Influence of strain and Egg Size on the Hatchability of Indigenous Tswana Chicken Eggs

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Abstract

The objectives of this study were to find the influence of strain and egg size on the hatchability of indigenous Tswana chicken (ITC) eggs. In the first part of the study, a total of 240 eggs were collected from each of the three strains (naked neck, normal and dwarf) of ITC and artificially incubated to determine the influence of strain on fertility and hatchability of ITC eggs. In the second part of the study, a total of 244 eggs were obtained from the normal strain of ITC and allocated into three weight treatments: large (>55g), medium (50-55g) and small (<50g) to determine the effect of egg size on fertility and hatchability of ITC eggs. There were no differences in fertility and hatchability of set eggs between the three strains of ITC. Hatchability of fertile eggs was however significantly higher in the normal than dwarf and naked-neck strains. Egg size had no influence on hatchability of fertile and hatchability of set eggs in the normal strain. Medium-sized eggs however had the highest hatchability of both fertile and set eggs than large-sized and medium-sized eggs. In order to maximize on hatchability and chick number, the selection of medium-sized eggs and eggs of the normal strain are recommended.

Key words: strain, egg size, fertility, hatchability, Indigenous Tswana chickens.

Introduction

Indigenous Tswana chicken production is an important agricultural activity of almost all rural communities in Botswana. Indigenous Tswana chickens are a valuable source of protein in the form of meat and eggs, generate income through occasional sale of live chickens and/or eggs, play an important role in biological pest control, are a source of poultry manure, are a valuable tool in poverty alleviation of the rural poor and play an important role in women economic empowerment due to their quick turnover rate and low capital investment.

In Botswana, the method of choice in the production of indigenous Tswana chicks especially in rural areas is natural incubation through the use of broody hens. However artificial incubation of indigenous Tswana chicken eggs is also gaining popularity especially in urban areas. Successful incubation of chicken eggs should result in live chicks; however that depend on the fertility and

hatchability of incubated eggs. Fertility refers to the proportion of incubated eggs that are fertile while hatchability refers to the proportion of fertile eggs that hatch (Hatchability of fertile eggs) or the proportion of incubated eggs that hatch (hatchability of total eggs set) (Tiwari and Maeda, 2005). According to King'ori (2011) fertility and hatchability are interrelated heritable traits that vary among breed, variety and individuals in a breed or variety. The physical characteristics of the egg also play a critical role in embryo development and successful hatching and one of the most influential egg parameters is egg weight (Narushin and Romanov, 2002). There is considerable genetic diversity within the indigenous Tswana chicken population and some strains found within the indigenous Tswana chicken population include the naked neck, normal and dwarf strains (Moreki, 1997). No research has been carried out to evaluate the influence of strain and of egg size within strain on fertility and hatchability traits of indigenous Tswana chicken eggs. The purpose of this study was therefore to evaluate the influence of strain and of egg size within strain on hatchability traits of indigenous Tswana chickens.

Materials and Methods

Study Area

The study was conducted at Botswana College of Agriculture, Content Farm, Sebele, Gaborone, in the Southern part of Botswana from October to December 2012. During the study period, environmental temperature averaged 330°C and ranged between 15.6°C and 38°C.

Experimental animals

Twenty females and 4 males of normal strain, 20 females and 4 males of dwarf strain and 20 females and 4 males of the naked neck strain of indigenous Tswana chicken were used to investigate the influence of strain on the hatchability of indigenous Tswana chicken eggs. Only the normal strain was used to investigate the influence of egg size on the hatchability of indigenous Tswana chicken eggs.

Housing and feeding

The males (n=4) and females (n=20) of each strain (mating ratio of 1:5) were kept in three separate deep litter houses according to strain. The houses were made from concrete blocks with corrugated iron sheet roofing. The chickens were fed commercial grower pellets and provided with water *ad libitum* from 4 weeks of age. Egg collection was done at 76 wk of age.

Measurement of parameters

A total of 240 eggs were collected for each of the three strains over 16 consecutive days period. A total of 60 eggs collected over a 4 d period for each of the strains formed a replicate resulting in a total of four replications for each of the strains. Eggs of the naked neck, normal and dwarf strains of indigenous Tswana chicken were collected on a daily basis, individually identified, weighed and the dimensions taken before storage at 18ºC. A 0.01 g sensitivity level electronic balance was used to take egg weight, and egg length and width were measured using vernier callipers. A total of 60 eggs collected over a 4 d period (replicate) for each of the three strains were placed in an automatic incubator with the broad end pointing upwards for a total of four replications. Eggs were incubated at 37.5°C and 55% relative humidity and placed in the hatcher at day 18 of incubation. After 23 days of incubation, the hatched chicks of each of the three strains were counted and all unhatched eggs carefully opened to determine fertility.

