DOI: 10.1590/1809-6891v24e-73851E

Ciência Animal Brasileira
Brazilian Animal Science

e-ISSN 1809-6891

Section: Animal science
Research article

Vegetable lipid sources in the diet of japanese quails in the rearing phase and effects on the initial phase of production

Fontes lipídicas vegetais na alimentação de codornas japonesas em fase de recria e sua repercussão na fase inicial de produção

Jean Kaique Valentim[1*], Rodrigo Garófallo Garcia[1], Maria Fernanda de Castro Burbarelli[1], Cláudia Marie Komiyama[1], Felipe Cardoso Serpa[1], Fabiana Ribeiro Caldara[1], Janaína Palermo Mendes[2], Rita Therezinha Rolim Pietramale[1], Deivid Kelly Barbosa[1], Luiz Fernando Teixeira Albino[3]

[1]Universidade Federal da Grande Dourados (UFGD), Dourados, Mato Grosso do Sul, Brazil
[2]Universidade Federal de Mato Grosso do Sul (UFMS), Campo Grande, Mato Grosso do Sul, Brazil
[3]Universidade Federal de Viçosa (UFV), Viçosa, Minas Gerais, Brazil
[*]Corresponding author: kaique.tim@hotmail.com

Abstract
This study aims to evaluate the residual effect of different lipid sources in the diet of Japanese quails (*Coturnix japonica*) in the rearing phase on the performance and egg quality in the initial phase of egg-laying. In the first stage, 400 Japanese quails aged 21 days were used, being distributed in a completely randomized experimental design, with five treatments and ten replicates of eight birds/replicate Treatments consisted of basal ration (BR) with 2.5% soybean oil; BR with 2.5% corn oil; BR with 2.5% cottonseed oil; BR with 2.5% sunflower oil; and BR with 2.5% canola oil. At 42 days, maintaining the initial design, all quails received a basal ration with soybean oil, in order to evaluate the residual effect of the previous phase on the performance and egg quality in the initial phase of egg-laying (43 - 84 days). The different lipid sources did not affect the performance of quails in the initial phase of production. For egg quality, yolk height, yolk diameter, yolk index, gravity, and Haugh unit (HU) showed better results in the treatment using sunflower oil. There was a residual effect of the use of lipid sources of vegetable origin in the rearing phase diet of Japanese quails on egg quality traits. Lipid sources from soybean, corn, cottonseed, canola, and sunflower seeds can be used as energy sources in the rearing diet of egg-laying quails for not being harmful to their initial performance. The longevity in egg production of quails fed with different lipid sources in the rearing phase was similar.
Keywords: Residual effect; laying phase; vegetable oils; effect on egg-laying.

Resumo
A pesquisa foi conduzida com objetivo de avaliar o efeito residual de diferentes fontes lipídicas na dieta de codornas japonesas (*Coturnix japonica)* na fase de recria sob o desempenho e a qualidade de ovos na fase inicial de postura. Na primeira etapa foram utilizadas 400 codornas japonesas com idade de 21 dias, as aves foram distribuídas em tratamentos seguindo um delineamento inteiramente casualizado com dez repetições, de oito aves, em cinco tratamentos: ração basal (RB) com 2,5% de óleo de soja, RB com 2,5 % de óleo de milho, RB com 2,5% de óleo algodão, RB com 2,5% de óleo de girassol e RB com 2,5% de óleo de canola. Aos 42 dias mantendo o delineamento inicial, todas aves receberam ração basal com óleo de soja, para que fosse avaliado o efeito residual da fase anterior sobre o desempenho e a qualidade dos ovos na fase inicial de postura (43 - 84 dias). As diferentes fontes lipídicas não afetaram o desempenho das aves na fase inicial de produção. Para a qualidade dos ovos, os parâmetros de altura, diâmetro e índice de gema, gravidade e UH foram melhores no tratamento com utilização de óleo de girassol. Houve efeito residual da utilização de fontes lipídicas de origem vegetal na dieta em fase de recria de codornas japonesas sobre as características da qualidade dos ovos. As fontes lipídicas oriundas das sementes de soja, milho, algodão, canola e girassol podem ser utilizadas como ingredientes energéticos na dieta de recria de codornas poedeiras por não serem prejudiciais ao desempenho inicial das aves. A longevidade na produção dos ovos das aves alimentadas com diferentes fontes lipídicas na fase de recria foi semelhante.
Palavras-chave: Efeito residual; fase de postura; óleos vegetais; repercussão da postura.

