PRODUCTIVE PERFORMANCE AND EGG QUALITY OF JAPANESE QUAILS FED WITH WHOLE RICE DIETS

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Received: 15/06/2020
Accepted: 25/08/2020

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RESUMO

This study aimed to evaluate the effects of substituting corn with whole rice (WR) in the diet of Japanese quails (*Coturnix coturnix japonica*) on productive performance, egg quality, sensory characteristics of eggs, and yolk color. One hundred 215-day-old Japanese quails were randomly allotted to the treatments in a completely randomized design. Five treatments were tested: 0% WR (control diet based on corn and soybean meal); 25% WR; 50% WR; 75% WR; and 100% WR in substitution of corn. A total of five replicates per treatment and four quails per cage were used. Data were subj ected to regression analysis using PROC REG of the software SAS. The substitution of corn with whole rice in the different levels promoted significant effects on yolk color measured by the colorimetric gradient, bitter taste, intensity of luminosity and the intensity of yellow and chroma. No changes were observed in the other variables. The substitution of corn by whole rice up to 100% in the diet of Japanese quails did not influence the performance or egg quality, however, it negatively affected the bitter taste and yolk color, therefore requiring the development of studies that include WR association of pigments.

Keywords: Alternative feedstuff. Nutrition. Sensory properties. Substitution. Yolk color.

INTRODUCTION

Quail industry has exhibited a strong development with promising results for producers in Brazil. Thus, an activity that was previously considered of subsistence took on an industrial character, primarily because of rapid growth of the birds, precocity of sexual maturity and production (35-42 days), high productivity (average of 300 eggs/year), need of small spaces for large flocks, great longevity in high production (14-18 months), low investment and quick payback (LIMA et al., 2013; MUNIZ et al., 2018; PASTORE et al., 2012).

Diets used for quails are based on corn and soybean meal (OLIVEIRA et al., 2007), commodities whose prices are regulated by the international market and dependent on several factors, particularly climatic ones, which determine the volume that will be available each year for marketing. Moreover, these feedstuffs have been increasingly used in the biofuel industry, which raises their prices and increase the cost of animals' diet. Thus, alternative feedstuffs have been studied and tested (ASYIFAH et al., 2012) aiming to the reduce costs without affecting performance and health of quails.

In this case, whole rice (WR) can be a feedstuffs option for replacement of corn in animal feed industry. However, up to this moment only its derivatives are used, especially broken rice and whole or defatted rice bran. Thus, the use of WR, a dehulled and unpolished whole grain (ASYIFAH et al., 2012; LEESON; SUMMERS, 2005), becomes an interesting alternative as the grain is a potential raw material for quail diets, particularly when found in high supply in the market, when its price become lower (KRABBE et al., 2012).

In terms of nutrition, WR and corn share a similar composition with, respectively, 88.6 and 88.9% of dry matter, 8.87 and 7.86% of crude protein, 2.21 and 3.81% of fat, 1.11 and 1.73% of crude fiber and 4314 and 3901 kcal/kg of gross energy (JUNQUEIRA et al., 2009; KRABBE et al., 2012; ROSTAGNO et al., 2011).

Whole rice seems to be a good foodstuff option for poultry, but information about its use in quail's nutrition is scarce (ASYIFAH et al., 2012). Then, to establish technical parameters and to guide the use of WR in the diet of quails, this trial was carried out aiming to evaluate the effect of replacement of corn with whole rice in the diet on performance, egg quality, egg sensory analysis, and yolk color of laying quails.

MATERIAL AND METHODS

The experiment was approved by the Animal Experimentation Ethics Committee (CEEA) of UFPEL under number 2167, as part of the project entitled Rice in the quails' diet.

One hundred 215-day-old Japanese quails (*Coturnix coturnix japonica*) were housed in metallic cages equipped with gutter-type feeders and nipple water drinkers in the Poultry Sector of the Laboratory of Animal Science Teaching and Experimentation (LEEZO) of the Federal University of Pelotas. Birds had *ad libitum* access to feed and water during the whole experiment. The light program used was 17 hours of light daily (MUNIZ et al., 2018).

