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Effect of Varying Protein Levels and Preservation Methods and Duration on Egg Production Performance and External Egg Qualities of Japanese Quails in a Semi-Arid Environment

Research Article

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ABSTRACT

The study was conducted to determine the effect of varying protein levels and preservation method on external egg qualities of Japanese quails. A total of 180 birds were randomly allotted into three dietary treatments in a completely randomized design (CRD) replicated six times. A factorial arrangement of 3 × 4 × 4 which involves 3 protein levels (15, 20 and 25% crude protein), 4 storage methods and 4 time intervals was designed to determine the effect of storage methods on external egg quality characteristics. The birds were fed diets containing 15, 20 and 25% crude protein in treatment 1, 2 and 3, respectively. The trial lasted for 10 weeks during which egg production, egg weight and external egg qualities were monitored. The egg weight, hen day and hen house egg production were significantly higher for quails fed diet containing 25% crude protein. There was significant effect of protein level on egg width, height and shell thickness (P<0.05). However, there was no significant effect of preservation on egg height, shell thickness and shell index. However, significant effects were observed in egg weight and shell area when the eggs were immersed in oil and stored at room temperature (P<0.05), Results indicated that length of preservation has no significant effect on Haugh unit, shell weight, shell index and shell area. However, egg weight was lower at week 0, other storage intervals remain the same. Storage time was found to be significant for all the traits observed. Refrigeration and immersion in oil and stored at room temperature provide significant (P<0.05) value for Haugh unit, indicating a minimal loss in quality. It was concluded that increasing dietary protein level of 25% will increase the production performance and internal egg quality of Japanese quails. Refrigeration and immersion in oil provided the best method for storage of eggs of the Japanese quails.

KEY WORDS egg quality, preservation method, protein level, quail, semi-arid environment.

INTRODUCTION

The type of protein to be fed to quails must be provided from a high quality source. Protein quality is generally based on amino acid composition and their availability in the feedstuff following digestion. Protein provides the amino acids for tissue growth and egg production. The dietary protein requirement of quail is influenced by metabolizable energy content and the ingredients used to formulate the diets. Quail flocks can be successfully raised on turkey starter diets containing 25-28% crude protein (Wilson *et al.* 1959; Woodard *et al.* 1973). Lee *et al.* (1977a) and Lee *et al.* (1977b) found that a dietary crude protein level of 24% is needed in starter diet for quail. Murakami (1991) evaluated nutrient requirements for laying quails and recommended higher than 18% crude protein in the diet during the laying period improved egg weight and feed conversion per egg, whereas feed intake, laying rate, feed conversion per dozen eggs shell percentage and shell thickness were not affected. Egg quality is composed of those characteristics of egg that affect its acceptability.

This makes it important to pay attention to the problems of preservation and marketing of eggs in order to maintain the quality (Adeogun and Amole, 2004). Among many quality characteristics, external factors including cleanliness, freshness, egg weight and shell weight are important in consumer's acceptability of shell eggs. Adeogun and Amole (2004) reported that poor storage conditions may result in deterioration of egg quality and consequently loss and waste of eggs.

The report further showed that prevention of loss of water through pores, inhibition of micro organism invasion and lower storage temperature are major considerations in retarding quality degradation. Since the storage environment influence quality of eggs, methods like lower temperature and modified atmosphere packaging such as refrigeration have been recommended (Chang and Chen, 2000). In some parts of Nigeria, most of the available eggs are usually stored at room temperature until they are completely sold or consumed because facilities for refrigeration are almost non-existent.

Room temperature in the semi-arid region of Nigeria could be as high as 35 ˚C in the dry hot season when ambient temperature reaches 40-45 ˚C (SERC, 1992). Egg quality comprises a number of aspects related to the shell, albumin and yolk and are divided into external and internal quality (Kul and Seker, 2004). Therefore, this study carried out to determine the effects of varying protein levels and preservation methods on external egg qualities of Japanese quails in a semi-arid environment.