1.Introduction

Quail farming is a segment of poultry farming that aims to breed, improve, and promote quail production. Quails have traits of great propensity for production, such as rapid growth, sexual precocity, high rusticity, and low food consumption. Quail farming is an option for poultry farming for being less costly and having a simplified management([1,2]), especially in nutritional aspects, due to the high feed conversion efficiency of the quails.

Among nutritional benefits in quail farming, performance improvements can be obtained through the fulfillment of energy requirements when using the correct percentage of oils or fat in the rations. In addition, lipids also contribute to fulfill essential fatty acid requirements, transporting liposoluble vitamins and improving palatability([3]).

The main lipid source used in the diets of non-ruminant animals is soybean oil. However, the industry has some difficulties in producing this oil ([4]) due to high demand. In this context, seeking food sources that improve production and reduce feed costs is relevant in the poultry

Received: August 25, 2022. Accepted: October 19, 2022. Published: December 27, 2022.

sector [5]. Thus, alternative products are being sought for this production, such as palm, corn, and sunflower oils [6], which have marked differences in their nutritional content. These differences are mostly related to their origin (plant or animal), which determines their degree of absorption in the animal organism [7], consequently affecting their performance.

Studies on nutrition in the growth phase of Japanese quails have great relevance, as these birds present rapid growth, which can result in early sexual maturity [8]. The nutritional conditions established during the growth period can influence the performance of birds in the production phase. However, most of the studies on quails aim to determine the levels and requirements of birds in the production period, with the initial phases being still little explored.

Therefore, this paper aims to evaluate the residual effects on performance and egg quality in the initial phase of egg-laying of Japanese quails (*Coturnix japonica*) fed with different lipid sources in the rearing phase.

2. Material and methods

The study was submitted and approved by the Research Ethics Committee of the Federal University of Grande Dourados (UFGD, acronym in Portuguese) under protocol number 16/2020. The experiment was carried out in the quail farming sector of the Faculty of Agricultural Sciences, UFGD, municipality of Dourados, Mato Grosso do Sul State (22º13'16" South Latitude and 54°48'20" West longitude, 449-477 m altitude). According to the Köppen classification, the climate of the region is Cwa (humid mesothermal), with rainy summers and dry winters, average annual rainfall of 1,500 mm, and average annual temperature of 22ºC.

The birds were housed in a masonry poultry house (6.0 m long, 2.5 m wide, and 3.5 m high) with a concrete floor, roof with fiber cement tiles, walls 0.60 m high and 0.50 m long, polyethylene yellow curtains in the external side with manual activation, and two air conditioners to control the poultry house temperature. The total experimental period comprised 63 days divided between the rearing phase (21 - 42 days) and the initial phase of egg-laying (42 - 84 days).

In the first phase of the experiment, 400 Japanese quails aged 21 days with average weight of 82.62 ± 3.71 (g) and reared in experimental cages were used, being distributed in a completely randomized experimental design, with five treatments and ten replicates of eight birds/replicate. Treatments consisted of basal ration (BR) with 2.5% soybean oil; BR with 2.5% corn oil; BR with 2.5% cottonseed oil; BR with 2.5% sunflower oil; and BR with 2.5% canola oil. Isonutritive diets were used, according to the recommendation of the National Research Council - NRC [9], as shown in Table 1.

