Acta Scientiarum

http://periodicos.uem.br/ojs/acta
ISSN on-line: 1807-8672
Doi: 10.4025/actascianimsci.v42i1.48281

NONRUMINANTES NUTRITION

Passion fruit waste in diets for quail in the laying phase

Adriana Aparecida Pereira[1*], Rosineide Silva de Alcântara[2], Andressa Souza de Moura[2], Dirceu Neutzling Griep Júnior[1], Gisele Maria Nunes Vieira[1] and José Rafael da Silva Almeida[1]

[1]Universidade Federal de Alagoas, Campus Arapiraca, Avenida Manoel Severino Barbosa, s/n, Bom Sucesso, 57309-005, Arapiraca, Alagoas, Brazil. [2]Centro de Ciências Agrárias, Universidade Federal de Alagoas, Rio Largo, Alagoas, Brazil. *Author for correspondence. E-mail: adri_zoo@hotmail.com

ABSTRACT. It was aimed to evaluate the effect of including the waste from passion fruit pulp extraction in diets for Japanese quail in the laying phase on their production performance and egg quality. A total of 280 female quail were distributed into five treatments with eight replicates and seven birds per cage. Treatments consisted of 0, 2, 4, 6, or 8% inclusion of passion fruit waste in the diet. The experiment began with quail at 70 days of age and lasted 63 days, with performance evaluated every 21 days and egg quality in the last two days of each cycle. There was no difference between the treatments for feed intake, body weight, specific gravity, or eggshell thickness. However, a decreasing linear regression was obtained for feed intake with the inclusion of the waste, while a quadratic response was show by egg production, weight and parts of the egg. Inclusion of up to 6% passion fruit waste in diets for quail is recommended to maintain the indices in relation to control treatment. However, the best values for egg-laying rate and for the weights of egg, albumen, yolk, and shell are obtained with 2.5 to 3.5% inclusion of passion fruit waste.

Keywords: by-product; egg quality; performance.

Received on June 10, 2019.
Accepted on July 15, 2019.

Introduction

Quail diets have a higher protein content than chicken and layer diets, which renders the feeding cost of quail per unit of meat or egg product supposedly higher (Silva, 2009). Moreover, the prices of raw materials like corn and soybean fluctuate over the year, making the feed cost unstable.

By-products or wastes generated by raw material-processing food industries can be used in animal feeding. Brazil is the largest producer and exporter of passion fruit juice, and the northeast region is the most productive in the country (Instituto Brasileiro de Geografia e Estatística [IBGE], 2015). The main by-products of the passion fruit juice extraction are the peel and seeds derived from its processing, which account for 65 to 70% of the fruit weight (Oliveira et al., 2002) and which are often not used, becoming a serious environmental problem (Togashi et al., 2007).

Seeds have stood out for being good sources of essential fatty acids (73.14% linoleic, 13.83% oleic, and 0.41% linolenic acid), proteins, and minerals (Ferrari, Colossi, & Ayub, 2004). However, they contain over 40% crude fiber, represented by soluble and insoluble fibers at similar quantities.

Research on the use of this waste for quail is still sparse, which suggests the need for a better assessment of the effects of their inclusion in diets for these birds. The present study was proposed to evaluate levels of inclusion of passion fruit waste in diets for Japanese quail in the laying phase on their production performance and egg quality.

Material and methods

The experiment took place in the Poultry Farming Unit of the Federal University of Alagoas, Arapiraca Campus, from October 2014 to January 2015.

For the experiment, 280 female Japanese quail (*Coturnix japonica*) were used. In the developer and grower phases, the quail were fed a corn- and soybean meal-based diet, as recommended by Rostagno et al. (2011).

A completely randomized design was adopted, with five treatments and eight replicates with seven birds per cage, totaling 40 plots. The total experimental period was 63 days, with egg quality and performance parameters evaluated on three occasions, every 21 days.

The shed was equipped with lateral curtains to help control the temperature and internal ventilation of the shed. A lighting program of 17 h of light per day (natural + artificial) was adopted. In the morning, the eggs were counted per plot and collected for a later calculation of the percentage of eggs. The temperature and relative humidity (RH) of the air were measured daily using a digital thermo-hygrometer, which recorded average maximum and minimum temperatures and RH of 31.8 and 23.8°C and 78.4 and 44.1%, respectively.

At 70 days of age, the quail had an average weight of 176 g and an egg-laying rate of 90.8%. Selected birds were housed in the plots as evenly as possible, with a maximum variation of 5% between the paddocks. The quail were distributed into galvanized-wire battery cages with aluminum trays beneath them for excreta collection. Water was supplied in automatic nipple drinkers, and the feed was provided *ad libitum* in trough feeders. Birds were weighed at the start and end of the experimental period to monitor their body weight.

