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Effects of Stocking Density on the Performance Characteristics, Egg Quality, and Nutrient Composition of the Eggs of Japanese Quails (*Coturnix coturnix japonica*)

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Abstract

Purpose: *The aim is to study the effects of stocking density on the performance characteristics, egg quality, and nutrient composition of the eggs of Japanese quails (Coturnix coturnix japonica).*
Study Design: Completely Randomized Design (CRD).
Subjects and Methods: *Two hundred and ninety-six (296) day-old sexed Japanese quails assigned to four different stocking densities (treatments) with four replicates conducted in the rainy season. The groups (I to IV) contained 11, 16, 21, and 26 quails in the approximate sex ratio of 1:1 (male: female) with stock densities 252.20 cm^2, 173.43 cm^2, 132.10 cm^2, and 106.73 cm^2/quail respectively. Standard procedures were adopted in data generation, collation and analyses.*
Results: *The results showed significant differences ($p < 0.05$) in weight gain, hen-day production, hen-housed production, total egg /hen, external and internal egg parameters across the treatments. The lowest feed conversion ratio (FCR) of 2.38 % and lowest mortality (2.27 %) were obtained from group one and compared with those in groups two and three. The highest mortality rate was observed in group IV (12.50 %). The proximate analysis and mineral composition of the eggs recorded the highest values from group I which was also compared with the rest of the groups.*
Conclusion: *It was concluded that 173.43 cm^2 and 132.10 cm^2/quail bird compared well with the standard (252.20 cm^2/quail bird) and hence could still be adopted in quail farming without compromising their welfare and performance.*

1. Introduction

The rearing/breeding of quail (Coturniculture) started in Nigeria in the year 1992 when the necessity to boost sources of animal protein for the teeming populace became unavoidable (Haruna *et al*., 1997). Moreover, the geometrical rate of increase in human population, continuous upsurge of urbanization, exacerbated by fixed supply of land for poultry production have engendered the search for good result-oriented management practices like stock density in quailary. The major derivable products from quails (meat and eggs) are good sources of animal protein. Quail eggs are a good source of nutrients for human health (Tanasorn *et al.,* 2013). It was reported that people especially from Asian countries consume eggs because the nutritional value is three to four times greater than chicken eggs. Regular consumption of quail eggs helps fight against many diseases and strengthens the immune system due to the rich sources of antioxidants, minerals, and vitamins (Lalwani, 2011). According to Khare *et al*. (1975) and Aggrey *et al*. (2003), eight species of quails have been documented Viz: Japanese quail (*Coturnix coturnix japonica*), European quail (*Coturnix coturnix coturnix*), Stubble quail (*Coturnix pectoralis*), Australian Brown quail (*Coturnix yapsilophorus*), New Zealand quail (*Coturnix novaezelandicae*), African Harleguin quail (*Coturnix delegorguei*), Indian Rain quail (*Coturnix coromendelia*) and Eurasian/Pharaoh quail (*Coturnix coturnix communis*). They are grouped into the genus coturnix and family phasianidae (new world quail: odontophoridae). The Japanese quails are known to be hardy, ideal for researches, early maturing (about 6 weeks) with low keeping cost. They produce delicious eggs and meat that are close in nutritional qualities to that of chicken. They eat less feed compared to chicken because of their relatively small size and hence one chicken's egg is an equivalent of five eggs from quail (Huss *et al.,* 2008).

Among various management stressors, stocking density has been known to affect behavioural and physiological indicators such as plasma corticosterone and heat shock protein 70 in birds (Mashaly *et al.,* 1984; Belmore *et al.,* 2010). Stocking density is expressed as mass per unit space (Thaxton *et al.,* 2006). It is the number of birds calculated on a weight basis per unit space. Increased urbanization, which reduces land available for agricultural purposes, has compelled poultry farmers to increase the number of birds per unit space to maximize the available space and at the same time increase profitability.