Table 1. Percentage and calculated composition of experimental diets for quails in the rearing phase (21 to 42 days)

Ingredients	Lipid sources				
	Soy	Corn	Cotton	Sunflower	Canola
Ground corn	49.229	49.246	49.070	49.070	49.235
Soybean meal	43.351	43.351	43.636	43.636	43.340
Corn starch	0.000	0.000	0.900	0.000	0.000
Inert	2.000	2.000	1.100	2.000	2.000
Lipid source	2.500	2.500	2.500	2.500	2.500
Limestone	1.226	1.214	1.226	1.226	1.226
Dicalcium phosphate	0.893	0.892	0.891	0.8905	0.893
Common salt	0.320	0.320	0.320	0.320	0.320
DL-methionine	0.165	0.158	0.156	0.156	0.165
L-lysine	0.116	0.119	0.000	0.000	0.120
Mineral premix [1]	0.100	0.100	0.100	0.100	0.100
Vitamin premix [2]	0.100	0.100	0.100	0.100	0.100
Calculated nutritional composition					
EM (kcal/kg)	2900.00	2900.00	2900.00	2900.00	2900.00
Crude protein (%)	24.00	24.00	24.00	24.00	24.00
Digestible lysine (%)	13.401	13.401	13.401	13.401	13.401
Digestible methionine + Cystine (%)	0.8949	0.8949	0.8949	0.8949	0.8949
Total methionine (%)	0.5000	0.000	0.5000	0.5000	0.5000
Calcium (%)	0.800	1.092	1.092	1.092	1.092
Available phosphorus (%)	0.300	0.300	0.300	0.300	0.300
Total phosphorus (%)	0.5269	0.5269	0.5269	0.5269	0.5269
Sodium (%)	0.1500	0.1500	0.1500	0.1500	0.1500

[1]Vitamin supplement/kg of diet: folic acid (min.) 145.4 mg; pantothenic acid (min.) 5931.6 mg; choline (min.) 121.8 g; niacin (min.) 12.9 g; Selenium (min.) 480.0 mg; vitamin A (min.) 5,000,000.0 IU; vitamin B12 (min.) 6,500.0 mcg; vitamin B2 (min.) 2000.0 mg; vitamin B6 (min.) 250.0 mg; vitamin D3 (min.) 1,850,000.0 IU; vitamin E (min.) 4,500.0 IU; vitamin K3 (min.) 918.0 mg. [2]Mineral supplement/kg: copper (min.) 7,000.0 mg; iron (min.) 50.0 g; iodine (min.) 1500.0 mg; manganese (min.) 67.5 g; zinc (min.) 45.6 g.

The quails remained in a photoperiod of 24 hours of artificial light (same lamps used as a heating source) until the 15th day of life, with the light being subsequently reduced every three days until reaching 12 hours of light at 42 days, thus reaching the natural photoperiod in order to prevent early sexual maturity. The birds were fed with rearing diets from 21 to 42 days; at the end of this stage, birds received a single ration from 42 to 84 days of age, which still complied with the distribution used in the previous phase. Feeding in this phase consisted of basal ration with the addition of soybean oil, so that the influence of the rearing phase on the initial phase of egg-laying could be evaluated. The single ration was calculated following the recommendations by Rostagno [(10)] (Table 2).

The experimental rations were fed ad libitum, three times a day, in a trough-type metal feeder covering the entire length of the cages. The feeder was divided according to each treatment and replicate. Water was also provided ad libitum in a nipple drinker.

Table 2. Percentage and calculated composition of the experimental diet for quails in the initial phase of egg-laying

Ingredients	% of inclusion
Corn	54.30
Soybean meal	33.00
Soybean oil	2.50
Limestone	7.40
Dicalcium phosphate	1.05
Mineral premix[1]	0.10
Vitamin premix[2]	0.10
DL-methionine	0.30
L – Lysine	0.20
Choline chloride (70%)	0.10
Salt (NaCl)	0.45
Inert	0.50
Calculated composition	
Metabolizable energy (Kcal/kg)	2800
Crude protein (%)	19.46
Digestible lysine (%)	1.08
Digestible methionine + Cystine (%)	0.94
Digestible tryptophan (%)	0.23
Digestible threonine (%)	0.68
Calcium (%)	3.07
Available phosphorus (%)	0.30
Sodium (%)	0.16
Crude fiber (%)	2.74

