



Distillers dried grains with solubles from corn in diet of japanese quails

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ABSTRACT. The objective of this study was to evaluate different inclusion levels of distillers dried grains with solubles (DDGS) from corn in the diet of quails. A total of 210 japanese quails (*Coturnix coturnix japonica*) were distributed in a completely randomized design of five treatments and six replicates, with seven quails per experimental unit. The treatments used were: control feed; inclusion of 5, 10, 15 and 20% of DDGS. The variables assessed were: feed intake, feed conversion per dozen and egg mass, egg production, egg weight, specific gravity, yolk color and economic analysis. Data were analyzed by regression model and Dunnett's test at 5% probability. For individual feed intake, laying rate, and feed conversion per egg mass, specific gravity and yolk color by color fan, there was effect caused by inclusion of DDGS ($p < 0.05$), but the other variables did not show significant difference. By Dunnett's test, for feed intake, feed conversion per egg mass, specific gravity and digital colorimeter's L parameter, there was effect ($p < 0.05$). As for economic analysis, DDGS presented low cost. It can be concluded that DDGS can be used in feed at a 20% level without impairing the performance and quality of quails eggs.

Keywords: economic analysis; egg quality; yolk color.

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Introduction

Quail farming for egg production is quite substantial in Brazil. This sector has been growing every year as a consequence of all positive performance aspects and low farming investment (Rocha-Silva et al., 2016).

The Brazilian population has been contributing to the growth of the sector due to social changes and, for being small, these eggs spark children's curiosity, in addition to being easily found at grocery stores, either fresh or canned.

DDGS (distillers dried grains with soluble) are a co-product of the corn ethanol industry (Abousekken, 2014; Lumpkins, Batal, & Dale, 2004). They are residues dried after corn starch fermentation by yeasts and enzymes, from which ethanol is produced (Cortes Cuevas et al., 2012). It is a product that has been used as an alternative source to feed non-ruminant and ruminant animals. DDGS are rich in protein, amino acids, energy, phosphorus, fiber, but a major problem when it comes to using them is their great variability, nutritional composition and quality (Lumpkins et al., 2004). This co-product is similar to soybean meal in terms of energy value, having tryptophan, arginine and lysine as limiting amino acids (Parsons, Baker, & Harter, 1983).

The objective of this research was to assess how the inclusion of distillers dried grains with solubles in the diet of quails affects the pigment potential of egg yolks, as well as eggs' internal and external quality, performance and economic analysis of feasibility of use.

Material and methods

The experiment was developed at an Experimental Farm in the Quail Farming Sector of Federal University of Mato Grosso Animal Husbandry and Rural Extension Department, located in the city of Santo Antônio do Leverger, MT, with a duration of 63 days (April to June 2017), being divided into three periods of

21 days each. The project was approved by the University's Animal Ethics Committee [*Comit  de  tica no Uso de Animais*] (CEUA) under protocol number 23108.187860/2016-11.

A group of 210 laying quails (*Coturnix coturnix japonica*) at 23 to 31 weeks of age was used. The quails were distributed in a completely randomized design of five treatments and six replicates, with seven quails per experimental unit. The treatments used were: control feed with 0% of DDGS; inclusion of 5% of DDGS; inclusion of 10% of DDGS; inclusion of 15% of DDGS and inclusion of 20% of DDGS. The poultry were housed in galvanized wire cages measuring 50 x 38 x 21cm (length x width x height). In each experimental unit, an area of 271 cm²/bird was provided. Experimental feed was provided at will, in trough feeders, three times a day (7:00, 13:00 and 17:00), along the entire length of the cages, separated with dividers according to each treatment and replicate. Water was provided at will as well, in trough drinking fountains.

Temperatures and relative humidity (RH) were monitored twice a day at 8:00 and 16:00 by means of a digital hygrometer positioned at the center of the barn, at the level of the poultry' back. A total of 16 hours of daily light (natural and artificial) was provided throughout the experimental period. Light supply was controlled by a timer that allowed the lights to be switched on and off during the night and dawn, in accordance with procedures adopted at commercial farms.

