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Egg production, quality parameters and sensory attributes of Japanese quails (*Coturnix japonica*) fed low crude protein diet supplemented with lysine

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Egg production, quality parameters and sensory attributes were assessed using two hundred and eight (208) uniform female Japanese quails aged six weeks fed low-protein diet supplemented with lysine. The birds were raised on a conventional diet before being allocated into 4 dietary groups of 4 replicates of 13 birds each in a completely randomized design in a six week feeding trial. Diet T1 had a crude protein (CP) content of 21% and lysine inclusion of 0.10% while diets T2, T3 and T4 contained 19%, 17% and 15% CP with lysine inclusion of 0.15%, 0.20% and 0.25% respectively. Birds fed T2 had significantly higher ($p < 0.05$) egg weight. External egg parameters including egg length, egg width, eggshell thickness, eggshell percentage, egg shape index and eggshell surface area were significantly influenced ($p < 0.05$). Internal egg quality characteristics including average yolk weight, yolk height, yolk length, yolk colour, albumen length, albumen weight and yolk index were significantly different ($p < 0.05$). The panelist response on egg sensory properties showed that ease of eggshell peeling, taste and overall acceptability were also significantly influenced ($p < 0.05$). Quails fed T1 and T2 compared favourably interms of egg weight, egg length, eggshell index, eggshell surface area, yolk weight, yolk height, yolk length, yolk colour, yolk index, albumen weight, egg taste and overall acceptability unlike those fed T3–T4. Quails fed T4 had the overall least egg weight, quality parameters and acceptance because they were not easily peeled and tastes unusual. Therefore, a 19% CP diet with 0.20% lysine is adequate for laying quails.

Keywords: amino acid, egg, external parameters, internal qualities, organoleptic properties

1 Introduction

Japanese quails (*Coturnix japonica*), a micro-livestock specie could be used to bridge the animal protein intake (Ani et al., 2009) among the increasing human population especially in the developing countries because of their short generation intervals, early attainment of sexual maturity, onset of lay between 5–6 weeks of age and more than 200 eggs in the first year of lay (NRC, 1991; Hemid et al., 2010). Most often than not, quails are usually reared for their eggs which is known for its high quality protein and biological value. As with other livestock species, nutrition plays an important role in the performance of quails. Diets are usually formulated to meet the NRC recommendations but the optimum least cost feed formulation and profit maximization has always been the target of livestock producers.

The protein content of a feed among other things is important but the attendant cost of protein sources has necessitated searches into alternative ways of staying competitive, decrease cost of production and still produce high quality product for consumers (Teguia and Beynen, 2004). Proteins are made up of amino acids, thus, an overall inadequate consumption of protein, a protein deficiency, caused by either one or more limiting amino acids resulted in decreases in parameters such as nitrogen retention and feed utilization in broilers (Corzo et al., 2005), while Sklan and Plavnik (2002) had earlier reported that an over-consumption of protein results in the catabolism of amino acids through deamination and excretion as uric acid which is both energetically and economically inefficient. It is essential to try to meet the requirement of the birds as closely as possible in order to maximize production and profitability.

The commercial availability of synthetic amino acids provides an avenue to decrease crude protein but has also necessitated the need for the appraisal of the limiting amino acids in low crude protein diets. Amino acids have been known to play an important role in animal performance (Ojediran et al., 2017). Thus, combining available feed ingredients in the best possible way becomes paramount because feeding birds with poor quality feed due to high cost of feeding will result in physiological imbalance and yield poor products.

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2 Material and methods

2.1 Site of the Experiment

The experiment was carried out at the Poultry unit of the Teaching and Research Farm, Ladoke Akintola University of Technology, Ogbomoso, Nigeria.