In the second study a total of 244 eggs were obtained from the normal strain of indigenous Tswana chicken to determine the influence of egg size on external egg quality characteristics and hatchability of indigenous Tswana chicken eggs. Upon collection, the dimensions of the eggs were measured using a vernier callipers and egg weight determined using an electronic balance. The eggs were then classified into three different size categories as large (>55 g), medium (50-55 g) and small (<50 g) and were stored at 18ºC prior to incubation. Eggs collected over five consecutive days were used to form replicates and the numbers of eggs of different size categories under each replicate are shown in Table 1.

Table 1: Number of eggs of different size categories under each replication

Egg size	Replication 1	Replication 2	Replication 3	Total
Large	20	24	24	68
Medium	30	34	30	94
Small	24	30	28	82

The experiment was replicated three times and the eggs under each replicate were placed in an automatic incubator with the broad end pointing upwards within 5 d of collection. Eggs were incubated at 37.5°C and 55% relative humidity and placed in the hatcher at day 18 of incubation.

After 23 days of incubation, the hatched chicks for each of the three strains were counted and all unhatched eggs carefully opened to determine fertility.

Statistical analysis

The two studies were set up as completely randomized design experiments. Hatchability data were analyzed using General Linear Models of SAS using a model that included fixed effects of strain (normal, naked neck and dwarf strains) for the first study and fixed effects of egg weight (large-sized, medium-sized and small-sized eggs) for the second study.

Results on the main effect of strain and main effect of egg size on hatchability of indigenous Tswana chickens egg are presented as least squares means ± SE, and means separation was by the usual paired t-test for the first study and paired t-test with Scheffe's adjustment for the second study to correct for unequal number of eggs in the different size categories under different replications. Differences between means were declared significantly different at $P<0.05$

Results and Discussion

There were no significant differences in egg weight between the naked neck and the normal strain and between the normal and dwarf strains of indigenous Tswana chickens (Table, 1). There was however, a significant difference in egg weight between the naked neck and the dwarf strains of indigenous Tswana chickens. The naked neck produced the heaviest eggs and the dwarf strain produced the lightest eggs. Consistent with the current findings, Rajkumar *et al.* (2009) found a non-significant difference in egg weight between the naked neck and normal Indian local chickens. Garcês and Casey (2003) also found a non-significant difference in egg weight between the naked neck and normal strains of Dahlem Red in Mozambique. Yakubu *et al.* (2008) however reported significantly heavier eggs in the naked neck than normal strain of Nigerian indigenous chickens (43.04 versus 40.38g, respectively). Similar egg weight between the normal and dwarf strains of indigenous Tswana chickens is consistent with Dakpogan *et al.* (2012) who reported non-significant differences in egg weight between the normal and dwarf strains in indigenous chickens of Benin. To the contrary, Yeasmin and Howlider (2012) reported significantly higher egg weight in the normal than dwarf indigenous (Deshi) hens of Bangladesh. Significantly higher egg weight in the naked neck than dwarf strain found in the present study is contrary to some studies that reported similar egg weight between the naked neck and dwarf

strains of indigenous chickens in different countries (Dakpogan *et al.*, 2012 and Garces and Casey, 2003).

Table 2: Influence of strain on external egg quality characteristics and hatchability of Tswana chicken eggs

PARAMETER	NACKED NECK	NORMAL	DWARF
Egg weight (g)	$52.99^{a} \pm 0.61$	$51.70^{ab} \pm 0.69$	$49.80^{b} \pm 0.71$
Egg length (cm)	$5.67^{a} \pm 0.04$	$5.52^{b} \pm 0.04$	$5.47^{b} \pm 0.04$
Egg width (cm)	4.09 ± 0.02	4.11 ± 0.02	4.05 ± 0.02
Shape index	$72.49^{b} \pm 0.49$	$74.95^{a} \pm 0.60$	$74.24^{ab} \pm 0.54$
Fertility (%)	70.68 ± 4.50	61.53 ± 4.50	63.60 ± 4.50
Hatchability of fertile eggs (%)	$70.82^{b} \pm 3.67$	$84.05^{a} \pm 3.67$	$63.08^{b} \pm 3.67$
Hatchability of set eggs (%)	50.26 ± 4.55	51.58 ± 4.55	40.56 ± 4.55