Many reported researches abound on the reproduction, mating ratio, hatching, the egg storage time and fertility duration of Japanese quail with proven results (Santos *et al*., 2011; Hassan *et al*., 2003). Other areas studied include the nutritional compositions of the eggs of Japanese quail from different breeds (Jeke *et al*., 2018). According to the report of Araujo *et al*. (2007) nutrition aspect of quails' farming had been extensively studied. In addition to the above, the feed intake and water intake, medicinal values of quail eggs, effect of heat on their immune responses, resistance of quail to many diseases of chickens had been carried out (Lalwani 2011; Jeke *et al*., 2018: Nazar *et al*., 2018). The dearth of valuable information as per the effects of high stocking density on the performance characteristics, egg qualities, and nutrient composition of the eggs of Japanese quails (*Coturnix coturnix japonica)* called for the design and execution of this research. The outcome could provide useful insights on which reasonable conclusions may be drawn and relevant recommendation(s) made in bridging the information inadequacy gap.

2. Methodology and Procedures

The present study was carried out at the Teaching and Research Farm of the Federal University of Technology, Akure, Nigeria. A total of 296-day old unsexed Japanese quail birds were brooded for three weeks before distribution in a Completely Randomised Design (CRD) into four groups of different stocking densities. The groups include I (252.20 cm^2/quail), II (173.43 cm^2/quail), III (132.10 cm^2/quail), and IV (106.73 cm^2/quail), housing 11, 16, 21, 26 quails respectively. Each group was replicated four times to give four treatments and four replicates. The quails were served feed and water without restriction (*ad libitum*). The compositions of the experimental diets are shown in Table 1.

Data collection and calculation

Initial weights of the birds (g) were recorded at the commencement of the experiment while the birds were subsequently weighed on a weekly basis thereafter. Weight gain was calculated by subtracting the final weight from the initial weight. Feed intake was calculated as the difference in feed served and the left-overfeed. Five eggs were subsequently broken into a non-absorbent flat surface to determine the eggs' internal qualities and composition according to the method described by Aro *et al,* (2009). Yolk colour score was determined with the aid of the Roche colour fan. Feed Conversion Ratio (FCR), Hen-Day Production and Hen-Housed Production were calculated using the formulae below:

$$\text{FCR} = \frac{\text{Feed intake (kg)}}{\text{Egg weight (kg)}} \text{ x } 100$$

$$\text{Hen-Day Production} = \frac{\text{Number of eggs produced per day}}{\text{Number of available birds}} \text{ x } 100$$

$$\text{Hen- Housed Production} = \frac{\text{Number of eggs produced per day}}{\text{Number of birds housed}} \text{ x } 100$$

Statistical Analysis

Data collected from this study were statistically analyzed by one-way analysis of variance (ANOVA) using SPSS version 23 (2015) and means separated by Duncan's New Multiple Range Test (Duncan, 1955) of the same package set at 5.00 % confidence level.

Table 1: Gross composition of Experimental diets

Ingredients	**Starters diet (kg)**	**Layers Diet (kg)**
Maize	51.60	58.60
GNC	30.00	21.00
SBM	11.00	11,00
Wheat offal	4.00	4.50
Bone meal	2.00	3.00
Limestone	0.50	1.00
Salt	0.30	0.30
Lysine	0.10	0.10
Methionine	0.25	0.25
Premix	0.25	0.25
Total	**100.00**	**100.00**
Calculated analysis		
Energy %	2869.60	2873.00
Crude Protein %	24.60	20.89
Calcium %	0.80	1.16
Phosphorous %	0.51	0.66
Lysine %	1.04	0.92
Methionine %	0.58	0.54

