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Effect of shed rooftype and babassu pie on the productive characteristics of meat quails

Efeito da cobertura do galpão e da torta de babaçu nas rações sobre as características produtivas de codornas de corte

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Abstract

We aimed to evaluate the effects of shed roof(SR) typeand the inclusion of babassu pie (BP) in rations on the productive characteristics ofmeat quailsfrom days 14 to 28 and days14 to 40. We studied 896 meatquails. The experimental design was completely randomized with a 4x4 factorial arrangement, using four types of shedroofs (fiber cement, ceramic, straw, and painted fiber cement) and four rations (with 0, 5, 10, and 15% inclusion of babassu pie). The performance variables evaluated from 14 to 28 and 14 to 40 days included food intake (FI, g/bird), mean weight gain (WG, g/bird), food conversion (FC, g/g), mean live weight on day 28 (MW28, g/bird), mean live weight on day 40 (MW40, g/bird), and energy efficiency (EF; g Mcal). After slautherthe birds on day 40, we measured the carcass weight (CW) and the carcass yield (CY, %), obtained for the breast (BY), legs (LGY), and wings (WINGY). We also obtained the relative weight of the heart (HRW), liver (LRW), gizzard (GRW), and intestine (IRW). To compare the economic efficiency between the experimental rations, we analyzed the cost of ration per kg of carcass (CC) and determined the gross margin (GM). Between day 14 and day 28, we found that the use of SR influenced the FI28, WG28, and the MW28 of the quails ($p < 0.05$). BP did not affect FI28 ($p > 0.05$), but it linearly improved WG28, FC28, MW28, and EF28. Between days 14 and 40, we found that SR influenced the WG40, FC40, MW40, and EF40 of the quails ($p < 0.05$) and that a BP increased the FI40, WG40, and MW40 in a quadratic manner. SR and BP did not affect the CW, BY, WINGY, LGY, HRW, LRW,or IRW. However, BP influenced MGRW, which increased linearly with the inclusion of BP. We concluded that a ceramic roof provides better environmental conditions than do other shed roofs. The inclusion of BP improved the performance characteristics, and it was technically feasible to include up to 15% BP in the rations of meat quails. Based on the current cost analysis, however, the inclusion of BP is economically unfeasible.

Key words: Alternative ingredient. Coturniculture. Facilities. Roof.

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Resumo

Objetivou-se avaliar os efeitos do tipo de cobertura do galpão (TC) e da inclusão da torta de babaçu nas rações (TB), sobre as características produtivas de codornas de corte dos 14 aos 28 e dos 14 aos 40 dias de idade. Foram utilizadas 896 codornas de linhagem de corte. O delineamento experimental foi o inteiramente casualizado em arranjo fatorial 4x4, sendo quatro tipos de coberturas nos galpões (fibrocimento, cerâmica, palha e fibrocimento pintado) e quatro rações (0, 5, 10 e 15% de inclusão de torta de babaçu). As variáveis de desempenho avaliadas dos 14 aos 28 e dos 14 aos 40 dias foram: consumo de ração (CR; g/ave), ganho de peso médio (GP; g/ave), conversão alimentar (CA; g/g), peso vivo médio aos 28 dias (PM28; g/ave); peso vivo médio aos 40 dias (PM40; g/ave) e eficiência energética (EF; g/Mcal) e após o abate no 40º dia, foi obtido o peso da carcaça (PC) e o rendimento (%) de carcaça (RC) de peito (RP), pernas (RPN) e asas (RASA), bem como os pesos relativos do coração (PRC), fígado (PRF), moela (PRM) e intestino (PRI). Para comparar a eficiência econômica entre as rações experimentais determinou-se o custo com alimentação por kg de carcaça (CC) e a margem bruta (MB). No período de 14 a 28 dias observou-se que o TC influenciou ($P < 0,05$) o CR28, GP28 e o PM28 das codornas. A TB não afetou ($P > 0,05$) o CR28, mas melhorou linearmente o GP28, a CA28, o PM28 e a EF28. No período de 14 a 40 dias observou-se que o TC influenciou ($P < 0,05$) o GP40, a CA40, o PM40 e a EF40 das codornas e a TB aumentou de forma quadrática o CR40, GP40 e o PM40. Não houve efeito de TC e TB no PC, RP, RASA, RPN, PRC, PRF, PRI, entretanto a TB influenciou o PRM, que aumentou linearmente com a inclusão de TB. Concluiu-se que a cobertura de cerâmica proporciona melhores condições ambientais em relação às demais coberturas. A inclusão de TB melhorou as características de desempenho sendo tecnicamente viável a inclusão de até 15% nas rações de codornas de corte. Com base na análise de custo atual, a inclusão de TB é economicamente inviável.

Palavras-chave: Coturnicultura. Instalações. Ingrediente alternativo. Telhado.

Introduction

The increasing growth of the Brazilian poultry industry is due, in part, to the improvement of the zootechnical indices, such as accelerated poultry growth and precocity in physiological maturity, which aim to create greater production efficiency (MURAKAMI; FURLAN, 2002) and are a consequence of advances in the fields of genetic engineering, environment, nutrition, and management. The breeding of broiler chickens and laying hens is based on a considerable amount of studies that have addressed these topics. However, there is a lack of information on the breeding of quails, especially meat quails.

Meat coturniculture is currently emerging as a highly promising activity, especially because of the low investment required for implantation, the need for small facility areas, and the short production cycle, which allows for a fast capital return, especially for small producers (CORRÊA et al., 2007; SILVA et al., 2012).In addition, the organoleptic characteristics of the meat have attracted the attention of consumers due to its accentuated color, softness, and taste, as well as its excellent sensory acceptance. It also contains chemical characteristics that are essential for feeding such as protein with high biological value, vitamins, minerals, and fatty acids (PASTORE et al., 2012).

High temperatures reduce food intake and, consequently, poultry performance. Thus, the construction of poultry facilities should aim to reduce internal temperatures by providing natural thermal maintenance, and use the most suitable materials for the construction of the sheds, ensuring they are built in a practical and economically viable way (TINÔCO, 2004). In this context, the roof is an important element to consider, as it is an important factor in creating an adequate environment inside the facilities (TURNPENNY et al., 2000; SANTOS et al., 2005).

The main limitation in poultry production is food cost, which represents on average 70% of the total production cost. Corn and soybean meal, which are the basis of poultry rations, have oscillating prices, and in many regions of the country there is little supply of these raw materials, which further increases production costs and reduces the producer's profit (CARNEIRO et al., 2013). The use of raw materials obtained from regional vegetables to partially replace corn and soybean meal may be an alternative to standard poultry rations in regions where there these materials are hard to find (SILVA et al., 2009).

Originally from the north, northeast, and center-west regions of Brazil, the babassu palm (*Palmaeorbignya* spp.) occupies a vast territorial area and is distributed in the states of Maranhão, Piauí, Tocantins, Goiás, Mato Grosso, Amazonas, Pará, Rondônia, Ceará, Bahia, and Minas Gerais (LIMA et al., 2006). The by-products resulting from processing the babassu coconut almond to extract the oil include pie, obtained from the mechanical pressing, and meal, obtained through extraction by organic solvents (CARNEIRO et al., 2009). In the last years, several studieshave beenconducted to examine the feasibility of using of these by-products in poultry rations (CARNEIRO et al., 2009; SANTOS NETA et al., 2011; SILVA et al., 2015a).

Thus, the objective of our study was to evaluate the effects of different shed roofs and inclusion of babassu pie in poultry rations on the productive characteristics of meat quails from 14 to 40 days of age.

Material and Methods

Our work was carried out at the Center for Agrarian and Environmental Sciences of the Federal University of Maranhão, located in Chapadinha, MA, with the geographic coordinates of 03° 44′ 30″ south latitude and 43° 21′ 33″ west longitude, and an altitude of 105 m (INPE, 2010). According to Köppen's climatic classification, this region has a climate type Aw and is considered to be tropical with dry winter (ALVARES et al., 2013).