[1]Vitamin supplement/kg of diet: folic acid (min.) 145.4 mg; pantothenic acid (min.) 5931.6 mg; choline (min.) 121.8 g; niacin (min.) 12.9 g; Selenium (min.) 480.0 mg; vitamin A (min.) 5,000,000.0 IU; vitamin B12 (min.) 6,500.0 mcg; vitamin B2 (min.) 2000.0 mg; vitamin B6 (min.) 250.0 mg; vitamin D3 (min.) 1,850,000.0 IU; vitamin E (min.) 4,500.0 IU; vitamin K3 (min.) 918.0 mg. [2]Mineral supplement/kg: copper (min.) 7,000.0 mg; iron (min.) 50.0 g; iodine (min.) 1500.0 mg; manganese (min.) 67.5 g; zinc (min.) 45.6 g.

In both phases, the birds were housed in galvanized wire cages measuring 50 x 50 x 16.5 cm (length x width x height), containing two partitions of 25 x 50 cm totaling 1250 cm². The animal density per experimental unit in the rearing phase was 156 cm²/bird. In the initial phase of egg-laying, the density of 178 cm²/bird was used to ensure more space for the animals due to bird growth, according to recommendations for animal welfare. The daily management in the initial phase of egg-laying consisted of collecting and counting the eggs (with the number of broken, cracked, soft-shelled, and shell-free eggs being computed daily), providing the ration, cleaning the egg supports, and reading the temperatures (maximum and minimum) and relative air humidity (RH).

Temperatures and relative air humidity (RH) were monitored once a day, at 8:00 am, using dry-bulb, wet-bulb, maximum and minimum thermometers positioned in the center of the poultry house at the height of the dorso of the birds. The minimum and maximum temperatures of 25.21 ± 0.31 (°C) and 29.8 ± 0.18 (°C), respectively, and the maximum and minimum relative humidity (RH) of 82.0 ± 2.7 (%) and 45.0 ± 1.2 (%), respectively, were obtained. The activation of the air conditioners and control of the curtains were conducted by analyzing the daily temperature. In the initial phase of egg-laying (42 to 84 days), 16 hours of light were provided daily, with a gradual transition from 12 to 16 hours through an increase of one hour every three days. This light supply was controlled by an automatic clock (timer), which allows the lights to be turned on and off during the night and dawn, according to the procedure adopted in commercial farms.

2.1. Performance in the early phase of egg-laying

Feed leftovers from each plot were weighed and deducted from the amount of feed provided in order to obtain feed consumption. Bird deaths that occurred during the experiment were discounted and corrected to calculate the average feed intake, obtaining the average intake for the experimental unit. Viability analysis was calculated by the formula: , according to the methodology by Sakomura and Rostagno ([11]).

Daily weight gain was evaluated by weighing the experimental plots individually at the beginning and at the end of the production cycles. The average egg production was obtained by computing the number of eggs produced, including broken, cracked, and abnormal eggs (soft-shelled and shell-free eggs), being expressed as a percentage of the average number of birds in the period (egg/bird/day) and the number of birds housed at the beginning of the experiment (egg/bird housed), thus verifying the productive longevity of the birds

To determine the production of commercial eggs, the number of broken, cracked, soft-shelled, and shell-free eggs was deducted from the total egg production, with the ratio between intact eggs and total eggs produced during each period being subsequently calculated. Feed conversion per dozen eggs was calculated as the ratio of total feed consumption (expressed as kg) divided by the dozen eggs produced (kg/dozen), while feed conversion per egg mass was calculated as feed consumption in kilograms divided by total egg mass (kg/kg). The days on which the quails started production were recorded to verify the variables 'days for the first egg', 'days/50% egg-laying, and 'days/80% egg-laying'.

2.2. Egg quality

In order to verify the external and internal quality of the eggs, three intact eggs were collected from each plot in the morning in the last three days of the experimental period, totaling 450 eggs. The eggs were individually weighed on a semi-analytical scale, being subsequently analyzed for specific gravity. The specific gravity was determined from the immersion of eggs in saline solutions of different densities ranging from 1.065 to 1.125, with a variation of 0.005 for each solution, according to the methodology proposed by [12]. Densities were adjusted using a hydrometer and the eggs were submerged from the lowest to the highest saline concentration.

