Original Research

Influence of Different Dietary Nutrients on Egg Production, Quality Traits and Serum Hormone Levels of Japanese Quails (*Coturnix coturnix japonica*)

Letorn A. F. Akinola[1]* and Blessing N. Igwe[2]

[1]Department of Animal Science, Faculty of Agriculture, University of Port Harcourt, Choba, Port Harcourt, P.M.B. 5323 Port Harcourt, Rivers State, NIGERIA
[2]Department of Animal Science, Faculty of Agriculture, Rivers State University, Port Harcourt, P.M.B 5020 Port Harcourt, NIGERIA

***Corresponding author:** letorn.akinola@uniport.edu.ng

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Abstract

This study was conducted to examine the influence of different dietary nutrients on hen day production, feed cost, egg quality traits and the serum hormone levels of Japanese quails. One hundred and thirty five (135), four weeks old female Japanese quails were randomly assigned to five treatment groups (T1 – T5) in a completely randomized design (CRD). Each treatment had three replicates of nine quails each. The control diet (T1) was compounded to consist of a balanced ration (2600 Kcal/kg metabolizable energy, ME, 24 % crude protein, 5 % fat, 6 % crude fibre) while the other diets were deficient or high in one of these nutrients. Feed and water were provided ad libitum while records of feed cost and daily egg production were kept. Three eggs were collected from each replicate for external and internal quality analysis. Blood samples were collected from two birds per replicate for serum hormone and cholesterol analysis. The diets significantly affected (P < 0.05) the hen day production (HDP) such that the birds fed the control and high fibre diets had higher HDP while those from the low energy diet had the least HDP. The cost of the low energy feed was the highest. The diets also significantly influenced (P< 0.05) the egg quality traits such that the egg, albumen and yolk weights from the control and the high fat diet had the highest weight. Eggs from the high fibre diet had the least weights. The hormone levels of the birds fed the low energy diet were the lowest (P > 0.05) while the control birds and the birds fed the high fibre diet had the best hormone levels which resulted in higher HDP. It was obvious that the nutritionally deficient diets, especially the low energy diet was not good for quail production and should never be used. The study served as a reference for the nutrients required for quail production.

Key words: Egg Production, Egg Quality, Haugh Unit, Hormones, Quails

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Introduction

An increase in the demand for foodstuffs, mostly eggs, and poultry meat has been noticed in many developing countries. This is due to the increasing human population over time. This has urged poultry researchers and farmers to be more interested in the research and production of relatively underutilized poultry species, including quails. This is intended to reduce the heavy burden on the production of domestic fowl. However, information regarding the effect of feeding different nutrients to other poultry species, including quails are not abundant (Dudusola, 2010).

Quails belong to the species, galliforms. It is a small bird with an average body weight of 150 – 500 g at adult age depending on the genetic lines (Tikk and Tikk, 1991). They are highly prolific, hardy, early maturing with shorter incubatuin period (16 – 18 days), and low cholesterol content of both the meat and the eggs (Schwartz and Allen, 1981; NRC, 1991). They lay 200 – 300 eggs/year and have low feed and space requirements. Quails adapt to commercial management or confinement conditions (Paulillo *et al*., 2009) and thrive in small cages. They can be managed easily and are resistant to common poultry diseases. Quails are good as laboratory animals because they are easy to maintain, mature early with short generation interval, high egg production rate and are fast gaining awareness as egg and meat source (Punga, 2008). The increasing awareness of the benefits of food products that are rich in unsaturated fats and low in saturated fats and cholesterol (Castor and Leeson, 1990, Musa *et al*., 2008) have led to the continuous increase in the demand for quail meat and eggs. Olubamiwa *et al.* (1999) recommended 2500 – 2800 kcal/kg metabolizable energy in one single diet for Japanese quail while Edache *et al.* (2007) recommended 24-25% crude protein (CP) level and NRC (1994), 24% CP and 2900Kcal ME/kg for good performance of Japanese quails. Farmers are compelled to compound their own feed, which is sometimes deficient or high in one or more of the major nutrients due the high cost of conventional feed ingredients (maize, soya beans meal, fish meal etc). This is as a result of the absence of standard or commercial feed specially made for quail production in Nigeria (Bawa *et al*., 2012). The consequences of such diets on the birds performance, egg production, egg quality and hormone production may not be realized by the farmers, except it is specially planned, as in the case of the use of fibre, to make it suitable for the class and/or the stage of growth of the birds (Akinola and Onunkwo, 2009). For the farmer/producer, the success of an egg-laying flock is determined by the total number of eggs produced (Monira *et al*., 2003). Egg processing industries, also need information on the external and internal qualities of eggs (Song, 2000). This is necessary since the weight of the egg shell, albumen and yolk are some of the qualities that determine the price of the product (Altan *et al*., 1998).