A total of 896 non-sexed meat quails (*Coturnixcoturnixcoturnix*) were used. During the pre-experimental period (days 1 to 13), the quails were kept in a protective circle with a bed of shavingsand 60W incandescent lamps to maintain the room temperature between 32 and 35°C, in a 38.5-m^2masonry room with lateral windows.

On the 14th day of age, quails, with an initial mean weight of 76.0 ± 8.5g, were randomly distributed into batteries containing cages of 0.375 m^2 (0.50 x 0.75 m), housed in four masonry sheds built in the east-west direction measuring 4.20 m x 2.2 m x 2.0 m, with a concrete floor, side walls 0.40 m high and inclined roofs with edges of 0.40 m. Each of the sheds received a different type of cover: ceramic, fiber cement, babassu straw,or fiber cement painted white on the outside.

We used a completely randomized design (CRD) with a 4x4 factorial arrangement, with four types of roofs in the sheds (fiber cement, ceramic, straw and painted fiber cement) and four rations (with 0, 5, 10 and 15% inclusion of babassu pie). We carried out 16 treatments with four replicates of 14 birds, totaling 64 experimental units.

Experimental rations with increasing levels of babassu pie were formulated according to the chemical composition of the ingredients (Table 1) to be isonutritive and meet the nutritional requirements of meat quails during the breeding stage (1 to 21 days) and growing stage (22 to 40 days) (SILVA; COSTA, 2009) (Tables 2 and 3). The birds had free access to water and experimental rations throughout the experimental period, which was carried out under continuous light (24 hours of natural + artificial light).

Temperature (TA) and relative humidity (RH) were recorded daily at 08h00, 11h00, 14h00, and 17h00, using digital thermohygrometers placed in the geometric center of the sheds. The black globe temperature (BGT) was also collected at the same time during the experimental period using a portable black globe digital thermometer. To characterize the different environments, we calculated the globe and humidity temperature index (GHTI), as proposed by Buffington et al. (1981): GHTI = Bgt + 0.36 Tdp = 330.08, where Bgt = Black Globe Temperature (K) and Tdp = Temperature of dew point (K).

Table 1. Composition of the ingredients used in the formulation of the experimental rations (based on natural matter).

Nutrient	Corn[1]	Soybean meal[1]	Babassu pie
Metabolizable energy (kcal/kg)	3440	2330	1180[2]
Crude Protein (%)	8.50	46.50	19.72[3]
Calcium (%)	0.04	0.34	0.12[4]
Available phosphorus (%)	0.06	0.16	0.41[4]
Sodium (%)	0.02	0.02	---
Chloride (%)	0.05	0.05	---
Total lysine (%)	0.41	2.83	0.63[3]
Total Met+Cis (%)	0.39	1.31	0.53[3]
Total threonine (%)	0.37	1.73	0.69[3]
Total valine (%)	0.45	2.06	0.98[3]
Crude fiber (%)	2.08	7.50	28.47[3]
Fiber in acid detergent (%)	2.80	9.40	45.97[3]
Fiber in neutral detergent (%)	9.60	13.30	75.57[3]

[1]According to Silva and Costa (2009); [2] Based on studies conducted at the Center for Agrarian and Environmental Sciences – UFMA; [3] According to Gasparini et al. (2015); [4] According to Rostagno et al. (2011).

Table 2. Composition of the experimental ration in the breeding phase (days 1 to 21).

Ingredients (%)	**Inclusion levels of babassu pie (%)**			
	0	**5**	**10**	**15**
Corn	51.685	45.942	40.197	34.455
Babassu pie	0.000	5.000	10.000	15.000
Soybean meal 45	44.050	42.925	41.801	40.677
Soybean oil	0.673	2.525	4.377	6.229
Dicalcium phosphate	1.181	1.099	1.016	0.934
Calcitic limestone	1.035	1.089	1.143	1.197
Ordinary salt	0.376	0.372	0.369	0.365
Mineral premix[2]	0.050	0.050	0.050	0.050
Vitaminic premix[1]	0.100	0.100	0.100	0.100
Choline chloride	0.060	0.060	0.060	0.060
L-Lysine HCl (78,5)	0.129	0.160	0.191	0.221
DL-Methionine (98)	0.389	0.400	0.411	0.421
L-Threonine (98)	0.272	0.278	0.285	0.291
Total	100.000	100.000	100.000	100.000
Calculated composition				
Metabolizable energy (kcal/kg)	2900	2900	2900	2900
Crude protein (%)	26.00	26.00	26.00	26.00
Calcium (%)	0.850	0.850	0.850	0.850
Available phosphorus (%)	0.320	0.320	0.320	0.320
Sodium (%)	0.170	0.170	0.170	0.170
Chloride (%)	0.270	0.264	0.259	0.254
Potassium (%)	1.132	1.113	1.094	1.076
Total lysine (%)	1.560	1.560	1.560	1.560
Total Met+Cis (%)	1.160	1.160	1.160	1.160
Total threonine (%)	1.220	1.220	1.220	1.220
Total valine (%)	1.165	1.164	1.163	1.163
Crude fiber (%)	4.379	5.598	6.818	8.038
Fiber in acid detergent (%)	5.588	7.620	9.652	11.684
Fiber in neutral detergent (%)	10.820	13.898	16.975	20.053

[1]Composition/kg of product: vit. A = 12.000.000 I.U.; vit. D3 = 3.600.000 I.U.; vit. E = 3.500 I.U.; vit B1 = 2.500 mg; vit. B2 = 8.000 mg; vit. B6 = 5.000 mg; Pantothenicacid = 12.000 mg; Biotin = 200 mg; vit. K = 3.000 mg; Folicacid = 1.500 mg; Nicotinicacid = 40.000 mg; vit. B12 = 20.000 mg; Se = 150 mg; vehicleq.s.p.; [2]Composition/kg ofproduct: Mn = 160 g; Fe = 100 g; Zn = 100 g; Cu = 20 g; Co = 2 g; I = 2 g; vehicleq.s.p.

Table 3. Composition of the experimental ration in the growing phase (days 22 to 40).

Ingredients (%)	Inclusion levels of babassu pie (%)[1]			
	0	5	10	15
Corn	59.834	54.086	48.338	42.590
Babassu pie	0.000	5.000	10.000	15.000
Soybean meal 45	35.957	34.862	33.766	32.671
Soybean oil	1.593	3.452	5.312	7.172
Dicalcium phosphate	0.954	0.872	0.789	0.706
Calcitic limestone	0.849	0.903	0.956	1.010
Ordinary salt	0.325	0.321	0.318	0.314
Mineral premix[2]	0.050	0.050	0.050	0.050
Vitaminic premix[1]	0.100	0.100	0.100	0.100
Choline chloride	0.060	0.060	0.060	0.060
DL-Methionine (98)	0.200	0.210	0.221	0.231
L-Threonine (98)	0.078	0.084	0.090	0.096
Total	100.000	100.000	100.000	100.000
Calculated composition				
Metabolizable energy (kcal/kg)	3050	3050	3050	3050
Crude Protein (%)	22.00	22.00	22.00	22.00
Calcium (%)	0.700	0.700	0.700	0.700
Available phosphorus (%)	0.270	0.270	0.270	0.270
Sodium (%)	0.150	0.150	0.150	0.150
Chloride (%)	0.239	0.234	0.229	0.224
Potassium (%)	1.156	1.139	1.122	1.105
Total lysine (%)	1.263	1.240	1.217	1.194
Total Met+Cis (%)	0.900	0.900	0.900	0.900
Total threonine (%)	0.920	0.920	0.920	0.920
Total valine (%)	1.010	1.011	1.011	1.012
Crude fiber (%)	3.941	5.163	6.385	7.607
Fiber in acid detergent (%)	5.055	7.090	9.124	11.159
Fiber in neutral detergent (%)	10.526	13.607	16.688	19.769

[1]Composition/kg of product: vit. A = 12.000.000 I.U.; vit. D3 = 3.600.000 I.U.; vit. E = 3.500 I.U.; vit B1 = 2.500 mg; vit. B2 = 8.000 mg; vit. B6 = 5.000 mg; Pantothenicacid = 12.000 mg; Biotin = 200 mg; vit. K = 3.000 mg; Folicacid = 1.500 mg; Nicotinicacid = 40.000 mg; vit. B12 = 20.000 mg; Se = 150 mg; vehicleq.s.p.; [2]Composition/kg ofproduct: Mn = 160 g; Fe = 100 g; Zn = 100 g; Cu = 20 g; Co = 2 g; I = 2 g; vehicleq.s.p.