Birds were distributed to the treatments in a completely randomized design with five replicates per treatment. The experimental unit corresponded to one cage with four quails each. The birds were evaluated for three production cycles of 28 days each (from August 2013 to October 2013), totaling 84 days.

A long-light grain variety of rice ("BRS Querencia") developed by the Brazilian Company of Farming Research (Embrapa) at its Genetic Improvement Program was only dried and dehulled, but not polished, in an industrial machine. The rice grains were ground, and experimental diets were mixed, resulting in five treatments: 0% WR (control diet based on corn and soybean meal); 25% WR; 50% WR; 75% WR; and 100% WR in substitution of corn, as shown in Table 1. The diets were formulated to meet the requirements for maintenance and egg production of laying quails, according to Silva (2009).

Table 1 - Ingredient composition and calculated chemical analysis of the experimental diets of quails fed whole rice.

Ingredient	Levels of whole rice (%)				
	0	25	50	75	100
Corn (7.8% CP)	50.225	36.827	24.511	10.931	0.000
Whole rice[1] (8.4% CP)	0.000	12.560	25.100	37.670	48.814
Soybean meal (45% CP)	37.027	36.680	36.098	35.741	35.223
Limestone	6.015	5.790	6.060	5.691	5.938
Salt	0.224	0.184	0.239	0.222	0.214
L-lysine	0.000	0.022	0.071	0.115	0.158
DL-methionine	0.074	0.092	0.121	0.135	0.161
Dicalcium phosphate	0.000	0.000	0.084	0.000	0.062
Soybean oil	3.000	4.000	4.500	5.500	6.000
Vitamin-mineral mix[2]	3.434	3.844	3.207	3.995	3.430
Calculated analysis (%)					
Metabolizable energy (kcal kg^{-1})	2800	2800	2800	2800	2800
Crude protein	20.00	20.00	20.00	20,00	20,00
Calcium	3.050	3.050	3.050	3.050	3.050
Available phosphorus	0.283	0.300	0.280	0.300	0.280
Methionine dig.	0.390	0.390	0.390	0.394	0.403
Met + Cist dig.	0.637	0.612	0.598	0.569	0.557
Threonine dig.	0.717	0.675	0.633	0.591	0.553
Tryptophan dig.	0.240	0.231	0.222	0.213	0.204
Arginine	1.345	1.288	1.228	1.170	1.117
Lysine	1.047	1.030	1.030	1.030	1.030
Gly + Ser dig.	1.771	1.677	1.580	1.485	1.398
Sodium	0.230	0.230	0.230	0.252	0.230
Analyzed composition (%)					
Gross energy (kcal/kg)	3824	3858	3949	3919	3921
Crude protein	22.41	22.51	21.68	22.42	22.30
Crude fiber	3.675	5.388	6.531	7.673	9.180
Ether extract	6.28	6.45	6.55	6.92	7.04

[1]Whole rice nutrient composition: Dry matter (DM): 86.35%; Crude protein: 8.4% of DM (dry matter basis); Ether extract: 2.32% of DM; Crude fiber: 11.56% of DM; Ash: 1.32% of DM; Gross energy: 3797 kcal/kg. [2]Composition/kg: vitamin A: 207,000 UI; vitamin D_3: 43,200 UI; vitamin E: 540 mg; vitamin K_3: 51.5 mg; vitamin B_1: 40 mg; vitamin B_2: 120 mg; vitamin B_6: 54 mg; vitamin B_{12}: 430 mcg; niacin: 840 mg; folic acid: 16.7 mg; pantothenic acid: 204.6 mg; choline: 42 mg; biotin: 1.4 mg; methionine: 11 g; magnesium: 1,485 mg; zinc: 1,585 mg; iron: 1,695 mg; copper: 244 mg; iodine: 29 mg; selenium: 3.2 mg; zinc bacitracin: 600 mg; BHT: 700 mg; calcium: 197.5 g; cobalt: 5.1 mg; fluoride: 400 mg; phosphorus: 50 g; sodium: 36 g.