Means with different superscripts within a row were significantly different (P<0.05)

There was no significant difference in egg length between the normal and dwarf strains (5.52 ± 0.04cm and 5.47 ± 0.04cm, respectively). The egg length of the naked neck strain was however significantly higher than those of the normal and dwarf strains. Significantly higher egg length in the naked neck than the normal strain in indigenous Tswana chickens is consistent with Yakubu *et al.* (2008) in Nigerian indigenous chickens and Dakpogan (2012) in indigenous chickens of Benin. Rajkumar *et al.* (2009) however reported similar egg length between the naked neck and normal genotypes under tropical climate from India. Similar egg length between the normal and dwarf strains of indigenous Tswana chicken is contrary to Dakpogan *et al.* (2012) who reported significantly higher egg length in the dwarf than normal strain in indigenous chicken of Benin. Significantly higher egg length in the naked neck than in the dwarf strain of indigenous Tswana chickens is also contrary to Dakpogan *et al.* (2012) who reported similar egg length between the naked neck and dwarf strains in indigenous chicken of Benin.

There were no significant differences in egg width between the naked neck, normal and dwarf strains of indigenous Tswana chickens. Similar egg width between the naked neck, dwarf and normal strains of indigenous Tswana chickens is consistent with Dakpogan *et al.* (2012) and Iqbal *et al.* (2012) who reported similar egg width between the three strains in indigenous chicken of Benin and in the four varieties of indigenous Aseel chicken in Pakistan, respectively. Rajkumar *et al.* (2009) also reported similar egg width between the homozygous naked neck, heterozygous naked neck and the normal strains under tropical climate from India. To the

contrary, Yakubu *et al.* (2008) found significantly higher egg width in the naked neck than in the normal strain (3.84cm versus 3.54cm, respectively) of Nigerian indigenous chicken. Yousif and Eltayeb (2011) found significantly higher egg width in the naked neck than in the dwarf strain (40.07±0.16mm versus 38.17±0.16mm, respectively) of Sudanese indigenous chickens.

There were no significant differences in egg shape indices between the naked neck and the dwarf and between the normal and dwarf strains of indigenous Tswana chickens. The egg shape index of the normal strain was however significantly higher than that of the naked neck strain. Similar egg shape indices between the normal and dwarf strains of indigenous Tswana chickens is consistent with Yeasmin and Howlider (2012) who found similar egg shape indices of 76.64±0.83 and 75.87±0.83 in the normal and dwarf indigenous (Deshi) hens of Bangladesh, respectively. Significantly higher egg shape index in the normal than in the naked neck strain of indigenous Tswana chickens is contrary to Yakubu *et al.* (2008) who found significantly higher egg shape index in the naked neck than normal strain in Nigerian indigenous chickens (74.68% versus 72.60%, respectively). Rajkumar *et al.* (2009) found similar egg shape indices between the naked neck and normal strains (76.36 and 74.81%, respectively) under tropical climate from India, respectively. Egg shape indices between 70 and 74 are considered normal shape indices for commercial layers (Zeidler, 2002) and any values below or above that range are cause for high incidence of cracked and broken eggs (Narushin, 2005).

There were no significant differences in apparent fertility between eggs of the naked neck, normal and dwarf strains of indigenous Tswana chickens. The naked neck strain however had slightly higher percentage of fertile eggs (70.68±4.50%) compared to the normal and dwarf strains (61.53±4.50% and 63.60% fertility, respectively). A slightly higher percentage of fertile eggs in the naked neck than dwarf strain of indigenous Tswana chickens are contrary to Yousif and Eltayeb (2011) who reported a significantly higher percentage of fertile eggs in the dwarf than naked neck strain of Sudanese indigenous chicken under improved traditional management system. The fertility for all the three strains of indigenous Tswana chickens ranged between 61.60±4.50 and 70.68±4.50% which is lower than the range of 75.66 - 92.29% reported by Elfaki (2000) for Sudanese native chickens and 83.37- 88.19% reported by Afifi *et al.* (2010) for the two developed chicken breeds of Egypt. The lower fertility reported for the three strains in the current study could be due to hen age as there is a general tendency for fertility to decline with age (King'ori, 2011).

