.010	1		
AH	0.309**	0.909**	0.356**	0.955**	0.586**	-0.172	1	
AL	0.197*	-0.742**	-0.290**	-0.775**	-0.283**	0.304**	-0.676**	1

** correlation is significant at the 0.01 level. *correlation is significant at the 0.05 level. N=105, EWT = egg weight, HU = Haugh unit, YI = yolk index, AI = albumen index, YH = yolk height, YD = yolk diameter, AH = albumen height, AL = albumen length.

($P < 0.01$). Albumin height was found to have negative association with albumin length ($P < 0.01$).

Conclusion

It could be observed from this study that the weight of the chicken egg had positive influence on the egg length, egg width, oblong circumference and eggshell weight. Egg weight also had positive influence on yolk height, yolk diameter and albumen height. Egg weight had positive association with egg length, egg width, oblong circumference, egg shell weight, shell thickness, yolk height, yolk diameter, albumen height and albumen length. The relationships between egg weight and egg shape index, yolk index and Haugh unit were insignificant. This information could be very important in designing a selection programme for the improvement of egg quality traits of Isa brown egg layers.

REFERENCES

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

Ahmadi, F., & Rahimi, F. (2011). Factors affecting quality and quantity of egg production in layers: a review. *World Applied Science Journal*, 12(3), 372-384

Alabi, O. J. Ngambi, J. W., Norris, D., & Mabelebele, M. (2012). Effect of egg weight on hatchability and subsequent performance of Potchefstroom Koekoek chicks. *Asian Journal of Animal and Veterinary Advances*, 7(8), 718-725.

Alkan, S., Galic, A., Karsli, T., & Karabag, K. (2015). Effect of egg weight on egg quality traits in Partridge (*Alectoris chukar*). *Journal of Applied Animal Research*, 43(4), 450-456.

Burra, A. (2014). Egg size and shell quality: an overview. Amo Farm Hatchery Ltd Bulletin. www.afshltd.com/egg-size-and-shell-quality-an-over-view. Retrieved on 7th April, 2017.

Esonu, B. O., Azubuike, J. C., & Ukwu, H. O. (2004). Evaluation of *Microdesmis puberula* leaf meal as feed ingredient in laying hen dies. *International Journal of Poultry Science*, 3(2), 96-99.

Huwaida, E. E. M., Ahmed, I. Y. S., Hind, A. A. E., Bakhiet, M. D., & Khalid, M. E. (2015). Effect of Egg Weight and egg Shell Thickness on Hatchability and Embryonic Mortality of Cobb Broiler Breeder Eggs. *Global Journal of Animal Scientific Research,* 3(1), 186-190.

John-Jaja, S. A., Udoh, U. H., & Nwokolo, S. C. (2016). Repeatability estimates of egg weight and egg-shell weight under various production periods for Bovan Nera Black laying chickens. *Beni-Suef University Journal of Basic and Applied Sciences*, 5(4), 389-394.

Khan, M., Khatun, M., & Kibria, A. (2004). Study on the quality of eggs of different genotypes of chicken under scavenging system at Bangladesh. *Pakistan Journal of Biological Science*, 7(12), 2163-2166.

Ojedapo, L. O. (2013). Effect of age and season on egg quality traits of Isa Brown layer strain reared in derived Savannah zone of Nigeria. *Transnational Journal of Science & Technology*, 3(7), 48-60.

Olawumi, S. O., & Ogunlade, J. T. (2008). Phenotypic correlation between some external and internal egg traits in the exotic Isa brown layer breeders. *Asian Journal of Poultry Science*, 2(1), 30-35.

Onagbesan, O. Bruggeman, V. Desmit, L., Debonne, M., Witters, A., Tona, K., Everaert, N., & Decuypere, E. (2007). Gas exchange during storage and incubation of avian eggs: effect on embryogenesi, hatchability, chick quality and post-hatch growth. *World's Poultry Science Journal*, 63, 557-573.

Sarica, M. H., Onder, H., & 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.

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

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

Tadesse, D., Esatu, W., Girma, M., & Desssie, T. (2015). Comparative study of some egg quality traits of exotic chickens in different production systems in East Shewa, Ethiopia. *African Journal of Agricultural Research*, 10(9), 1016-1021.