The performance variables evaluated at day 28 and day 40 included food intake (FI, g/bird), mean weight gain (WG, g/bird), food conversion (FC, g/g), mean live weight (MW, g/bird) and energy efficiency (EF, g/Mcal).

The FI was calculated by the difference between the amounts of ration provided (g) and the leftovers (g) in each plot in each evaluation period, divided by the number of birds corrected according to mortality (SAKOMURA; ROSTAGNO, 2007). The MW28, MW40, and WG for each period were obtained by weighing the birds of each plot on days 14, 28, and 40. The FC was calculated using the ratio between FI and WG. The EF was obtained by calculating the ratio between WG (g) and the consumption of metabolizable energy (Mcal), which was obtained by calculating the product of FI (kg) and the metabolizable energy of the ration (Mcal kg).

On the 40th day, we selected a quail weighing close to the average weight of each experimental unit (± 5%). This selection provided 64 birds, which were identified and maintained on a fasting diet for

6 hours, to reduce the content of the digestive tract. After fasting, quails were sacrificed by cervical dislocation, plucked, and eviscerated to measure carcass weight (CW). We then cut the breast, leg (thigh + leg quarter + foot) and wing, and separated the viscera to weight each organ individually. All procedures were approved by the Ethics Committee on Animal Experimentation of the Federal University of Maranhão (Process 23115.003173/2013-11).

The carcass yield (CY, %) was calculated by using the relationship between the weight of the eviscerated carcass (CW) and the weight during fasting. Breast (BY), leg (LGY), and wing (WINGY) yields and the relative heart (HRW), liver (LRW), gizzard (GRW), and intestine (IRW) weights were determined in relation to the weight of the eviscerated carcass.

Data for all the variables were evaluated submitted to normality (Cramer-Von Mises) and homoscedasticity (Levene) tests, both positive for all variables. Subsequently, the data of each variable were submitted to analysis of variance according to the statistical model: $Y_{ijk} = \mu + R_i + F_j + CxR_{ij} + e_{ijk}$; with i = 1, 2, 3, 4; j = 1, 2, 3,4 and k = 1, 2, 3, 4, in which Y_{ij} = value observed for k-th repetition of each variable analyzed in i-th roof,receiving j-thration; μ = effect of the general mean; R_i = effect of the i-th roof; F_j = effect of the j-thration, RxF_{ij} = effect of the interaction between i-th roof and j-thration; e_{ijk} = experimental error associated with k-th repetition.

To explore the effects of the type of roof, means were compared with the Student Newman Kells (SNK) test. The effects induced by different levels of babassu pie present in the ration were explored by decomposing the degrees of freedom of babassu pie levels into orthogonal polynomials of the first and second order. Statistical analyses were performed using the software SAS 9.0 (2002), considering a level of significance of up to 5%.

To compare the economic efficiency between experimental rations, ration cost per kg of carcass was determined as follows: $CC_i = (QF_i \times CF_i) / CW_i$, in which CC_i = ration cost per kg of carcass produced using the i-thration (R$/kg), QF_i = quantity of ration consumed at the i-th level of inclusion of babassu pie (kg), CF_i = cost of the i-thration(R$/kg) and CW_i = carcass weight of birds that received the i-thration (kg).

The gross margin in relation to the cost of ration per kg of carcass for each level of inclusion of babassu pie was calculated by the expression: $GM_i = SPC - CC_i$, in which GM_i = gross margin in relation to the cost of ration per kg of carcass obtained with the use of the i-thration (R$); SPC = sale price of the plucked and eviscerated carcass (R$/kg). The optimal level of inclusion of babassu pie in the ration of meat quails, which was defined based on the economic approach, was considered as that which provided lower CC_i and higher GM_i.

Results and Discussion

Based on the recordings of daily climatic variables (TA, BGT, and RH) at different times (08h00, 11h00, 14h00 and 17h00), we calculated the daily mean values inside the sheds with different roofs. We then used these data in GHTI calculations, whose mean values were compared throughout the experimental period (Table 4).

The TA and BGT observed with a ceramic roof were, on average, 1.5°C and 2.5°C, respectively, lower than those obtained with other roofs. According to Baêta and Sousa (2010), ceramic has lower thermal conductivity than fiber cement and straw, resulting in slower heating and lower emission of radiation, which may justify these results.

Table 4. Mean values of the air temperature (AT), black globe temperature (BGT), relative air humidity (RH) and globe and humidity temperature index (GHTI), observed throughout the experimental period according to the type of shed roof.

Variable	Roof				VC (%)
	Ceramics	Fiber cement	Straw	Painted fiber cement	
TA (°C)	32.19B	33.47A	33.00A	33.04A	2.65
BGT (°C)	32.93B	34.52A	34.21A	34.31A	3.11
RH (%)	63.95A	58.97B	60.81B	61.10B	6.76
GHTI	79.14B	83.03A	82.91A	83.05A	1.26

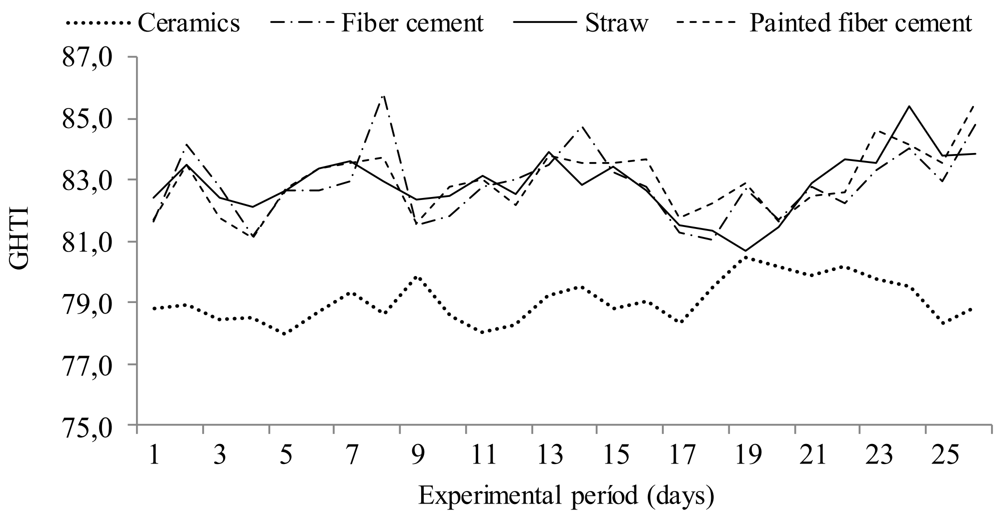
Mean values followed by equal letters in the lines are not different from each other in the SNK test (p>0,05).

The RH was 3.7 percentage points higher in the shed with a ceramic roof, compared to other roofs. This result was obtained because the RH is inversely related to the TA,owing to a reduction in the water retention capacity caused by air mass as the TA increases (FERREIRA, 2005).