2.2 Experimental Birds and Management

The total of two hundred and eight (208) uniform female Japanese quails were selected (on the basis of weight and fitness) from a six week old flock. The birds were acclimatized on a conventional diet having 21% crude protein before being allocated into 4 dietary group of 4 replicate of 13 birds each. The experiment lasted for six weeks. The feed ingredients were purchased from FMG feedmill. L-Lysine HCl 99% feed grade manufactured by Ajinomoto animal nutrition group was used.

2.3 Data collection

Data were recorded on the egg production performance indices such as feed intake, number of egg produced, egg weight, hen-day-production, daily feed consumption per crate of egg produced and feed cost per crate of egg produced; external egg quality parameters includes average egg weight, length, width, thickness, shell percentage, egg shape index and shell surface area; internal egg quality parameters: average yolk weight, height, length and colour, average albumen weight, height, length and colour, average Haugh unit, yolk index, albumen index and egg shape index; sensory egg parameters: ease of peeling boiled egg, albumen, yolk colour, smell, taste, texture and overall acceptability. Egg production parameters, external and internal parameters were recorded and measured on daily basis. Eggs collected on two consecutive days are weighted (egg weight (g), yolk weight (g), albumen weight (g) and shell weight (g) using a digital sensitive scale. Yolk index was calculated as the ratio of yolk height to yolk width while the colour was scored using Roche colour fan. Haugh unit was also calculated. To get accurate recording of parameters, each egg was carefully broken and the shell was removed. The eggshell was dried using tissue paper and weighed. The internal content which includes albumen and egg yolk was carefully separated using a spoon. Eggshell thickness (mm) was measured

Table 1 Gross composition of experimental diet

Ingredients (%)	T1 (21%)	T2 (19%)	T3 (17%)	T4 (15%)
Maize	45.02	46.04	51.64	56.64
Soybean meal	11.76	9.75	7.89	5.89
Groundnut meal	23.52	19.51	15.77	12.77
Corn bran	10.00	14.95	14.90	14.85
Bone meal	3.00	3.00	3.00	3.00
Limestone	6.00	6.00	6.00	6.00
Salt	0.20	0.20	0.20	0.20
Methionine	0.15	0.15	0.15	0.15
Lysine	0.10	0.15	0.20	0.25
Premix	0.25	0.25	0.25	0.25
Total	100.00	100.00	100.00	100.00
Calculate composition				
ME (Kcal kg-1)	2680.91	2668.00	2714.00	2755.00
Crude protein	20.81	18.71	16.71	14.92
Ether extract	3.84	3.72	3.67	3.62
Crude fibre	3.56	3.73	3.56	3.40
Calcium	2.96	2.94	2.93	2.92
Available P	0.52	0.51	0.50	0.50
Lysine	0.98	0.93	0.88	0.84
Methionine	0.43	0.41	0.39	0.37
Cost/Kg (₦)	108.38	104.69	104.98	105.00

ME – metabolizable energy, P – phosphorus from three part of the egg (top, middle, bottom) together with shell membranes at the using a micrometer screw guage.

The sensory evaluation involved 10 untrained panelists but usual egg consumers. Eggs were collected three days before each test and stored at 5 °C. The collected egg samples were placed in 150 ml of water to a egg, heated at 97 *C for 15 min after which they were transferred into a cool water and served to the panelist as coded samples. The descriptor were quantified on a 9-point hedonic scale (1 = dislike extremely, 9 = like extremely).

2.4 Experimental design and statistical analysis

All data collected were subjected to analysis of variance in a completely randomized design using SAS (2000) software package and means were separated using Duncan (Duncan, 1955) multiple range test of the same package.