The passion fruit used was composed of seeds and a little pulp that was adhered to the seeds, obtained after the pulp extraction for juice making. This waste was obtained from a cooperative in the municipality of Maragogi - AL. The material was moist; therefore, it was dried in the sun and stirred twice daily, over a period of five days. After dried, it was passed through a forage chopper and through a 4-mm sieve to acquire a meal form for later inclusion in the experimental diets.

The chemical composition of the passion fruit waste used in the diet formulations was indicated by Malacrida and Jorge (2012), containing 92.62% dry matter, 12.23% crude protein, 30.32% ether extract, 48.73% crude fiber, and 1.27% ash.

Five experimental diets were formulated according to the recommendations of Rostagno et al. (2011), considering the requirements for Japanese quail in the laying phase: a corn- and soybean meal-based control diet, and others including 2, 4, 6, and 8% passion fruit waste (Table 1).

Table 1. Composition of experimental diets.

	Inclusion of passion fruit waste (%)				
Ingredient	0.0	2.0	4.0	6.0	8.0
Corn grain	54.88	53.37	52.11	49.74	49.34
Soybean meal	34.92	34.67	33.72	35.00	34.30
Passion fruit waste	-	2.00	4.00	6.00	8.00
Choline chloride	0.04	0.04	0.04	0.04	0.04
Dicalcium phosphate	1.04	1.06	1.07	1.11	1.12
Limestone	6.65	6.64	6.64	6.67	6.68
Common salt	0.32	0.32	0.32	0.32	0.35
Soybean oil	1.57	1.30	1.00	0.76	0.450
DL-methionine	0.33	0.34	0.38	0.36	0.38
L-lysine HCl	0.09	0.11	0.15	0.15	0.16
Vit. premix Layer[1]	0.10	0.10	0.10	0.10	0.10
Min. premix Poultry[2]	0.05	0.05	0.05	0.05	0.05
Antioxidant[3]	0.01	0.01	0.01	0.01	0.01
Total	100.00	100.00	100.00	100.00	100.00
Nutritional and energy composition					
Met. energy (kcal kg^{-1})	2,800	2,800	2,800	2,800	2,800
Crude protein (%)	20.388	20.388	20.388	20.667	20.398
Calcium (%)	2.909	2.909	2.909	2.901	2.906
Sodium (%)	0.145	0.145	0.145	0.144	0.144
Lipids (%)	4.158	4.149	4.187	4.150	4.130
Total phosphorus (%)	0.303	0.303	0.303	0.303	0.303
Total gly + ser (%)	1.936	1.908	1.853	1.849	1.827
Total phenyl + tyr (%)	1.746	1.720	1.671	1.696	1.647
Total histidine (%)	0.545	0.536	0.521	0.527	0.511
Total isoleucine (%)	0.888	0.876	0.851	0.867	0.842
Total leucine (%)	1.738	1.706	1.656	1.663	1.615
Total lysine (%)	1.174	1.174	1.174	1.174	1.174
Total met + cys (%)	0.951	0.951	1.371	0.954	0.956
Total methionine (%)	0.620	0.626	0.630	0.637	0.648
Total arginine (%)	1.369	1.352	1.313	1.340	1.302
Total phenylalanine (%)	1.027	1.012	0.983	0.997	0.969
Total threonine (%)	0.797	0.785	0.762	0.771	0.749
Total tryptophan (%)	0.252	0.249	0.242	0.248	0.241
Total valine (%)	0.974	0.960	0.932	0.945	0.918

[1]Provides per kg of diet: 1,000 mg folic acid; 1,562 mg pantothenic acid; 100 µg biotin; 3,980 mg niacin; 7,000,000 IU vit. D3; 2,000 mg vit. E; 3,000 µg vit. B12; 4,000 mg vit. B2; 3,000 mg vit. B; 2,100,000 IU vit. D3; 2,000 mg vit. K3; 200 mg selenium; 100,000 mg antioxidant. [2]Provides per kg of diet: 70,000 mg zinc (min.); 1,500 mg iodine (min.); 8,500 mg copper (min.); 75,000 mg manganese (min.); 50,000 mg iron (min.); 200 mg cobalt. [3]BHT.

With the increasing levels of inclusion of passion fruit waste, 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^{-1} diet). Additionally, the synthetic amino acids l-lysine and dl-methionine were used to keep the diets isoproteic (20.33%).