GNC = Groundnut cake; SBM = Soybean meal

3. Results and Discussion

The results of the performance characteristics, external and internal egg parameters, proximate and mineral composition of eggs from the experimental quails are as shown in Tables 2 to 5 respectively. The weight gain of the experimental birds as shown in Table 2 decreased following an increase in stocking density significantly ($p < 0.05$). This observation agrees with the reports of Fahmy *et al.* (2005), Toplu and Fidan, (2007), andAbdel-Azeem, (2010) in a study on Japanese quail. They opined that increasing stocking density in quail farming was associated with marked significant decrease in weight. The body weight gain for quails kept at the lowest stocking density was the highest due to more availability of space for feeding and drinking The insignificant variations in feed intake in this study disagrees with decrease feed intake as space per bird decreases as reported by some authors (Feddes *et al*., 2002; Al-Homidan and Robertson, 2007). The absence of statistical difference ($p > 0.05$) in the FCR also supports the earlier findings (Waheda *et al*., 1999; Camci and Erensanyin, 2004) that stocking density did not influence FCR. Mortality rate (Table 2) was the lowest and the highest in group I (2.27 %) and IV (12.50 %) respectively and it is in agreement with the report of Abdel-Azeeem, (2010) and Seker *et al*. (2009) that the mortality rate of Japanese quail increases with an increasing population per square cm. This is at variance with Tinoco *et al.* (2007), Turkyilmaz (2008) and Ayoola *et al*. (2014) who reported contrariwise. Egg weight did not differ significantly between group I and II but slightly differed in group III in comparison with the other groups. Hen-Day Production decreased correspondingly with an increase in stocking density and was better in Group I and II when compared with Groups III and IV. Hen-Housed production followed a similar trend as observed in hen-day production while egg production per hen decreased significantly ($p < 0.05$) as stocking density increased which agrees with other authors' observations in quail farming experiments (Nagarajan *et al*., 1991; Sohail *et al.,* 2001; Özbey *et al.,* 2004; El-Shafei *et al.,* 2012).

The external egg parameters (Table 3) followed a decrease in egg width from Group I to IV vis a vis increase in stocking density is in consonance with El-Tarabany (2014), who reported a significant ($p < 0.05$) higher estimates for the external parameters of eggs from birds with the lowest stocking density. However, this result contradicts EL-Shafei (2012) who reported no significant difference in the external parameters of eggs from hens subjected to different stocking densities. In the current experiment, however, only the egg weight and egg width seemed to be influenced by the increase in stocking density because egg shape, shell and shell membrane, shell thickness and egg specific gravity did not follow a particular pattern. The insignificant difference ($p > 0.05$) in shell thickness agrees with Nagarajan *et al*. (1991) who reported that shell thickness was neither influenced by age of hens nor by stocking density. There were significant differences ($p < 0.05$) in many of the observed internal egg parameters (Table 4). Whole egg weight and albumen weight were negatively influenced by high stocking density while yolk width, yolk colour index and yolk to egg weight ratio were positively influenced.

Albumen to yolk ratio was only depressed at the highest stocking density (Group IV) but yolk weight and yolk index showed no consistent trend. No statistically significant differences were shown in albumen height, Haugh's unit, yolk height and shell thickness among the four treatment groups. This observation disagrees with Faitarone *et al*. (2005) who reported a non-significant effect of stocking density on albumen ratio, yolk ratio, yolk weight and albumen weight. The insignificant difference in Haugh's unit and yolk height in this study is also at variance with the report of Faitarone *et al*. (2005). Birds housed at 252.2, 173.43 and 132.10 cm^2/bird showed improved albumen-yolk ratio over those birds assigned 106.73 cm^2/bird. This is probably suggesting that stocking density could still go higher to 173.43 cm^2/bird and 132.10 cm^2/bird without any consequential effect on the albumen-yolk ratio of the birds.