There were no significant differences in hatchability of fertile eggs between the naked neck and the dwarf strains (70.82±3.67 and 63.08±3.67%, respectively). The normal strain however had significantly higher hatchability of fertile eggs (84.05±3.67%) than both the normal and dwarf strains. Similar hatchability of fertile eggs between the naked neck and dwarf strains of indigenous Tswana chicken is contrary to Yousif and Eltayeb (2011) who found significantly higher hatchability of fertile eggs in the dwarf than naked neck strain of Sudanese native chicken (65.6±5.17 and 59.09±5.00%, respectively). Afifi *et al*. (2010) also reported significantly higher hatchability of fertile eggs in Gimmizah (94.01±1.09%) than Mandarah (89.81±1.29%) developed chicken breeds of Egypt. Significantly higher hatchability of fertile eggs in the normal than in the naked neck and dwarf strains of indigenous Tswana chickens is an indication of less embryonic mortality in the normal than in the other two strains.

There were no significant differences in the hatchability of total eggs set among the three strains of indigenous Tswana chickens. The normal strain however had the highest hatchability of total eggs set (51.58±4.55), followed by the naked neck strain (50.26±4.55) and lastly the dwarf strain (40.56±4.55). Miazi *et al.* (2012) also found no significant difference in hatchability of set eggs between the Fayoumi and Sonali chickens of Bangladesh (86% and 87.5% hatchability of set eggs, respectively). To the contrary, Yousif and Eltayeb (2011) found significantly higher hatchability of total eggs set in the dwarf than in the naked neck strain of Sudanese native chicken (50.76±4.82 and 48.56±4.40%, respectively). Afifi *et al.* (2010) also found significantly higher hatchability of set eggs in Gimmizah (82.87±1.56%) than Mandarah (75.17±2.05%) developed chicken breeds of Egypt. Similar hatchability of total eggs set among the three strains of indigenous Tswana chickens is consistent with Islam (2002) who concluded that breed has little effect on hatchability of poultry eggs. According to Rizk *et al.* (2008) differences in fertility and hatchability between chicken strains could be due to the differences in egg size and egg quality traits between the strains. Physical egg characteristics play an important role in the process of embryo development and successful hatching and the most influential parameters are egg weight, shell thickness, porosity, shape index and the consistency of the egg contents (Narushin and Romanov, 2002; King'ori, 2011). It was therefore hypothesized that it was probably the differences in egg size between the three strains that resulted in minor variations in fertility and hatchability traits in the three strains of indigenous Tswana chickens. The purpose of the second study was therefore to test this hypothesis.

Effect of egg size on fertility and hatchability traits in the normal strain of Tswana chicken

Egg size had a significant influence on egg weight, egg length, egg width, fertility and hatch weight of the chicks (Table 2). Large-sized eggs had the highest values for egg weight, egg length, egg width and hatch weight of the chicks, followed by medium-sized eggs and lastly small-sized eggs. The differences in egg weight, egg length, egg width and average chick weight were significantly different between the three egg size categories. Significantly higher egg weight, egg length and egg width in large-sized compared to medium-sized and small-sized eggs is consistent with Alabi *et al.* (2012b) who reported the highest egg weight, egg length and egg width in large-sized eggs and the lowest egg weight, egg length and egg width in small-sized eggs of indigenous Venda chickens. Just like in the present study, Alabi *et al.* (2012) also reported a non-significant influence of egg size on egg shape index. Significantly higher hatch weight in large-sized eggs than medium sized and small-sized eggs found in the current study is consistent with Alabi *et al.* (2012a), Abiola *et al.* (2008) and Petek *et al.* (2005) who found higher hatch weight in large-sized than medium-sized and small-sized eggs in Potchefstroom Koekoek, Anak broiler chicks and Pharaoh quail, respectively.