This study was therefore investigated to know the influence of different dietary nutrients on egg production, egg quality traits and the serum hormone levels of Japanese quails with the aim to sensitize

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quail farmers on the type of feed that is appropriate for quail production and clear the suspicions by researchers of the implications of using nutrient deficient diets.

Materials and Methods

This study was carried out at the Teaching and Research Farm of Rivers State University, Port Harcourt, Nigeria. It was conducted between April and July when the daily temperature was within 21 -23 ^{0}C. The Farm is within the tropical rain forest zone of Nigeria with a mean daily minimum and maximum temperature of 21 – 23 ^{0}C and 32 – 34 ^{0}C and an annual rainfall of about 2,405mm. One hundred and thirty-five (135) four weeks old female Japanese quails were selected from a flock of 260 quails kept at the University Teaching and Research Farm. They were randomly assigned to five treatment groups (T1 – T5) with three replicates each in a completely randomized design (CRD). Each replicate consisted of nine birds each, housed in each unit of the cages which were specially constructed, cleaned and disinfected to accommodate the birds throughout the 12 weeks experimental period. The dietary treatments were compounded to contain 2600kcal/kg ME, 24 % crude protein, 5 % fat and 6 % crude fibre for the control diet (T1) while the other diets had low energy diet (T2 = 2200 kcalME/kg), low protein (T3 = 17 %), high fat (T4 = 10 %) and high fibre (T5 = 10 %) as shown in Table 1.

Table 1: Composition of Experimental Diets

Ingredients (%)	**T1 (Control)**	**T2 (LED)**	**T3 (LCPD)**	**T4 (HFD)**	**T5 (HFID)**
Corn	30.00	0.00	30.00	10.00	25.00
Palm kernel cake	14.00	23.00	30.00	23.00	20.00
Soya beans meal	20.00	17.00	0.00	15.00	0.00
Fishmeal (72 % CP)	0. 00	0.00	0.00	0.00	5.00
Wheat bran	16.15	39.15	25.15	25.15	15.15
Palm oil	0. 00	0.00	0.00	4.00	0.00
GNC	15.00	16.00	10.00	18.00	20.00
Maize cob	0.00	0.00	0.00	0.00	10.00
[1]Premix	0.25	0.25	0.25	0.25	0.25
Limestone	2.00	2.00	2.00	2.00	2.00
Bone meal	2.00	2.00	2.00	2.00	2.00
D-L meth	0.10	0.10	0.10	0.10	0.10
Salt	0.40	0.40	0.40	0.40	0.40
Lysine	0.10	0.10	0.10	0.10	0.10
Total	100	100	100	100	100
Nutrient Composition					
CP (Calculated)	24.00	24.00	17.10	24.10	21.10
CP (Analyzed)	23.80	24.00	16.90	23.90	22.40
ME(Kcal/kg)	2616.70	2247.30	2603.40	2633.90	2598.00
CF (Calculated)	5.80	7.10	5.90	5.80	9.50
CF (Analyzed)	5.90	6.10	6.00	6.00	10.10
Fat (Calculated)	5.10	5.20	5.00	9.60	4.50
Fat (analyzed)	4.90	4.80	4.80	9.70	4.60

