Use of Distillers Dried Grains Plus Solubles in Laying Hen Diets

B. Lumpkins, A. Batal,[1] and N. Dale

Poultry Science Department, 208 Poultry Science Building,
University of Georgia, Athens, Georgia 30602-2772

Primary Audience: Nutritionists, Researchers

SUMMARY

A major emphasis on ethanol production in the US has led to the construction of new ethanol plants and an increased production of distillers dried grains plus solubles (DDGS). In the past DDGS came largely from the beverage industry and consisted of several grains used during fermentation. Recently, a majority of the DDGS produced is from corn fermentation for ethanol production. Little research has been conducted to test the use of this new generation DDGS from modern ethanol plants in laying hen diets. Hy-line W-36 laying hens were used to test an elevated inclusion level of DDGS from modern ethanol plants that can be incorporated into layer diets. Hens were fed a commercial or low-density diet formulated to contain 0 or 15% DDGS for 25 to 43 wk of age. No differences were observed in the majority of parameters evaluated between hens fed 0% or 15% DDGS. However, there was a significant (P < 0.05) reduction in hen-day egg production through 35 wk of age when hens were fed the low-density diet with 15% DDGS. Hens fed the commercial diet with 15% DDGS had numerically lower egg production to 32 wk of age, but this was not statistically significant. Distillers dried grains plus solubles proved to be an acceptable feed ingredient for laying hen diets. A suggested maximal inclusion level of 10 to 12% DDGS, based on these data and previous research, may be used in commercial diets, but it is speculated that DDGS should be incorporated at lower levels in low-density diets.

Key words: distillers dried grains plus solubles, laying hen, egg quality, egg production
2005 J. Appl. Poult. Res. 14:25–31

DESCRIPTION OF PROBLEM

The US has recently placed a major emphasis on increasing ethanol production. The government's reasoning for this increase in ethanol production is due mainly to environmental issues; ethanol burns cleaner and supplies more energy than crude oil [1]. Due to this emphasis, the production of nonbeverage ethanol has climbed to over 2 million gal/year, and additional modern ethanol plants are currently being built that will further increase this quantity. In the production of ethanol, 3 approximately equal components are formed: one-third is ethanol, one-third is lost as carbon dioxide, and the final one-third is the by-product distillers dried grains plus solubles (DDGS). Currently in North America, there are approximately 3 million tonnes of DDGS available to feed producers, and by the year 2005, it is estimated that there will be 5 to 7 million tonnes [2].

In past decades, DDGS was used as a feed ingredient in poultry diets, partially due to its unidentified growth factors. Later, it was determined that these unidentified growth factors were

[1]To whom correspondence should be addressed: batal@uga.edu.

TABLE 1. Composition of layer diets (as-fed basis)

Ingredient	Commercial		Low density	
	Control	DDGS[1]	Control	DDGS
	(%)			
Corn, yellow, ground	54.944	48.082	61.415	54.554
Soybean meal (48%)	29.659	21.585	25.450	17.375
DDGS	—	15.000	—	15.000
Limestone	9.358	9.484	9.432	9.557
Fat, poultry	3.430	3.447	1.180	1.197
Dicalcium phosphate	1.666	1.289	1.574	1.197
Salt	0.417	0.386	0.418	0.387
Egg layer premium[2]	0.250	0.250	0.250	0.250
DL-Methionine	0.211	0.199	0.176	0.164
Trace mineral premix[3]	0.060	0.060	0.060	0.060
L-Lysine	0.005	0.219	0.045	0.259
Contents by calculation				
ME, kcal/kg	2,871	2,871	2,805	2,805
Protein, %	18.5	18.5	17.0	17.0
Lysine, %	1.02	1.02	0.94	0.94
Methionine, %	0.52	0.53	0.47	0.48

[1]DDGS = distillers dried grains plus solubles, estimated TME_n = 2,800 kcal/kg, 27% crude protein, and 0.94% lysine.
[2]Vitamin mix provided the following per kilogram of diet: thiamin•mononitrate, 2.4 mg; nicotinic acid, 44 mg; riboflavin, 4.4 mg; D-Ca pantothenate, 12 mg; vitamin B_{12} (cobalamin), 12.0 μg; pyridoxine•HCL, 2.7 mg; D-biotin, 0.11 mg; folic acid, 0.55 mg; menadione sodium bisulfate complex, 3.34 mg; choline chloride, 220 mg; cholecalciferol, 1,100 IU; transretinyl acetate, 5,500 IU; all-*rac*-tocopherol acetate, 11 IU; ethoxyquin, 150 mg.
[3]Trace mineral mix provides the following per kilogram of diet: manganese ($MnSO_4 \cdot H_2O$), 60 mg; iron ($FeSO_4 \cdot 7H_2O$), 30 mg; zinc (ZnO), 50 mg; copper ($CuSO_4 \cdot 5H_2O$), 5 mg; iodine (ethylene diamine dihydroiodide), 1.5 mg; selenium (selenium selenite), 0.5 mg.

usually vitamins synthesized during fermentation that were limiting in diets. Thus, feeding DDGS resulted in improved overall performance. By the 1950s, synthesis of these vitamins and availability of trace minerals were common, and DDGS was largely removed from poultry rations and used more in ruminant and pet foods. The DDGS available in the past was from the fermentation of a variety of different grains used by the beverage industry. Today, the DDGS available is almost exclusively from corn fermentation in the process of producing ethanol.