The proximate and mineral constituent results obtained in the study (Table 5) agrees with the report of Song *et al*. (2000) that egg albumen as the major part of the egg (taking up about 60%), consists of water (88%), proteins (11%), minerals, and carbohydrates (1%). According to Sun *et al*. (2019) albumen moisture is 87.70%, protein 10.60% ash 0.76%. The proximate analyses showed that the moisture content of yolk ranged from 45.25% - 49.12%, protein 13.22% -14.02%, fat 36.48% - 39.51% and ash 1.15% - 1.26%. The yolk moisture content was within the limit (49.70%) reported by Dudusola, (2010). However, the values for moisture, protein, ash, and fat were at variance with that of Song *et al*. (2000) who reported higher values for these parameters but similar to that of Thomas*et al*. (2016) who reported 70.94 %, 13.30 %, 11.99 % and 1.07 % for moisture, crude protein, ether extract, and ash respectively on whole eggs of quail birds. The bulk of the parameters evaluated in this study recorded the best values in group I followed by II and III and the least most of the time from group IV. This falls in line with the report of Gökçe *et al*. (2016) that parameters related to development and performance in quail are negatively affected by high stocking density.

Table 2: Performance Characteristics of Japanese quails subjected to different stocking densities

Parameters	Group I	Group II	Group III	Group IV
Initial Weight (g)	75.85±1.65	75.51±3.69	75.93±2.78	75.70±1.18
Final weight (g)	150.88±3.07^{a}	145.05±1.05^{a}	129.12±2.43^{b}	122.79±4.13^{b}
Weight Gain (g)	75.03±2.17^{a}	69.54±2.86^{b}	53.19±2.93^{b}	47.09±4.30^{c}
Feed intake (per bird/day) (g)	23.28±0.33^{b}	24.48±0.37^{a}	22.89±0.48^{b}	23.51±0.22^{ab}
Feed Conversion Ratio	2.38±0.02^{b}	2.47±0.04^{a}	2.43±0.06^{a}	2.44±0.03^{a}
Egg Weight (g)	9.79±0.15^{a}	9.93±0.06^{a}	9.42±0.10^{b}	9.64±0.07^{ab}
Mortality (%)	2.27±2.27^{b}	10.94±1.56^{ab}	10.71±4.01^{ab}	12.50±2.42^{a}
Hen-Day production (%)	89.85±4.10^{a}	85.87±5.37^{a}	78.45±2.90^{b}	72.42±1.26^{b}
Hen-Housed Production (%)	86.24±3.81^{a}	84.31±3.63^{a}	73.12±1.79^{b}	68.39±1.84^{b}
Egg Production/hen	31.97±3.13^{a}	27.32±1.91^{b}	25.02±1.88^{b}	19.86±1.58^{c}

a, ab, b, c = Means in the same row but with different superscripts are statistically ($P<0.05$) significant. Group I = 252.20cm^{2}/bird (11 birds), Group II = 173.43cm^{2}/bird (16 birds), Group III = 132.10cm^{2}/bird (21 birds) and Group IV= 106.73cm^{2}/bird (26 birds).

Table 3: External qualities of Quail Eggs subjected to different stocking densities

Parameters	Stocking densities (cm^2/quail)			
	252.20	173.43	132.10	106.73
Weight (g)	9.95 ± 0.08^a	9.80 ± 0.16^a	9.62 ± 0.09^b	9.75 ± 0.17^b
Length (cm)	4.01 ± 0.02^a	3.99 ± 0.02^a	3.96 ± 0.02^b	3.99 ± 0.02^a
Width (cm)	3.38 ± 0.01^a	3.38 ± 0.02^a	3.36 ± 0.03^{ab}	3.35 ± 0.01^b
Shape Index (%)	84.15 ± 0.45^b	84.67 ± 0.37^b	85.12 ± 0.67^a	84.20 ± 0.44^b
Shell and Shell membrane (g)	0.84 ± 0.02^a	0.84 ± 0.02^a	0.80 ± 0.01^b	0.86 ± 0.02^a
Specific gravity	1.21 ± 0.05^b	1.15 ± 0.04^b	1.35 ± 0.10^a	1.19 ± 0.03^b

a, ab, b, c = Means in the same row but with different superscripts are statistically ($P<0.05$) significant.

