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RESEARCH PAPER

The inclusion of distiller's dried corn grains with solubles in the feed of laying hens during the production stage

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Abstract

H.E. Rodríguez-Ríos, J.A. Campos-Parra, P.A. Williams-Salinas, M.H. Blanck-Heimann, R.G. Astudillo-Neira, and J.D. Grande-Cano. 2015. The inclusion of distiller's dried corn grains with solubles in the feed of laying hens during the production stage. Cien. Inv. Agr. 42(3): 331-339. The aim of this study was to assess the effects of distiller's dried corn grains with solubles (DDGS) in the diet of laying hens on their productive parameters (live weight, laying percentage, and feed intake) and egg quality (egg weight, mass, yolk color and shell thickness). This study was conducted in the Andes Mountains in Parral, Chile. It covered a span of 13 weeks of productive egg laying, ranging from the 31st to the 44th week of life of the hens. The experimental design was a random complete block using 225 Hy-Line Brown breed hens, distributed in 5 treatments, where each treatment consisted of three repetitions in 15 hens. The treatments included replacing soybean concentrate with DDGS at levels that corresponded to inclusion in the diet of 5, 10, 15 and 20%. The laying percentage, feed intake and feed conversion did not decrease with increasing levels of DDGS in the diet, but there was a slight decrease in egg weight and a lower egg mass. Yolk color increased with increasing levels of DDGS. The use of DDGS is possible as a replacement for soybean bran in levels up to 20% in the diet of laying hens without affecting their production, as demonstrated by the lack of significant differences among treatments in measured egg laying parameters.

Key words: Egg production, Hy-Line Brown, soybean bran.

Introduction

In Chile, both corn and soybean concentrate are the most common products in the diets of laying hens (Fundación Chile, 2007; ODEPA, 2010).

Distiller's dried corn grains with solubles (DDGS) are considered a by-product of the bioethanol elaboration process, and they are formed in the same proportion as the other resulting products, ethanol and CO_2. Thus, they correspond to about one third of the final products (Roberson *et al.,* 2005).

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The availability of DDGS is incrementally increasing as a result of the production of bioethanol. In 2008, the USA had a total production of 12 million tons (Gibson and Karges, 2006), whereas in 2011 the production was 52 million tons (De Camargo Bini, *et. al.,* 2012). In Chile, there have been emerging studies of the installation of biodiesel plants from agriculture products (Muñoz-Lagos *et al.,* 2010). Therefore, the possibility of the efficient use of DDGS in animal production, especially in the diets of poultry and swine, is increasing.

The nutritional composition of DDGS suggests that its concentration of proteins fluctuates between 23 and 30% (Batal and Dale, 2006). However, the protein values are lower in maize (8.84%) and below that registered for soybean concentrate (47%) (Cuca *et al.,* 2003). The metabolizable energy in DDGS varies between 2490 and 3190 kcal kg^{-1} on a dry matter basis (Batal and Dale, 2006; Waldroup *et al*., 2007).

According to Roberson *et al.* (2005), the incorporation of 15% DDGS into the diet of laying hens does not affect egg production, and additional synthetic lysine is not needed.

There has been a lack of studies in our country regarding the use of DDGS in the commercial feed of laying hens. The aim of the current study was to assess the effect of the inclusion of DDGS as a replacement for soybean bran in relation to productive parameters and egg quality in laying hens.

Material and Methods

The study was conducted in a poultry farm located in Villa Baviera, Municipality of Parral, Chile (36°09′00′′ S and 71°50′00′′ W). It lasted 13 weeks, from the 31st to the 44th weeks of life of the hens. A total of 225 Hy-Line Brown breed laying hens were used, aged 31 weeks of age at the beginning of the study, with an initial weight of 2011 ± 54.46 g. Hens were part of a stable of 3,200 hens inside a barn 27 m long, 7 m wide and 5 m high. Natural ventilation was produced by side openings in both upper and lower sectors of the wall. Hens were confined in cages divided in three sections each with a capacity of 5 hens per section, housed on three floors.