Table 3: Influence of egg size on external egg quality characteristics and hatchability of Tswana chicken eggs

Trait	**Large**	**Medium**	**Small**
Egg weight (g)	$58.17^{a} \pm 0.31$	$52.35^{b} \pm 0.91$	$47.69^{c} \pm 0.24$
Egg length (cm)	$5.83^{a} \pm 0.04$	$5.59^{b} \pm 0.03$	$5.40^{c} \pm 0.03$
Egg width (cm)	$4.23^{a} \pm 0.01$	$4.12^{b} \pm 0.01$	$3.99^{c} \pm 0.01$
Egg Shape Index	72.70 ± 0.67	73.82 ± 0.41	74.01 ± 0.52
Fertility (%)	$71.49^{a} \pm 4.50$	$76.27^{a} \pm 4.50$	$54.99^{b} \pm 4.50$
Hatchability of fertile eggs (%)	60.19 ± 8.95	78.30 ± 8.95	70.78 ± 8.95
Hatchability of set eggs (%)	42.93 ± 6.27	59.27 ± 6.27	39.67 ± 6.27
Average chick weight (g)	$33.53^{a} \pm 0.53$	$31.10^{b} \pm 034$	$28.15^{c} \pm 0.41$

Means with different superscripts within a row were significantly different (P<0.05)

There were no significant differences in apparent fertility between large-sized and medium-sized eggs but the two size categories had significantly higher apparent fertility than small-sized eggs. Medium-sized eggs however had the highest apparent fertility (76.27±4.5%) followed by large-sized eggs (71.49±4.5%) and lastly small-sized eggs (54.99±4.5%). Petek *et al.* (2005) also found no significant influence of egg size on apparent fertility of quail eggs and numerically higher apparent fertility in large-sized and medium-sized eggs than in small-sized eggs. The apparent fertility for the different egg size categories of the normal strain ranged between 54.99±4.5% and 76.27±4.5% and this is lower than the range of 86.54 - 92.12% reported for the different size categories of quail eggs. Miazi *et al.* (2012) also reported numerically higher apparent fertility in Fayoumi (88.6%) and Sonali (89.8%) chickens of Bangladesh compared to the fertility of the normal strain of indigenous Tswana chicken reported in the current study. Higher apparent fertility values were also reported for the Gimmizah (88.19±1.37) and Mandarah (83.37±1.74%) developed chicken breeds in Egypt. According to Silversides and Scott (2001) some of the factors influencing fertility include breed, season and storage period.

There were no significant differences in both hatchability of fertile eggs and hatchability of set eggs between the three egg size categories. Medium-sized eggs however had the highest hatchability of both fertile and set eggs. Small-sized eggs had the lowest hatchability of set eggs while large-sized eggs had the lowest hatchability of fertile eggs. Hatchability of fertile in the normal strain of indigenous Tswana chickens ranged from 60.19% - 78.30% which is consistent with the 55% - 75% and 55.71% - 81.89% hatchability of fertile eggs reported in Potchefstroom Koekoek and Venda indigenous chickens (Alabi *et al.*, 2012a, b), respectively. Similar hatchability of both fertile and set eggs between the different egg size categories is consistent with Petek *et al.* (2005) who also found a non-significant influence of egg size on hatchability of both fertile and set eggs in the Pharaoh quail. Numerically higher hatchability of both fertile and set eggs in medium-sized eggs than in large-sized and small-sized eggs is consistent with Alabi *et al.* (2012a,b) who reported significantly higher hatchability of both fertile and set eggs in medium-sized than in large-sized and small-sized eggs in Potchefstroom Koekoek and indigenous Venda chickens. Abiola *et al.* (2008) also reported the highest hatchability of set eggs (96.67%) in medium-sized eggs and the lowest hatchability of set eggs (82.88%) in large-sized eggs. Hatchability of set eggs values in the Anak broiler breed reported by Abiola *et al.* (2008) ranged between 82.88% and 96.67% which is much higher than the range of 39.67% and 59.27%

reported for the normal strain of indigenous Tswana chicken in the current study. Alabi *et al.* (2012b) also reported higher hatchability of set eggs (53.61±1.03% - 76.39±1.03) in indigenous Venda chickens compared to the current hatchability of set eggs in the normal strain of indigenous Tswana chickens.

Conclusion

There were no differences in fertility and hatchability of set eggs between the naked neck, normal and dwarf strains of indigenous Tswana chicken. Hatchability of fertile eggs was however higher in the normal than dwarf and naked neck strains of indigenous Tswana chickens. Egg size had no influence on hatchability of fertile and hatchability of set eggs in the normal strain of indigenous Tswana chicken. Medium-sized eggs however had the highest hatchability of both fertile and set eggs than large-sized and medium-sized eggs. To maximize hatchability, medium-sized eggs of the normal strain are the most desirable.