The eggs were subsequently broken, separating the albumen, yolk, and shell manually. Yolks were individually weighed on an analytical scale. Shells were washed in running water and dried in a natural environment for 72 hours, being individually weighed. Albumen weight was obtained by the difference between whole egg weight and yolk weight plus shell weight. Yolk and albumen height and yolk diameter were measured using a digital caliper and a tripod, with yolk height being measured in the central region, while albumen height was measured at approximately 1.0 cm from the yolk. The yolk index was calculated by the ratio between the height and diameter of this structure, according to [13].

The Haugh unit was calculated using its mathematical model, according to the methodology by[14]:

$$UH = 100 \log (H + 7.57 – 1.7W0. 37)$$

where: H = dense albumen height (mm); W = egg weight (g).

2.3. Statistical analysis

Data were checked for normality of the residuals using the Shapiro-Wilk test and for homogeneity of the variances using the Levene's test. Subsequently, data were submitted to analysis of variance using the SAS MIXED procedure (SAS 9.3). When significant effect was observed, comparisons of means were performed using the Tukey test. For all analyzes, a 5% significance level was used.

3. Results and discussion

There was no effect of the different lipid sources on the performance and egg production of the birds in the period of repercussion of the rearing phase (Table 3).

Table 3. Productive performance of Japanese quails in the initial phase of egg-laying as a function of different lipid sources in the rearing phase (42 to 84 days)

Variables	Lipid sources					SEM	P value
	Soybean	Corn	Cotton	Sunflower	Canola		
DWG bird/day (g)	2.17	2.16	2.26	2.13	2.25	0.025	0.4177
Individual consumption. (g)	29.07	30.58	28.51	29.12	28.31	0.379	0.3639
Initial production at the 42th day (%)	54.28	49.85	51.71	52.88	52.54	0.735	0.9585
Initial production of comercial eggs (%)	51.14	48.28	50.71	51.83	50.38	0.622	0.9723
Days 80% egg-laying (dias)	83.78	80.84	80.02	83.05	82.81	1.39	0.9102
Days 50% egg-laying (dias)	83.24	80.19	79.48	82.64	82.51	1.36	0.8882
Days first egg (days) (days)	32.30	32.00	31.70	32.40	31.90	0.141	0.5187
Egg mass (g)	41.60	42.30	41.60	41.40	41.60	0.272	0.8738
FC/m (g/g)	9.68	9.49	9.72	9.55	9.54	0.13	0.9818
FC/dozen (g/dozen)	810.89	767.13	783.23	794.57	787.10	0.42	0.6587
Viability from 42 to 84 days (%)	99.10	99.44	99.56	99.40	99.85	0.177	0.455

DWG bird/day g: daily weight gain; industrial consumption (g): individual feed intake from 42 to 84 days; FC/m g/g: feed conversion by mass; FC/dz (g/dz): feed conversion per dozen. SEM: standard error of the mean; P: probability.

When evaluating the effect of the lipid sources during the rearing phase on the initial period of production of the birds (42 to 84 days), it is verified that the performance of the quails was similar between the different treatments, with no differences for the beginning of egg-laying and the variables of production during the initial phase of egg-laying. Thus, the different oil sources can be used in the rearing phase without impairing the performance at the beginning of egg production. When evaluating the performance and egg quality of semi-heavy laying hens fed with soybean and canola oils at 0, 1, 2, and 3% levels in the diet, Costa et al. [15] did not observe significant effects of oil type on feed consumption, corroborating the present paper.

Ismail et al. [16] also did not verify significant differences in the feed conversion with the inclusion of canola oil in the diet for laying hens. However, in contrast to this paper, Costa et al. [15] found a lower feed conversion in laying hens as the percentage of canola oil increased when compared to soybean oil. The higher feed intake and higher feed conversion may be related to the lower metabolizable energy available in the feed containing canola oil.