Artificial illumination 18 Watt light bulbs were placed over the longitudinal corridors separated 6 m each. Artificial illumination was controlled by an automatic clock. The illumination regimen used included an average of 17 h light per day, both natural and artificial light. A proximate analysis of the used DDGS is shown in Table 1. The diet for laying hens was formulated (Table 2) in order to satisfy their nutritional requirements, modifying the remaining ingredients to preserve isocaloric and isoproteic diets (Table 3). Drinking water was available *ad libitum* during the study. In order to provide water, nipple drinkers were located convenient to the hens. Feed was offered once a day. Treatments were formulated using increasing levels of DDGS in replacement of soybean concentrate, corresponding to inclusion levels in the diet of 0, 5, 10, 15 and 20% on a dry weight basis (Table 2). Diets were subjected to proximal chemical analysis, according to standardized analytical protocols (Cunniff, 1996). The experimental design was randomized by complete blocks, with 5 treatments of 3 repetitions of 15 birds each. During the study, the following measurements were performed: a) The live weight of the hens (g $bird^{-1}$) was measured. All hens were weighed on a

Table 1. Proximal analysis of DDGS used in diets.

Nutrients	Dry-matter basis, g 100 g^{-1}
Dry matter	100.00
Ash	4.84
Crude protein	24.56
Ether extract	13.52
Crude fiber	5.66
Nitrogen free extracts	51.42
Metabolizable energy	3,987 kcal kg^{-1}

Table 2. Composition of the diets used in the five treatments (kg 100 kg^{-1}).

	Treatments (%)				
Ingredients	0	5	10	15	20
Corn grain	64.00	60.70	57.50	54.20	51.00
Wheat bran	1.70	3.20	4.60	6.10	7.50
Soybean concentrate	16.00	12.00	8.00	4.00	0.00
Corn DDGS	0.00	5.00	10.00	15.00	20.00
Fish meal	6.00	7.00	8.00	9.00	10.00
Calcium bicarbonate (Ca CO_3)	11.00	11.00	11.00	11.00	11.00
Common salt (Na Cl)	0.20	0.20	0.20	0.20	0.20
Bicalcium phosphate	0.80	0.60	0.40	0.20	0.00
Vitamin mixture	0.10	0.10	0.10	0.10	0.10
Mineral mixture	0.10	0.10	0.10	0.10	0.10
D. L. Methionine	0.10	0.10	0.10	0.10	0.10
Lysine amino acid	0.01	0.01	0.01	0.01	0.01

Vitamin mixture: consisted of vitamins A, D, E, K, B2, B12, nicotinic acid, calcium pantothenate, folic acid, biotin, choline chloride and antioxidants.
Minerals: mixture consisted of Cu, Fe, Zn, Mn and Co.

Table 3. Nutrients supplied by diets v/s requirements (Hy-Line International, 2005), according to the inclusion levels of corn DDGS.

	Treatments (%)					
Nutrients	0	5	10	15	20	Requirements
Crude protein (%)	16.40	16.30	16.30	16.30	16.30	16.30
Metabolizable energy (kcal kg^{-1})	2,716	2,719	2,723	2,726	2,729	2,700
Lysine (%)	0.93	0.91	0.89	0.87	0.85	0.85
Methionine+Cysteine (%)	0.70	0.72	0.74	0.76	0.79	0.65
Calcium (%)	4.07	4.06	4.04	4.03	4.01	4.00
Phosphorous (%)	0.38	0.40	0.42	0.43	0.45	0.34

Soehnle electronic scale at the initiation and the end of the experimental period; b) Weekly average egg-laying was measured on the basis of the hen-day method; c) Weekly average feed intake was measured once a week before feeding the hens, and the residual feed was collected from feeders. The actual intake of the hens per week was obtained from the difference (feed offered - feed collected) (number birds^{-1}); d) Weekly feed conversion was measured; the consumed feed in kg was quantified, and it was divided by dozens of eggs produced; and d) Mortality was determined by calculating the number of dead hens divided by the total of number of hens in the treatment, and it was expressed in percentage. In addition, in a sample of 10 eggs randomly obtained weekly per treatment the following aspects were measured: a) average weight (g), weighed on an Osenle electronic scale with 1 g sensitivity; b) Egg mass, which corresponded to the egg weight per laying percentage divided by 100; c) Yolk color, determined by the Hoffman-La Roche (1-15) colorimetric scale; and d) Egg shell thickness, determined using the method by Olsson (1936).

