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Original Article

Coconut Cake in Diets for Quail in the Laying Phase

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ABSTRACT

Currently, agro-industrial by-products have increasingly been used in animal feeding, as they constitute an alternative source of nutrients for the animal diet and a way to simultaneously reduce environmental pollution. The objective of this study was to examine increasing levels of inclusion of coconut cake in Japanese quail diets in the laying phase on their production performance and egg quality. A total of 360 Japanese quails were allotted to eight treatments with nine replicates and eight birds per experimental unit, in a randomized-block design. Five diets were formulated: a diet without inclusion of the by-product; and diets containing 3, 6, 9, and 12% coconut cake. The experiment lasted 63 days, with evaluations occurring at every 21 days. The following variables were analyzed: feed intake, laying rate, feed conversion, egg weight, specific gravity, Haugh unit, yolk, albumen and shell percentage, shell thickness, and shell weight. The treatments elicited a positive linear response from laying rate, whereas feed conversion per egg mass decreased linearly. In terms of egg-quality traits, shell percentage was influenced, increasing linearly. Coconut cake inclusion at 12% in the diet of Japanese quail in the laying improved feed conversion per egg mass and increased egg-laying rate and eggshell percentage.

INTRODUCTION

At the present time, there has been a greater concern over the destination of the waste generated by the agricultural industry, and endeavours have been put forward to minimise the environmental damage caused by it. The use of this waste in animal feeding has emerged as a means of lessening environmental pollution while providing an alternative source of nutrients to the animal diet.

One of such waste materials generated in Brazil is coconut meal/cake, high-protein and high-energy by-products derived from the coconut oil extraction process (Jácome *et al.,* 2002). Approximately 90 t of this waste is produced per year, in the country. Only the northeast region of Brazil, which concentrates the largest production of coconut (1,313,298 t/yr), generates 70 t of this material per year (IBGE 2015).

The oil extraction process can influence the energy value of these by-products, which contain 3 to 17% ether extract, a portion rich in short-chain fatty acids like lauric (46.5%) and myristic (19%) acids (Omena, 2008). These products have a protein content of 20 to 25%, but with some amino acid deficiencies (Pascoal *et al.,* 2006).

Some authors (Braga *et al.,* 2005; Lima *et al.,* 2007) claim that the use of coconut meal in the feeding of commercial poultry does not negatively affect their production and that this ingredient can be included at up to 15% in the diet.

However, research addressing the use of coconut cake in poultry feeding is still limited, especially for quail, indicating the need for further studies investigating this feedstuff. The present study was thus conducted to evaluate the effect of increasing levels of inclusion of coconut cake in the diet of Japanese quail in the laying phase on their production performance and egg quality.

MATERIALS AND METHODS

The experiment was developed in the Quail Farming Unit at the Federal University of Alagoas/ Arapiraca Campus, located in Arapiraca - AL, Brazil, from November 2016 to January 2017.

A total of 360 female quail (*Coturnix japonica*) at approximately 300 days of life, with a laying rate of 83%, weighing 178.7 g, were used in the experiment. The quails were housed in a masonry shed where each cage was divided into three equal 0.33-m^2 partitions which were equipped with a trough feeder and a nipple drinker. Each partition was considered an experimental unit.

Feed troughs were replenished with the experimental diets twice daily, at 08.00 and 16.00. Birds had free access to feed and water. The lighting program adopted consisted of 17 h of light per day (12 h of natural light + 5 h of artificial light) using a digital timer as a controller. Temperature and relative humidity (RH) of the air within the shed were measured daily by digital thermo-hygrometers positioned at the height of the birds, near the cages. These devices recorded respective minimum and maximum temperatures of 24.9 and 33.4 °C and minimum and maximum RH of 32.5 and 76.9%, respectively.

The experimental period was 63 days, which were divided into three 21-day cycles that constituted the performance evaluations. Egg-quality traits were measured on the last three production days of each period, totalling nine days of data collection per treatment.

The coconut cake was purchased from a coconut processing company located in Feliz Deserto - AL, Brazil. The material was sieved to better homogenise the feed, and a sample was harvested for chemical analyses and stored in a freezer to be used over the course of the experimental period.

Gross energy, metabolisable energy, and crude fibre contents in the coconut cake were analysed as described by Silva & Queiroz (2002). Dry matter, ash, crude protein, and ether extract were determined by following the methodology proposed in INCT-CA (2012). Energy and ether extract analyses were performed at the laboratory of animal nutrition at the Federal University of Sergipe (UFS), whereas the other analyses were carried out at the laboratory of animal nutrition at UFAL/Arapiraca campus.