Table 4: Internal Parameters of Quail Eggs subjected to different stocking densities

Parameters	Group I	Group II	Group III	Group IV
Whole egg Weight (g)	8.34±0.10^{a}	8.17±0.13^{b}	8.05±0.13^{b}	8.14±0.18^{b}
Albumen Weight (g)	3.40±0.10^{a}	3.32±0.09^{ab}	3.28±0.05^{b}	3.23±0.13^{b}
Albumen Height (cm)	0.30±0.00	0.29±0.00	0.30±0.01	0.30±0.01
Haugh's Unit (%)	85.41±0.26	85.60±0.04	85.69±0.04	85.62±0.02
Yolk Weight (g)	3.20±0.03^{a}	3.09±0.06^{b}	3.08±0.08^{b}	3.21±0.05^{a}
Yolk Height (cm)	0.91±0.01	0.92±0.01	0.91±0.01	0.93±0.01
Yolk Width (cm)	2.78±0.02^{b}	2.76±0.01^{b}	2.76±0.02^{b}	2.84±0.05^{a}
Yolk Index (%)	32.73±0.46^{b}	33.33±0.02^{a}	32.97±0.45^{b}	32.75±0.44^{b}
Yolk Colour Index	1.42±0.15^{c}	1.58±0.15^{b}	1.92±0.15^{a}	2.08±0.15^{a}
Yolk to Egg weight ratio (%)	38.40±0.35^{ab}	37.81±0.19^{b}	38.23±0.35^{ab}	39.46±0.66^{a}
Albumen : Yolk	1.06:1.00^{a}	1.07:1.00^{a}	1.07:1.00^{a}	1.01:1.00^{b}
Shell Thickness (mm)	0.21±0.00	0.22±0.00	0.21±0.00	0.22±0.01

a, ab, b, c = Means in the same rows but with different superscripts are statistically ($P<0.05$) significant. Group I = 252.20cm^2/bird (11 birds), Group II= 173.43cm^2/bird (16 birds), Group III = 132.10cm^2/bird (21 birds) and Group IV = 106.73cm^2/bird (26 birds).

Table 5: Proximate analysis and mineral composition of egg yolk from Japanese quails (hens) subjected to different stocking densities

Parameters		Group I	Group II	Group III	Group IV
	Whole Egg	75.40±0.75	75.06±1.99	75.54±1.22	75.00±2.23
Moisture (%)	Albumen	88.68±1.16	88.64±0.95	88.16±0.77	88.30±1.19
	Yolk	45.25±1.67^{c}	45.31±2.97^{c}	46.76±1.14^{b}	49.12±1.00^{a}
	Whole Egg	12.56±0.26	12.00±0.41	12.20±0.81	12.07±0.26
Protein (%)	Albumen	10.21±0.22	10.25±0.08	10.22±0.14	10.22±0.07
	Yolk	14.02±0.42^{a}	13.92±0.14^{b}	13.56±0.65^{b}	13.22±0.74^{b}
	Whole Egg	11.06±2.73^{b}	11.26±1.34^{b}	11.46±1.62^{b}	12.10±3.17^{a}
Fat (%)	Albumen	0.09±2.98^{c}	0.12±0.98^{b}	0.15±2.14^{a}	0.13.±2.37^{b}
	Yolk	39.43±7.85^{a}	39.51±3.05^{a}	38.53±4.32^{b}	36.48±6.72^{c}
	Whole Egg	0.78±0.61^{b}	0.78±0.84^{b}	0.80±0.41^{a}	0.83±0.65^{a}
Ash (%)	Albumen	1.02±1.77^{a}	0.93±0.48^{b}	0.90±1.44^{b}	0.92±0.72^{b}
	Yolk	1.23±1.20^{a}	1.26±0.70^{a}	1.15±0.49^{b}	1.18±0.46^{b}
	Whole Egg	10.35±1.65^{a}	8.59±0.82^{b}	9.78±0.26^{a}	9.81±0.98^{a}
Ca (ppm)	Albumen	8.65±0.58	8.70±0.48	8.59±0.61	8.26±0.64
	Yolk	10.26±0.64^{a}	8.54±0.27^{b}	8.31±0.77^{b}	8.76±0.43^{b}
	Whole Egg	4.88±0.68^{a}	4.56±0.26^{ab}	4.46±0.27^{b}	4.66±0.73^{ab}
Mg (ppm)	Albumen	6.85±0.55	6.59±0.66	6.34±0.83	6.49±0.29
	Yolk	2.47±0.64^{b}	3.96±0.67^{a}	3.53±1.59^{a}	2.09±0.31^{b}
	Whole Egg	1.20±0.25^{a}	0.89±0.03^{b}	0.90±0.22^{b}	1.06±0.41^{a}
P (ppm)	Albumen	0.24±0.03^{a}	0.14±0.01^{b}	0.16±0.02^{b}	0.15±0.02^{b}
	Yolk	0.79±0.53^{b}	0.84±0.16^{a}	0.70±0.05^{b}	0.91±0.51^{a}