A bromatological analysis of the DDGS of the corn used for feed formulation was carried out (Table 1). The experimental feeds (Table 2) were formulated with corn and soybean meal, being isoenergetic and isoproteic, as per recommendations and nutritional compositions presented by Rostagno et al. (2017). Amino acid content was analyzed based on AMINODat[®] 5.0 as described by Wiltafsky et al. (2010).

The following parameters were assessed:

The amount of feed consumed (g bird⁻¹ day⁻¹) by number of quails in each treatment was assessed during the experimental period (63 days).

Feed conversion per dozen eggs was calculated by the ratio of total feed consumption in kilograms divided by dozen eggs produced (kg dz⁻¹), and feed conversion per egg mass was calculated by feed consumption in kilograms divided by total egg mass (kg kg⁻¹).

The average egg production in the period was known by summing the number of eggs produced, including broken, cracked and abnormal ones (eggs with soft shells and without shells) and expressed as percentages over the average number of birds in the period (egg bird⁻¹ day⁻¹). To determine the production of marketable eggs at each 21-day period, the number of broken, cracked, soft-shell and shell-less eggs was subtracted from total egg production, and the ratio between intact eggs and total eggs produced during each period was calculated.

All quails were weighed at the beginning and end of the experimental phase for determination of their weight variation (g).

Mortality was recorded, the number of deaths was subtracted from the total number of live birds, and the values were converted into percentage at the end of the experimental period.

Four eggs from each replicate were individually weighed and then their average weight was calculated over the last three days of each 21-day experimental period for each replicate.

Analyses were performed on the 19th, 20th and 21st days of each 21-day period, and all intact eggs from each replicate were collected, among which four were randomly selected. After weighing, the eggs were identified, and then the specific gravity was determined by immersing the eggs in saline solutions with density ranging from 1.070 to 1.095 g cm⁻³, with an interval of 0.005 g cm⁻³, duly calibrated by means of a densimeter (OM-5565, Incoterm).

Table 1. Bromatological analysis of corn DDGS.

Analyses	Natural Matter (%)
Crude protein	42.73
Ethereal Extract	1.66
Crude Fiber	18.37
Mineral Matter	1.87
Dry matter	89.00
Nitrogen-free extract	47.73
NDT (estimated)	79.09
Calcium	0.13
Phosphorus	0.53

Table 2. Percentage and calculated composition of experimental feeds.

Ingredients (%)	DDGS Levels, %				
	0.0	5.0	10.0	15.0	20.0
Ground corn	52.85	48.85	46.85	44.85	42.85
Soybean meal	34.00	32.00	29.00	26.00	23.00
Calcitic Limestone	7.10	7.10	7.10	7.10	7.10
Dicalcium phosphate	1.00	1.00	1.00	1.00	1.00
Table salt	0.35	0.35	0.35	0.35	0.35
Nucleus ⁽¹⁾	1.80	1.80	1.80	1.80	1.80
Starch	1.00	2.00	2.00	2.00	2.00
Soy oil	1.90	1.90	1.90	1.90	1.90
DDGS	0	5.0	10.00	15.00	20.00
Nutritional composition calculated					
Metabolizable energy (kcal kg ⁻¹)	2800.00	2800.00	2800.00	2800.00	2800.00
Crude protein (%)	19.46	19.46	19.46	19.46	19.46
Digestible lysine (%)	1.080	1.080	1.080	1.080	1.080
Digestible methionine + cystine (%)	0.94	0.94	0.94	0.94	0.94
Digestible tryptophan (%)	0.23	0.23	0.23	0.23	0.23
Digestible threonine (%)	0.68	0.68	0.68	0.68	0.68
Calcium (%)	3.07	3.07	3.07	3.07	3.07
Available phosphorus (%)	0.30	0.30	0.31	0.32	0.33
Sodium (%)	0.16	0.16	0.16	0.16	0.16
Crude fiber (%)	2.74	3.49	4.21	4.93	5.65