MATERIALS AND METHODS

The study was conducted at the poultry research unit of the Department of Animal Science, Usmanu Danfodiyo University, Sokoto situated at the Sokoto veterinary centre, Aliyu Jodi in Sokoto north Local Government area of Sokoto State. Sokoto State is located within Sudan Savannah zone in the north western part of Nigeria and lies within longitudes 3-6 ˚E and latitudes 8-13 ˚N (Mamman *et al.* 2000). Sokoto has a semi-arid climatic condition, characterized by low rainfall varying widely in amount from year to year (500-1300 mm) and long dry season. Diurnal and seasonal temperature fluctuations are very wide. Maximum temperature of 41˚C is attained in April while minimum temperature of 13.2 ˚C occurs in January (Mamman *et al.* 2000). Humidity is very low during most part of the year and solar radiation is relatively high due to dry atmosphere and clear skies (Mamman *et al.* 2000).

A total of 180 four weeks old, female Japanese quail chicks (Brown strain) were randomly allotted to three (3) dietary treatments with 6 replicates with 10 chicks in a completely randomized design. The chicks were allowed to adapt to the experimental diet for 7 days. The pens were cleaned and disinfected using detergent and CID 20 solution, (alkyldimethlbenzylammonium chloride). The pens were allowed to dry for two days. Fresh wood shavings were used as the litter material. The animals were subjected to the same management practice (lighting, feeding and watering) throughout the experimental period. A single diet that had 2700 kcal/kg and 27% crude protein fed to the birds for the pre-laying period based on the recommendation of Lee *et al*. (1977a) and Lee *et al*. (1977b). Three diets containing three (3) different crude protein levels (15, 20 and 25%) were formulated as dietary treatments. All the diets were iso-caloric (2600 kcal/kg). Composition of experimental diets is shown in Tables 1 and 2.

Table 1 Ingredients and chemical compositions of quails grower diets used in the pre-laying experiment

Items	Composition (%)
Ingredients	
Maize	29.00
Sorghum	9.00
Soy bean meal	8.00
Ground nut cake	13.00
Wheat offal	33.70
Blood meal	3.00
Limestone	2.00
Bone meal	2.00
Premix	0.25
Salt	0.25
Methionine	0.25
Lysine	0.25
Calculated analysis	
Metabolizable energy (kcal/kg)	2700
Crude protein (%)	20.0
Crude fiber (%)	4.8
Available P (%)	0.6
Lysine (%)	1.0
Methionine (%)	0.5
Ether extract (%)	4.5
Calcium (%)	1.3
Cost (₦/kg)	102.2

The chicks were weighed on arrival; they were also weighed at the beginning and at the end of the experiment. Data were collected daily on feed intake and number of eggs.

Weight of eggs laid was also determined daily. The percentage egg production was calculated as a proportion of the number of eggs produced per bird in relation to the total number of eggs produced by all the birds in a treatment.

Minimum and maximum temperature was monitored on daily basis using minimum and maximum thermometer.

Table 2 Ingredients and chemical compositions of layer experimental diets

Ingredients (%)	Treatments (Protein levels %)		
	15	20	25
Maize	33.00	24.00	15.00
Ground nut cake	6.00	14.00	20.00
Soya bean	1.00	8.00	17.00
Wheat offal	38.00	34.00	30.00
Sorghum	12.00	10.00	8.00
Blood meal	3.00	3.00	3.00
Bone meal	3.00	3.00	3.00
Limestone	3.00	3.00	3.00
Salt	0.25	0.25	0.25
Premix	0.25	0.25	0.25
Methionine	0.25	0.25	0.25
Lysine	0.25	0.25	0.25
Total	**100**	**100**	**100**
Calculated analysis			
Metabolizable energy (kcal/kg)	2607	2616	2615
Crude protein (%)	15.0	20.2	25.3
Crude fiber (%)	4.6	4.9	5.2
Available P (%)	0.7	0.7	0.8
Lysine (%)	0.9	1.0	1.2
Methionine (%)	0.5	0.5	0.5
Ether extract (%)	3.9	4.5	4.9
Calcium (%)	1.9	2.0	2.0
Cost (₦/kg)	**94.1**	**103.6**	**108.8**