a, ab, b, c = Means in the same row but with different superscripts are statistically (P<0.05) significant. Group I = 252.20cm²/bird (11 birds), Group II= 173.43cm²/bird (16 birds), Group III= 132.10cm²/bird (21 birds) and Group IV= 106.73cm²/bird (26 birds)

4.Conclusion and Suggestion

Feed intake and egg weight were not affected by high stocking density. The FCR, egg production, liveability, and weight gain were, however, decreased by high stocking density. The group II birds were compared with the control in terms of HDEP, HHEP, egg weight, egg width and final weight. Egg length, egg shape index, eggshell weight, egg specific gravity, yolk index yolk weight, and yolk width were not negatively influenced by stocking density, while yolk colour index was positively influenced. High stocking density increased the yolk moisture content and yolk Phosphorus but it decreased yolk protein, yolk fat, yolk ash, and yolk calcium relative to the control. The fat and ash content of the whole egg were improved at higher stocking densities, while the ash and Phosphorus content of the albumen were decreased relative to the control. It was concluded that 173.43 cm^2 and 132.10 cm^2/quail bird compared well with the standard (252.20 cm^2/quail bird) and hence could still be adopted in quail farming without any adverse effect on the birds' performance, welfare and egg quality characteristics.

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Conflict of Interest

The authors of this research have no competing interest(s) to declare.

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References

Abdel-Azeem, F.A. (2010). The Influence of different stocking density and sex on productive performance and some physiological traits of Japanese quail. *Egypt Poultry Science,* 30: 203-227.

Agrey, S.E., Ankra-Badu, B.A. & Marks, H.L. (2003). Effect of long-term divergent selection on growth characteristic in Japanese quail. *Poultry Science*, 82: 538- 542.

Al-Homidan, A. & Robertson, J.F. (2007). The effect of stocking density and litter type on ammonia, dust, carbon dioxide concentration on broiler performance. *Egypt Poultry Science,* 24: 37-51.

Araujo, M.S., Barreto, S.L.T., Donzele, J.L., Oliveira, R.F.M. Umigi, R.T., Oliveira, W.P., Balbino, E. M., Assis, A.P. & Maia, G.V.C. (2007). Nivels de cromo organic na dieta de codornas japonesas mantidas em estresse por calor na fase de postura. *Revista Brasileira de Zootecnia, 36*(3): 584 – 588.

Aro, S.O., Tewe, O.O. & Aletor, V.A. (2009). Potentials of *Chromolaena odorata* leaf meal as egg yolk colourant for laying hens. *Livestock Research for Rural Development.* 21, 171.

Ayoola, A.A., Adeyemi, O.A., Egbeyale, L.T., Sogunle, O.M. & Ekunseitan, D.A. (2014). Effects of Sex and Stocking Density on Growth Performance and Some Physiological Traits of Japanese Quails (*Coturnix coturnix japonica*). *Malaysian Journal of Animal Science*, *17*(2): 43-53.