At the start and end of the 21-day cycles, the feed remaining in the troughs and buckets from each plot was weighed to calculate feed intake and feed conversion per dozen eggs and per mass of eggs produced. On the last two days of each cycle, all eggs from each plot were collected and weighed on a precision scale (0.001g) to determine the average weight of the eggs.

After being identified, the eggs were analyzed for specific gravity by being immersed in saline solutions (NaCl) with different densities (1.050 to 1.100, at intervals of 0.005g cm^{-3}). The three most homogeneous eggs were cracked, the yolk was separated from the albumen, and then the yolk was weighed.

The shells of homogeneous eggs were washed and left to dry at room temperature. After 48 h, they were weighed, and their thickness was measured with a digital caliper. The albumen weight was obtained as the difference between the weights of egg, yolk, and shell of each identified egg.

The data from these analyses were subjected to variance and regression analyses ($p < 0.05$) using the GLM procedure (General Linear Models) of the Statistical Analysis System (SAS, 2003), which made it possible to estimate the best level of inclusion of passion fruit waste. To compare the results obtained between control diet and each of the passion fruit waste levels tested, the data were subjected to Dunnett's test at the 5% probability level.

Results and discussion

In general, an environment is considered comfortable for adult birds when the temperature is 21 °C and the relative humidity of the air is between 57 and 69% (Oliveira et al., 2006). However, such values are seldom found in commercial production conditions, especially in the Brazilian Northeast and during the summer. Therefore, during the experimental periods, the quail were found to be under moderate heat stress (31.8 to 23.8°C), but the relative humidity was adequate on most days (78.4 to 44.1%). This fact indicates that, when reared in thermal-discomfort temperatures (especially hot temperatures), quail have their performance compromised (Souza et al., 2014). However, the control-treatment data indicate that even under thermal discomfort, the quail had satisfactory performance and egg quality.

There was a difference between the passion fruit waste levels for feed intake and egg weight; however, no significance was observed for laying rate, feed conversion, or body weight. In a comparison of each treatment with control, the level of 8% of inclusion of the waste provided differences for feed intake and egg weight (Table 2).

Table 2. Production performance of the quail in the laying phase.

Variable	Inclusion of passion fruit waste (%)					P value	SEM	CV
	0.0	2.0	4.0	6.0	8.0			(%)
FI (g quail^{-1} day^{-1})[1]	29.08	27.09	26.42	26.28	25.89*	0.03	0.13	6.54
Egg weight (g)[2]	11.67	11.76	11.72	11.80	11.16*	0.01	0.06	3.55
Laying rate (%)	91.68	89.61	90.19	89.39	91.28	0.07	1.21	4.27
FC (g dz^{-1})	376.43	362.88	364.96	370.25	361.25	0.25	<0.01	11.24
FC (g g^{-1})	2.61	2.52	2.55	2.56	2.63	0.21	0.03	8.34
Initial weight (g)	178.35	176.28	174.75	176.76	175.5	0.18	<0.01	2.92
Final weight (g)	186.90	180.70	179.10	183.96	181.58	0.13	<0.01	3.87
Weight gain (g)	8.55	4.42	4.35	7.20	6.08	0.20	<0.01	4.89

FI = feed intake; FC (g dz^{-1}) = feed conversion per dozen eggs; FC (g dz^{-1}) = feed conversion per mass of eggs produced; Prob = probability; SEM = standard error of the mean; CV = coefficient of variation; [1] = linear regression (FI (g quail^{-1} day^{-1}) = –35.95 PFW + 28.39, R^2 = 0.88); [2] = quadratic regression (EW (g) = –0.0234 PFW^2 + 0.1386 PFW + 11.625, R^2 = 0.80); * = significant by Dunnett's test at 5%.

Feed intake decreased linearly as the level of passion fruit waste (PFW) in the diet was increased, as shown by the equation FI (g quail^{-1} day^{-1}) = –35.95 PFW + 28.39 (R^2 = 0.88).

Because the passion fruit is rich in ether extract, as its inclusion levels were elevated, we had to reduce the inclusion of soybean oil in the diet so all diets remained isoenergetic (2,800 kcal kg^{-1} diet). The fact that the diets are distinct might have increased the net energy of those with a greater inclusion of the waste, which might have led to a reduction in feed intake, since the bird's energy requirement had been met.

This fact supports the chemotactic theory, which states that quail regulate their intake based on their energy requirement (Freitas et al., 2005). Further, because the waste is very high in pectin (around 18%), the declined feed intake might have been due to the satiety effect provided by the soluble fiber.