¹Nucleus composition: Calcium (min) 80 g kg⁻¹, Calcium (max) 100 g kg⁻¹ Phosphorus (min) 37 g kg⁻¹, Sodium (min) 20 g kg⁻¹, Methionine (min) 21.5 g kg⁻¹, Lysine (min) 18 g kg⁻¹, Vitamin A (min) 125000 UI kg⁻¹, Vitamin D3 (min) 25000 UI kg⁻¹, Vitamin E (min) 312 UI kg⁻¹, Vitamin K3 (min) 20 mg kg⁻¹, Vitamin B1 (min) 20 mg kg⁻¹, Vitamin B2 (min) 62.5 mg kg⁻¹, Vitamin B6 (min) 37.5 mg kg⁻¹, Vitamin B 12 (min) 200 mcg kg⁻¹, Folic Acid (min) 6,25 mg kg⁻¹, Pantothenic acid (min) 125 mg kg⁻¹, Biotin (min) 1.25 mg kg⁻¹, Choline (min) 1700 mg kg⁻¹, Niacin (min) 312 mg kg⁻¹, Copper (min) 125 mg kg⁻¹, Iron (min) 680 mg kg⁻¹, Iodine (min) 8.75 mg kg⁻¹, Manganese (min) 937 mg kg⁻¹, Selenium (min) 3.75 mg kg⁻¹, Zinc (min) 500 mg kg⁻¹, Fluorine (max) 370 mg kg⁻¹.

The eggs were broken and the intensity of the yolks' yellow color was analyzed using a DSM® color fan. To do so, the yolks were placed on a flat surface. The color of the yolk *in natura* was visually compared and classified using the fan (1-15 score, ranging from light yellow to orange). This procedure was carried out by the same assessor on each assessment day. The mean of each treatment was calculated by the mean of the pigmentation scores of the egg yolks from the respective replicates. A Konica Minolta colorimeter, model CR-410, was used as a more accurate method to assess egg yolk color, and 3 color parameters were analyzed: B*, a* and b*. The a* value characterizes color in the red (+a*) to green (-a*) region, the b* value indicates color in the yellow (+b*) to blue (-b*) range. The B value indicates brightness.

The yolk of each egg was separated from the albumen and had its weight recorded. Albumen weight was obtained by the difference of egg weight plus yolk weight plus shell weight, with the latter being obtained after shell washing and subsequent natural drying for 72 hours. Albumen, yolk and shell percentages were obtained by dividing the weights of the respective components by the weight of the eggs, and the result was multiplied by 100.

This research assessed some variable costs associated with the activity of laying quail farming, related to the feeding of poultry; in the experimental feed, at each tested level of corn DDGS there was variation as to ingredient composition.

Corn and soybean meal prices were obtained from the database of an electronic address known as *Notícias Agrícolas* (Agricultural News), according to the day's quotation (05/12/2017) for the city of Cuiabá - Mato Grosso (MT). In their turn, price quotations for the other ingredients were obtained in the local market (Cuiabá - MT).

About corn DDGS, the input price was determined by equation:

$$\text{DDGS price} = (\text{DDGS protein ratio/soybean meal ratio}) \times \text{average price of soybean meal ton.}$$

For cost-benefit assessment of each treatment analyzed, it was necessary to verify which feed presented the best level of profitability. The profit margin of each treatment was determined by Equation:

$$\text{Profit margin treatment} = (\text{egg production} \times \text{carton price}) - \text{feeding cost treatment.}$$

The marketing price used for the sale of quail eggs was 1.40 BRL per dozen.

Statistical analysis

The parameters assessed were subjected to analysis of variance by SISVAR. Contrasts were tested by Dunnett's test at 5%, comparing the treatment without inclusion of corn DDGS (control) to the others (5, 10, 15 and 20% of DDGS). Afterwards, regression analysis was performed for treatments with inclusion of corn DDGS of in the diets.

Results and discussion

Maximum and minimum temperatures and relative humidity of the air checked daily at 08:00 and 16:00 during the experiment are displayed in Table 3.

According to the values recorded by the thermometers, the quails went through a period of high temperatures, considering that conditions of thermal comfort are close to 21°C, and relative humidity of the air around 57 to 69% (Oliveira et al., 2006).

There was effect for individual feed intake and feed conversion per egg mass (Table 4), with quadratic adjustment ($p < 0.05$), with the corn DDGS level that maximized consumption being 6.17%. When Dunnett's test was applied, it was possible to observe that, comparing the control level (0% of corn DDGS) with all levels assessed, only the 20% level of corn DDGS showed variation ($p < 0.05$), and the 13.23% level of corn DDGS maximized feed conversion per egg mass, not being desirable, considering 15 and 20% levels of DDGS as usual. Besides, for feed conversion per dozens of eggs and marketable eggs, no effect ($p > 0.05$) was found for inclusion of DDGS in the quails' diet.