The mean values of the TA, regardless of the type of roof, remained above the thermal comfort zone (TCZ). According to Sousa et al. (2014), the TCZ for meat quails, from the fourth week of age, ranges between 21 and 25°C. However, we observed that the ceramic roof favored the environmental conditions more than did the fiber cement, straw, and painted fiber cement roofs ($p < 0.05$), such that they provided similar conditions inside the sheds. The RH remained within the appropriate limits because, according to Oliveira et al. (2006), the ideal RH value to avoid compromise of latent exchanges must be between 57 and 69%.

To characterize the thermal environment in a single value that represents the impact of all the variables that interfere with the thermal equilibrium of the animal, Buffington et al. (1981) proposed the GHTI, which has been widely used tointegrate TA, BGT, and RH. Based on the recorded values of these variables, the GHTI was calculated for the sheds with different types of cover. We noted that the ceramic roof favored, in general, the environmental conditions throughout the experimental period, compared to the fiber cement, straw, and painted fiber cement roofs (Table 4, Figure 1).

Figure 1. Mean Global Humidity and Temperature Index (GHTI) observed throughout the experimental period according to the type of shed roof.



Sousa et al. (2014) studied the effects of different thermal environments on the performance of meat quails from day 22 to day 35, in order to determine thermal comfort bands based on the GHTI. The authors observed that values between 75.3 and 75.8 were associated with a comforting environment, values between 79.7 and 79.9 were associated with moderate heat, and values above 80.8 were associated with severe heat. In this view, the GHTI values observed in the present study were associated with moderate heat in the shed with ceramic roof (79,14) and with severe heat in sheds with roofs of fiber cement (83,03), straw (82,91) and painted fiber cement (83.05), such that all sheds presented values above the recommended comfort range.

We found no interactions (p> 0.05) between shed roof (SR) and levels of babassu pie (BP) in any of the evaluated characteristics at any of the evaluation periods (14 to 28 days and 14 to 40 days). These results indicate that these factors acted independently, suggesting that the behavior of the responses due to BP was similar in the different SRs, and vice-versa, such that the mean values presented referred to the main effects of each evaluated factor.

We observed that, in the initial period (14 to 28 days), the SR influenced food intake (FI28) (p<0.05), weight gain (WG28), and the mean live weight (MW28) of the quails, but there was no effect on food conversion (FC28) and energy efficiency (EF28) (p> 0.05, Table 5).

Table 5. Food intake (FI), weight gain (WG, food conversion (FC), mean weight (MW) and energetic efficiency (EF) of meat quails according to type of shed roof and levels of babassu pie present in the rations from day 14 to day 28.

Factor/Level	Variable				
	FI_{28} (g/bird)	$WG_{28}{}^{1}$ (g/bird)	$FC_{28}{}^{2}$ (g/g)	$MW_{28}{}^{3}$ (g/bird)	$EF_{28}{}^{4}$ (g/Mcal)
Roof					
Ceramics	319.87^{A}	126.04^{A}	2.54	202.13^{A}	129.20
Fiber cement	309.18^{C}	121.45^{B}	2.55	197.63^{B}	128.84
Straw	317.03^{AB}	123.53^{AB}	2.57	199.35^{AB}	127.81
Pain fiber cement	311.65^{BC}	122.99^{AB}	2.54	198.72^{B}	129.41
Babassu pie (%)					
0,0	312.05	120.62	2.59	196.59	126.77
5,0	316.26	124.40	2.54	200.37	128.99
10,0	314.94	124.33	2.54	200.21	129.46
15,0	314.49	124.65	2.52	200.65	130.04
			P>F		
Roof (SR)	0.004	0.021	0.636	0.018	0.649
Babassu pie (BP)	0.589	0.020	0.090	0.019	0.095
Linear effect	0.536	0.010	0.018	0.009	0.019
Quadratic effect	0.284	0.092	0.404	0.100	0.388
SR x BP	0.389	0.616	0.141	0.539	0.127
VC (%)	2.68	3.19	2.91	1.95	2.88

Mean values followed by equal letters in the lines are not different from each other in the SNK test (p>0,05).

[1] WG_{28} (g/bird) = 121.55 + 0.248 BP (r^2=0.71)

[2] FC_{28} (g/g) = 2.579 – 0.004 BP (r^2=0.85)

[3] MW_{28} (g/bird) = 197.51 + 0.247 BP(r^2=0.71)

[4] EF_{28} (g/Mcal) = 127.25 + 0.206 BP(r^2=0.87).

We observed that the birds kept within ceramic roofs showed higher FI28 compared to that of birds kept under fiber cement (3.46%) and painted fiber cement (2.63%) roofs. This value, however, was similar to that of birds kept in sheds with a straw roof. These differences influenced performance, such that birds kept under ceramic roofs had higher WG28 (3.81%) than those kept under fiber cement roofs, but were not different from those maintained under straw or painted fiber cement roofs.

Considering that the WG28 increased in proportion to FI28, and that these variables are the basis for calculating FC28 and EF28, we found no effects of the type of roof on FC28 and EF28 in quails.

The MW28 showed a similar pattern of response to that of WG28, and the birds under the ceramic roof had higher mean weights than those kept in sheds with a fiber cement (2.27%) and painted fiber cement (1.71%) roofs. We found no differences in MW28 between roofs of fiber cement, straw, or painted fiber cement.

The response of the analyzed variables measured in birds kept under different roofs is related to the environmental conditions, since FI is dependent on the thermal conditions and has a direct impact on the performance of the birds (OBA et al., 2012; OLIVEIRA et al., 2014). The differences in thermal conditions between sheds with different roofs are due to the thermal energy of the upper surface being transferred to the lower surface, which can increase the internal temperature of the shed (ABREU et al., 2011).

According to Michels et al. (2008) and Baêta and Sousa (2010), ceramic tiles have lower thermal conductivity than tiles of fiber cement and have higher water absorption capacity due to their porosity so that ceramic tiles take longer to heat, which make them potentially more comfortable. These characteristics led to a reduction of the GHTI inside the ceramic-roofed shed, which favored the FI28 and, consequently, the WG28 and the MW28 of the quails, compared to those of quails kept in sheds with fiber cement and painted fiber cement roofs.

Lima et al. (2009) evaluated the thermal indices in sheds with different roofs and reported the lowest GHTI and TA in sheds with ceramic roofs, compared to sheds with fiber cement roofs. They concluded that ceramic roofs favor animal performance, which corroborates the results found in our work.

Straw roofs, due to the voids between the layers that act as an insulator, reduce radiation flux, thereby exerting a positive effect on thermal comfort (BARNABÉ et al., 2014). This helps to explain the similarity between responses in birds kept in sheds with ceramic and straw roofs found in our study.

We also observed that the levels of BP did not affect the FI28 of the quails and that there was a linear increase in FI28 with the inclusion of BP, according to the equation: FI28 (g) = 121.55 + 0.248 BP (%) (r^2 = 0.71). The absence of an effect on the FI28 allowed the FC28 to accompany the same response of the WG28, with a linear improvement according to the equation: FC (g/g) = 2.579 – 0.004 BP (%) (r^2 = 0.85). The MW28 presented a similar behavior to the WG28, as described by the equation MW28 (g/bird) = 197.51 + 0.247 BP (%) (r^2 = 0.71), in which we observed that the increase of one percentage point in the level of babassu pie in rations promoted an increase of approximately 0.25g in MW28 and WG28. The EF28 followed the same behavior as the other variables, improving linearly as a consequence of the absence of effect on the FI28 and increase in the WG28, according to the equation EF (g/Mcal) = 127.25 + 0.206 BP (%) (r^2 = 0, 87).

Considering the differences in the nutritional composition of BP in relation to maize and soybean meal (Table 1), it was necessary to include higher levels of oil and synthetic amino acids in the rations so that they remained isoenergetic and isoaminoacidic with increasing levels of BP (Table 2 and 3).