[1]Vitamin and Trace mineral for each kg contained: Mn 40g, Fe 20g, Zn 18g, Cu 0.8g, I 0.62g, Co 0.09g and Se 0.04g, pantothenic acid 1,000,000 I.U, cholecalciferol 1,100,000 I.U, quinones 0.8g, thiamin 0.6g and riboflavin 2.4g, folic acid 0.4g, biotin 0.02g, ascorbic acid 10.0g, Choline chloride 120.0g, zinc bacitracin 80.0g, avatec 30.0g; LED = Low energy diet, LCPD = Low crude protein diet, HFD = High fat diet, HFID = High fibre diet

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The nutrient composition of the diets was calculated while a sample of each diet was analyzed for their proximate nutrient composition by the method of AOAC (1990). Feed and water were provided *ad libitum* while routine management activities were carried out. Records of the cost of feed and daily egg production were kept for further use.

At the end of the study, the hen day production, mean egg weight and cost of feed per dozen egg were calculated from the records that were collected during the study. Three eggs were collected from each replicate to study the external and internal quality traits of the eggs. The eggs were weighed using an electronic weighing scale and recorded in grams. The egg length was measured with a vernier caliper by taking the longitudinal distance between the narrow and broad ends of the egg while the egg width was obtained from the diameter of the widest cross-sectional region. These values were used to calculate the egg shape index (ESI = egg width ÷ egg length × 100 %). The shells were washed with slight flowing water to properly clean them. They were left to dry at room temperature along with the membranes for 24 hours, then weighed with a sensitive electronic weighing scale, while the shell thickness along with the membrane was recorded as the average value of the thickness taken from the broad end, narrow end and the equatorial parts of each egg with the aid of micrometer screw gauge. The shell weight and the egg weight was used to calculate the shell index (SI = shell weight ÷ egg weight × 100 %).

The eggs were carefully broken in the middle to keep the yolk intact and emptied into a petri dish. The individual yolk was separated from the albumen and weighed. Yolk height was recorded and the diameter was taken as the maximum cross-sectional diameter with a pair of vernier caliper. The yolk index was obtained from the formula: yolk height ÷ yolk diameter × 100 %. Albumen weight was obtained using a sensitive weighing balance after removing the intact yolk. Albumen heights were also obtained by measuring the widest expanse of the thick albumen, between the yolk edge and the external edge of the thick albumen and was used to obtain the yolk: albumen ratio (yolk weight ÷ albumen weight). The albumen and yolk P^H were determined using the universal P^H indicator while the haugh unit (HU) was calculated using the mathematical expression: Haugh unit (HU) = $100\log(H+7.5 - 1.7w^{0.37})$, where H = albumen height and w = egg weight. Blood samples were collected from two birds per replicate into non-heparinized tubes for the analysis of serum hormone levels (luteinizing hormone, LH, follicle stimulating hormone, FSH, and estrogen) and the cholesterol levels as described by Clinotech Diagnostic and Pharmaceuticals (1999).

All the data collected were subjected to statistical analysis using SAS software (SAS, 1990) while significant difference between the means was determined accordingly.

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Results and Discussion

The influence of the nutrients on hen day production and feed cost is presented in Table 2.

Table 2: Influence of diets on hen day production and feed cost

Parameters	Treatments					
	T_1	T_2	T_3	T_4	T^5	SEM
Hen-day Production, %	79.1^a	61.2^c	73.5^b	70.3^b	81.5^a	2.61
Cost/dozen egg, N	187^b	263^a	199^b	201^b	166^c	14.2

a,b,c - Means within same row the with different superscripts are different (p < 0.05)

The control diet (T1) and the high fibre diet (T5) had significantly (P < 0.05) higher HDP, followed by the birds that were fed the low protein diet (T3) and the high fat diet (T4). The birds fed the low energy diet (T2) had the least HDP. The cost of feed per dozen egg produced was also significantly (P < 0.05) affected by the dietary nutrients fed to the birds. Birds fed the high fibre diet had notably the lowest cost of producing each dozen of egg while the highest cost was incurred by feeding the low energy diet. The birds fed the control, low crude protein diet and high fat diet had moderate cost.