The different lipid sources did not influence egg, yolk, and shell weight, as well as yolk, albumen, and shell percentage. However, yolk and albumen height, albumen weight, yolk diameter, specific gravity, yolk index, and HU were affected ($p<0.05$) by the lipid sources used (Table 4).

Table 4. Quality of Japanese quail eggs at the end of the initial phase (84th day) of egg-laying as a function of different lipid sources in the rearing phase

Variáveis	Lipid sources					SEM	P value
	Soybean	Corn	Cotton	Sunflower	Canola		
Egg weight (g)	9.940	9.805	9.755	9.723	9.397	0.060	0.0680
Shell weight (g)	2.699	2.701	2.664	2.785	2.714	0.024	0.6156
Albumen weight (g)	6.410a	6.253ab	6.242ab	6.130ab	5.876b	0.053	0.0264
Shell weight (g)	0.830	0.793	0.821	0.806	0.790	0.005	0.0843
Yolk (%)	27.354	27.823	27.511	28.568	29.167	0.271	0.1749
Albumen (%)	64.243	64.313	64.097	63.169	62.391	0.285	0.1408
Shell (%)	8.401	8.091	8.391	8.262	8.475	0.054	0.1918
Yolk height (cm)	10.896a	10.734a	10.598a	10.898a	10.020b	0.058	<0.0001
Yolk diameter (cm)	22.308a	21.464b	22.156ab	21.983ab	21.874ab	0.090	0.0363
Albumen height (cm)	4.712ab	4.802ab	4.687ab	5.046a	4.443b	0.051	0.0056
Specific gravity	1.086b	1.086b	1.086b	1.092a	1.088ab	0.001	0.0013
Yolk index	0.489a	0.501a	0.478ab	0.496a	0.462b	0.003	0.0001
Haugh unit	91.881ab	92.561ab	91.851ab	93.662a	90.694b	0.277	0.0134

Means followed by different letters on the line differ from each other by Tukey's test at the 5% probability level.

Canola oil in the diet of birds provided a shorter yolk height compared to the other oils. Yolk diameter was smaller in the treatment with corn oil when compared to soybean oil. The diet using sunflower oil resulted in higher albumen height, specific gravity, and yolk index, consequently providing a higher Haugh unit when compared to the treatment with canola oil. As reported by Baucells et al. [17], sunflower oil is considered the most unsaturated oil among vegetable oils, as it is rich in omega-6 fatty acids, especially linoleic acid. This author reported that the greater the oil unsaturation, the greater its digestibility, which can explain the best performance of egg quality of birds from this treatment.

The Haugh Unit of eggs from all diets showed a superior quality than the minimum recommended by the EGG-Grading Manual [18], and the diet containing sunflower oil presented the highest HU (93.662). According to Oliveira et al. [19], the percentages of egg yolk produced by laying hens fed with diets using sunflower and canola oils and with a diet without the addition of oils were similar, as in the present paper. This fact can be explained by the similarity between the energy supply provided by these sources.

Ceylan et al. [20] and Sarıçiçek et al. [21] evaluated the replacement of soybean oil by other sources (fish, linseed, canola, and sunflower oils) and found no significant differences for internal and external egg quality, except for yolk color, in which better colorization was attributed to the content of carotenoids from egg yolks of birds fed with sunflower oil. Reda et al. [22] investigated the impact of dietary oil sources (soybean, corn, peanut, linseed, olive, and sunflower oils as sources of omega 3, 6, and 9) on productive and reproductive traits, egg quality, and biochemical traits in the blood of egg-laying quails.

The results showed that the heaviest egg weights and the best feed conversion rates were recorded for quails fed with diets supplemented with 1.5% soybean and peanut oil, showing that the individual composition of the lipid inserted in the diet influences productive traits and the health of the birds, unlike the present study. Due to the non-significant difference for the initial performance, both sources used can be indicated in the rearing phase, without compromising the productive longevity of the eggs.

4. Conclusions

There was a residual effect of the use of lipid sources of vegetable origin in the diet in the rearing phase of Japanese quails on the egg quality traits. The lipid sources from soybean, corn, cotton, canola, and sunflower seeds can be used as energy ingredients in the rearing diet of laying quails for not being harmful to the initial performance of the birds. The longevity in egg production of birds fed with different lipid sources in the rearing phase was similar.