Results obtained in the study were subjected to a variance analysis using the contrast test proposed by Duncan (1974). Assumptions from the variance analysis were verified by means of the Shapiro Wilks test, modified for normality, and Bartlett's test for the homogeneity of the variance. Variables that did not fulfill the assumptions of the model were transformed by means of the function $\sqrt{x+0.5}$. For the yolk color variable, the Kruskal-Wallis non-parametric variance analysis test and the contrast test proposed by Conover (1999) were used. Statistical analyses were performed using the Infostat statistical software (Balzarini *et al*., 2008), with 95% confidence.

Results and Discussion

Hens' live weight

Hens' live weight at the beginning of assessment varied between 1957 and 2057 g per hen and at the end between 1886 and 1970 g per hen. In all treatments, a lowering in body weight was observed (Table 4). Nevertheless, at the beginning and end of the experimental period, the average weight of the hens was found to be above the range recommended for the Hy-Line Brown breed at this age (1910 – 1950 g). Low weight was due to the increase in the room temperature during the assessment period (Figure 1), which generated lower feed intake. This is in agreement with results obtained by Castello *et al.* (1989) and Leeson *et al.* (2000).

Egg-laying

Egg-laying percentage fluctuated between 88.6 and 93.1% when using DDGS as a diet ingredient, replacing soybean concentrate, without statistically significant differences among treatments (p>0.05). The highest laying percentage (93.1%) was obtained in birds in the control treatment, and the lowest laying percentage (88.6%) was obtained in hens with 15% inclusion (Table 5).

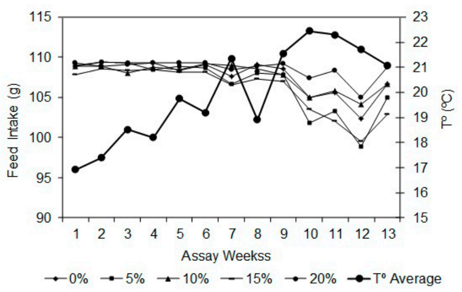

Figure 1. Feed intake (g bird-1 day-1) during the study with respect to the inclusion levels of corn DDGS v/s weekly temperature (ºC).

In Table 5, it can be observed that the production of eggs tended to decrease as the inclusion percentage of DDGS increased. However, the reduction did not occur uniformly because hens from treatments with 10% and 20% inclusion showed higher values of egg-laying percentages than those of 5% and 15%, respectively.

Treatment with an inclusion of 10% DDGS with an egg-laying percentage of 91.2% was highlighted among other treatments, although it was only 1.9 percentage points lower than the control and was not statistically significantly different from the other groups (p>0.05). Roberson *et al.* (2005) and Lumpkins *et al.* (2005) observed a negative trend in egg production with increasing levels of DDGS in the diets of laying hens, but production was not significantly affected (p>0.05) by using up to 15% of this product in the total diet. However, in this study differences in egg-laying were observed (p>0.05) until a level of 20% DDGS. This trend towards a decrease in production could be explained because the quality of protein from DDGS is lower than that of soybean, and the contents of the amino acids are relatively deficient, especially in the case of the lysine (Lumpkins *et al.*, 2005).

According to Elwinger (2007), in the USA, no more than 10% DDGS is recommended in poultry diets. This recommendation would not be appropriate in terms of productivity because the outcomes from the present study indicate that with some variations, production would tend to be stable over time.

By analyzing the egg-laying percentage in the evaluation period, a production decrease across

Table 4. Live weight variation of birds with respect to inclusion levels of corn DDGS.

	Treatments (%)				
Parameters	0	5	10	15	20
Initial weight (g bird^{-1})	2,029	2,047	2,057	1,957	1,967
Final weight (g bird^{-1})	1,963	1,970	1,946	1,866	1,885
Weight variation (g)	- 66	- 78	- 111	- 90	- 82

CV: coefficient variation.

Table 5. Productive parameters and egg quality in laying hens, according to the inclusion levels of corn DDGS.