Quails were fed daily and the amount of feed provided was recorded. At the end of each cycle, the leftover feed was weighed to calculate daily feed intake. In addition, eggs were identified, collected, and weighed individually to calculate the total production and average weight. Egg mass was calculated by multiplying the number of eggs produced by their average weight. The feed conversion per egg mass was calculated by dividing the feed intake by the egg mass. Feed conversion per dozen of eggs was obtained by dividing the feed intake by the number of eggs produced, and the result divided by 12.

A total of 40 eggs per treatment (eight from each replicate) produced in the last two days of each experimental cycle were identified, collected, and evaluated each day, to obtain the average data for internal and external quality. The following variables of internal egg quality were analyzed: albumen height and percentage, yolk color and percentage, and Haugh unit. To determine albumen height (mm), a specific rule (FHK® trademark) was used. The percentage of yolk and albumen was determined by weighing the yolk (g) and albumen (g) on a digital scale (Marte®, AS 5500C model, accurate to 0.1 g), multiplying the result by 100 and dividing by the egg weight. Yolk color was obtained by Roche® color fan. The Haugh unit was obtained from the egg weight and albumen height, using the formula: $HU = 100_{log} (H + 7.57 – 1.7 W^{0.37})$, in which H = albumen height and W = egg weight.

The following variables were obtained for external egg quality: egg length (mm) and diameter (mm), specific gravity ($g.cm^{-3}$), shell thickness (mm), and percentage weight (%). To measure the length and diameter of eggs a digital caliper (*Electronic digital caliper* 6̋ 150 mm, accurate to 0.01 mm) was utilized. These values were subsequently used as a reference to obtain the shape index by dividing the diameter by the length of the egg and multiplying the result by 100. To determine the specific gravity, eggs were placed in the bottom of a plastic mesh basket and immersed in buckets containing NaCl solutions with increased densities ranging from 1.050 to 1.098 $g.cm^{-3}$, with an interval of 0.004 $g.cm^{-3}$. The eggs were removed as soon as they floated in the solution and the density was registered.

After breaking the eggs, the shells were washed and dried at room temperature to later obtain their weights and thicknesses. To determine shell percentage weight, they were individually weighed on an analytical digital balance (Unibloc®, AUY-220, accurate to 0.1 mg), and the result was multiplied by 100 and divided by the weight of the egg. Thickness (µm) was measured at the central ring of the shell of each egg using a manual micrometer (Starret ® brand).

Ten raw eggs from each treatment were evaluated at the end of the experimental period, with each egg being a replicate. Eggs were collected at random from each treatment and identified; they were subsequently broken individually for reading by a digital colorimeter (Minolta® CR 410) to obtain parameters of L (luminosity), a* and b* (red and yellow color intensities, respectively), chroma (ratio between the values of a* and b*) and to obtain the real color of the analyzed obj ect (HARDER et al., 2007) was then calculated.

For sensory analysis, 20 eggs were collected at the end of experimental period, identified according to their respective treatment, and stored under refrigeration for seven days. To prepare the samples, eggs were cooked in boiling water for seven minutes (until to get a solid yolk) and left to cool at room temperature. Then, eggs were shelled and placed in plastic containers, coded with three random digits for evaluations, and arranged in individual tasting cabins.

Eight trained sensory panelists were randomly and individually directed to tasting cabins to receive samples. The panelists evaluated intensity perceived for each of the attributes on a continuous unstructured graphical scale. The measurements were evaluated by acceptability test, with hedonistic scale of nine points, corresponding to the lowest intensity at 0 and the highest intensity at 9. The left side of the scale corresponded to the lowest intensity of the attribute and the right side of the scale corresponded to the highest intensity, according to the following characteristics: odor, unknown odor, oily odor, characteristic flavor, oily flavor, bitter flavor, and yolk color (STONE; SIDEL, 1998). The results were automatically converted to numerical values (from 0 to 9) by a ruler. Water and unsalted crackers were provided, and panelists were asked to rinse their mouths between each sample. All samples were evaluated in five sessions with three eggs each (which tested five replicates out of five treatments) preceded by an introductory session. Each session compared three different treatments. Halves of each egg were served.