Treatments elicited a quadratic response from egg weight. For this variable, the optimal passion fruit waste inclusion level of 2.96% would provide eggs weighing 11.83 g, as shown by the following equation: EW (g) = –0.0234 PFW^2 + 0.1386 PFW + 11.625 (R^2 = 0.80).

The high levels of crude fiber (over 40%) present in the passion fruit waste might have impaired egg weight when more than 2.96% was present in the diet, because of the possible decrease in digestibility processes and nutrient absorption, coupled with a reduction of feed intake.

The levels of passion fruit waste in the diet did not lead to changes in egg-laying rate or in feed conversion analyzed both as the amount of feed consumed per dozen eggs produced or as the amount of feed consumed per egg mass. These data agree with the reports of Zanetti et al. (2016), who also did not observe the influence of up to 12.5% passion fruit seed waste for commercial layers.

No difference was found between the initial and final weight of the quail receiving the treatments, indicating that the decrease in feed intake with the inclusion of the waste was not sufficient to reduce the quail's weight. It can be inferred that the maintenance requirements were met with a lower amount of feed, but the production requirement was deficient, given the lower weight of the eggs.

Togashi et al. (2008), on the other hand, did not observe losses in the performance of broilers at 42 days, after including 8% passion fruit seed meal in their feeding. By contrast, Zanetti et al. (2017) noted a linear decrease in the feed conversion of broilers aged 1 to 42 days with the inclusion of 0 to 12.5% passion fruit seed waste.

No significant effect of the treatments was observed on specific gravity or eggshell thickness. However, the egg components responded quadratically to the passion fruit waste levels. When each treatment was compared with control, the inclusion level of 8% differed for the weight of albumen, yolk, and shell (Table 3).

Table 3. Mean values for quality parameters of quail eggs.

Variable	Inclusion of passion fruit waste (%)					Prob.	SEM	CV (%)
	0.0	2.0	4.0	6.0	8.0			
Spec. gravity (g cm^{-3})	1.071	1.073	1.073	1.072	1.073	0.38	<0.01	0.15
Shell thick. (mm)	0.227	0.226	0.229	0.227	0.226	0.35	<0.01	3.26
Albumen (g)[1]	7.15	7.21	7.20	7.29	6.77*	<0.01	0.05	4.28
Yolk (g)[1]	3.54	3.57	3.60	3.64	3.45*	0.03	0.02	4.49
Shell (g)[1]	0.90	0.90	0.91	0.91	0.87*	0.01	<0.01	3.58

Prob = probability; SEM = standard error of the mean; CV = coefficient of variation; [1] = quadratic regression; * = significant by Dunnett's test at 5%.

The use of up to 8% passion fruit waste did not compromise specific gravity or eggshell thickness, which are parameters associated with the external egg quality. When high-fiber diets are used, the eggshell quality is expected to be changed, since the fibers are negatively associated with calcium absorption (Buzinato et al., 2006). However, this fact was not observed in the present study.

These data corroborate the findings of Zanetti et al. (2016), who also did not see differences in specific gravity testing treatments with up to 12.5% passion fruit seed waste in diets for commercial layers.

Treatments affected the weights of albumen, yolk, and eggshell, which responded quadratically (Table 4).

Table 4. Effect of quadratic regression of the levels of passion fruit waste (PFW) on the weights of albumen, yolk, and shell.

Regression equation	R^2	Optimal level (%)	Weight (g)
Albumen = –0.071799 PFW^2 + 0.358320 PFW + 6.84266	0.77	2.50	7.29
Yolk = –0.031887 PFW^2 + 0.178654 PFW + 3.377030	0.70	2.80	3.63
Shell = –0.007590 PFW^2 + 0.041738 PFW + 0.864536	0.76	2.75	0.92

As occurred with egg weight, the egg components (yolk, albumen, and shell) also had optimal weight values with the inclusion of 2.5 to 3.0% passion fruit waste, suggesting that the variation in egg weight was a result of the change in the weight of all its components.

It should be stressed that no scientific studies have been found investigating the use of passion fruit waste in the feeding of Japanese quail during the laying phase. On this basis, this product is a new option in quail farming.

Conclusion

The inclusion of up to 6% passion fruit waste in diets for Japanese quail in the laying phase is recommended to maintain the indices in relation to control treatment (without waste). However, the best values for egg-laying rate and for the weights of egg, albumen, yolk, and shell are obtained with 2.5 to 3.5% inclusion of passion fruit waste.