Treatments (%)	Productive Parameters				Egg Quality Parameters		
	Egg-laying %	FI g hen^{-1} day^{-1}	FC kg dozen eggs^{-1}	S.T. mm	EW g	EM g hen^{-1} day^{-1}	YC
0	93.1	106.7 bc[1]	1.39 a	0.33	65.0 bc	60.57 b	10.4 a
5	91.2	105.0 ab	1.41 ab	0.34	64.1 abc	58.00 a	10.5 b
10	92.5	106.7 bc	1.43 ab	0.33	62.8 ab	57.72 a	10.6 bc
15	88.6	102.8 a	1.44 ab	0.34	65.2 c	57.76 a	10.7 c
20	89.3	108.8 c	1.46 b	0.33	63.0 a	56.34 a	10.8 d
CV%	2.52	0.65	2.31	1.47	1.50	1.85	
Significant[2]	Ns	s	s	s	s	s	s

[1]Differences (by letter) in columns for egg laying, feed intake, feed conversion, shell thickness, egg weight, egg mass and yolk color were statistically significant, according to Duncan and yolk color to Conover ($p \leq 0.05$).
[2]Significant. ns: not significant. s: significant.
Egg-laying (%). FI: Feed Intake (g (hens day)$^{-1}$). FC: Feed Conversion (kg (dozen eggs)$^{-1}$). ST: Shell Thickness (mm). EW: Egg Weight (g). EM: Egg Mass (g hens day)$^{-1}$). YC: Yolk Color.
CV: coefficient variation

all treatments was observed without significant statistical differences (p>0.05) (Figure 2). This could be due to the hens aging (Castello *et al.*, 1989), to lower feed intake, or it could be a product of an increase in the room temperature (Calvert, 1978). This phenomenon also appeared in the study of Roberson *et al.* (2005). Therefore, this variation was not attributed to the change of the diet because the decrease in the production was similar across all treatments, including the control treatment. When the temperature decreases, the egg-laying percentage tends to decrease because of decreasing feed intake. This also causes a decrease in the protein ingestion which, in turn, results not only in lower production but also in a notorious decrease in the weight of the eggs (Calvert, 1978), all of which are aspects considered in this study. Maximum egg-laying percentage is usually achieved in the range of 18 to 21 ºC. Production is worsened both above and under these levels (Calvert, 1978).

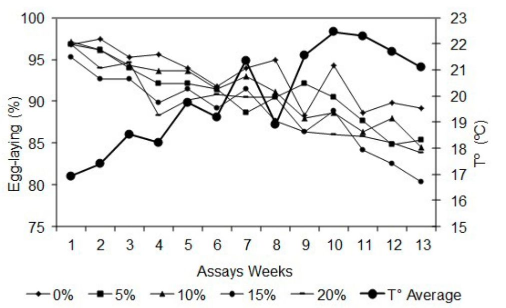

Figure 2. Variations in egg production (% egg-laying) during the study with respect to the inclusion levels of corn DDGS v/s weekly average temperature (ºC).

Feed intake

In Table 5, the effects on intake were observed by incorporating increasing doses of DDGS in replacement of the soybean concentrate in the diet of laying hens. Among controls and treatment groups with an inclusion of 5, 10 and 20%, no statistically significant differences were observed ($p>0.05$), but the birds from the treatment group with 15% inclusion presented with lower intake with respect to the others, reaching only 102.8 g (bird day)$^{-1}$. This treatment differentiated ($p\leq0.05$) from treatment groups 0, 10 and 20%, but was not significantly different ($p\leq0.05$) from the birds treated with 5% inclusion. It is interesting to note that birds from the treatment group with 20% DDGS in their diets presented with greater intake and were differentiated ($p\leq0.05$) from the birds treated with 5 and 15% inclusion. These results showed a clear trend in the feed intake with increasing levels of DDGS in the diet. This could be due to the temperatures present during the period of assessment (Figure 1). Roberson *et al.* (2005) observed a slight decrease in feed intake by including 5, 10 and 15% DDGS, whereas Lumpkins *et al.* (2005) indicated the feed intake tends to increase by including 15% corn DDGS in the diet of laying hens, without observable differences ($p>0.05$). Feed intake averages during the whole period were lower than the standards for laying hens from the Hy-Line Brown breed, from 31 to 44 weeks of age (Hy-Line International, 2005). These differences could be because the assessment was carried out from November 2008 to January 2009, in which maximum temperatures reached 32 ºC. This may be why from the ninth week, there was a notable decrease in feed intake (Figure 1). According to Hy-Line International (2005), room temperature must be within the range of 18 to 27 ºC. According to Castello *et al.* (1989), feed intake should not be lower than between 6 and 9 g as a result of an increase in the room temperature of 5 ºC. Castello *et al.* (1989) asserts that the reductions in feed intake due to an increase in room temperature vary by approximately 1.5% per 1 ºC under moderate temperatures (18 ± 4 ºC). This allows for the deduction that the decrease in feed intake during the study did not occur as a result of the inclusion of DDGS in the diet but as a result of an increase in the room temperature.