3 Results and discussion

Table 2 shows the egg production performance of layer quails fed low crude protein diet supplemented with lysine. Average egg weight was significantly influenced (p <0.05) by the dietary treatments unlike the feed intake, average egg produced, % hen day production, daily feed consumption per crate of egg and feed cost per crate of egg. Birds fed T2 had the highest egg weight; birds on the control was comparable to those fed T3 while quails on T4 had the least value. Observations on the egg production performance of layer Japanese quails fed low crude protein diet supplemented with lysine are similar to the findings of Demuner et al. (2009a, b) who evaluated the nutritional requirements of digestible lysine for Japanese quails at the laying phase. Contrary to this, Garcia et al. (2005) and Manju et al. (2015) obtained lower egg production with 16% CP which may be as result of inadequate quantity of amino acid in the diet while Bunchasak et al. (2005) also reported poor egg production, egg weight and egg mass from birds that received 14% CP. Similar to the result of this study, Murakami et al. (1993) had earlier observed a non-significant effect of dietary protein level on feed intake of Japanese quails. This is similar to the report of Costa et al. (2004) that feed intake is not necessarily controlled by protein levels in the diet, although (Dumont et al., 2017) reported an increase in feed intake among birds fed low crude protein level.

Below 17% CP and 0.20% lysine inclusion, average egg weight was below that observed for the control. Egg weight climaxed at 19% CP and 0.15% lysine and decreased linearly such that reducing the CP and fortifying with lysine did not remedy the decrease in weight. Garcia et al. (2005) recorded significant influence of dietary lysine on egg weight but Abd El-Maksoud et al. (2011) attributed the increase to increase in CP levels from 12 to 16% for layers. Although, Bamgbose and Biobaku (2003), reported that methionine influence egg production and egg size on laying hens. But from this study, low crude protein and lysine supplementation caused insignificant setback to feed intake, rate of egg production, hen day production, feed consumption per crate of egg produced and cost of feed per crate of egg produced. This may not be on the long term as explained by Khajali et al. (2008) and Alagawany and Mahrose (2014), however, lysine supplementation may have played a role.

External egg quality of layer quail fed varying level of low crude protein supplemented with lysine is shown on Table 3. The average egg weight, length, width, shell thickness, % shell, egg shape index and shell surface area

Table 2 Egg production performance of layer quails fed low crude protein diet supplemented with lysine

Parameter	T1	T2	T3	T4	SEM
TFI (kg)	1.49 ±1.29	1.53 ±0.10	1.57 ±0.26	1.42 ±1.42	0.26
ADFI (g\d)	353.88 ±30.90	364.82 ±2.45	374.46 ±6.16	337.42 ±33.88	6.28
ADFI (g\b\d)	27.22 ±2.37	28.07 ±0.19	28.80 ±0.47	25.96 ±2.60	0.48
TEP	476.00 ±23.09	458.00 ±28.87	473.00 ±40.41	439.00 ±2.31	7.21
AEP/rep	11.34 ±0.55	10.91 ±0.69	11.27 ±0.96	10.45 ±0.06	0.17
AEM (g)	10.15 ±0.18b	11.18 ±1.07a	9.42 ±0.09bc	8.87 ±0.03c	0.25
% HDP	87.18 ±4.23	83.88 ±5.29	86.63 ±7.40	80.41 ±0.42	1.32
DFC/30 (kg)	0.94 ±0.04	1.01 ±0.07	1.01 ±0.09	0.97 ±0.10	0.02
CF/30 (₦kg)	101.38 ±3.94	105.42 ±7.35	105.40 ±10.72	101.73 ±10.75	2.00