Cost of feed, cost of feed consumed and cost of feed/egg were determined. Mortality was also recorded throughout the period of the study. A 3 × 4 × 4 that includes 3 protein levels 4 storage methods and 4 time interval of factorial experiment was designed for egg preservation trial. A total of 144 non defective eggs were randomly divided into four preservation treatments including 1) storage at room temperature 32 ˚C (P1), 2) storage in refrigerator 4 ˚C (P2), 3) immersion in vegetable oil and stored at room temperature (P3) and 4) immersion in vegetable oil, and refrigerated (P4) that each treatment consisting of 48 eggs, (each replicate consisting of 12 eggs. Each egg was subjected to weekly weight loss determination and external quality assessment. The parameters determined include; egg weight, egg width, egg height, shell weight and proportion of shell surface area and shell thickness. Egg shell surface area was calculated as described by Haugh (1937) using the following equation:

Shell surface area= w 0.667 × 4.67

Egg mass was computed according to the procedure of North and Bell (1990). Haugh unit was calculated using the mathematical expression:

$$Hu = 100 \log (H7.57-1.7w^{0.37}).$$

Where:
Hu: Haugh unit.
H: albumen height.
W: observed weight of egg.

Using a complete randomized design, the data were analyzed with a 3 × 4 × 4 factorial arraignment with the PROC ANOVA of SAS (2002) following statistical model: the LSD test of significant method used for means comparison when significance was declared at P < 0.05.

RESULTS AND DISCUSSION

Results of the experiment on the egg production performance are presented on Table 3. The percentage egg production, hen day and hen house egg production recorded similar significant response with one another where quails fed 25% crude protein (CP) had significantly better levels of these two parameters (P<0.05). Mean egg weight of quails for all treatment groups followed the same pattern with hen day and hen house egg production where quails fed 25% CP had heavier egg weight compared to 15 and 20% CP levels (Table 3).

Egg production curve

There were no significant difference between the treatments group at week 2, 3 and 8 (P>0.05). Figure 1 indicated high significant difference (P<0.05) in percentage egg production at week 4, 5, 6 and 7 with treatment T3 having significantly higher egg production compared to other treatments. The peak of production (for all the treatments) was attained at week 8 of the experiment (Figure 1).

Results indicated no significant effect of preservation on egg height, shell thickness and shell index (P>0.05). Significant effects were however observed for egg weight and shell area when the eggs were immersed in oil and stored at room temperature (P<0.05). Egg stored at room temperature and those immersed in oil and then refrigerated were the same (P>0.05). Egg width and shell weight are also significantly higher for eggs immersed in oil and then refrigerated (P<0.05).

Length of preservation has no significant effect on Haugh unit, shell weight, shell index and shell area (P>0.05). However egg weight was significantly (P<0.05) lower at week 0, other storage sessions remain the same (P<0.05). Egg height was also significantly higher (P<0.05) at the initial stage of the experiment (weeks 0) and at week 2 but lower (P>0.05) at weeks 1 and 3. Shell thickness was also higher (P<0.05) at week 1 and lower (P>0.05) at weeks 2 and 3.

Table 3 Performance of Japanese quails fed varying protein levels

Parameter	Treatments (protein levels %)			
	T1 (15)	T2 (20)	T3 (25)	SEM
Initial body weight (g/b)	137.77	139.44	137.22	4.249
Final body weight (g/b)	157.14[b]	153.57[b]	173.81[ab]	5.897
Weight gain (g/b)	19.36[b]	19.12[b]	38.25[a]	5.118
Daily weight gain (g/day)	0.30[b]	0.30[b]	0.60[a]	0.729
Feed intake (g/b/d)	29.36	30.47	29.80	0.741
FCR	18.98[a]	12.41[b]	5.03[c]	4.004
Egg production (%)	75.49[b]	82.50[a]	85.86[a]	1.784
Hen day egg production	42.63[b]	46.53[ab]	49.94[a]	1.350
Hen house egg production	42.63[b]	43.91[b]	48.25[a]	1.200
Weight/egg (g)	7.25[b]	8.00[b]	8.95[a]	0.249
Live weight (g)	158.76[c]	174.69[b]	183.84[a]	2.836
Mortality (%)	0.000	3.33	5.55	2.283