Conflicts of interest

The authors declare that there is no conflict of interest.

Author contributions

Conceptualization: R. G. Garcia, C. M. Komiyama and M. F. C. Burbarelli. *Data curation*: J. K. Valentim and F. C. Serpa. *Investigation*: J. K. Valentim, F. C. Serpa, J. P. Mendes and R. T. R. Pietramale. *Methodology*: J. K. Valentim, D. K. Barbosa and F. C. Serpa. *Resources*: R. G. Garcia, F. R. Caldara, L. F. T. Albino. *Project management*: R. G. Garcia and M. F. C. Burbarelli. *Validation*: R. G. Garcia and M. F. C. Burbarelli. *Visualization*: J. K. Valentim and M. F. C. Burbarelli. *Supervision*: R. G. Garcia, C. M. Komiyama and M. F. C. Burbarelli. *Writing (original draft)*: J. K. Valentim. *Writing (review and editing):* R. G. Garcia, C. M. Komiyama, M. F. C. Burbarelli, F. R. Caldara and L. F. T. Albino.

Referências

1 - Castro MLS, Silva SN, Bavaresco C, Dias RC, Gopinger E, Xavier EG, ... & Schafhauser JJ. Pigmentantes naturais em dietas de codornas japonesas a base de arroz integral descascado e não polido. Arch. de Zoot. 2020; 69(267): 280-287. Doi: https://doi.org/10.21071/az.v69i267.5346

2 - Souza EB, Valentim JK, Garcia RG, Serpa FC, Felix GA, de Assis Souza MF, ... & Komiyama CM. Addition of homoeopathy in the diet of Japanese quails increases egg weight. Sem: Ciê. Agrá. 2021; 42(3Supl1): 1879-1890. DOI: http://dx.doi.org/10.5433/1679-0359.2021v42n3Supl1p1879

3 – Baron LF, Pazinatto R & Baron CP. Oxidação de lipídeos e as implicações na nutrição e saúde de animais de produção. Cader. de Ciê. & Tec. 2020; 37(1); 265-297. Doi: https://doi.org/10.35977/0104-1096.cct2020.v37.26597

4 – Valentim JK, Carneiro SA, Geraldo A, Dallago GM, de Oliveira JÉF, & de Oliveira MJK. Uso de emulsificante e óleo de macaúba em dietas para poedeiras comerciais e seus efeitos sobre desempenho e qualidade de ovos. Rev. Cient. Rur. 2018; 20(1): 275-286. http://ediurcamp.urcamp.edu.br/index.php/RCR/article/view/221/pdf_34

5 – Silva VC, da Fonseca SS, Valentim JK, & Geraldo A. Desempenho de frangos de corte alimentados com dietas com redução energética contendo diferentes tipos de emulsificantes. Rev. Acad. Ciê. Ani. 2018: 16, 1-11. Doi: https://doi.org/10.7213/1981-4178.2018.16009

6 – Roll AAP, Forgiarini J, Bavaresco C, Roll VFB, Dionello NJL & Rutz F. Desempenho e metabolizabilidade de dietas em codornas alimentadas com níveis crescentes de óleo ácido de soja. Arq. Bras. de Med. Vet. e Zoot. 2018; 70: 1282-1292. Doi: https://doi.org/10.1590/1678-4162-9185

7 - Calixto RC, Costa LV, Júnior JDM, de Moura MI, & Duarte FOS. Desempenho de frangos de corte alimentados com dietas contendo óleo de soja. Braz. Jour. of Ani. and Env. Res. 2020; 3(2): 670-674. Doi: https://doi.org/10.34188/bjaerv3n2-026

8 - Freitas Amaral EF, Bittencourt TM, Lima HJD, Quirino CS, Pereira IDB, & de Amorim CMM. Grãos secos de destilaria de milho na recria de codornas japonesas e sua repercussão na fase de produção. Rev. Acad. Ciê. Ani. 2021; 19: 1-6. DOI: https://doi.org/10.7213/acad.2021.19008

9 - National Research Council – NRC. Nutrient requirements of poultry. Washington, D.C.: 1994. p.44- 45.