Although FI was similar among the various treatments, indicating that nutrient intake and metabolizable energy were also similar, the increase in the amount of soybean oil in rations with BP inclusion may have provided greater efficiency in the use of metabolizable energy and a higher energy utilization for growth, due to the lower caloric amount provided by rations containing higher levels of BP. This helps explain the improvement in the performance of quails fed with rations containing higher levels of BP.

In addition, higher amounts of oil in the ration stimulate the secretion of the cholecystokinin hormone (CCK) by the gastrointestinal mucosa, which reduces gastric motility and, consequently, slows passage through the digestive tract (SILVA et al., 2014). Consequently, there is an increase in the absorption of vitamins and digestibility of amino acids (SAKOMURA et al., 2004), which also helps explain the results obtained in the present study.

In view of the above, the inclusion of up to 15% of BP in rations in the initial period (14 to 28 days) is technically feasible, provided that the rations are balanced to meet the requirements of the birds.

In the accumulated period (14 to 40 days), we observed that SR influenced weight gain (WG40), food conversion (FCA40), mean live weight (MW40) and energy efficiency (EF40) of the quails (p <0.05), but no effect was found on food intake (FI40) (p> 0.05, Table 6).

Table 6. Food intake (FI), weight gain (WG, food conversion (FC), mean weight (MW), and energetic efficiency (EF) of meat quails according to type of shed roof and levels of babassu pie present in the rations from day 14 to day 40.

Factor/Level	Variable				
	[1]FI_{40} (g/bird)	[2]WG_{40} (g/bird)	FC_{40} (g/g)	[3]MW_{40} (g/bird)	EF_{40} (g/Mcal)
Roof					
Ceramics	667.61	184.60^{A}	3.62^{A}	260.64^{A}	90.66^{A}
Fiber cement	662.73	182.49^{AB}	3.63^{A}	258.82^{AB}	90.30^{A}
Straw	669.86	178.61^{B}	3.75^{B}	254.45^{B}	87.43^{B}
Pain fiber cement	667.85	178.44^{B}	3.74^{B}	254.18^{B}	87.61^{B}
Babassu pie (%)					
0,0	664.50	176.73	3.76	252.74	87.22
5,0	671.23	183.81	3.65	259.76	89.80
10,0	671.10	183.41	3.66	259.24	89.60
15,0	661.23	180.19	3.67	256.34	89.38
			P>F		
Roof (SR)	0.612	0.046	0.009	0.038	0.009
Babassu pie (BP)	0.192	0.031	0.101	0.037	0.111
Linear effect	0.567	0.229	0.083	0.218	0.095
Quadratic effect	0.038	0.007	0.089	0.009	0.096
SR x BP	0.248	0.510	0.413	0.515	0.427
VC (%)	2.33	4.06	3.63	2.87	3.70

Mean values followed by equal letters in the lines are not different from each other in the SNK test (p>0,05).
[1]FI_{40} (g/bird) = 664.36 + 2.290 BP – 0.166 BP ^{2} (R^2=0.99).
[2]WG_{40} (g/bird) = 176.96 + 1.746 BP – 0.103 BP ^{2} (R^2=0.97).
[3]MW_{40} (g/bird) = 252.99 + 1.695 BP – 0.099 BP ^{2} (R^2=0.96).

SR did not influence the FI40, however, we observed that the birds kept under ceramic roofs had higher WG40 than those kept under straw (3.35%) or painted fiber cement (3.45%) roofs, but did nothave different WG40 than birds kept under fiber cement roofs. As a consequence, the FC40 of the birds kept under the ceramic roof improved 3.47% relative to those in sheds witha straw roof, 3.20%

relative to those kept under a painted fiber cement roof, and was the same as those kept under a fiber cement roof. Similarly, the EF40 of the birds kept under ceramic roofs was higher than that of birds kept under straw roofs (3.69%) and painted fiber cementroofs (3.48%) roofs, but was the sameas that of birds kept under fiber cement roofs.

The MW40 showed a similar pattern of response to that of the WG40, as birds kept in sheds with ceramics roof had a higher MW40 than those kept under straw (2.43%) and painted fiber cement (2.54%) roofs, with no differences between fiber cement, straw or painted fiber cement roofs.

Regardless of SR, quails that showed signs of heat stress had been in sheds with temperatures above TCZ. Therefore, assuming that the environmental conditions affect quail performance and that the ceramic roof promoted the best thermal conditions compared to the others, the similarity of responses observed in sheds with ceramic and fiber cement roofs in the accumulated period (14-40 days) was not expected. We found that ceramic roofs resulted in better performance than did fiber cement roofs in the initial phase, mainly because environmental conditions and GHTI were more favorable with this type of coverage.

Considering the effects of BP, we observed that the FI40 increased in a quadratic manner according to the equation FI40 (g/bird) = 664.36 +2.290 BP (%) – 0.166 BP^2 (%) ($R^2 = 0.99$), with the maximum point estimated at 6.9%. This behavior influenced the WG40, which also presented an increased quadratic response according to the equation WG40 (g/bird) = 176.96 + 1.746 BP (%) – 0.103 BP^2 (%) ($R^2 = 0.97$), which increased up to the estimated level of 8.4% of BP in rations.

Due to the proportional response of the FI40 and MW40 responses, the FC40 and EF40 were not influenced by the inclusion of BP, as we observed a quadratic response in the MW40 according to MW40 (g/bird) = 252.99 + 1.695 BP (%) – 0.099 BP^2 (%) ($R^2 = 0.96$), and the optimum level estimated at 8.5%, in accordance with the estimated maximum point for WG40 (8.4%).

The inclusion of increasing levels of BP caused a reduction in the amount of corn and soybean meal present in the experimental rations, which in turn resulted in the substitution of digestible carbohydrates (starch) by indigestible carbohydrates (insoluble PNA) that present low fermentation capacity in the intestines of the birds and produce lower caloric content than digestible carbohydrates. Thus, the inclusion of higher levels of BP caused an increase in the amount of oil in the rations, and may have provided extra amounts of liquid energy owing to a decrease in heat production by the birds.

According to Gous (2011), birds are more sensitive to the caloric contentof food in the termination phase than in the initial phase because aging is associated with an increase in metabolic heat production. Older birds also have a lower heat dissipation capacity. Considering that, regardless of the type of roof, birds remained at temperatures above the TCZ, it may be that the reduction in the caloric content of the rations favored FI in birds up to a point in which the use of metabolizable energy (liquid energy) limited the FI (6.9% of BP), resulting in a reduction in nutrient consumption from this level on and explaining the increase in WG40 to a similar level of BP (8.4%).

A limited number of studies have evaluated the inclusion of BP in quail rations. However, this ingredient has been widely studiedin broiler chickens and its use has shown promising potential.

Using increasing levels (0, 4, 8 and 12%) of BP in rations for Hubbard broiler chickens from days 1 to 21, Santos Neta et al. (2011) found no effect on poultry performance and recommended the inclusion of up to 12% of this material in rations. Similarly, Carneiro et al. (2009), who evaluated different levels of BP (0, 3, 6, 9, and 12%) in rations for Hubbard chickens from days 22 to 42, showed the technical feasibility of including up to 12% of BP in rations.

Silva et al. (2015b) analyzed increasing levels (0, 10, 20,and 30%) of soybean meal replacement by BP in rations for broiler chickens and showed no effect on the WG and FC of birds, recommending the substitution of up to 30% of the soybean meal with BP, which is equivalent to the inclusion of 8.4% of BP in rations.

We observed that the SR influenced carcass yield (CY, p <0.05), with no effects on carcass weight (CW) or breast (BY), wings (WINGY), and legs (LGY) yields at 40 days of age (p> 0.05, Table 7).

Table 7. Carcass weight (CW) and carcass (CY), breast (BY), wing (WINGY), and leg (LGY) yields of meat quails depending on the type of shed roof and level of babassu pie included in the rations at 40 days of age.