^{abc} – mean in the same row not sharing a common superscript are significantly different (p <0.05); T1: 21% CP supplemented with 0.10% lysine; T2: 19% CP supplemented with 0.15% lysine; T3: 17% CP supplemented with 0.20% lysine; T4: 15% CP supplemented with 0.25% lysine; TFI: total feed intake, ADFI g/b/d: average daily feed intake gram/bird/day, TEP: total egg production, AEP: average egg production, AEM : average egg mass, % HDP: percentage hen day production; DFC/30: daily feed consumption per crate produced, CF/30: cost of feed per crate of egg produced were significantly influenced (p <0.05) while the shell weight was not significantly different (p >0.05). A linear decrease (p <0.05) was observed in egg weight as the crude protein level of the diet decreases. The egg weight was highest in birds fed T1 while those fed T4 had the least, although birds on T1 and T2 compare favourably. This trend is similar for the egg width, egg length, egg shape index (ESI) and the shell surface area. Bawa et al. (2011) reported that a good quail egg should weigh about 9.3 g but birds fed T4 (15% CP supplemented with 0.25% lysine) fell short of this. This suggests that there is a limit to lysine supplementation. Although,Garcia et al. (2005) recorded significant influence of dietary lysine on egg weight. The decrease in the egg weight is as a result of the decrease in the dietary protein level of the diet. This shows that the weight of the egg is dependent on the protein content of the diet (Bawa et al., 2011). The statistical pattern of egg length, egg width, eggshell thickness, eggshell index and eggshell surface area suggested that egg weight may depend on these parameters. The percentage of the egg shell indicates that lysine may not influence calcium deposition or shell formation in quails. The eggs with the thickest eggshell was observed in quails fed 21% and 19% CP, although no specific reason could be suggested to this trend as dietary protein has no direct effect on egg calcification during egg formation. Alagawany et al. (2014) had similar report at 20% CP. Nevertheless, it was observed that the eggshells were thicker at the middle for the said CP. The increase in lysine level could be a contributing factor to the thinness of the eggshell according to Pinto et al. (2003) and Panda et al. (2010). The decrease in the ESI and SSA can also be attributed to the increase in the lysine level of the diet not the protein level as stated earlier. The most important quality traits of the eggshell are its strength and thickness.

Table 4 shows the internal egg quality parameters of layer quail fed varying levels of low crude protein diets supplemented with lysine. Significant differences (P< 0.05) were observed in the average yolk weight, yolk height, yolk length, yolk colour, average albumen length, yolk weight and yolk index unlike (p >0.05) the average albumen height, average Haugh unit, yolk percentage, albumen percentage and yolk:albumen ratio. Linear decreases were observed in the yolk weight from T1–T4, yolk length, average albumen length, albumen weight while quadratic responses were observed in average yolk height, yolk colour, and yolk index with birds fed T2 having the highest value. Wu et al. (2005) explained that the decrease of egg weight due to feeding 14% and 2600 kcal ME is attributable to a decrease of yolk weight, which is affected to a greater extent rather than albumen weight by the nutrients in the diets. Furthermore, the significant linear decreases in yolk weight, yolk height and yolk length; albumen length and albumen weight can be attributed to the size of the egg as shown on Table 4. Result of this study conforms with the observation of Gunawardana et al. (2008) who indicated that dietary protein had a significant effect on egg yolk colour, however, egg specific gravity decreased, when dietary energy level increased in the diet of laying chickens, which contrast Novak et al. (2008) report that albumin percentage decreased, whereas yolk percentage and colour increased when fed laying chickens on low protein

Table 3 External egg quality parameters of layer quails fed varying level of low crude protein supplemented with lysine

Parameters	T1	T2	T3	T4	SEM
Av egg wt (g)	10.59 ±0.55^{a}	10.23 ±0.20^{a}	9.69 ±0.60^{b}	9.21 ±0.35^{c}	0.12
Av Egg length (cm)	3.13 ±0.07^{a}	3.08 ±0.04^{ab}	3.00 ±0.09^{b}	3.04 ±0.09^{b}	0.02
Av Egg width (g)	2.46 ±0.04^{a}	2.43 ±0.02^{a}	2.42 ±0.06^{ab}	2.38 ±0.06^{b}	0.01
Av shell tk top	0.09 ±0.01^{a}	0.08 ±0.01^{a}	0.08 ±0.01^{a}	0.07 ±0.01^{b}	0.002
Av shell tk middle	0.09 ±0.01^{ab}	0.11 ±0.06^{a}	0.08 ±0.01^{ab}	0.07 ±0.01^{b}	0.007
Av shell tk bottom	0.09 ±0.01^{a}	0.08 ±0.01^{ab}	0.07 ±0.01^{bc}	0.07 ±0.01^{c}	0.002
Av shell tk (mm)	0.09 ±0.01^{a}	0.09 ±0.02^{a}	0.08 ±0.01^{b}	0.07 ±0.01^{b}	0.003
Av shell wt (g)	1.00 ±0.00	0.99 ±0.01	1.00 ±0.00	1.00 ±0.00	0.001
SPER (%)	10.87 ±0.48^{a}	10.36 ±0.27^{b}	9.74 ±0.65^{c}	9.47 ±0.41^{c}	0.13
ESI	3.38 ±0.12^{a}	3.32 ±0.07^{ab}	3.23 ±0.12^{b}	3.03 ±0.11^{c}	0.03
SSA	23.06 ±0.81^{a}	20.54 ±0.29^{a}	21.72 ±0.91^{b}	20.99 ±0.54^{c}	0.18