10 - Rostagno HS, Albino LFT, Hannas MI, Donzele JL, Sakomura NK, Perazzo FG, & Brito CO. Tabelas Brasileiras para Aves e Suínos: Composição de Alimentos e Exigências Nutricionais. 2017; 488: Departamento de Zootecnia-UFV, Viçosa, MG, BR.

11- Sakomura NK, Rostagno HS. Métodos de pesquisa em nutrição de monogástricos. 2° edição. Jaboticabal: Funep. 2015; 262 p.

12 - Castelló JAL, Pontes M, González FF. Producción de huevos. 1. ed. Barcelona: Real Escuela de Avicultura. 1989; 367 p.

13 - Bittencourt TM, Lima HJDA, Valentim JK, Martins ACDS, Moraleco DD, & Vaccaro BC. Distillers dried grains with solubles from corn in diet of japanese quails. Act. Sci. Anim. 2019; 41: 1 -12. Doi: https://doi.org/10.4025/actascianimsci.v41i1.42749

14 - Alleoni ACC & Antunes AJ. Unidade Haugh como medida da qualidade de ovos de galinha armazenados sob refrigeração. Sci. Agri. 2001; 58(4): 681-685. Doi: https://doi.org/10.1590/S0103-90162001000400005

15 - Costa FGP, Souza CJD, Goulart CDC, Lima Neto RDC, Costa JSD, & Pereira WE. Desempenho e qualidade dos ovos de poedeiras semipesadas alimentadas com dietas contendo óleos de soja e canola. Rev. Bras. de Zoo. 2008; 37: 1412-1418. Doi: https://doi.org/10.1590/S1516-35982008000800011

16 - Ismail IB, Al-Busadah KA & El-Bahr SM. Effect of dietary supplementation of canola oil on egg production, quality and biochemistry of egg yolk and plasma of laying hen. Inter. Jou. of Bio. Chem. 2013; 7(1): 27-37. Doi: https://doi.org/10.3923/ijbc.2013.27.37

17 - Baucells MD, Crespo N, Barroeta AC, Lopez-Ferrer S & Grashorn AM. Incorporation of different polyunsaturated fatty acids into eggs. Poul. Scie. 2000; 79(1): 51-59. Doi: https://doi.org/10.1093/ps/79.1.51

18 - EGG-Grading Manual. Washington: Department of Agriculture/Agricultural Marketing Services. 2000. (Agricultural Handbook, 75).http://ediurcamp.urcamp.edu.br/index.php/RCR/article/view/221

19 - Oliveira GE, Figueiredo TC, Souza MR, Oliveira AL, Cançado SV, & Gloria MBA. Bioactive amines and quality of egg from Dekalb hens under different storage conditions. Poul. Sci. 2009; 88(11): 2428-2434. Doi: https://doi.org/10.3382/ps.2009-00028

20 - Ceylan N, Ciftçi I, Mizrak C, Kahraman Z & Efil H. (2011). Influence of different dietary oil sources on performance and fatty acid profile of egg yolk in laying hens. Jour. of Ani. and Fee. Scie;, 20(1), 71-83. Doi: https://doi.org/10.22358/jafs/66159/2011

21 - Sarıçiçek BZ, Kılıç Ü & Garipoğlu AV. Replacing soybean meal (SBM) by canola meal (CM): The effects of multi-enzyme

and phytase supplementation on the performance of growing and laying quails. Asi. Jou. of Ani. Scie. 2005; 18(10): 1457-1463. Doi: https://doi.org/10.5713/ajas.2005.1457

22 - Reda FM, El-Kholy MS, Abd El-Hack ME, Taha AE, Othman SI, Allam AA & Alagawany M. Does the use of different oil sources in quail diets impact their productive and reproductive performance, egg quality, and blood constituents?. Poul. Sci. 2020; 99(7): 3511-3518. Doi: https://doi.org/10.1016/j.psj.2020.03.054