For laying rate (%), differences ($p < 0.05$) were observed for corn DDGS levels used in the quails' feed, since there was quadratic effect, with the 13.59% level being the one that minimizes laying rates. In a study, Lumpkins, Batal, and Dale (2005), assessing two DDGS levels (0 and 15%), observed a reduction in egg production in chickens fed with inclusion of 15% DDGS in their diet.

The use of corn DDGS in the diets did not affect the quails' weight variation in the experimental period. Likewise, the egg's weight was not influenced ($p > 0.05$) by inclusion of DDGS in the quails' feed. On the other hand, the treatment with 15% of DDGS presented, in absolute values, the heaviest egg weight (10.55 g), followed by the 20% level of DDGS (10.3 g), justified by the variation of individual feed intake as a function of corn DDGS levels (Table 4). Abousekken (2014) also did not find significant differences as to egg weight in poultry fed with inclusion of 10, 15 and 20% of DDGS in laying hens' feed.

Yolk weight was also not influenced ($p > 0.05$) by inclusion of DDGS in the Japanese quails' diet according to regression analysis. However, only for quails fed with 15% of corn DDGS, yolk weight was influenced by Dunnett's test ($p < 0.05$), and at this substitution level the yolk weight was heavier than that presented by the poultry that consumed diet without DDGS. Świątkiewicz and Koreleski (2006) recommend the use of 15% of corn DDGS without negatively affecting egg production and quality parameters.

The other variables (albumen weight, shell weight, yolk percentage, shell percentage, albumen percentage) were not influenced ($p > 0.05$) by inclusion of DDGS in the feed.

Because corn DDGS is food rich in protein (42.7%) and fiber (18.4%), most of which is insoluble, and as its processing occurs at high temperatures, there are amino acid losses that may end up affecting the performance or quality of the quails' eggs. Furthermore, the soluble fraction of the fiber produces some negative effects on the utilization of nutrients by the poultry, associated with increased intestinal viscosity and morphological and physiological changes in the digestive tract (Classen, 1996).

As for specific gravity of eggs, there was linear reduction ($p < 0.05$) by inclusion of DDGS in the feed. According to Harder, Brazaca, Savino, and Coelho (2008), specific gravity is a method used to verify the amount of calcium deposited, being directly related to eggshell quality.

Roberson, Kalbfleisch, Pan, and Charbeneau (2005) observed that as DDGS increased there was a linear decrease in egg production (52-53 weeks of age), egg weight (63 weeks of age), egg mass (51 and 53 weeks of age) and specific gravity (51 weeks of age); for this reason, they suggest that DDGS levels should not be greater than 5% so as not to affect nutrient availability in the feed and, consequently, the poultry's production and performance data.

The color of any product of animal origin, meat or egg, is one of the criteria used in acceptance or rejection; for this reason, in the food industry color is an important characteristic for consumers. For the quail egg yolk color (Table 5) analyzed by color fan, with inclusion of DDGS in the feed, there was linear increase in treatments by regression analysis ($p < 0.05$) and by Dunnett's test; the 10, 15 and 20% levels of corn DDGS intensified yolk color ($p < 0.05$).

Table 3. Maximum and minimum temperatures and relative humidity recorded inside the facility.

Temperature and humidity	Morning	Afternoon
Maximum temperature (°C)	30.6	33.4
Maximum humidity (%)	86.5	80.2
Minimum temperature (°C)	21.5	21.8
Minimum humidity (%)	55.1	20.1

Table 4. Performance and quality of Japanese quail eggs by DDGS levels in the diet.