^{abc} – mean in the same row not sharing a common superscript are significantly different (p <0.05); Av: average, tk: thickness, wt: weight, SPER: eggshell percentage, ESI: egg shape index, SSA: eggshell surface area; T1 (control) = 21% crude protein diet supplemented with 0.10% lysine, T2 = 19% crude protein diet supplemented with 0.15% lysine, T3 = 17% crude protein diet supplemented with 0.20% lysine, T4 = 15% crude protein diet supplemented with 0.25% lysine, SEM = standard error mean

Table 4 Internal egg quality of layer quail fed varying level of low crude protein supplemented with lysine

Parameter	T1	T2	T3	T4	SEM
Av. yolk weight (g)	3.17 ±0.20[a]	3.06 ±0.13[ab]	2.85 ±0.21[bc]	2.67 ±0.30[c]	0.05
Av. yolk height (cm)	0.97 ±0.03[b]	1.05 ±0.07[a]	0.98 ±0.05[b]	0.95 ±0.04[b]	0.01
Av. yolk length (cm)	2.22 ±0.13[a]	2.19 ±0.05[ab]	2.12 ±0.08[b]	2.12 ±0.05[b]	0.02
Av. yolk colour	4.30 ±0.21[ab]	4.33 ±0.21[a]	4.130.10[b]	4.23 ±0.17[ab]	0.03
Av. alb length (cm)	4.83 ±0.21[a]	4.58 ±0.36[b]	4.05 ±0.18[c]	3.77 ±0.13[d]	0.09
Av. alb height (cm)	2.89 ±0.28	3.04 ±0.20	2.84 ±0.16	2.92 ±0.27	0.04
Av. alb weight (g)	5.31 ±0.30[a]	5.13 ±0.17[ab]	5.00 ±0.33[b]	4.58 ±0.20[c]	0.07
Av. Haugh unit	79.96 ±1.87	81.37 ±1.39	80.37 ±1.14	80.87 ±2.65	0.33
yolk index	0.44 ±0.04[b]	0.48 ±0.03[a]	0.46 ±0.04[ab]	0.45 ±0.02[ab]	0.01
% yolk (%)	29.97 ±2.18	29.95 ±1.43	29.51 ±2.10	29.22 ±3.44	0.41
% albumen (%)	50.19 ±0.92	50.10 ±1.41	51.64 ±2.13	49.82 ±2.50	0.34
Yolk: albumen	0.60 ±0.01	0.60 ±0.01	0.57 ±0.00	0.59 ±0.01	0.71

[abcd] – means with superscript are significantly (p <0.05) different; T1 (control) = 21% crude protein diet supplemented with 0.10% lysine; T2 = 19% crude protein diet supplemented with 0.15% lysine; T3 = 17% crude protein diet supplemented with 0.20% lysine; T4 = 15% crude protein diet supplemented with 0.25% lysine; SEM = standard error mean; Av. = average

Table 5 Organoleptic/ sensory (egg) properties of quails fed varying levels of low crude protein supplemented with lysine