Distillers dried grains with solubles have been extensively incorporated into dairy and beef cattle diets, but the levels fed will not fully use the increasing quantities available. The DDGS from modern ethanol plants may be an attractive alternative ingredient for layer diets. Thus, our primary objective was to evaluate the effects of feeding an elevated quantity of DDGS in laying hen rations.

MATERIALS AND METHODS

Experimental Procedures

All procedures were approved by the University of Georgia Committee on Laboratory Animal Care. Hy-line W-36 [3] White Leghorn hens were housed in a completely enclosed fan-ventilated building with elevated wire cages in which they were exposed to a 16 L:8 D daily lighting schedule, and 2 hens were placed in a 12 × 18 in. cage. The experiment was conducted for a 22-wk period from June to October. The hens were provided feed and water ad libitum throughout the study. A total of 4 diets were formulated for the experiment; 2 were commercial diets to observe how DDGS would perform at industry standards, and 2 were low-density diets to test the sensitivity of this feed ingredient. Prior to formulating the diets, it was determined that the DDGS sample had a TME_n of 2,805 kcal/kg, 27% CP, and 0.94% lysine [4]. For the first 4 wk of the study, hens were divided into 2 groups and only fed the commercial-grade diets, which contained 0 or 15% DDGS (Table 1). The 15% DDGS level was selected as a level higher than what may actually be fed as a means for observing any performance limitations that may occur. These diets were fed from 21 to 25 wk of age to 16 replicates of 16 hens, 256 hens per treatment. The commercial-grade diets were fed to ensure that the hens would reach the

TABLE 2. Effect of feeding DDGS[1] in a commercial and low-density diet to laying hens on hen-day egg production[2]

	Commercial diets			Low-density diets		
Age (wk)	0% DDGS	15% DDGS	Pooled SEM	0% DDGS	15% DDGS	Pooled SEM
	(%)			(%)		
22	62.9	64.2	2.29	—	—	—
24	94.2	92.3	1.42	—	—	—
26	95.2	94.3	0.99	95.4^{a}	91.1^{b}	0.84
28	95.5	92.3	1.02	94.9	91.6	1.29
30	96.2^{a}	92.2^{b}	1.14	95.3^{a}	89.9^{b}	1.29
32	94.2	91.7	1.03	93.7^{a}	90.2^{b}	1.04
34	92.7	92.4	0.96	90.3	87.6	1.43
36	90.0	92.3	0.96	89.6	88.1	2.97
38	91.0	91.3	1.04	89.0	88.4	0.84
40	90.7	91.7	0.79	88.9	87.2	0.96
42	89.5	90.8	1.14	88.9	88.9	1.09

[a,b]Means within a row and diet with no common superscript differ significantly ($P < 0.05$).
[1]DDGS = distillers dried grains plus solubles.
[2]Means represent 8 replications per treatment (16 hens per replication).

recommended BW before being placed on a more sensitive low-density diet, due to the hot summer conditions and the pullets being slightly underweight.

At 25 wk of age, 2 additional diets were incorporated into the experiment. The 2 additional diets formulated were low-density diets, lower in protein and energy than that of the commercial-grade diets. The commercial-grade diets were formulated to contain 18.5% protein and a TME_n of 2,871 kcal/kg, and the lower-density diets contained 17.0% protein and a TME_n of 2,805 kcal/kg (Table 1). Half of the hens being fed the commercial-grade diet with 0% DDGS were switched to the low-density diet, containing 0% DDGS, and half the hens being fed the commercial-grade diet with 15% DDGS were then fed the low-density diet with 15% DDGS. Therefore, at 25 wk of age, all 4 diets were each fed to 8 replications of 16 hens until 43 wk of age. The low-density diets were designed to be more sensitive than the commercial grade by allowing any nutritional limitations of DDGS to become evident. When mortality occurred, the hen was weighed, and hen-day egg production and feed intake were adjusted accordingly.