Polynomial regression analysis was used to predict the effects of the substitution of corn by whole rice. Data were analyzed using PROC REG of the software SAS (9.2; Cary, NC) (SAS, 2002). The polynomial regression model was selected from the level of significance of the regression coefficients (p<0.05) and the coefficient of determination value. The results of the variables of sensory analysis were subj ected to analysis of variance and the treatment means were compared by Tukey test at 5%.

RESULTS AND DISCUSSION

As shown in Table 2, the levels of substitution of corn by WR had no influence on the body weight, daily feed intake, egg mass, conversion per dozen, conversion per mass, egg production or egg weight (p>0.05). Different from the obtained in this study, Gopinger et al. (2014) tested the same variety of WR found that increased levels of WR until 80% in the diets of quails provided a significant linear increase in the egg production and egg mass. On the other hand, Filardi et al. (2007) tested levels of 0, 5, 10 and 15% of rice bran in the diets of laying hens and found no significant effects (p>0.05) on performance and egg quality even at the maximum level (15%).

In another study, Brum Júnior et al. (2007a) evaluated the levels of whole rice bran (WRB) in the diet of laying hens. They found no significant effect on egg weight; however, egg production exhibited a quadratic response that showed a minimum point of 22.32% of WRB inclusion in the diet. The authors also observed a decreasing linear effect on feed conversion. As a matter of fact, as the level of inclusion of WRB increased, the feed conversion improved. The authors attributed this to the lower feed intake with increasing levels of WRB, explained by the presence of anti-nutritional factors that have a significant fiber fraction. However, no difference was observed in the performance parameters in any of the treatments, possibly because the whole rice has lower crude fiber content compared to the rice bran (ASYIFAH et al., 2012; LESSON; SUMMERS, 2005).

Quevedo Filho et al. (2013), evaluated the performance variables such as feed intake, egg production, egg weight, egg mass and feed conversion, fed Japanese quails parboiled rice bran and found no significant difference for such variables. The authors suggested that this result was most likely due to a beneficial effect of the heat treatment to which grain is subj ected in the parboiling process, which inactivates the anti-nutritional factors present in the grain. In this sense, Leeson and Summers (2005) say that rice does contain high levels of trypsin inhibitor that will be destroyed at normal pelleting temperatures. In current study we did not pellet the diets fed to Japanese quails, and even with no significant results (p>0.05), a numerical drop in egg production can be seen, as the percentage of WR in the diet increased.

Furthermore, the presence of non-starch polysaccharides in WR (ADRIZAL et al., 2002) that non-ruminants cannot digest, and which lead to an increase in the viscosity of intestinal chyme, may negatively affect the performance of the animals. In varieties of WR that Asyifah et al. (2012) studied the presence of non-starch polysaccharides was low, and one can speculate that in the variety of this study was also low.

Table 2 - Productive performance of Japanese quails fed different levels of whole rice.

Variables	Levels of whole rice (%)					P*	CV
	0	25	50	75	100		
Body weight (g)	194.01	187.32	184.87	190.28	188.63	0.40	4.64
Daily feed consumption (g)	33.77	35.20	35.09	31.89	32.73	0.21	8.74
Egg mass (g/bird/day)	9.88	9.56	9.36	9.43	9.16	0.23	9.58
FC (dozen eggs) (g/dz)	3.66	3.83	4.53	3.75	4.15	0.53	24.54
FC (egg mass) (g/g)	3.47	3.83	4.12	3.77	3.99	0.27	15.94
Egg production (%)	80.00	79.16	77.91	76.40	75.05	0.20	8.75
Egg weight (g)	12.36	12.05	11.98	12.21	12.14	0.51	3.52

FC = feed conversion; P* = significance level at 5% by the adjusted regression analysis; CV = coefficient of variation.