The means within the same row with at least one common letter, do not have significant difference (P>0.05).
FCR: feed conversion ratio.
SEM: standard error of the means.

Table 4 indicated no significant interaction (P>0.05) between protein level and preservation methods on egg weight, egg height, shell weight, shell index and shell area (P>0.05). However egg width and shell thickness were significant (P<0.05).

The highest percentage egg production was recorded for quails on treatment T3. This was higher than the 70-80% reported by Pigareva *et al.* (1989). The egg production curve revealed that the differences between the investigated dietary treatments became pronounced from fourth week of production (Figure1), which was maintained throughout the production phase. The high egg laying intensity of the hens combined with the high egg mass produced as the protein levels increases from treatments T1 to T3. The positive effects with respect to production performance obtained in this experiment when laying quail fed diets containing different protein levels could be due to inclusion of different levels of soya bean meal which is a good source of conjugated linoleic acid (CLA). Aydin *et al.* (2006) showed that dietary CLA influenced egg production and fatty acid composition of egg yolk of Japanese quail in a dose and time dependent mode.

The hen day egg production reported in this study (42.64-49.94%) was higher than the values obtained by Babangida and Ubosi, 2006; (30.28-36.39%) but lower than those reported (57%) for with Shika brown layer hens by Abdullahi, (2004); (58-64%) by Abubakar (2005) with layer chicken and (50-59%) by Yahaya (2008). This variation could be attributed to the difference in crude protein levels of the diets fed to the birds and age as well as specie of the birds. Hen house egg production for all the treatments were almost similar to the hen-day values, which could be due to very low mortality (Table 3).

The mean egg weight obtained was lower than the 9.5g reported by Babangida and Ubosi (2006) when coturnix Japanese quails were fed diet containing 20% CP.

This could be attributed to the differences in energy content of the diets used, environmental location probably or breed differences.

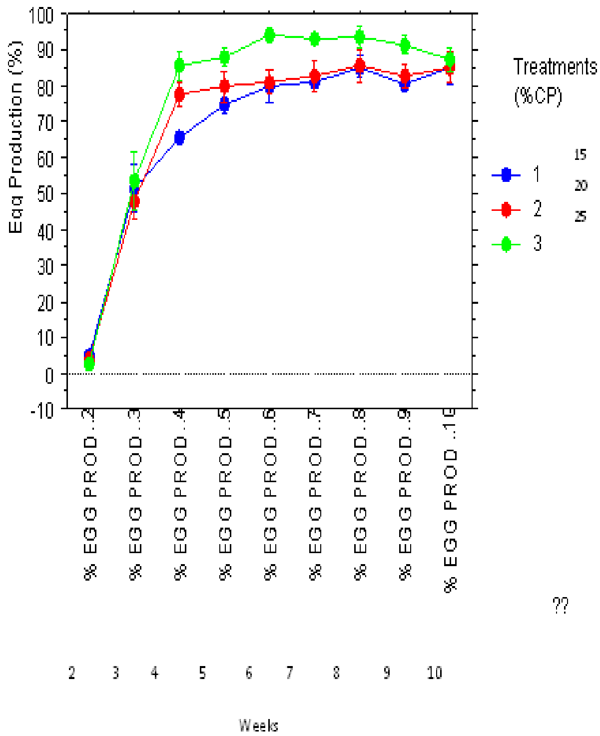

Figure 1 Percentage egg production of Japanese quails fed varying protein levels ??. There was significant effect of protein level on egg weight, shell weight, shell index shell area and shell thickness (P<0.05). Egg width was significantly higher for birds fed diet containing 15% CP (P<0.05) and lower for birds fed diet containing 20 and 25% CP (P>0.05). Egg height and shell thickness were significantly higher for treatment T3 and lower for treatment T1 (P<0.05)

Result indicated that the range of egg weight obtained in the present study conform with the findings of Li *et al.* (2011) who reported non-significant differences in the egg weight of birds fed varying protein levels.