Based on the results of the chemical analysis of coconut cake (Table 1), the experimental diets were formulated following recommendations of Rostagno *et al.* (2011) for Japanese quail in the laying phase weighing 189 g.

Table 1 – Chemical composition of coconut cake.

Gross energy (kcal/kg)	5,802.00
Metabolisable energy (kcal/kg)	3,610.60
Dry matter (%)	93.00
Crude protein (%)	20.41
Mineral matter (%)	3.48
Ether extract (%)	38.23
Crude fibre (%)	12.22

The quail were allotted to five treatments with nine replicates, eight quails were used per experimental unit (plot), totalling 45 plots, in a randomised-block design.

Five experimental diets were formulated: one corn- and soybean meal-based basal diet (control treatment, 0% inclusion of by-product) and diets with 3, 6, 9, and 12% inclusion of coconut cake (Table 2).

On the 21st day of each cycle, the leftover feed in the trough of each unit was weighed, and the feed intake in the period was determined as the difference between total feed supplied and leftovers. In the case of mortality occurring during the period, the feed intake of the plot was corrected, as recommended by Sakomura & Rostagno (2007), to determine the true average intake of the experimental unit.

For the performance analyses, the laying rates per plot, corresponding to the total egg production, were measured. Feed conversion was calculated in two ways: by dividing feed intake by production in a dozen eggs (kg/dozen eggs) and by dividing feed intake by the egg mass (kg/kg egg mass) obtained during the experimental period.

On the last three days of each 21-day cycle, all eggs were weighed on a 0.01-g precision scale. Subsequently, specific gravity was measured by immersing all collected eggs in NaCl solutions with density ranging from 1.005 to 1.100 g/cm^3, with 0.005 g/cm^3 intervals. The solution density was measured using a densimeter. Eggs were classified according to their specific gravity based on their density.

Table 2 – Composition of experimental diets.

Coconut cake (%)					
Ingredient	0.0	3.0	6.0	9.0	12.0
Grain corn	36.23	39.79	43.35	46.91	50.47
Soybean meal	28.81	28.40	27.99	27.58	27.17
Wheat bran	18.09	13.57	9.05	4.52	-
Coconut cake	-	3.00	6.00	9.00	12.00
Soybean oil	5.87	4.75	3.36	2.51	1.39
Inert	2.15	1.61	1.08	0.54	-
Limestone	6.91	6.89	6.86	6.84	6.82
Dicalcium phosphate	0.81	0.85	0.89	0.93	0.97
Common salt	0.32	0.32	0.32	0.33	0.33
DL-methionine	0.36	0.36	0.36	0.36	0.37
L-lysine	0.22	0.24	0.26	0.28	0.29
L-threonine	0.02	0.02	0.02	0.02	0.01
Mineral premix[1]	0.05	0.05	0.05	0.05	0.05
Vitamin premix[2]	0.10	0.10	0.10	0.10	0.10
Choline chloride	0.04	0.04	0.04	0.04	0.04
TOTAL (kg)	100.00	100.00	100.00	100.00	100.00
Calculated composition					
ME (kcal/kg)	2,800	2,800	2,800	2,800	2,800
Crude fibre (%)	3.873	3.873	3.873	3.873	3.873
Crude protein (%)	18.710	18.710	18.710	18.710	18.710
Lipids (%)	8.032	8.032	8.032	8.032	8.032
Sodium (%)	0.145	0.145	0.145	0.145	0.145
Calcium (%)	2.909	2.909	2.909	2.909	2.909
Av. phosphorus (%)	0.303	0.303	0.303	0.303	0.303
Total phenyl (%)	1.559	1.562	1.565	1.569	1.572
Total phenyl + tyr (%)	1.559	1.562	1.565	1.569	1.572
Total gly + ser (%)	1.787	1.785	1.784	1.782	1.781
Total arginine (%)	1.286	1.315	1.344	1.373	1.401
Total histidine (%)	0.507	0.504	0.501	0.498	0.495
Total leucine (%)	0.799	0.801	0.802	0.803	0.805
Total isoleucine (%)	1.521	1.538	1.555	1.572	1.590
Total lysine (%)	1.174	1.174	1.174	1.174	1.174
Total met.+ cys. (%)	0.951	0.951	0.951	0.951	0.951
Total methionine (%)	0.632	0.635	0.639	0.642	0.646
Total threonine (%)	0.740	0.740	0.740	0.740	0.740
Total tryptophan (%)	0.247	0.241	0.235	0.229	0.223
Total valine (%)	0.901	0.906	0.911	0.916	0.922

[1]Composition per kg of diet 70000 mg zinc (min.); 1500 mg iodine (min.); 8500 mg copper (min.); 75000 mg manganese (min.); 50000 mg iron (min.); 200 mg cobalt. [2]Composition per kg of diet: 1000 mg folic acid; 1562 mg pantothenic acid; 100 µg biotin; 3980 mg niacin; 7000000 IU vit. D3; 2000 mg vit. E; 3000 µg vit. B12; 4000 mg vit. B2; 3000 mg vit. B; 2100000 IU vit. D3; 2000 mg vit. K3; 200 mg selenium; 100000 mg antioxidant.