Feed conversion

There was a variation from 1.39 to 1.46 kg of consumed feed per dozen eggs produced and a slight increase as the percentage of DDGS was incremented in diet, without statistically significant differences ($p>0.05$) (Table 5). These values were below the standards (1.49 kg) established by Hy-Line International (2005) for laying hens of the Hy-Line breed because of the temperatures during the course of the assay. However, they are within normal standards compared to tables from National Research Council (NRC, 1994). There were no differences in feed conversion among treatments ($p>0.05$), except for birds with 20% inclusion, which differentiated from controls ($p\leq0.05$) due to a high intake and lower production presented compared to the other treatments. Lumpkins *et al.* (2005) also observed a trend towards an increase in feed conversion with respect to controls by incorporating 15% corn DDGS in the diet, which is in agreement with the results of this study. The results for feed conversion obtained in the current study are analyzed and are within normal standards compared with tables from the NRC (1994).

Mortality

No cases of mortality were observed.

Egg weight

In Table 5, it can be observed that there was a slight variation in recorded values between 62.8 g in birds from the 10% inclusion treatment group and 65.2 g for birds from the 15% inclusion treatment group. In this case, significant differences were found ($p\leq0.05$) between birds from treatments 10 and 15% and between 0 and 20%, but a consistent trend was not observed in changes in egg weight with increasing DDGS inclusion levels. Three out of four treatments where in DDGS was included in the diet led to a slight decrease in weight with respect to control birds. Nevertheless, the egg weight of 65.2 g of birds in the treatment group with 15% inclusion was still slightly higher than birds from the control group and only significantly differentiated from birds in the 10 and 20% treatment groups. The results are similar to those obtained by Roberson *et al.* (2005), who found a decrease in the egg weight by including up to 10% DDGS in diet, but by including 15% corn DDGS as a replacement for soybean concentrate, they also observed a rise in the egg weight. According to Lumpkins *et al.* (2005), who assessed behavior in laying hens after including up to 15% corn DDGS in the diet, no significant differences were observed in the weights of the eggs. The main measured factors related to egg weight are follows: energy, proteins, methionine and lysine (Castello *et al.*, 1989; Leeson *et al.*, 2000). By analyzing the nutrients provided by the ingredients of the diet (Table 2), as well as the nutritional analyses of the diet, no nutritional deficiency was observed. Therefore, the observed slight decrease in the egg weight could be attributed to other factors, such as the protein quality of the DDGS (Lumpkins *et al.,* 2005) and the availability and digestibility of the amino acids found below the corn grain (Batal and Dale, 2006) as a result of the application of high temperatures during the process of bioethanol production. Temperatures oscillated between 130 and 620 ºC (U.S. Grain Council, 2012). Among the main factors that influence the digestibility of the protein, the nature of the protein is highlighted. Treatments by heat, pressure or steam or the nature of the remaining elements of the diet should be mentioned (De Blas and Gonzalez, 1991). In the nutritional analysis during the study, an increase in the raw fiber was observed as DDGS levels increased in the diet. De Blas and Gonzalez (1991) indicate that a high content of raw fiber in the diet results in the greater secretion of mucin in the intestine, and endogenous losses of amino acids increase.