The result obtained from the hen day production showed that the control and high fibre diets supported better utilization of the feed, resulting in better egg production, in terms of the number of eggs laid. The low conversion of diets to eggs in T3 and T4 was shown by the less HDP of the birds fed these diets. Birds fed the T2 diet which had the least HDP from this study showed how devastating the diet without adequate energy level can affect the number of egg produced since HDP or rate of lay of the bird expresses the percentage of eggs produced by a flock on a particular day or period of time divided by the number of birds in the flock. In this case, the birds fed the low energy diet started laying egg very late, thus producing only a few dozens of eggs before the termination of the study. This was in line with Akinola *et al*. (2012) who stated that Japanese quails fed low energy diet (2200 kcalME/kg) had reduced ovary-oviduct development (weight) which delayed follicular genesis and eventual egg lay in the birds beyond 9 weeks of age. This highest cost of feed recorded in this study which was associated with the production of birds using the low energy diet was due to the low number of egg laid despite the *ad libitum* feeding throughout the study. The energy deficient diet led to pronounced higher feed intake (Akinola and Sese, 2012) to satisfy their energy need.

Result obtained from the influence of diets on the external and internal qualities of egg is shown in Table 3. Egg weight was the only external quality that was significantly affected by the dietary nutrients consumed by the birds. The egg obtained from the birds fed the control and the high fat diets had the best weight. Birds fed the low energy diet and those fed the low protein diets had intermediate weight while the bids fed the high fibre diet had the least weight.

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Table 3: Influence of diets on the external and internal characteristics of the eggs

Parameters	Treatments					
External qualities	**T_1**	**T_2**	**T_3**	**T_4**	**T^5**	**SEM**
Egg weight, g	9.02^a	7.63^b	7.91^b	9.41^a	7.04^c	0.4
Egg length, cm	3.27	2.92	2.96	3.31	2.87	0.12
Egg width, cm	2.48	2.3	2.37	2.5	2.26	0.1
Shell weight, g	1.24	1.01	1.03	1.31	0.98	0.06
Shell thickness, mm	0.3	0.2	0.23	0.32	0.24	0.08
Egg shape index, %	75.8	78.8	80.1	75.5	78.7	1.04
Shell index, %	13.7	13.2	13	13.9	13.9	0.54
Internal qualities						
Albumen weight, g	4.02^a	3.61^b	3.78^b	4.13^a	2.81^c	0.45
Albumen height, mm	4.51	4.1	4.21	4.62	3.71	0.98
Albumen pH	8.15	7.92	7.96	7.98	8.01	0.27
Yolk weight, g	3.72^a	3.01^b	3.21^b	3.81^a	2.61^c	0.31
Yolk height, mm	5.02^a	4.76^a	4.79^a	5.12^a	3.80^b	0.53
Yolk diameter, cm	3.41^a	3.16^a	3.21^a	3.46^a	2.52^b	0.72
Yolk pH	7.12	7.01	7.08	7.2	6.91	0.16
Yolk index	13.2	13	13.1	13.4	14.7	1.82
Yolk:Albumen ratio	0.93	0.82	0.85	0.92	0.93	0.1
Haugh Unit, HU	71.6	72.7	72.5	71.4	72.9	1.61

[a,b,c] *- Means within the same row with different superscripts are different ($P < 0.05$)*

The other qualities (egg length, egg width, shell weight, shell thickness, egg shape index and shell index) were not affected by the dietary nutrients consumed by the quails. Most of the internal characteristics of the eggs were influenced by the diets. The albumen height and pH, yolk pH, yolk: albumen ratio, yolk index and haugh unit (HU) were not affected by the diets.