Parameters	DDGS levels, %					CV (%)	P valor
	0	5	10	15	20		
Individual consumption (g bird ⁻¹ day ⁻¹) ²	21.52	22.65	24.02	19.68	18.32*	10.94	0.0013
Feed conversion per egg mass (kg kg ⁻¹) ²	2.16	2.27	2.35	1.86	1.76*	11.79	0.0009
Feed conversion per dozens of eggs (kg dz ⁻¹) ^{ns}	2.73	2.69	2.98	2.94	2.39	17.52	0.1643
Laying rate (%) ²	64.44	69.38	66.48	57.38	63.23	10.06	0.0259
Marketable eggs ^{ns}	63.95	70.70	66.49	56.49	63.30	14.10	0.9881
Specific Gravity (g cm ⁻³) ¹	1.075	1.075	1.075	1.074*	1.074	0.10	0.0266
Egg Weight (g) ¹	9.94	10.02	10.25	10.55	10.33	3.51	0.1174
Yolk Weight (g) ¹	3.05	3.11	3.21	3.32*	3.19	4.01	0.0829
Albumen weight (g) ^{ns}	6.11	6.13	6.09	6.42	6.32	6.01	0.3857
Shell weight (g) ^{ns}	0.85	0.84	0.84	0.84	0.84	4.66	0.9319
% Yolk ^{ns}	29.78	30.42	30.82	30.42	30.24	3.30	0.7903
% Albumen ^{ns}	61.71	61.13	61.02	61.44	61.47	1.60	0.8136
% Shell ^{ns}	8.50	8.46	9.63	8.14	8.29	18.00	0.4294
Poultry feasibility (%) ³	100	100	97.61	97.61	97.61	-	-
Body weight variation (g bird ⁻¹) ³	0.004	0.009	0.006	0.003	0.007	-	-

ns = not significant ($p > 0.05$); ¹linear effect ($p < 0.05$); ²quadratic effect ($p < 0.05$); ³Descriptive data analysis; *Significant at 5% probability by Dunnett's test; CV = coefficient of variation. Regression equations: Individual consumption (g bird⁻¹ day⁻¹): $Y = 2.3334 + 0.0045x - 0.0017x^2$; $R^2 = 0.82$; Feed conversion per egg mass (kg kg⁻¹): $Y = 22.0814 + 0.3367x - 0.0273x^2$; $R^2 = 0.81$; Laying rate (%): $Y = 81.9537 - 2.7395x + 0.08735x^2$; $R^2 = 0.72$; Specific gravity (g cm⁻³): $Y = 1.0762 - 0.0009x$; $R^2 = 0.61$.

Table 5. Egg yolk color of laying quails fed with DDGS analyzed through color fan and digital colorimeter.

Parameters	Corn DDGS levels (%)					CV (%)	P value
	0	5	10	15	20		
Color fan	3.58	3.70	3.85*	3.98*	4.19*	4.85	0.0006
B ^{ns}	79.58	77.99*	78.78	79.23	78.83	1.05	0.0869
b ^{ns}	67.05	66.04	68.00	68.89	69.05	4.17	0.2014
a ^{ns}	4.78	4.35	4.10	4.03	3.86	24.6	0.8947

ns = not significant ($p > 0.05$); ¹linear effect ($p < 0.05$); *Significant at 5% probability by Dunnett's test; CV = coefficient of variation. Regression equation: Color fan: $Y = 3.6221 + 0.0146x$; $R^2 = 0.93$.

By regression analysis, the 20% level of DDGS presented a more intense egg yolk color. It can be considered that, with the use of corn DDGS in the quails' feed, the latter will be more yellow, and since consumers usually accept a darker color, corn DDGS can be an alternative food that can help in the pigmentation of quails' egg yolk. Egg yolk color results from deposition of xanthophylls (carotenoid pigments) and may have different sources, being natural or synthetic; among natural ones, those contained in the corn are the most common (Garcia et al., 2002).

In the analysis with the Konica Minolta digital colorimeter, B*, a* and b* values can be observed. For B*, a* and b* parameters, there was no difference ($p > 0.05$) between treatments. Only the brightness parameter (B*) presented a difference ($p < 0.05$) at the 5% level of corn DDGS by Dunnett's test. These results agree with those of other authors, such as Roberson et al. (2005) and Świątkiewicz and Koreleski (2008), who reported that inclusion of DDGS in feed for laying hens intensifies yolk color, due to presence of xanthophylls in corn DDGS. For the B parameter, since no differences ($p > 0.05$) were found between DDGS levels in the feed, this indicates similarities between the brightness of the yolks, that is, any of the DDGS levels tested could be used.