Parameters	T1	T2	T3	T4	SEM
Peeling Ease	4.38 ±2.48[a]	3.67 ±1.86[ab]	5.33 ±3.08[a]	1.50 ±0.84[b]	0.52
Albumen strenght	5.67 ±2.66	7.50 ±0.83	6.33 ±0.51	5.33 ±2.50	0.40
Yolk colour	3.33 ±0.82	3.83 ±0.75	4.00 ±1.90	3.33 ±2.07	0.29
Egg Smell	3.83 ±2.40	3.50 ±0.55	2.83 ±0.75	3.00 ±1.26	0.29
Egg Taste	6.83 ±0.75[ab]	7.67 ±0.52[a]	7.17 ±1.47[ab]	6.33 ±1.03[b]	0.22
Egg Texture	6.67 ±2.33	6.00 ±1.79	6.67 ±1.51	6.50 ±2.88	0.42
Overall	7.83 ±0.75[ab]	8.00 ±0.63[a]	7.50 ±1.04[ab]	6.17 ±2.22[b]	0.29

[abc] – mean in the same row not sharing a common superscript are significantly different (p <0.05); T1 (control) = 21% crude protein diet supplemented with 0.10% lysine, T2 = 19% crude protein diet supplemented with 0.15% lysine, T3 = 17% crude protein diet supplemented with 0.20% lysine, T4 = 15% crude protein diet supplemented with 0.25% lysine, SEM = standard error mean

diet. The yolk colour may be attributed to the nutritional composition of the experimental diets which involve an equivalent inclusion corn amongst the treatment. Corn is rich in pigments which directly affect the colouring of yolks. Moreover, Tuleun et al. (2013) demonstrated that egg composition could be influenced at varying protein levels of 17–21% CP.

The analysis of the panelist response (Table 5) showed the organoleptic/ sensory (egg) properties of quails fed varying levels of low crude protein supplemented with lysine. The ease of eggshell peeling, taste and overall acceptability were significantly influenced (p <0.05) by the dietary treatments while the albumen strength, yolk colour, egg smell and egg texture were not significantly influenced (p >0.05). Quadratic responses were observed across the treatments with eggs from birds fed T2 and T3 compared favourably with those fed the control diet (T1). Birds fed T3 had the highest ease of peeling, followed by T1 and T2 respectively while those fed T4 had the least. The taste and overall acceptance followed similar trend with eggs from birds fed T4 having the least; Taste score from T1–T4 was 6.83, 7.67, 1.17 and 6.33 respectively while the overall acceptability score was 7.83, 8.00, 7.50 and 6.17 respectively from T1–T4. The significant (ease of peeling, taste and overall acceptability) sensory analysis shows that consumer preference was adversely influenced. Birds fed T4 was not easy to peel, the taste and acceptability was slightly liked. Ease of peeling boiled eggs is an important consumption quality because eggs easily peeled gives a smoother surface and visual appeal to consumers unlike ones with rough surface which gives and impression that they are spoilt (Shittu and Ogunjimi, 2011). It is believed that the albumen of just laid egg contains a store of dissolved carbon dioxide which exits the egg over time through the tiny pores in the shell thus increasing the pH making the albumen less acidic causing the membrane tougher. At a lower pH, the proteins in the albumen binds tightly to the membrane during cooking but upon the alkalinity, the membrane soften leading to a looser bond.

4 Conclusions

Quails fed 21% and 19% CP with 0.10 and 0.15% lysine respectively compared favourably: feeding quails with a 19% CP diet with 0.20% lysine inclusion does not adversely affect egg weight, egg length, egg shell index, eggshell egg surface area, yolk weight, yolk height, yolk length, yolk colour, yolk index, albumen weight, egg taste and overall acceptability unlike those feed lower CP diets. Quails fed 15% CP diet with 0.25% lysine inclusion had the overall least egg weight, quality parameters and acceptance. Therefore, a 19% CP diet with 0.20% lysine is adequate for laying quails.

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