The best weight of eggs obtained from birds fed the control and high fat diets implied that the eggs obtained from the control and high fat diets will attract higher price as they will be classified as 'grade A' eggs. Egg weight and size is the most important marketing parameter apart from the internal quality of the egg (Nikolova, 2014). Farooq *et al*. (2001) also noted that some of the parameters that influence egg quality and grading include egg weight, albumen and yolk weight and egg width. The egg weight and the other external qualities were similar to the values reported by Nazligul *et al*. (2001), Dudusola (2010), Tabeekh (2011) and Odunsi (2016) but were contrary to the report of Bagh *et al*. (2016) who gave values of 10.58, 10.58 and 11.6 g as the weight of brown, white and gray Japanese quail eggs. Although the shape index gives an idea about the shell thickness, it is not regarded as a good estimator of the thickness of the shell. It is however used as a criterion for determining the stiffness of the eggshell (Yannakopoulus and Tserveni-Gousi, 1986). The albumen and yolk weight which were significantly different followed similar trend as the egg weight, such that the birds fed the control and high fat diets the highest albumen and yolk weights. This was followed by the albumen and yolks from the low energy and low protein diet and lastly, those from the high fibre diet. These pronounced differences may be due to the difference in

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egg weight. The yolk usually contributes about 30 % of the liquid weight of the egg and contains about 60 calories which is three times the caloric value of the albumen. The yolk is very important to the egg industries and pharmaceuticals companies as it is a source of lecithin (a phospholipid) used as food additive, in cosmetics and pharmaceutical applications. This higher yolk obtained along with the higher weight will help to determine the price of the eggs as stated by Altan *et al*. (1998). All the eggs had similar yolk height and yolk diameter except those obtained from the high fibre diet which recorded low values.

The similarities in values of albumen height and pH, yolk pH, yolk: albumen ratio, yolk index and haugh unit (HU), which were within the normal range reported by most researchers (Yannakopoulus and Tserveni-Gousi 1986; Altan *et al*., 1998; Selim and Ibrahim, 2004; Tabeekh, 2011) could be the reason why farmers do not feel the strong impact of using nutritionally deficient diets in feeding their birds. The uniform values obtained from the yolk index implied that the eggs were all fresh and freshness is a factor that influences the customer's preference or acceptability of eggs. The consistency in the values of the HU which along with the yolk index are strong determinants of egg quality possibly makes the egg farmer not to yield to the call to use only nutritionally balanced feeds. The HU obtained in this study (71.6 – 72.9), which was above 57.95 - 61.86, termed to be high quality and far above the 'less than 40', termed as inferior eggs by Garba *et al*. (2010) for the humid tropics, can actually mislead the farmers to continuously fed birds with sub-standard feeds, not considering the impact on the egg weight, hen day production and the high feed cost especially when low energy diet is used.

The influence of diets on serum hormones and cholesterol showed that the diets significantly affected the serum hormone levels of the quails (Table 4). The birds fed the control and the high fibre diets had higher levels of LH and estrogen in the serum, while those from the low protein and high fat diets had intermediate values. The birds fed the low energy diet had the least LH and estrogen.

Table 4: Influence of diets on serum hormones and cholesterol

Parameters	Treatments					
	T_1	T_2	T_3	T_4	T^5	SEM
LH, mlU/mL	3.34^a	2.10^c	3.06^b	2.79^b	3.37^a	0.04
FSH, mlU/mL	1.92^b	1.31^c	1.92^b	1.82^b	2.26^a	0.361
Estrogen, ng/mL	0.230^a	0.131^c	0.181^b	0.182^b	0.221^a	0.022
Cholesterol, mmol/L	3.99^b	2.51^c	3.79^b	4.48^a	3.81^b	0.23

^{a,b,c} *- Means within the same row with different superscripts are different (P < 0.05)*