Regarding economic analysis, it was relevant to assess reductions in the production costs of the quails due to the substitution of corn and soybean meal for corn DDGS in different proportions, and fixed increase of corn starch. Based on information in Table 6, with 0% of corn DDGS the feeding cost was 122.43 BRL, followed in ascending order in monetary terms by 5% of DDGS (129.01 BRL), 10% of DDGS (129.06 BRL), 15% of DDGS (129.11 BRL) and 20% of DDGS (129.16 BRL).

There was linear reduction for feeding costs ($p < 0.05$) (Table 7), as the level with 20% of DDGS presented a* lower cost of 14.60.

Table 6. Information about technical matters and feed production costs using corn DDGS in Japanese quails' diet

	Corn DDGS levels (%)											
	0		5		10		15		20			
	Unit value (BRL weight unit ⁻¹)	Quantity (Kg)	Total Value (BRL)	Quantity (Kg)	Total Value (BRL)	Quantity (Kg)	Total Value (BRL)	Quantity (Kg)	Total Value (BRL)	Quantity (Kg)	Total Value (BRL)	
Corn	22.00 BRL kg ⁻¹ sac	60	65.01	23.84	60.09	22.03	57.63	21.13	55.17	20.23	52.71	19.33
Soybean meal	62.50 BRL kg ⁻¹ sac	60	41.82	43.56	39.36	41.00	35.67	37.16	31.98	33.31	28.29	29.47
Limestone	2.90 BRL kg ⁻¹		8.73	25.32	8.73	25.32	8.73	25.32	8.73	25.32	8.73	25.32
Nucleus*	79,90 BRL kg ⁻¹ sac	20	2.21	8.83	2.21	8.83	2.21	8.83	2.21	8.83	2.21	8.83
Soy oil	3,30 BRL L ⁻¹		2.34	7.72	2.34	7.72	2.34	7.72	2.34	7.72	2.34	7.72
Phosphate	5.00 BRL kg ⁻¹		1.23	6.15	1.23	6.15	1.23	6.15	1.23	6.15	1.23	6.15
Table salt	2.00 BRL kg ⁻¹		0.43	0.86	0.43	0.86	0.43	0.86	0.43	0.86	0.43	0.86
Corn starch	5.00 BRL kg ⁻¹		1.23	6.15	2.46	12.30	2.46	12.30	2.46	12.30	2.46	12.30
DDGS	0.78 BRL kg ⁻¹		0.00	0.00	6.15	4.80	12.30	9.59	18.45	14.39	24.60	19.19
Feeding cost (BRL)			122.43		129.01		129.06		129.11		129.16	
Egg production (dozens)			142.08		153		144.67		124.33		139.17	
Total revenue (R\$)			198.91		214.20		202.54		174.06		194.84	
Profit margin (R\$)			76.48		85.19		73.48		44.95		65.68	
Poultry feasibility (%)			100.00		100.00		97.61		97.61		97.61	
Laying rate (%)			64.44		69.38		66.48		57.38		63.23	

Source: Research results. Note: BRL – Brazilian Reais; Kg – kilos.

Table 7. Statistical analysis of feeding costs per experimental unit using corn DDGS in the Japanese quails' diet.

	Corn DDGS levels, %					CV (%)
	0	5	10	15	20	
Feeding cost (BRL/experimental period) ¹	16.79	18.33	18.20	15.46	14.60	3.45
Egg production (dozens)	142.08	153.00	144.67	124.33	139.17	-
Total revenue (BRL) ^{ns}	90.21	99.08	93.64	79.51	89.05	10.25
Profit margin ^{ns}	73.42	80.74	75.44	64.05	74.45	10.29

ns = not significant ($p > 0.05$); ¹linear effect ($p < 0.05$); CV = Coefficient of Variation. Regression Equation: Feeding cost: $\hat{Y} = 18.12348433 - 0.144953233x$; $R^2 = 0.99$.

For profit margin and total revenue, there was no significant difference ($p > 0.05$). Among the treatments analyzed, the one that presented the best cost-benefit ratio was the 20% level of corn DDGS. Thus, inclusion of corn DDGS can be considered an adequate strategy as an alternative ingredient in the feed of laying quails. Among the treatments analyzed, the one that presented the best cost-benefit ratio was the 20% level of corn DDGS, as it reached the highest profit margin. Thus, inclusion of corn DDGS can be considered an adequate strategy as an alternative ingredient in the feed of laying quails.