Table 4 External egg quality characteristics of Japanese quails as affected by protein level preservation method and storage session

Factor	Egg weight (g)	Egg width (cm)	Egg height (cm)	Shell weight (g)	Shell thickness (mm)	Shell index (cm)	Shell area (cm)
Dietary protein levels (% of drymatter)							
15	9.809	2.478^{b}	3.148^{b}	1.077	0.257^{b}	1.271	30.555
20	10.354	2.533^{a}	3.213^{a}	1.141	0.261^{ab}	1.270	32.251
25	10.106	2.556^{a}	3.179^{ab}	1.136	0.271^{a}	1.246	31.479
SEM	0.192	0.015	0.02	0.026	0.003	0.009	0.599
Preservation methods							
P1	9.706^{b}	2.519^{ab}	3.208	1.065^{b}	0.269	1.274	30.233^{b}
P2	10.104^{ab}	2.494^{b}	3.150	1.125^{ab}	0.261	1.264	31.473^{ab}
P3	10.459^{a}	2.518^{ab}	3.188	1.095^{b}	0.259	1.268	32.579^{a}
P4	10.090^{ab}	2.558^{a}	3.174	1.187^{a}	0.262	1.243	31.428^{ab}
SEM	0.021	0.019	0.025	0.027	0.004	0.010	0.673
Storage Session							
W0	9.941^{b}	2.542^{a}	3.189^{a}	1.110	0.255^{b}	1.256	30.964
W1	10.256^{a}	2.511^{b}	3.147^{b}	1.107	0.298^{a}	1.256	31.964
W2	10.053^{ab}	2.500^{b}	3.207^{a}	1.120	0.248^{c}	1.284	31.314
W3	10.109^{a}	2.537^{a}	3.176^{b}	1.134	0.251^{c}	1.254	31.490
SEM	؟	؟					
Interaction effect							
Protein levels × preservation method	NS	**	NS	NS	*	NS	NS
Protein levels × storage session	-	-	-	-	-	-	-
Preservation method × protein levels × storage session	-	-	-	-	-	-	-
Protein levels × storage session × storage session	-	-	-	-	-	-	-
	0.228	0.019	0.025	0.029	0.005	0.011	0.709

The means within the same column with at least one common letter, do not have significant difference (P>0.05).
SEM: standard error of the means.
P1: storage at room temperature; P2: storage in refrigerator; P3: immersion in vegetable oil and storage at room temperature and P4: immersion in vegetable oil storage in a refrigerator.
W1: week one; W2: week two and W3: week three.

Shrivastav *et al.* (1993) also found that quails egg was unaffected by varying protein levels in diets. When comparisons were made among dietary protein levels from 14 to 20% (Yamagami and Kobayashi, 1983), reported non-significant differences in the egg composition.

Results indicated that the range of egg weight obtained from the study conform with the findings of Li *et al.* (2011) who reported non significant differences in the egg weight of birds fed varying protein levels. Shrivastav *et al.* (1993) found out that quail's egg was unaffected by varying protein levels in diets. When comparisons were made among dietary protein levels from 14 to 20%, Yamagami and Kobayashi (1983) reported a non-significant difference in egg composition. The significant value of Shell thickness reported from the study agreed with the findings of Ahn *et al.* (1999) who concluded that shell weight does not change with increase in storage time. However, report of Murakami (19991) showed that shell thickness was not affected by varying crude protein levels in diets of laying quails. Gardner and Young (1972) reported subsequent decrease in the proportion of shell thickness with increasing dietary protein level from 12 to18%.