The pattern of serum cholesterol concentration in this study revealed the highest concentration in birds fed the high fat diet, followed by T1, T3 and T5. The birds fed the low energy diet had the least cholesterol concentration. The higher levels of LH and estrogen in the serum of birds fed the control and the high fibre diets, with those from the low protein and high fat diets having intermediate values while

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the birds fed the low energy diet had the least, confirmed the result obtained from the egg production which had the same trend. This implied that there was a higher rate of follicular genesis and maturation (ovulation) in birds fed the control and high fibre diets, resulting in higher HDP as obtained in this study. The lowest LH and estrogen obtained from the birds fed the low energy diet confirmed why they had the lowest HDP. This is in line with the report of Miclea *et al*. (2002) who stated that ovary-oviduct growth and maturation are correlated to the levels of LH in the blood. It supports Akinola *et al*. (2012) who found that quails fed same diets came into lay on day 48 of age (quails fed high fibre diet), day 49 (quails fed control diet), day 52 (quails fed low protein diet) and day 57 (quails fed high fat diet) and no egg laid till day 63 (quails fed low energy diet). This is in line with the finding of Shanaway (1994) who stated that ovarian growth and functions are closely associated with the increases in the concentrations of plasma LH and FSH levels. This further explained why the birds fed the low energy diet had the lowest HDP in this study but did not come into lay till day 63 (Akinola *et al*., 2012) and had the least body lipid but highest body protein concentrations (Akinola and Sese, 2012).

The pattern of serum cholesterol concentration in this study which showed highest concentration in birds fed the high fat diet, followed by T1, T3 and T5 is clear evidence that dietary nutrients had an effect on cholesterol levels of quails. The least cholesterol concentration in the serum of the quails fed the low energy diet which was significantly different from the other hormonal concentrations of the quails supported the finding of Campbell *et al*. (2003) who documented that cholesterol is the precursor for the biosynthesis of steroids. It, therefore, indicated that the nutrient availability and utilization determined the production potentials (hen day production) of the quails despite the chronological age of the bird. The levels of serum cholesterol (2.51 – 4.48 mmol/l) obtained in this study was not sharply different from the serum cholesterol values reported by other researchers for other poultry species, such as, 162 mg/dl equivalent to 4.15 mmol/l (where mg/dl ÷ 39 = mmol/l) for broilers (Shim *et al*., 2003), 115.5 – 126.6 mg/dl equivalent to 2.96 – 3.25 mmol/l for laying birds (Ramesh *et al*., 2009), 183 mg/dl equivalent to 4.69 mmol/dl for broilers (Khaki *et al*., 2012), 2.63 – 3.48 mmol/l for broilers (Abdulaze *et al*., 2016) and 99.9 – 116.3 mg/dl, equivalent to 2.56 – 2.98 mmol/l for laying birds (Akinola and Egwuanumku, 2017). However, report by Schwartz and Allen (1981) and NRC (1991) stated that quails have low cholesterol content of both the meat and the eggs.

Conclusion

Based on the results obtained, it was obvious that the dietary nutrients affected the hen day production and the feed cost which will, in turn, affect the profit that will accrue from the sales of eggs. Although the choice of the dietary fibre in the high fibre diet was carefully selected and milled finely to suit the age of the birds, it will be proper to use the control diet which had balanced nutrients and gave similar HDP as

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T5 as well as better egg weight and moderate feed cost per dozen egg. Even though, the other determinants of egg quality such as shell thickness, shape index, shell index, albumen height, albumen and yolk pH, yolk: albumen ratio, yolk index and haugh unit (HU) had consistent values, it may only be at the fresh stage of the eggs since the nutritionally deficient diet (the low energy diet in this case) had great impact on hen day production and feed cost/dozen egg.

The poor levels of the HDP, high cost of feed and low hormone levels recorded from the birds fed the low energy diet showed how devastating a nutritionally deficient diet can ruin an egg production enterprise.

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