Factor/Level	Variable				
	CW (g)	CY (%)	BY (%)	WINGY (%)	LGY (%)
Roof					
Ceramics	197.03	77.29^{B}	33.86	7.26	21.35
Fiber cement	197.09	76.78^{B}	33.37	7.17	21.36
Straw	197.68	78.20^{B}	33.72	7.26	21.14
Pain fiber cement	204.13	80.06^{A}	33.56	7.02	21.14
Babassu pie (%)					
0,0	196.25	78.50	34.11	7.23	21.43
5,0	199.47	77.91	33.41	7.21	21.10
10,0	200.72	78.11	33.30	7.18	21.15
15,0	199.50	77.80	33.68	7.08	21.31
		P>F			
Roof (SR)	0.061	0.005	0.787	0.475	0.897
Babassu pie (BP)	0.471	0.874	0.382	0.840	0.809
Linear effect	0.253	0.518	0.396	0.389	0.787
Quadratic effect	0.296	0.832	0.139	0.756	0.374
SR x BP	0.529	0.715	0.649	0.727	0.709
VC (%)	4.11	3.22	4.16	6.66	5.05

Mean values followed by equal letters in the lines are not different from each other in the SNK test (p>0,05).

Birds kept in sheds with painted fiber cement roofs had an FI (%) higher than that of birds kept under ceramic (2.77%), fiber cement (3.28%),or straw (1.86%) roofs, with no differences between the last two types. It is known that birds kept at elevated temperatures tend to present higher CY (%) due to a reduction in the size of internal organs, a strategy to reduce heat production (OLIVEIRA NETO et al., 2000; OBA et al., 2012, GHARIB, 2014). As such, we expected that the CY (%) of the quails kept under ceramic roofs would be lower than that of birds under other roofs, since the ceramic roof favored the environmental conditions inside the sheds. Similarity in the CY responses (%) of quails kept under ceramic, fiber cement and straw roofs was unexpected, and we found no explanation for these results.

The similarity in CW, BY, WINGY, and LGY responses of meat quails kept at different ambient temperatures was also observed in Bonfim et al. (2015), who explained these results with the fact that quails have a higher surface area/body volume ratio than broiler chickens and, consequently, have a greater ability to dissipate metabolic heat. For this reason, quails are less susceptible to carcass and body changes when kept in hot environments.

The inclusion of BP in the rations did not influence the absolute weight and carcass and cut yields in quails (p> 0.05), confirming the feasibility of using up to 15% of this ingredient in quail rations, provided that nutritional requirements of birds are maintained.

Results with broiler chickens were similar to those found in our work. Carneiro et al. (2009) evaluated the effect of including BP in broiler chicken rations from day 21 to 42, and observed that the carcass yield was not influenced by BP, which indicated that the inclusion of up to 12% BP does not compromise these variables.

Similarly, Silva et al. (2015b) found that the levels of substitution of soybean meal with babassu pie did not affect carcass, thigh, quarter, and breast yields in sacrificed chickens at 42 days of age, indicating that babassu pie can substitute up to 30% of the soybean meal in the rations (corresponding to a level of 8.4% of BP), provided these meet the nutritional requirements of the birds.

SR influenced the relative gizzard weight (GRW) but had no effect on the relative weight of the heart (HRW), liver (LRW), and intestine (IRW) of the quails at day 40 (p> 0.05, Table 8).

Table 8. Relative weight of the heart (HRW), gizzard (GRW), liver (LRW), and intestine (IRW) of meat quails depending on the type of shed roof and levels of babassu pie introduced in the rations at 40 days of age.

Factor/Level	Variable			
	HRW (%)	[1]GRW (%)	LRW (%)	IRW (%)
Roof				
Ceramics	1.05	2.33^{A}	2.56	3.60
Fiber cement	1.02	2.12^{B}	2.46	3.45
Straw	0.98	2.23^{AB}	2.45	3.53
Pain fiber cement	1.06	2.30^{AB}	2.56	3.50
Babassu pie (%)				
0,0	1.07	2.18	2.63	3.57
5,0	1.01	2.16	2.43	3.39
10,0	1.04	2.29	2.49	3.59
15,0	1.00	2.34	2.48	3.55
		P>F		
Roof (SR)	0.100	0.043	0.690	0.847
Babassu pie (BP)	0.162	0.091	0.480	0.641
Linear effect	0.119	0.022	0.362	0.813
Quadratic effect	0.529	0.574	0.304	0.559
SR x BP	0.531	0.516	0.838	0.279
VC (%)	9.09	9.34	14.48	13.92

Mean values followed by equal letters in the lines are not different from each other in the SNK test (p>0,05).
[1]GRW (%) = 2.154 + 0.012 BP(r^2=0.81).

We noted that the GRW (%) of the birds kept under painted fiber cement or straw roofs was not different from that of birds kept under the other roof types. However, the GRW (%) was higher in quails kept under ceramic roof compared to those kept under the fiber cement roof. This result is in agreement with those of studies with broiler chickens, in which the authors reported a reduction in the GRW (%) of birds kept at higher temperatures as an adaptation to reduce endogenous heat production (OLIVEIRA NETO et al., 2000; OLIVEIRA et al., 2006; ROSA et al., 2007).

The inclusion of BP in the rations did not affect the HRW (%), LRW (%),or IRW (%). However, there was an increasing linear response in the GRW (%), according to the equation GRW (%) = 2.154 + 0.012 BP (r^2 = 0.81). Similarly, Silva et al. (2015b), who evaluated the effect of replacing soybean meal by BP (0, 10, 20,or 30%) in the rations of Cobb 500 strain broiler chickens, observed that the gizzard relative weight increased linearly due to the increase in fiber content, which corroborates our own results.

Several studies reported that an increase in the fiber content of rations led to an increase in the relative weight of digestive organs, especially the gizzard (GONZÁLEZ-ALVARADO et al., 2008; JIMÉNEZ-MORENO et al., 2010; SACRANIE et al., 2012), suggesting that high levels of fiber promote the mechanical stimulation of this organ and elicits a muscular adaptation to meet a greater grinding demand, causing its hypertrophy and, consequently, weight increase. This may explain the increase in the GRW (%) observed in our study after we increased BP levels.

The results of the analysis of performance, cuts, and organs in the present study showed that the ceramic roof favored the productive characteristics of the quails, and provided better environmental conditions for production than did all other roof types. From a more technical point of view, the ceramic roof is the most highly recommended.

The inclusion of increasing levels of BP (0, 5, 10, and 15%) improved the productive characteristics of birds in the initial and the accumulation period without changing the characteristics of their carcass and organs at day 40. Considering that quails are mainly marketed as plucked and gutted carcasses and that the inclusion of BP in the rations did not affect these parameters, we believe the inclusion of up to 15% of BP in the rations of these animals is technically feasible. However, the technical indication of BP in the rations is not sufficient for its practical use – it is also necessary to analyze its economic feasibility, considering that the main purpose of its use is to reduce food costs.

We observed that, regardless of the type of shed roof, the highest gross margin was obtained with quails that had been fed without the inclusion of BP, due to the lower ration cost (Table 9).

Table 9. Ration cost (RC), ration cost per kg of carcass (CC) and gross margin (MB) of meat quail from 14 to 40 days.

Variables	Inclusion level			
	0	5	10	15
Ration cost[1] (R$/kg)	1.165	1.214	1.263	1.311
Ration cost per kg of carcass (R$/kg)	3.949	4.087	4.224	4.345
Gross margin[2] (R$/kg)	15.451	15.313	15.176	15.055

[1] Considering the following local prices: corn = R$0.70/kg; Soybean meal = R$1.70/kg; Babassu pie = R$1.10/kg; Dicalcium phosphate = R$2.77/kg; Soybean oil = R$3.00/kg; Limestone = R$0.50/kg; Salt = 0.80/kg; DL-methionine = R$15.72/kg; L-lysine HCl = R$6.67/kg; L-threonine = R$6.76/kg; Mineral and vitamin supplement = R$9.00/kg. [2] Considering a price of kg of quail carcass as R$19.40/kg.