Belmore, J., Kang, H.K., Kim, Y.J., Subramani, V.K., Jang, I.S., Sohn, S.H. & Moon, Y.S. (2010). The effects of stocking density on stress-related genes and telomeric broiler chickens. *Asian-Australian Journal of Animal Science. 23:437-443.*

Camci, O. & Erensayin, C. (2004). Effect of stocking density during the early growth phase on fattening performance of Japanese quail (*Coturnix coturnix japonica*). Arch. Geflugelk. 68 :94-96.

Dudusola. I.O. (2010). Comparative evaluation of internal and external qualities of eggs from quail and guinea fowl. *International Research Journal of Plant Science*, 1(5) pp. 112- 115.

Duncan, D.B. (1955). Multiple range and Multiple F tests. *Biometrics.11*(1) , 1– 42.

El- Shafei, A.A., Abdel – Azeem, A.F. & Abdullaha, E.A. (2012). Stocking density effects on performance and physiological changes of laying japanese quail. *Journal of Animal and Poultry Production., Mansoura University, 3*(8),379 - 398.

El-Tarabany, M. S., Abdel-Hamid, T. M., & Mohammed, H. H. (2015). Effects of cage stocking density on egg quality traits in Japanese quails. *Kafkas niversitesi Veteriner Fak ltesi Dergisi*, *21*(1), 13-18.

Fahmy, M.O., El-Faramawy, A.A. & S.A. Gabr (2005). Changes in blood parameters, reproductive and digestive systems of Japanese quail as response to increased population density. *Isotope and Rad. Res*., *37*(2), 287-298.

Faitarone, A.B.G., Pavan, A.C., Mori, C., Batista, L.S., Oliveira, R.P., Garcia, E.A., Pizzolante, C.C., Mendes, A.A. & Sherer, M.R. (2005). Economic traits and performance of Italian quails reared at different cage stocking densities. *Brazilian Journal of Poultry Science*, *7*(1), 19 – 22.

Feddes, J.J.R., Emmanuel, E.J. & Zuidhof, M.J. (2002). Broiler performance, body weight variance, feed and water intake, and carcass quality at different stocking densities. *Poultry Science Journal.* 81, 774–779.

Gökçe, Ö., İnci, H., Söğüt, B., Şengül, T., Yüksel, H., Şimşek, H. & Özdemir, A. (2016). Effects of dietary boron supplementation on performance and some haematological and antioxidant parameters in Japanese quail exposed to high stocking density. *Europ.Poult.Sci.,* 80. 2016, DOI: http//:10.1399/eps.2016.137

Haruna, E.S., Musa U., Lombin, L.H., Tat, P.B., Shamaki, P.D., Okewale, P.A. & Molokwu, J.U. (1997). Introduction of quail production in Nigeria. *Nigerian Veterinary Journal*.18, 104-107

Hassan, S.M., Mady, M.E., Cartwright, A.L., Sabri, H.M & Mobarak, M.S. (2003). Effect of feeding time on the reproductive performance of Japanese Quail (*Coturnix coturnix japonica*). *Poultry Science, 82*: 1188 – 1192.

Huss, D., Poynter, G., & Lansford, R. (2008). Japanese quail (Coturnix japonica) as a laboratory animal model. *Laboratory Animal*, *37*(11), 513-519.

Jeke, A., Phiri, C., Chitiindingu, K & Taru, P. (2018). Nutritional compositions of Japanese quail (*Coturnix coturnix japonica*) breed lines raised on a basal poultry ration under farm conditions in Ruwa, Zimbabwe. Cogent Food & Agriculture, 4: 1473009, 1 – 8.

Khare, M.C., Grun, J. & Adams, E.U. (1975). In: Marek‟s disease in Japaneses quail - A pathological, virological and serological study. *Poultry Science*, 54, 2066-2081.

Lalwani, P. (2011). Quail Egg Nutrition. http://www.buzzle.com/articles/quail-egg-nutrition.html Accessed 15th April 2012.

Mashaly, M.M., Webb, M.L., Youtz, S.L., Roush, W.B. & Graves, H.B. (1984). Changes in Serum Corticosterone Concentration of Laying Hens as a Response to Increased Population Density. *Poultry ScienceJournal*. *63*(11), 2271-2274.