Results indicated that eggs that were immersed in vegetable oil, and stored at room temperature recorded the highest weight (10.256 g), while the lowest egg weight was recorded for eggs stored at room temperature only (9.706 g). Walsh and Barka (1995), indicated that one requirement for successful long-term storage was the prevention of water loss from the egg, which could be provided by vegetable oil.

Results on egg preservation using different methods indicated significant increase in egg weight with increase in storage period. This though disagrees with several findings which indicated decrease in egg weight with increased days of storage (Imai *et al.* 1986; Altan *et al.* 1998; Fasenko *et al.* 2001; Tilki and saatci, 2004).

The difference could be due to the season of the year or storage methods used Haugh unit and yolk indices are generally considered as good indicators of egg quality evaluation (Chang and Chen, 2000).

The higher the yolk index (Ayorinde, 1987) and the haugh unit (Haugh, 1937), the more desirable the egg quality. The HU was initially 142.54 at week 0 and subsequently decrease to 117.12 at week 3.

The values however contradicted the report of Trava *et al.* (2009), which indicated that Haugh unit and yolk index from quail eggs do not change during storage periods of between 0 and 20 days at room and refrigerated temperature with supplementation of organic zinc in diet.

CONCLUSION

It was concluded that increasing protein level in the diet of Japanese quails to 25% CP will increase egg production performance. Refrigeration and immersion in oil provided insignificant losses to quality of eggs of the Japanese quails.

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REFERENCES

Abdullahi A.U. (2004). Performance and egg quality characteristics of the Shika Brown layers in Sokoto Nigeria. MS Thesis. Usmanu Danfodiyo Univ., Sokoto. Nigeria.

Abubakar A. (2005). Influence of yeast supplementation on the performance characteristics of broiler and laying chickens fed diets containing different levels of rice bran. Ph D. Thesis. Usmanu Danfodiyo Univ., Sokoto, Nigeria.

Adeogun I.O. and Amole F.O. (2004). Some quality parameters of exotic chicken eggs under different storage conditions. *Bullet. Anim. Health Prod. African*. **52,** 43-47.

Ahn D.U., Sell J.L., Jo C., Chamruspollert M. and Jeffrey M. (1999). Effect of dietary conjugated linoleic acid on the quality characteristics of chicken eggs during refrigerated storage. *Poult. Sci*. **78,** 922-928.

Altan O., Dguz l. and Akbas Y. (1998). Effect of selection for high body weight and age of hen on egg characteristics in Japanese quail (*Coturnix and Coturnix Japouica*). *Turkish J. Vet. Anim. Sci*. **22,** 67-473.

Aydin N., Karaman R., Toprak M., Ozugur H.H.C., Aydin A.K.D. and Cicek T. (2006). The effect of long term feeding of conjugated linoleic acid on fertility in Japanese quail . *South African J. Anim. Sci.* **36(2),** 99- 104.

Ayorinde K.L. (1987). Physical and chemical characteristics of eggs of four indigenous guinea fowls (*Numidia meleagris gallenta pallas*). *Nigerian J. of Anim. Prod*. **14(1),** 125-128.

Babangida S. and Ubosi C.O. (2006). Effects of varying dietary protein levels on the performance of laying Japanese quails (*Cortunix Cortunix japonica*) in a semi-arid environment. *Nigerian J. Anim. Prod.* **33(1),** 45-52.

Chang Y. and Chen T.C. (2000). Effects of packaging of shell egg quality stored: http://www.aginfo.snu.ac.kr/foodengin/internetposter/13/13.htm.

Fasenko G.M., Robinson F.E., Whelan A.I., Kremeniuk K.M. and Walker J.A. (2001). Prestorage incubation of long term stored broiler eggs effect on hatchability. *Poult. Sci*. **80,** 1406-1411.