The inclusion of BP increased food cost, as we needed to increase soybean oil and synthetic amino acids to maintain the energy and amino acid balance in the rations. In addition, the higher price of BP than that ofcorn and soybean meal also increased ration costs per kg of carcass produced and, consequently, reduced the gross margin, making it unfeasible for regular use. Considering a constant cost of inputs and kg of carcass produced, in order to include 15% of BP in the rations and make this economically feasible under the conditions of the present study, it should cost a maximum price of R$0.30/kg, the equivalent to 27 % of the current cost (R$1.10).

The results of the present study showed that it is possible to include up to 15% of BP in the rations for meat quails from 14 to 40 days of age, although its use is economically unfeasible.

Conclusion

A ceramic roof provides better environmental conditions thana fiber cement, straw,or painted fiber cement roof, benefiting the performance of meat quails.

The inclusion of babassu pie improves the performance characteristics in the initial and accumulated periods, without affecting carcass, cuts, organs,or body temperatures. It is technically feasible to include up to 15% of babassu pie in quail rations regardless of the type of shed roof.

Based on the current cost analysis, the inclusion of babassu pie in meat quail rations is economically infeasible regardless of the type of shed roof.

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References

ABREU, P. G.; ABREU, V. M. N.; COLDEBELLA, A.; LOPES, L. S.; CONCEIÇÃO, V.; TOMAZELLI, I. L. Análise termográfica da temperatura superficial de telhas. *Revista Brasileira de Engenharia Agrícola e Ambiental*, Campina Grande, v. 15, n. 11, p. 1193-1198, 2011.

ALVARES, C. A.; STAPE, J. L.; SENTELHA, P. C.; GONÇALVES, J. L. M.; SPAROVEK, G. Köppen's climate classification map for Brazil. *MeteorologischeZeitschrift*, Stuttgart, v. 22, n. 6, p. 711-728, 2013.

BAÊTA, F. C.; SOUZA, C. F. *Ambiência em edificações rurais:* conforto animal. Viçosa, MG: UFV, 2010. 269 p.

BARNABÉ, J. M. C.; PANDOFI, H.; ALMEIDA, G. L. P.; GUISELINI, C.; JACOB, A. L. Temperatura superficial de materiais utilizados para cobertura individual de bezerreiros. *Revista Brasileira de Engenharia Agrícola e Ambiental*, Campina Grande, v. 18, n. 5, p. 545-550, 2014.

BONFIM, D. S. *Efeito do ambiente sobre as características de desempenho, carcaça, órgãos e temperaturas corporais de codornas europeias*. 2015. Dissertação (Mestrado em Ciência Animal) – Universidade Federal do Maranhão, Chapadinha.

BUFFINGTON, D. E.; COLLAZO-AROCHO, A.; CANTON, G. H.; PITT, D.; THATCHER, W. W.; COLLIER, R. J. Black globe humidity index (BGHI) as a comfort equation for dairy cows. *Transactionofthe ASAE*, St. Joseph, v. 24, n. 3, p. 711-714, 1981.

CARNEIRO, A. P. M.; PASCOAL, L. A. F.; WATANABE, P. H.; SANTOS, I. B.; LOPES, J. M.; ARRUDA, J. C. B. Farelo de babaçu em rações para frangos de corte na fase final: desempenho, rendimento de carcaça e avaliação econômica. *Ciência Animal Brasileira*, Goiânia, v. 10, n. 1, p. 40-47, 2009.

CARNEIRO, M. I. F.; SAKOMURA, N. K.; KAWAUCHI, I. M.; SILVA, E. P.; ARAUJO, J. A.; FERNANDES, J. B. K.; GOMES FILHO, J. S. Avaliação do mesocarpo de babaçu (*Orbignyassp*) na alimentação de frangos de corte. *ArsVeterinaria*, Jaboticabal, v. 29, n. 3, p. 175-182, 2013.

CORRÊA, G. S. S.; SILVA, M. A.; CORRÊA, A. B.; FONTES, D. O.; TORRES, R. A.; DIONELLO, N. J. L.; SANTOS, G. G.; FREITAS, L. S. Exigências de proteína bruta e energia metabolizável em codornas de corte durante a fase de crescimento. *Arquivo Brasileiro de Medicina Veterinária e Zootecnia*, Belo Horizonte, v. 59, n. 2, p. 488-494, 2007.

FERREIRA, R. A. *Maior produção com melhor ambiente para aves, suínos e bovinos*. Visçosa, MG: Aprenda fácil, 2005. 371 p.

GASPARINI, S. P.; RIBEIRO, F. B.; SIQUEIRA, J. C.; BOMFIM, M. A. D.; NASCIMENTO, D. C. N. Avaliação nutricional da torta de babaçu para frangos de crescimento lento em diferentes idades. *Revista Caatinga*, Mossoró, v. 28, n. 2, p. 126-134, 2015.

GHARIB, H. B. Evaluation of using dietary phytogenics, as growth promoters, on broiler performance, under normal and subnormal temperature conditions. *Egyptian Journal of Animal Production*, Cairo, v. 51, n. 1, p. 49-59, 2014.

GONZÁLES-ALVARADO, J. M.; JIMÉNEZ-MORENO, E.; VALENCIA, D. G.; LÁZARO, R.; MATEOS, G. G. Effects of fiber source and heat processing of the cereal on the development and pH of the gastrointestinal tract of broilers fed diets based on corn or rice. *Poultry Science*, Champaign, v. 87, n. 9, p. 1779-1795, 2008.

GOUS, R. M. *Strategies to deal with heat dissipation in broilers*. Durban: University of KwaZulu-Natal, and EFG Software Pietermaritzburg, South Africa, 2011. 13 p.

INSTITUTO NACIONAL DE PESQUISAS ESPACIAIS – INPE. Manual do software SPRING (sistema de processamento de informações georreferenciadas). Rio de Janeiro: Divisão de Processamento de Imagens, 2010. v.4.3.3.

JIMÉNEZ-MORENO, E.; GONZÁLES-ALVARADO, J. M.; GONZÁLES-SÁNCHEZ, D.; LÁZARO, R.; MATEOS, G. G. Effects of type and particle size of dietary fiber on growth performance and digestive traits of broilers from 1 to 21 days of age. *Poultry Science*, Champaign, v. 89, n. 10, p. 2197-2212, 2010.

LIMA, A. M.; VIDAURRE, G. B.; LIMA, R. M.; BRITO, E.O. Utilização de fibras (Epicarpo) de babaçu como matéria prima alternativa na produção de chapas de madeira aglomerada. *Revista* Árvore, Viçosa, v. 30, n. 4, p. 645-650, 2006.

LIMA, K.R.S.; ALVES, J.A.K.; ARAÚJO, C.V.; MANNO, M.C.; JESUS, M.L.C.; FERNANDES, D.L.; TAVARES, F. Avaliação do ambiente térmico interno em galpões de Frango de corte com diferentes materiais de cobertura na mesorregião metropolitana de Belém. *Revista Ciências Agrárias*, Belém, v. 51, n. 51, p.37-50, 2009.

MICHELS, C.; LAMBERTS, R.; GÜTHS, S. Evaluation of heat flux reduction provided by the use of radiant barriers in clay tile roofs. *Energy and Buildings*, Amsterdam, v. 40, n. 4, p. 445-451, 2008.

MURAKAMI, A. E.; FURLAN, A. C. Pesquisas na nutrição e alimentação de codornas em postura no Brasil. In: SIMPÓSIO INTERNACIONAL DE COTURNICULTURA, 1., 2002, Lavras. *Anais*... Lavras: Universidade Federal de Lavras, 2002. p. 113-120.