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References

1. Abiola SS, Meshioye OO, B.O. Oyerinde BO and M.A. Bamgbose MA. 2008. Effect of egg size on hatchability of broiler chicks. Arch. Zootec. 57:83-86.
2. Afifi YK., El-Ella NYA, Ghanem HH, Aly OM, Balat MM. 2010. Factors affecting hatchability traits and post-hatch growth in two developed chicken breeds. Egypt. Poult. Sci. 30:157-177.
3. Alabi OJ, Ng'ambi JW and Norris D. 2012b. Effect of egg weight on physical egg parameters and hatchability of indigenous Venda chickens. Asian J. Anim. Vet. Ad. 7:166-172.
4. Alabi OJ, Ng'ambi JW, Norris D and Mabelebele M. 2012a. Effect of egg weight on hatchability and subsequent performance of Potchefstroom Koekoek chicks. Asian J. Anim. Vet. Ad. 7:718-725.
5. Dakpogan HV, Salifou S, Gbangboche AB, Chrysostome CAA. 2012. Laying performance of five local hen phenotypes in improved rearing conditions. J. Plant Anim. Sci. 15:2130-2134.
6. Elfaki AE. (200). Comparative study on the performance of five large Baladi native fowl groups and white hisex under relatively improved condition. MSc. Thesis. Faculty of animal Prod.U. of K.
7. Garcês A and Casey NH. 2003. Oviposition and egg quality traits of dwarf and naked neck layers. S. African J. Anim. Sci. 33:105-110.
8. Iqbal A, Akram M, Sahota AW, Javed K, Hussain J, Sarfraz Z and Mehmod S. 2012. Laying characteristics and egg geometry of four varieties of indigenous Aseel chicken in Pakistan. J. Anim. Plant Sci. 22:848-852.
9. Miazi OF, Mich G, Miazi M, Uddin MW, Hassan M and Faridah M. 2012. Fertility and

hatchability of Fayoumi and Sonali chicks. Scholarly J. Agric. Sci. 2:83-86.
10. Moreki JC. 1997. Small-scale poultry production systems in Serowe-Palapye Sub-district (Botswana). Master of Applied Science in Agriculture Thesis, University of Melbourne, Melbourne, Austraulia.
11. King'ori AM. 2011. Review of the factors that influence egg fertility and hatchability in poultry. Int. J.. Poult. Sci. 10:483-492.
12. Narushin VG. 2005. Egg geometry calculations using measurements of length and breadth.Poult. Sci. 84:482-484.
13. Narushin VG and Ramanov MN. 2002. Egg physical characteristics and hatchability. World's Poult.Sci. J. 58:297-303.
14. Rajkumar U, Sharma RP, Rajaravindra KS and Niranjan M. 2009. Effect of genotype and age on egg quality traits in naked neck chicken under tropical climate from India. Int. J. Poult. Sci. 8:1151-1155.
15. Rizk RE, El-Sayed NA, Shahein EHA, Shalan HM. 2008. Relationship between eggshell, shell membranes and embryonic development through different egg production periods in two developed chicken strains. Egypt. Poult. Sci., 28:535-551.
16. Siversides FG and Scott TA. 2001. Effect of egg storage and layer age on quality of eggs from two lines of hens. Poult. Sci. 88:1240-1245.
17. Tiwari AKR and Maeda T. 2005. Effects of egg storage position and injection of solutions in stored egg on hatchability in chicken (Gallus domesticus) research note. J. Poult. Sci. 42:356-362.
18. Yakubu A, Ogah DM and Barde RE. 2008. Productivity and egg quality characteristics of free range naked neck and normal feathered Nigerian indigenous chicken. Int. J. Poult. Sci. 7:579-585.
19. Yeasmin T and Howlider MAR. 1998. Comparative physical features, egg production and egg quality characteristics of normal and dwarf indigenous (Deshi) hens of Bangladesh. J. Appl. Anim. Res. 13:1-2.
20. Yousif IA and Eltayeb NM. 2011. Performance of Sudanese native dwarf and bare neck chicken raised under improved traditional production system. Agric. Biol. J. N. Am. 2:860-866.
21. Zeidler G. 2002. Shell egg quality and preservation. In: Commercial chicken meat and egg production, 5th edition, Kluwer academic publishers, Massachusetts, USA.