Table 3 shows the results of the linear regression analysis (p>0.05) for the substitution levels of corn by WR for albumen height, albumen percentage, yolk percentage, Haugh unit, shape index, specific gravity, shell thickness and shell percentage; no significant effect was observed for any of the variables analyzed. However, as observed in Figure 1, a decreased linear response (R^2 = 0.9471) was found for yolk color with the increased inclusion of WR in the diets. The results obtained by Minolta for the coloring of yolks are presented in Table 4. For the color characteristics of raw yolks, there was difference for luminosity (L value) (p<0.0001), intensity of yellow color (b* value) (p<0.0001) and chroma (C) (p<0.0001), these parameters being reduced with increased levels of WR in the diets.

Regarding egg components, the results of this study corroborate with Filardi et al. (2007), who tested levels of 0, 5, 10 and 15% rice bran in the diet of laying hens and observed no significant effects (p>0.05) in specific gravity, shell thickness and percentage of eggshell. However, Samli et al. (2006), tested the same inclusion levels, found differences in the Haugh unit and obtained a value of 102.2 with 15% rice bran in the diet of the birds. The authors attributed that response to the high biological value of proteins and fat present in rice bran. However, no significant differences were found in this study for any egg quality variable, except in the yolk color.

The observed reduction in yolk color is attributed to the use of rice in the poultry feed. Brum Júnior et al. (2007b) found reductions in the pigmentation of beaks and shins of broilers with the progressive substitution of corn by broken rice in the diet, proving the effect of the lack of pigments substances in that ingredient compared to corn. Quevedo Filho et al. (2013) used up to a 30% inclusion of parboiled rice whole bran in the diet of Japanese quails, but this by-product has lower content of pigments such as xanthophylls, resulting in less intensity in pigmentation of egg yolk. The average values of the parameter luminosity (L) observed in this study corroborate with those found by Harder et al. (2007) and are consistent with the patterns found in the literature, as noted by Paz et al. (2010). According to Freitas et al. (2011), yolk pigmentation may vary from slightly clear yellow to dark orange, in accordance with the feeding and individual characteristics of the bird. In this study, a lower intensity of the yellow color (b*) was observed due to the substitution of corn, a source of natural pigments, with WR, which lacks these factors. Harder et al. (2007), tested different concentrations of annatto in the diet of commercial laying hens, and found that as the level of inclusion of pigments increased the higher was the chroma value. As expected, in this study, the increased substitution of corn with WR promoted a reduction in chroma, confirming a lower degree of color purity due to the low pigment content in rice.

Table 3 - Egg components and egg quality of Japanese quails fed whole rice.

Variables	Levels of whole rice (%)					P*	CV
	0	25	50	75	100		
AH (mm)	4.79	4.56	4.77	4.65	4.66	0.64	11.71
Albumen (%)	47.95	48.77	48.86	47.95	49.75	0.49	11.35
Yolk (%)	30.98	30.24	31.82	30.58	33.55	0.11	10.94
HU	92.04	91.75	92.00	92.12	91.66	0.81	2.94
SI (%)	77.45	77.98	78.86	78.65	78.28	0.21	3.27
SG (g.cm^{-3})	1069.94	1070.34	1069.80	1071.01	1068.04	0.13	0.40
ST (µm)	22.33	22.56	22.14	22.50	22.21	0.69	5.08
Shell (%)	7.83	8.00	8.08	8.08	7.88	0.36	7.49

AH = albumen height; HU = Haugh unit; SI = shape index; SG = specific gravity; ST = shell thickness; %shell = percentage of shell; P* = significance level at 5% by the adjusted regression analysis; CV = coefficient of variation.