The three most homogeneous eggs, whose weight near the average weight of each plot, were selected per experimental unit and cracked for albumen height measurements. Albumen height was measured as the distance between the surface where the cracked egg and the intercession between albumen and yolk, using a digital calliper with 0.01-mm graduation, on a flat glass surface.

To calculate the Haugh unit, egg weight and albumen height were used in the following formula: $HU = 100 \times \log (H - 1.7W^{0.37}+7.57)$, where H is albumen height in millimeters and W represents egg weight in grams (Romanoff & Romanoff, 1963; Silversides *et al.*, 1993).

Yolks were weighed individually to determine their percentage relative to the egg weight. Eggshells were washed in running water, left to dry in the shade at room temperature for 48 h, and weighed. Subsequently, the eggshell weight was calculated relative to egg weight.

Albumen percentage was determined as the difference between the fractions that composed the egg weight: 100 – (% yolk + % shell). Next, eggshell thickness was measured at two distinct points in the centre-transverse area of the egg using a digital calliper with 0.01-mm graduations (Lin *et al.,* 2004). The value defined as shell thickness was determined as the average of two measurements from each egg.

STATISTICAL ANALYSIS

The evaluated parameters were subjected to analysis of variance using the System for Statistical and Genetic Analyses (SAEG, Universidade Federal De Viçosa - UFV, version 8.0) at a 5% probability level of acceptance or rejection of null hypothesis. Next, a linear or quadratic regression analysis was carried out according to the behavior of the data to determine the best level of coconut cake to be added to the diet.

RESULTS AND DISCUSSION

With the increasing levels of inclusion of coconut cake, an ingredient rich in ether extract, there was a need to gradually reduce the addition of soybean oil so that all diets remained isoenergetic (2,800 kcal/kg diet). Wheat bran was used to equalise the fibre concentration of the diets, with its amount decreasing as coconut cake was added. Additionally, the synthetic amino acids lysine, methionine, and threonine were used to keep the diets isoproteic (18.7%).

No differences were detected across the treatments for feed intake, feed conversion per dozen eggs, or egg weight. Laying rate and feed conversion per egg mass, however, differed in response to the diets (Table 3).

Table 3 – Performance of quail in the laying phase as a function of coconut cake levels in the diet.

Coconut cake (%)						Probability (%)			
	0.0	3.0	6.0	9.0	12.0	*p*-value	SEM	CV(%)	Regression
FI (g/day)	23.53	22.89	23.46	23.25	23.55	0.81	0.20	5.51	
LR (%)	81.65	86.82	87.67	87.55	88.93	0.02	0.94	6.91	L*
FC (kg/dz)	0.33	0.31	0.31	0.32	0.31	0.18	3.03	6.05	
FC (kg/kg)	2.51	2.39	2.40	2.29	2.36	0.02	0.02	7.02	L**
EW (g)	11.55	11.54	11.44	11.67	11.72	0.20	0.05	2.90	

FI = feed intake; % LR = laying rate; FC = feed conversion per dozen eggs and per kilogram of egg mass; EW = egg weight; SEM = standard error of the mean; CV = coefficient of variation; L = linear. *Equation: y = 81.9439 + 1.52811x; **Equation: y = 2.52093 – 0.04624542x

Feed intake was not influenced by the composition of the diet containing coconut cake. In this study, this parameter was low when compared with the intake of 25 to 29 g/day normally observed in quail during the laying phase. These results corroborate the reports of Panigrahi (1989), who concluded that the addition of 10 and 20% coconut meal does not influence the intake of commercial layers.

There was an increase in egg-laying rate as the coconut cake inclusion level was increased, according to the following equation: y = 81.9439 +1.52811X (R^2 = 0.73) (Figure 1), which indicates an 8.91% increase in egg-laying rate in comparison with the control treatment. This finding contrasts a few literature reports (Barretos *et al.,* 2006; and Lima *et al.,* 2007) where authors did not find significant results for this variable using up to 20% inclusion of coconut meal.