Conclusion

In this way, inclusion of 20% of corn DDGS in the diet of Japanese quails is indicated for being viability economically and not impairing egg performance and quality. Distillers dried grains with solubles from corn have pigment potential in egg yolk, causing the latter to be more yellow.

References

- Abousekken, M. S. M. (2014). Use of corn distillers dried grains with solubles (ddgs) in laying quail diets. *Egyptian Poultry Science Journal*, 34(3), 681-703.
- Classen, H. L. (1996). Cereal grain starch and exogenous enzymes in poultry diets. *Animal Feed Science and Technology*, 62(1), 21-27.
- Cortes Cuevas, A., Esparza Carrillo, C. A., Sanabria Elizalde, G., Iriarte, J. M., Ornelas Roa, M., & Ávila González, E. (2012). El uso de granos secos de destilería con solubles (DDGS) en dietas sorgo-soya para pollos de engorda y gallinas de postura. *Revista Mexicana de Ciencias Pecuarias*, 3(3), 331-341.
- Garcia, E. A., Mendes, A. A., Pizzolante, C. C., Gonçalves, H. C., Oliveira, R. P., & Silva, M. A. (2002). Efeito dos níveis de cantaxantina na dieta sobre o desempenho e qualidade dos ovos de poedeiras comerciais. *Revista Brasileira de Ciência Avícola*, 4(1), 1-7.

- Harder, M. N. C., Brazaca, S. G. C., Savino, V. J. M., & Coelho, A. A. D. (2008). Efeito de *Bixa orellana* na alteração de características de ovos de galinhas. *Ciência e Agrotecnologia*, 32(4), 1232-1237.
- Lumpkins, B. S., Batal, A. B., & Dale, N. M. (2004). Evaluation of distillers dried grains with solubles as a feed ingredient for broilers. *Poultry Science*, 83(11), 1891-1896.
- Lumpkins, B., Batal, A., & Dale, N. (2005). Use of distillers dried grains plus solubles in laying hen diets. *Journal of Applied Poultry Research*, 14(1), 25-31.
- Oliveira, R. F. M., Donzele, J. L., Abreu, M. L. T., Ferreira, R. A. o., 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.
- Parsons, C. M., Baker, D. H., & Harter, J. M. (1983). Distillers dried grains with solubles as a protein source for the chick. *Poultry Science*, 62(12), 2445-2451.
- Roberson, K. D., Kalbfleisch, J. L., Pan, W., & Charbeneau, R. A. (2005). Effect of corn distiller's dried grains with solubles at various levels on performance of laying hens and egg yolk color. *International Journal of Poultry Science*, 4(2), 44-51.
- Rocha-Silva, M., Araujo, C. V., Pires, A. V., Paula, E. J. H., Ferreira, E. B., & Silva, F. G. (2016). Curva de crescimento de codornas de corte por meio de modelos de regressão não-lineares. *Archives of Veterinary Science*, 21(4), 26-34. doi: 10.5380/avs.v21i4.41571.
- Rostagno, H. S., Albino, L. F. T., Donzele, J. L., Gomes, P. C., Oliveira, R., Lopes, D. C., ... Euclides, R. F. (2017). *Composição de alimentos e exigências nutricionais* (Vol. 1, 3a ed.). Viçosa, MG: Universidade Federal de Viçosa.
- Świątkiewicz, S., & Koreleski, J. (2006). Effect of maize distillers dried grains with solubles and dietary enzyme supplementation on the performance of laying hens. *Journal of Animal and Feed Sciences*, 15(2), 253-260.
- Świątkiewicz, S., & Koreleski, J. (2008). The use of distillers dried grains with solubles (DDGS) in poultry nutrition. *World's Poultry Science Journal*, 64(2), 257-266.
- Wiltafsky, M., Fickler, J., Hess, V., Reimann, I., Zimmer, U., & Reising, H. W. (2010). AminoDat ®5.0, animal nutritionist's information edge. *Evonik Nutrition & Care*, 3, 370.