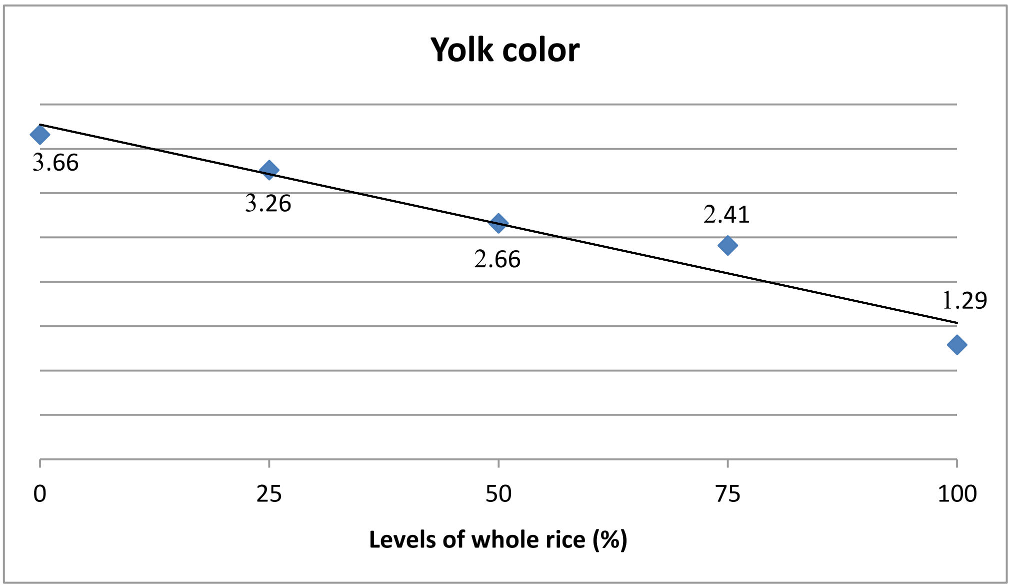

Figure 1 - Yolk color of eggs in Japanese quails fed different levels whole rice determined by color gradient (Roche®). Blue diamonds are the average of yolk color observed for each treatment. Regression equation: Y = 3.77 – 0.22X; R^2 = 0.94.

Table 4 - Yolk color of eggs of Japanese quails fed whole rice measured with digital colorimeter.

Variables	Levels of whole rice (%)					P*	RE	P**	RE	R^2
	0	25	50	75	100					
L	67.95	67.47	63.91	58.55	53.74	<0.0001	y=69.79-0.14x	<0.0001	$y=68.30-0.03x-0.001x^2$	0,99
b*	51.93	49.59	44.57	39.88	26.44	<0.0001	y=54.62-0.24x	<0.0001	$y=51.49+0.007x-0.002x^2$	0,98
a*	-6.59	-6.94	-6.45	-5.92	-6.06	0.14	-	0.34	-	-
Chroma	52.38	50.10	45.06	40.36	27.15	<0.0001	y=55.05-0.24x	<0.0001	$y=51.97+0.005x-0.002x^2$	0,98

P* = significance level at 5% by the adjusted linear regression analysis; P** = significance level at 5% by the adjusted quadratic regression analysis; RE = regression equation; L = luminosity; b* = yellowness; a* = redness.

The results of the sensory attributes, shown in Table 5, indicate that the characteristic bitter taste differed among the treatments ($p<0.05$). As observed in current study, a slightly bitter residual taste was also observed by Bernal-Gómez (2002) when laying hens were fed diets containing oils rich in omega-3 fatty acids. A tendency to produce carcasses with a better fatty acid profile occurs when using a diet based on rice and soybean meal because of the higher content of saturated (0.52%) and monounsaturated (0.96%) fatty acids and lower content of polyunsaturated (0.72%) fatty acids of rice (KRABBE et al., 2012). These fatty acids may also be deposited in the eggs and, therefore, be the determining factor for such changes.

Modifications in flavor and odor and “off-flavor” generation could be the result of the rancidity of polyunsaturated omega-3 fatty acids in either food and/or animal products because these acids are particularly susceptible to lipid oxidation. Even small differences in the concentration of these fatty acids may be important in the development of the oxidative process (LOPEZ-BOTE et al., 1998).

Table 5 - Sensory properties of eggs of Japanese quails fed whole rice.