OBA, A.; LOPES, P. C.; BOIAGO, M. M.; SCATOLINI, A. M.; MONTASSIER, H. J.; SOUZA, P. A. Características produtivas e imunológicas de frangos de corte submetidos a dietas suplementadas com cromo, criados sob diferentes condições de ambiente. *Revista Brasileira de Zootecnia*, Viçosa, MG, v. 41, n. 5, p. 1186-1192, 2012.

OLIVEIRA, D. L.; NASCIMENTO, J. W. B.; CAMERINI, N. L.; SILVA, R. C.; FURTADO, D. A.; ARAUJO, T. G. P. Desempenho e qualidade de ovos de galinhas poedeiras criadas em gaiolas enriquecidas e ambiente controlado. *Revista Brasileira de Engenharia Agrícola e Ambiental*, Campina Grande, v. 18, n. 11, p.1186-1191, 2014.

OLIVEIRA, R. F. M.; DONZELE, J. L.; ABREU, M. L. T.; FERREIRA, R. A.; VAZ, R. G. M. V.; CELLA, P. S. Efeitos da temperatura e da umidade relativa sobre o desempenho e o rendimento de cortes nobres de frangos de corte de 1 a 49 dias de idade. *Revista Brasileira de Zootecnia*, Viçosa, MG, v. 35, n. 3, p.797-803, 2006.

OLIVEIRA NETO, A. R.; OLIVEIRA, R. F. M.; DONZELE, J. L.; ROSTAGNO, H. S.; FERREIRA, R. A.; MAXIMIANO, H. C.; GASPARINO, E. Efeito da temperatura ambiente sobre o desempenho e características de carcaça de frangos de corte alimentados com dieta controlada e dois níveis de energia metabolizável. *Revista Brasileira de Zootecnia*, Viçosa, MG, v. 29, n. 1, p. 183-190, 2000.

PASTORE, S. M.; OLIVEIRA, W. P.; MUNIZ, J. C. L. Panorama da coturnicultura no Brasil. *Revista Eletrônica Nutritime*, Viçosa, MG, v. 9, n. 6, p. 2041-2049, 2012.

ROSA, P. S.; FARIA FILHO, D. E.; DAHLKE, F.; VIEIRA, B. S.; MACARI, M.; FURLAN, R. L. Performance and carcass characteristics of broiler chickens with different growth potential and submitted to heat stress. *Brazilian Journal of Poultry Science*, Campinas, v. 9, n.3, p. 181-186, 2007.

ROSTAGNO, H. S.; ALBINO, L. F. T.; DONZELE, J. L.; GOMES, P. C.; OLIVEIRA, R. F.; LOPES, D. C.; FERREIRA, A. S.; BARRETO, S. L. T.; EUCLIDES, R. F. *Tabela brasileira para aves e suínos. Composição de alimentos e exigências nutricionais*. Viçosa, MG: UFV, Imprensa Universitária, 2011. 252 p.

SACRANIE, A.; SVIHUS, B.; DENSTADLI, V.; MOEN, B.; IJI, P. A.; CHOCT, M. The effect of insoluble fiber and intermittent feeding on gizzard development, gut motility, and performance of broiler chickens. *Poultry Science*, Champaign, v. 91, n. 3, p. 693-700, 2012.

SAKOMURA, N. K.; ROSTAGNO, H. S. *Métodos de pesquisa em nutrição de monogástricos*. Jabotical: Funep, 2007. 283 p.

SAKOMURA, N. K.; LONGO, F. A.; RABELLO, C. B. A.; WATANABE, K.; PELÍCIA, K.; FREITAS, E. R. Efeito do nível de energia metabolizável da dieta no desempenho e metabolismo energético de frangos de corte. *Revista brasileira de Zootecnia*, Viçosa, MG, v. 33, n. 6, p.1758-1767, 2004.

SANTOS NETA, E. R.; VAZ, R. G. M. V.; RODRIGUES, K. F.; SOUSA, J. P. L.; PARENTE, I. P.; ALBINO, L. F. T.; SIQUEIRA, J. C.; ROSA, F. C. Níveis de inclusão da torta de babaçu em rações de frangos de corte na fase inicial. *Revista Brasileira de Saúde e Produção Animal*, Salvador, v. 12, n. 1, p. 234-243, 2011.

SANTOS, P. A.; YANAGI JUNIOR, T.; TEIXEIRA, V. H. Ambiente térmico no interior de modelos de galpões avícolas em escala reduzida com ventilação natural e artificial dos telhados. *Engenharia Agrícola*, Jaboticabal, v. 25, n. 3, p. 575-584, 2005.

SILVA, E. P.; SILVA, D. A. T.; RABELLO, C. B.; LIMA, R. B.; LIMA, M. B.; LUDKE, J. V. Composição físico-química e valores energéticos dos resíduos de goiaba e tomate para frangos de corte de crescimento lento. *Revista Brasileira de Zootecnia*, Viçosa, MG, v. 38, n. 6, p. 1051-1058, 2009.

SILVA, J. H. V.; COSTA, F. G. P. *Tabela para codornas japonesas e europeias*. 2. ed. Jaboticabal: FUNEP. 2009. 110 p.

SILVA, J. H. V.; JORDÃO FILHO, J.; COSTA, F. G. P.; LACERDA, P. B.; VARGAS, D. G. V.; LIMA, M. R. Exigências nutricionais de codornas. *Revista Brasileira de Saúde e Produção Animal*, Salvador, v. 13, n. 3, p. 775-790, 2012.

SILVA, J. H. V.; LIMA, R. B.; LACERDA, P. B.; OLIVEIRA, A. C. Digestão e absorção de lipídeos. In: SAKOMURA, N. K.; SILVA, J. H. V.; COSTA, F. G. P.; FERNANDES, J. B. K.; HAUSCHILD, L. *Nutrição de não ruminantes.* Jaboticabal: FUNEP, 2014. p. 64-76.

SILVA, M. C.; SIQUEIRA, J. C.; VAZ, R. G. M. V.; RODRIGUES, K. F.; ALBINO, L. F. T.; SOUSA, L. F.; NEIVA, A. C. G. R.; FONSECA, F. L. R.; SOUSA, J. P. L.; PARENTE, I. P.; CAMPOS, C. F. A.; SILVA, A. S. R. Substituição do farelo de soja pela torta de babaçu em rações balanceadas para frangos de corte de 1 a 21 dias de idade. *Semina: Ciências Agrárias*, Londrina, v. 36, n. 6, p. 3947-3956,

SILVA, M. C.; SIQUEIRA, J. C.; VAZ, R. G. M. V.; RODRIGUES, K. F.; SILVA, G. F.; NEIVA, A. C. G. R.; SILVA, G. F.; FONSECA, F. L. R.; SOUSA, C. F. A.; CUNHA, L. P. N. Substituição do farelo de soja pela torta de babaçu em rações para frangos de corte dos 22 aos 42 dias de idade. *Semina: Ciências Agrárias*, Londrina, v. 36, n. 2, p. 1099-1110, 2015b.

SOUSA, M. S.; TINOCO, I. F. F.; BARRETO, S. L. T.; AMARAL, A. G.; PIRES, L. C.; FERREIRA, A. S. Determinação de limites superiores da zona de conforto térmico para codornas de corte aclimatizadas no Brasil de 22 a 35 dias de idade. *Revista Brasileira de Saúde e Produção Animal*, Salvador, v. 15, n. 2, p. 350-360, 2014.

TINÔCO, I. F. F. A granja de frango de corte. In: MENDES, A. A.; NAAS, I. A.; MACARI, M. *Produção de frangos de corte*. Campinas: FACTA, 2004. p. 55-85.

TURNPENNY, J. R.; WATHES, C. M.; CLARK, J. A.; MCARTHUR, A. J. Thermal balance of livestock. 2. Applications of a parsimonious model. *Agricultural and Forest Meteorology*, Amsterdam, v. 101, n. 1, p. 29-52, 2000.