Gardner F.D. and Young L.L. (1972). The effect of energy to protein ratio on production performance and characteristics of Japanese quails eggs. *Poult. Sci. J*. **49,** 1687-1692.

Haugh R.U. (1937). The haugh unit for measuring egg quality. *US Egg. Poult. Mag*. **43,** 548-553.

Imai C., Mowlah A. and Saito J. (1986). Storage stability of Japanese quail eggs at room temperature. *Poult. Sci*. **65,** 474-480.

Kul S. and Seeker I. (2004). Phenotypic correlations between some external and internal egg quality traits in the Japanese quail. *Int. J. Poult. Sci*. **36,** 400-405.

Lee T.K., Shim K.F. and Tan E.L. (1977a). Protein requirement of growing Japanese quails in the tropics. *Singapore J. Prim. Indust*. **5,** 70-81.

Lee T.K. Shim K.F. and Tan E.L. (1977b). Protein requirement of laying Japanese quails in the tropics. *J. Prim. Indust*. **5,** 82-90.

Li Y.X., Wang Y.Q., Pang Y.Z., Li J.X., Hie X.H., Guo T.J. and Li W.Q. (2011). The effect of crude protein level in diets on laying performance, nutrient digestibility of yellow quail. *Int. J. Poult. Sci*. **10(2),** 110-112.

Mamman A.B., Oyebanji J.O. and Peters S.W. (2000). Nigeria: A People United A Future Assured (Survey of States). Gabumo Publishing Co. Ltd. Calabar, Nigeria.

Murakami A.E. (1991). Níveis de proteína e energia em dietas de codornas japonesas (*Coturnix coturnix japonica*) nas fases de crescimento epostura. MS. Thesis. Universidade Estadual Paulista, Pernambuco, Brazil.

North M.O. and Bell D.D (1990). Commercial Chicken Production Manual. Chapman and Hall, New York.

Pigareva M.D., Afanasiev G.D. and Neps V.P. (1989). Quail breeding. *Trakia J. Sci*. **10(1),** 48-56.

SAS Institute. (2002). SAS®/STAT Software, Release 9.1. SAS Institute, Inc., Cary, NC. USA.

SERC. (1992). Sokoto Meterological Data. Energy Research Centre, Usmanu Danfodiyo University, Sokoto, Nigeria.

Shrivastav A.K., Raju M.V.L.N. and Johri T.S. (1993). Effect of varied dietary protein on certain production and reproduction traits in breeding Japanese quail. *Indian J. Poult. Sci.* **28(1),** 20-25.

Tilki M. and Saatci M. (2004). Effect of storage time on external and internal characteristics in partridge (*Alectoris graeca*) eggs. *Rev. Med. Vet.* **11,** 561-564.

Trava C.M., Fernandez I.B. and Cruz V.C. (2009). Efeito da temperatura e do tempo de armazenamento sobre a qualidade interna de ovos de codornas submetidas a dietas com Selênio e Zinco orgânicos. Pp. 24 in Conf. Ann. Soc. Brasileira de Zootecnia, Maringá. Brasil.

Wilson W.O., Abbott U.K. and Abplanalp H. (1959). Developmental and physiological studies with a new pilot animal for poultry. Coturnix quail. *Poult. Sci*. **38,** 1260.

Woodard A.E. Abplanalp, H. Wilson, W.O. and Vohra, P. (1973). Japanese Quail Husbandry in the Laboratory (Coturnix coturnix japonica). University of California, US.

Yahaya B.A. (2008). Performance characteristics of broiler and layer chickens fed diets containing three different plant proteins. Ph D. Thesis. Usmanu Danfodiyo Univ., Sokoto, Nigeria.

Yamagami Y. and Kobayashi M. (1983). Bulletin of the Saitama Prefectural Poultry Experiment Station. Japon.

Walsh T.J., Rizk R.E. and Barke J. (1995). Effect of temperature and carbon dioxide on albumen characteristics, weight loss and long stored hatching eggs. *Poult. Sci.* **74,** 1403-1010.