References

Buzinato, E. F., Almeida, R. N. A., & Mazeto, G. M. F. S. (2006). Biodisponibilidade de cálcio dietético. *Arquivo Brasileiro de Endocrinologia e Metabolismo, 50*, 852-861. doi: 10.1590/S0004-27302006000500005

Ferrari, R. A.; Colossi, F.; & Ayub, R. A. (2004). Caracterização de subprodutos da industrialização do maracujá - Aproveitamento das Sementes. *Revista Brasileira de Fruticultura, 26*(1), 101-102. doi: S0100-29452004000100027.

Freitas, A. C., Fuentes, M. F. F., Freitas, E. R., Sucupira, F. S., & Oliveira, B. C. M. (2005). Efeito de níveis de proteína bruta e de energia metabolizável na dieta sobre o desempenho de codornas de postura. *Revista Brasileira de Zootecnia, 34*(3), 838-846. doi: 10.1590/S1516-35982005000300015

Instituto Brasileiro de Geografia e Estatística [IBGE]. (2015). *Produção da Pecuária Municipal* 2015 (Vol. 43, p. 1-49). Rio de Janeiro, RJ: IBGE. Retrieved from https://biblioteca.ibge.gov.br/visualizacao/periodicos/84/ppm_2015_v43_br.pdf

Malacrida, C. R., & Jorge, N. (2012). Yellow passion fruit seed oil (*Passiflora edulis f. flavicarpa)*: physical and chemical characteristics. *Brazilian Archives Biology Technology, 55*, 127-134. doi: 10.1590/S1516-89132012000100016

Oliveira, L. F., Nascimento, R. F., Borges, S. V., Ribeiro, P. C., & Ruback, V. R. (2002). Aproveitamento alternativo da casca do maracujá-amarelo (*Passiflora Edulis F. Flavicarpa*) para produção de doce em calda. *Ciência e Tecnologia de Alimentos, 22*(3), 259-262. doi: 10.1590/S0101-20612002000300011

Oliveira, R. F. M., Donzele, J. L., Abreu, M. L. T., Ferreira, R. A., Vaz, R. G. M. V. & Cella, P. S. (2006). 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, 35*(3), 797-803. doi: 10.1590/S1516-35982006000300023

Rostagno, H. S., Albino, L. F. T., Donzele, J. L., Gomes, P. C. Oliveira, R. F. M., Lopes, D. C., ... Barreto, S. L. T. (2011). *Tabelas Brasileiras para Aves e Suínos. Composição de alimentos e exigências nutricionais*. Viçosa, MG: UFV.

Statistical Analysis System [SAS]. (2003). *SAS/STAT User's guide, Version* 9.1. Cary, NC: SAS Institute Inc.

Silva, J. H. V., & Costa, F. G. P. (2009). *Tabela para Codornas Japonesas e Européias*. Jaboticabal, SP: Funep.

Sousa, M. S., Tinôco, I. F. F., Barreto, S. L. T., Amaral, A. G.; Pires, L. C., & Ferreira, A. S. (2014). 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, 15*(2), 350-360. doi: 10.1590/S1519-99402014000200019

Togashi, C. K., Fonseca, A. B., Soares, R. T. R. N., Gaspar, A., & Detmann, E. (2007). Composição em ácidos graxos dos tecidos de frangos de corte alimentados com subprodutos de maracujá. *Revista Brasileira de Zootecnia, 36*(6), 2063-2068. doi: 10.1590/S1516-35982007000900016

Togashi, C. K., Fonseca, A. B., Soares, R. T. R. N., Costa, A. P. D., Silveira, K. F., & Detmann, E. (2008). Subprodutos do maracujá em dietas para frangos de corte. *Acta Scientiarum. Animal Sciences, 30*(4), 395-400. doi: 10.4025/actascianimsci.v30i4.948

Zanetti, L. H., Murakami, A. E., Diaz-Vargas, M., Guerra, A. F. Q. G., Ospina-Rojas, I. C., Nascimento, G. R., ... Pintro, P. T. M. (2016). By-product of passion fruit seed (*Passiflora edulis*) in the diet of commercial laying hens. *Canadian Journal of Animal Science, 96*(4), 488-494. doi: 10.1139/cjas-2016-0027

Zanetti, L. H., Murakami, A. E., Diaz-Vargas, M., Guerra, A. F. Q. G., Ospina-Rojas, I. C., Nascimento, G. R., ... Pintro, P. T. M. (2017). By-product of passion fruit seed (*Passiflora edulis*) in the diet of broilers. *Canadian Journal of Animal Science, 98*(1). doi: 10.1139/cjas-2016-0210