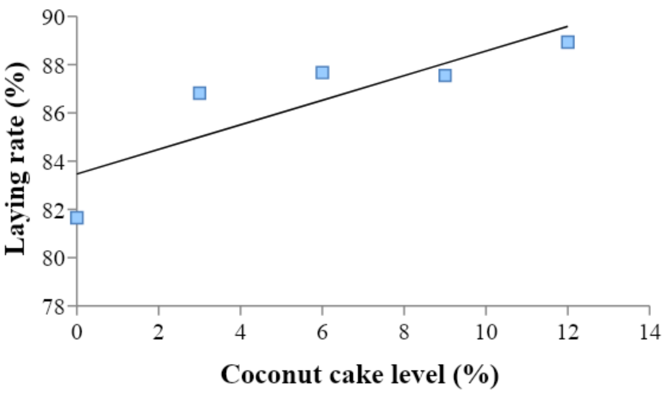

Figure 1 – Laying rate as a function of coconut cake levels in quail diets.

Two of the main factors that may compromise egg production are the amounts of energy and protein ingested. In the present study, the energy:protein ratio did not change across the treatments (isoproteic and isoenergetic); however, what might have caused the differences in laying rates between the treatments is the different lipid composition of the diets, because the increasing levels of inclusion of coconut cake in them reduced the need for soybean oil inclusion so that they would remain isoenergetic. According to Lesson & Summers (1976), the synergism of two energy sources increases the energy content of the diet, contributing to the absorption of saturated and polyunsaturated fatty acids and improving the digestibility of both ingredients.

Coconut cake is rich in short-chain fatty acids, which are rapidly mobilized and whose energy is used with a lower heat increment, resulting in more net energy for egg production by the bird. Furthermore, when this fat is included in the diet, fatty acid synthesis decreases, and the bird consequently has more energy available for production purposes (Rodrigues *et al.,* 2005).

Feed conversion per dozen eggs was not influenced by the diets. Since there was no difference in feed intake, the significance of egg-laying rate was not sufficient to alter feed conversion. However, conversion per egg mass decreased linearly, as shown in the equation y = 2.52093 – 0.04624542x (R^2 = 0.68) (Figure 2), representing a 142-g decrease per kilogram of feed provided, in comparison with control treatment. Because egg mass is measured as the product of egg production — which increased linearly — by the weight of these eggs, it is possible that feed conversion improved with the increasing levels of inclusion of the by-product.

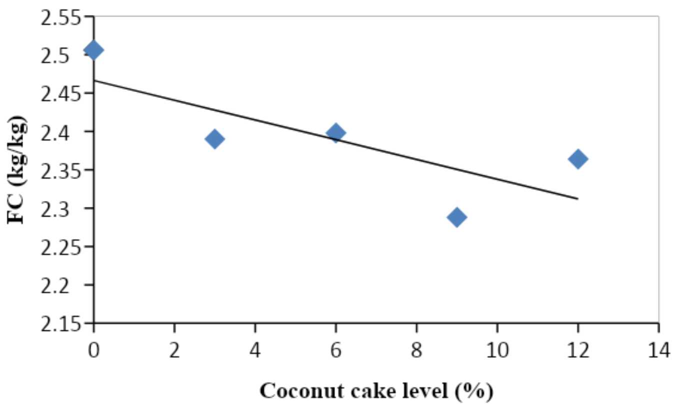

Figure 2 – Feed conversion (kg/kg of egg) as a function of coconut cake levels in quail diets.

Egg weight was not influenced by the dietary inclusion of coconut cake. This finding agrees with the results reported by Barretos *et al.,* (2006), and Braga *et al.,* (2005), who worked with commercial layers and concluded that the inclusion of 0 to 20% coconut meal has no significant effects.

As stated by Leeson & Summers (1997), in nutritional terms, egg weight is affected by the amounts of protein, amino acids, and linolenic acid present in the diet. However, in the current experiment, synthetic amino acids (lysine, methionine, and threonine) were added for these essential amino acids and the crude protein content to be the most similar possible between the treatments. Because there was no difference between the coconut cake inclusion levels, the nutrients present in the diets were assumed sufficient for the egg weights to remain within the ideal standards for the line (between 10 and 12 g).

Treatments did not affect specific gravity, yolk percentage, albumen percentage, shell thickness, or shell weight. A significant effect was only observed for shell percentage (Table 4).

Specific gravity was not influenced at any of the coconut cake inclusion levels, remaining stable. Because this variable is related to the egg density, and since higher egg densities mean a higher specific gravity, this result is explained by the lack of differences occurring in egg weight.

Table 4 – Quality of quail eggs as a function of coconut cake levels in the diet.