Egg mass

This parameter indicates the total mass of the eggs produced by a hen as a daily average and directly depends on the number of eggs produced and their weight. Significant differences were found ($p \leq 0.05$) among the control treatment (60.57 g) and the birds from treatments 5, 10, 15 and 20% (with values of 58.00, 57.72, 57.6 and 56.34 g, respectively), which indicates that the egg masses in all treatment groups were lower than the control treatment (Table 5). Among birds from the 5, 15 and 20% treatment groups, the egg mass was not affected ($p > 0.05$); although between birds from treatment groups with 15 and 20% inclusion, a notable decrease was observed, with a difference of 1.4 g. As egg mass depends on both production and egg weight, this parameter followed the same production trend, which was affected by high temperatures.

Yolk color

An increment in yolk color was produced as the DDGS percentage was increased in the diet. Significant differences were observed ($p \leq 0.05$) among birds from the control group and birds from the other treatments (Table 5). However, the variation range in the Hoffmann – La Roche scale was minimal, ranging from 10 for control birds to 11 for birds from the treatment group with 20% DDGS inclusion. This trend was also observed by Roberson *et al.* (2005). In contrast, Lumpkins *et al.* (2005) found no significant differences ($p > 0.05$) by including 15% corn DDGS in the diet. Yolk color depends exclusively on the feed consumed by the hen, particularly on the total level of xanthophylls contained in the diet (Castello *et al.*, 1989). Xanthophylls are generally supplied by natural raw materials such as corn (De Blas and Gonzalez, 1991). Leeson *et al.* (2000) found that higher levels of corn in the diet have a positive effect on yolk color. Therefore, we can deduce that DDGS corn retains most of the xanthophylls and higher amounts in the diet may cause greater color intensity of the yolk.

Shell thickness

Variation in the egg shell thickness among different treatments was 33-34 mm, and statistically there were no differences (p>0.05) from control (Table 5). Calcium content in the diet is the most important nutritional factor in relation to the quality of the egg shell because 90% of the minerals are contained in the shell, and 98% correspond to calcium (De Blas and Gonzalez, 1991). DDGS contains 0.22% calcium, a value that is below soybean concentrate (0.67%) but above corn (0.03%) (Cuca *et al.,* 2003). Because soybean concentrate was replaced by DDGS, the calcium percentage provided in the diet (Table 3) decreased 0.06 percentage points. However, no limitations were observed with respect to the formation of the egg shell by using up to 20% corn DDGS in the diet of laying hens. Therefore, this production parameter was not affected by the inclusion of DDGS in soybean bran replacement. However, a slight decrease in the weight and mass variables, but not pigmentation, was observed for egg quality. Based on these considerations, we conclude that DDGS can replace soybean bran in the diet of laying hens in levels up to 20% of the total feed without affecting production, and these conclusions are due to the lack of significant differences between treatments for important egg laying parameters.

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Resumen

H.E. Rodríguez-Ríos, J.A. Campos-Parra, P.A. Williams-Salinas, M.H. Blanck-Heimann, R.G. Astudillo-Neira y J.D. Grande-Cano. 2015. Inclusión de granos secos de destilería con solubles en gallinas de postura en la alimentación durante la etapa de postura. Cien. Inv. Agr. 42(3): 331-339. El objetivo de este ensayo fue evaluar el uso de granos secos de destilería con solubles (DDGS) en la dieta de gallinas de postura en relación a los parámetros productivos (peso vivo, porcentaje de postura, consumo de alimento) y calidad del huevo (peso de huevo, masa, color de yema y grosor de la cáscara). Este estudio fue realizado en la Cordillera de los Andes, Comuna de Parral, Chile. Tuvo una duración de 13 semanas de postura, desde la semana 31 a la 44 de vida de las aves. El diseño experimental fue bloques completos al azar, usando 225 gallinas de la raza Hy-Line Brown, distribuidas en 5 tratamientos, donde cada uno tuvo 15 repeticiones de 15 gallinas. El tratamiento consistió en el reemplazo en diferentes niveles del concentrado de soya por DDGS, que correspondieron a niveles de inclusión en la dieta de 5, 10, 15 y 20%. El color de la yema fue mayor con aportes incrementales de DDGS. Se concluye que el uso de DDGS es posible como reemplazo del afrecho de soya en niveles de hasta 20% en la dieta de gallinas de postura, debido a la falta de diferencias estadísticas entre tratamientos postura de huevos.

Palabras clave: Afrecho de soya, Hy-line Brown, producción de huevos.

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