Nagarajan, S., Narahar, L.D., Jayaprasad, I.A. & Ihyagarajan, D. (1991). Influence of stocking density and layer age on production traits and egg quality in Japanese quail. *British Poultry Science*, *32*(3): 243 – 248.
Nazar, F.N., Videla, E.A., Fernandez, M.E., Labaque, M.C. & Marin, R.H. (2018). Insights into thermal stress in Japanese quail (*Coturnix coturnix*): dynamics of immunoendocrine and biochemical responses during and after chronic exposure. *Stress 21*(3): 257 – 266.
Ozbey, O., Yildiz, N., Aysondu, M.H. & Ozmen, O. (2004). The effect of high temperatures on blood serum parameters and the egg productivity characteristics of Japanese quails. *International Journal of Poultry Science*. 3,485–489.
Santos, T.C., Murakami, A.E., Fanhani, J.C. & Oliveria, C.A.L. (2011). Production and Reproduction of Egg and Meat type Quails Reared in Different Group Sizes. *Brazilian Journal of Poultry Science, 13*(1): 09 – 14.
Seker, I., Selim, K. & Metin, B.A. (2009). Effect of group size on fattening performance, mortality rate, slaughter and carcass characteristics in Japanese quail (Corturnix corturnix japonica).*Journal of Animal and Veterinary Advances 8*(4), 688-693.
Sohail, S.S., Bryant, M.M., Rao, S.K. & Roland, D.A. (2001). Influence of cage density and prior dietary phosphorous level on phosphorus requirement of commercial Leghorns. *Poultry Science Journal80(*6), 769-775.
Song, K.T., Choi, S.H. & Oh, H.R. (2000).A comparison of Egg quality of Pheasant, Chukar, Quail and Guinea Fowl. *Asian- Australian Journal of Animal Science.13*(7), 986 – 990.
Sun, C., Liu, J., Yang, N. & Xu, G. (2019). Egg quality and egg albumen property of domestic chicken, duck, goose, turkey, quail, and pigeon. *Poultry Science98*(10)4516–4521 http://dx.doi.org/10.3382/ps/pez259.
Tanasorn, T., Wanna, T. & Wattasit, S. (2013). Nutrient Benefits of Quail (*Coturnix Coturnix Japonica*) Eggs. *International Journal of Scientific and Research Publications.* 3(5).1-8.
Thaxton, J.P., Dozier, W.A., Branton, S.L., Morgan, G.W., Miles, D.W., Roush, W.B., Lott, B.D. & Vizzier-Thaxton, Y. (2006). Stocking density and physiological adaptive responses of broilers. *Poultry Science*, *85*(5), 819-824.
Thomas, S.K., Richard-Jagatheesan, P.N., Lurthu-Reetha, T. & Rajendran, D. (2016). Nutrient composition of japanese quail eggs. *International Journal of Science, Environment and Technology*, *5*(3),1293 – 1295.
Tinoco, I.F.F., Fonseca, J.M., Alvarengae Melo, R.C., Tinôco, A.L.A., Moraes, S.R.P. & Yanagi Jr, T. (2007). Effects of stocking density on the performance of broiler chickens grown under water fogging and ventilation systems. *American Society of Agricultural and Biological Engineers,* 256-261.
Toplu, H.D.O. & Fidan, E.D. (2008). Effect of cage stocking density on growth and carcass characteristics of Japanese quail. *Indian Vet. J.,* 85,1083 – 1085.
Turkyilmaz, M.K. (2008). The effect of stocking density on stress reaction in broiler chickens during summer. *Turkish Journal of Veterinary and Animal Sciences*, 32, 31-36.
Waheda, P., Rabba, M.G., Howlider, M.A.R. & Waid, M.A. (1999). Interaction of group size and stocking density on egg production performance of Japanese quail. *Bangladesh Veterinarian*, *16*(1),29 – 33.