Attributes[1]	**Levels of whole rice (%)**					**P***	**SEM**
	0	**25**	**50**	**75**	**100**		
Characteristic odor	4.67	5.14	4.74	4.15	4.57	0.26	0.30
Unknown odor	3.89	3.29	2.90	3.50	3.23	0.38	0.35
Oily odor	2.72	3.76	3.03	3.59	2.65	0.05	0.31
Characteristic flavor	4.87	4.88	4.52	4.56	4.15	0.52	0.33
Oily flavor	4.18	4.63	4.48	4.23	4.21	0.87	0.36
Bitter flavor	2.66^{ab}	2.34^{b}	2.52^{ab}	2.80^{ab}	3.80^{a}	0.04	0.35
Yolk color	4.59	4.63	4.59	3.84	3.67	0.12	0.34

P* = significance level of 5% (Tukey test); SEM = standard error of the mean; Atributes[1] = Unstructured scale of 9 cm (1 = lower intensity; 9 = higher intensity); ^{ab} = means on the same line with different lowercase letters indicate statistical difference between them.

CONCLUSION

The substitution of corn by whole rice up to 100% in the diet of Japanese quails does not influence the performance or egg quality, however, it does negatively affect the bitter taste and raw yolk color.

DESEMPENHO PRODUTIVO E QUALIDADE DE OVOS DE CODORNAS JAPONESAS ALIMENTADAS COM ARROZ INTEGRAL NA DIETA

RESUMO

Este estudo objetivou avaliar os efeitos da substituição do milho porarroz integral (AI) na dieta de codornas japonesas (*Coturnix coturnix japonica*) sobre o desempenho produtivo, qualidade dos ovos, características sensoriais dos ovos e cor da gema. Cem codornas japonesas com 215 dias de idade foram distribuídas aleatoriamente nos tratamentos, em um delineamento inteiramente casualizado. Cinco tratamentos foram testados: 0% AI (dieta controle à base de milho e farelo de soja); 25% AI; 50% AI; 75% AI; e 100% AI em substituição ao milho. Foram utilizadas cinco repetições por tratamento e quatro codornas por gaiola. Os dados foram submetidos à análise de regressão utilizando o PROC REG do software SAS. A substituição do milho por AI nos diferentes níveis promoveu efeitos significativos na cor da gema, medida pelo gradiente colorimétrico, sabor amargo, intensidade de luminosidade e intensidade de amarelo e croma. Não foram observadas alterações nas demais variáveis. A substituição do milho pelo AI até 100% na dieta de codornas japonesas não influenciou o desempenho produtivo ou aqualidade dos ovos, no entanto, afetou negativamente o sabor amargo e a cor da gema e requer o desenvolvimento de estudos que incluam a associação AI a pigmentantes.

Palavras-chave: Alimento alternativo. Cor da gema. Nutrição. Propriedades sensoriais. Substituição.

RENDIMIENTO PRODUCTIVO Y CALIDAD DE LOS HUEVOS DE CODORNIZ JAPONESAS ALIMENTADAS CON ARROZ INTEGRAL EN LA DIETA

RESUMEN

Este estudio tuvo como objetivo evaluar los efectos de reemplazar el maíz con arroz integral (AI) en la dieta de las codornices japonesas (*Coturnix coturnix japonica*) sobre el rendimiento productivo, la calidad del huevo, las características sensoriales del huevo y el color de la yema. Cien codornices japonesas con 215 días de edad se distribuyeron aleatoriamente en los tratamientos, en un diseño completamente al azar. Se probaron cinco tratamientos: 0% de IA (dieta de control basada en harina de maíz y soya), 25% AI, 50% AI, 75% AI y 100% AI, para reemplazar el maíz. Se utilizaron cinco réplicas por tratamiento y cuatro codornices por jaula. Los datos se sometieron a análisis de regresión utilizando el PROC REG del software SAS. La sustitución del maíz por AI en diferentes niveles promovió efectos significativos sobre el color de la yema, medido por el gradiente colorimétrico, el sabor amargo, la intensidad de la luminosidad y la intensidad del amarillo y el croma. No hubo cambios en las otras variables. El reemplazo del maíz por AI hasta el 100% en la dieta de codorniz j aponesa no influye en el rendimiento productivo o la calidad de los huevos, sin embargo, afecta negativamente el sabor amargo y el color de la yema y requiere el desarrollo de estudios que incluyan la asociación AI con pigmentantes.

Palabras clave: Alimentación alternativa. Color de la yema. Nutrición. Propiedades sensoriales. Reemplazo.

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