Coconut cake (%)						Probability			
	0.0	3.0	6.0	9.0	12.0	*p*-value	SEM	CV (%)	Regression
SG	1.069	1.068	1.069	1.069	1.068	0.90	0.00	0.30	
HU	92.548	92.444	91.921	92.383	92.087	0.48	0.19	1.30	
ALB (%)	62.236	61.517	61.514	61.733	61.559	0.27	0.14	1.46	
YLK (%)	30.084	30.723	30.700	30.471	30.470	0.17	0.12	2.62	
SHL (%)	7.679	7.759	7.785	7.794	7.970	0.04	0.04	3.41	L*
ST (mm)	0.173	0.174	0.171	0.174	0.177	0.11	0.00	2.91	
SW (g)	0.890	0.899	0.900	0.912	0.914	0.18	0.00	4.14	

SG = specific gravity; HU = Haugh unit; ALB = albumen height; YLK = yolk percentage; SHL = shell percentage; ST = shell thickness, SW = shell weight; SEM = standard error of the mean; CV = coefficient of variation; L = linear

*Equation: Y = 7.61228 + 0.0618029X

Haugh unit (HU) is the main form of measuring alterations in the albumen (Mano *et al.,* 2007), which consists mostly of water (87 to 89%) and protein (9.5 to 11.5%) (Grobas & Mateos, 1996). In this study, there were no alterations in the HU of the analysed eggs, since no effect was detected on albumen percentage and egg weight, which are the variables used in the formula for the calculation of HU. It should be stressed that the experimental diets were balanced so that there would be no protein deficiency, and water was available *ad libitum*. Therefore, in all treatments, HU remained above 90%, evidencing the good quality of the eggs. According to USDA (2000), eggs of excellent quality have a HU greater than 70%.

The albumen can be affected by the egg storage time, because as time passes, the water present in the albumen tends to migrate into the yolk, consequently decreasing in quantity and height and enlarging the yolk. However, albumen height was measured on the same day the eggs were collected, which explains the lack of significant effects on this variable across the treatments.

Yolk percentage did not change with the inclusion of coconut cake in the diets. It can be inferred that the levels of saturated fatty acids present in the waste did not interfere with yolk formation, since dietary levels of saturated fatty acids have little influence on the fat composition of this egg component. Moreover, short-chain fatty acids are rapidly degraded and converted to long-chain fatty acids, which prevents them from being deposited into the egg yolk (Hargis & Van Elswyk, 1993).

Eggshell percentage rose linearly with the inclusion of coconut cake in the diet, as shown by the following equation: $Y = 7.61228 + 0.0618029X$ ($R^2 = 0.84$) (Figure 3), which reveals that this variable increased by 3.91% at the level of 12% when compared with control diet. This fact indicates greater resistance of the shell as the levels of coconut cake in the diet were increased.

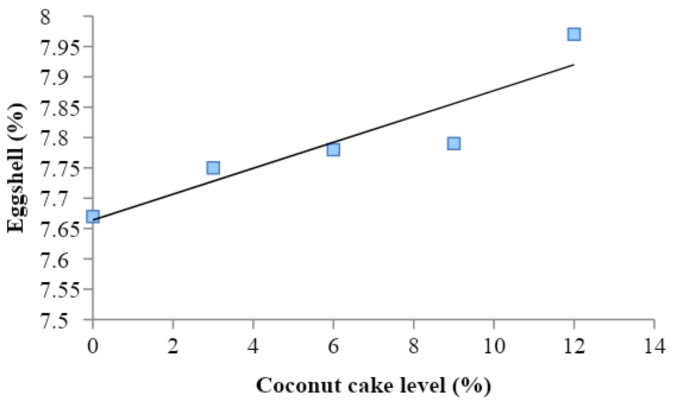

Figure 3 – Eggshell percentage as a function of coconut cake levels in quail diets.

Fibres are negatively related to calcium absorption (Buzinato *et al.,* 2006). Although the crude fibre concentration was the same in all experimental diets, the amounts of soluble and insoluble fibres differed, as they originated from different feedstuffs (wheat bran and coconut cake).

Eggshell thickness and weight were not influenced by the treatments, which can be explained by the fact that the diets contained similar Ca and P contents. Ninety-five percent of the shell consists of calcium carbonate, whereas calcium accounts for approximately 4% of the egg weight (Araujo, 2009). Therefore, it is understood that the coconut cake inclusion levels did not influence the mobilization or fixation of calcium for the formation of the eggshell; i.e., the nutritional components present in this waste did not interfere with the diet minerals.

The coconut cake inclusion level of 12% in diets for Japanese quail in the laying phase improves feed conversion per egg mass and increases laying rate and eggshell percentage.

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