Egg production was measured daily (hen-day production), and egg weights were measured on a weekly basis after all eggs were collected for that day. Feed consumption, feed efficiency, and hen BW were measured at 25, 31, and 43 wk of age. The exterior (shell) quality was tested, using 2 different methods. The 2 tests performed, specific gravity and shell-breaking strength, were conducted at 25, 35, and 43 wk of age. Shell-breaking strength was measured on each individual egg using a texture analyzer [5] with a 5-kg load cell. The test speed was set at 2 mm/s with a 1-g trigger. The eggs were placed in a cradle under the load cell with the air cell pointing up. The load cell applied pressure to the top of the egg until it cracked, and the force required to crack the egg was recorded in newtons. Eggs were also evaluated for interior quality by determining Haugh units and yolk color. Haugh units were measured using the quantum chromodynamics super system [6]. Yolk color was tested using a Minolta colorimeter [7]. The colorimeter takes 3 measurements and averages them into 3 axis values of L* (lightness) for white and black, a* (redness) representing red and green, and b* (yellowness) represents yellow and blue. The L,* a,* and b* values allow for the exact pinpoint of a color in a color sphere. The DDGS used in these diets had a color value of L* = 58.52, a* = 6.38, and b* = 20.48. The color testing of our DDGS sample will allow for future comparisons of other DDGS samples. Research by Cromwell et al. [8] suggests that color may be an indicator of DDGS quality or amino acid availability or both.

Statistical Analysis

Data from all parameters for both the commercial and low-density diets were subjected to AN-

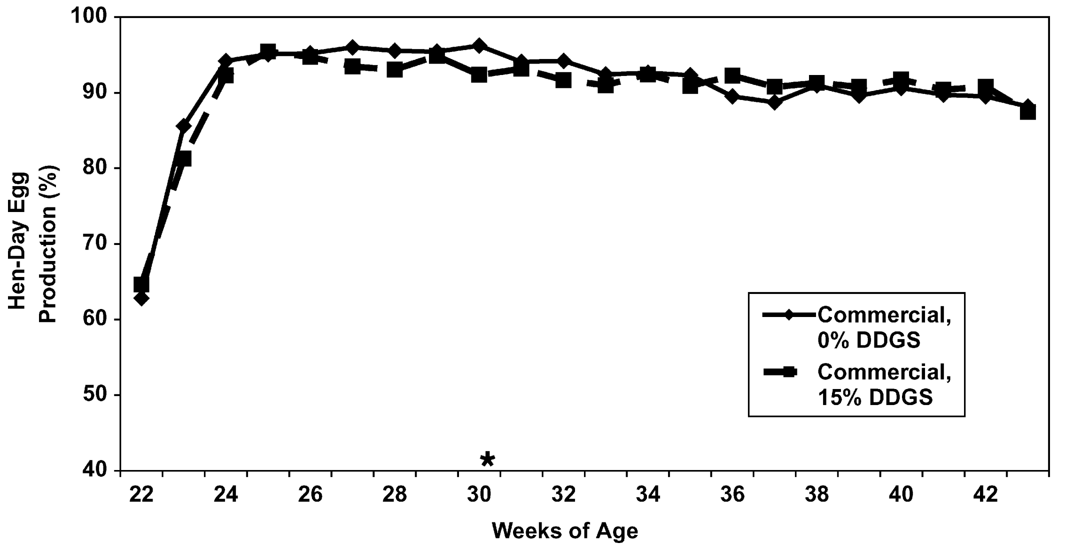

FIGURE 1. Effects of feeding distillers dried grains plus solubles (DDGS) in commercial-grade diets to laying hens on hen-day egg production. *Denotes a significant ($P < 0.05$) difference between the 2 treatments.

OVA procedures for completely randomized designs [9], and statistical differences were determined through the use of SAS software [10]. Least significant difference test was used to assess any statistical significance of differences among the dietary treatments [9].

RESULTS AND DISCUSSION

No statistical differences ($P > 0.05$) in hen-day egg production or cumulative egg production were observed when hens were fed the commercial-grade diets with 0 or 15% DDGS throughout the 22-wk experiment. However, egg production of hens fed the diet with 15% DDGS was consistently lower through 32 wk of age (Table 2 and Figure 1). When hens were fed the low-density diets, there was a significant depression ($P < 0.05$) in egg production and cumulative egg production from 26 to 34 wk of age due to the 15% level of DDGS (Table 2 and Figure 2). However, after 34 wk of age, there was no difference in egg production between the low-density diets with 0 or 15% DDGS (Figure 2). There was no difference in egg weights or cumulative mass throughout the duration of the experiment, when hens were fed the commercial or low-density diets, containing either 0 or 15% DDGS (Table 3).

At the 3 test periods (25, 31, and 43 wk of age), there was no statistical difference ($P > 0.05$) in feed intake between the commercial and low-density diets with 0 or 15% DDGS (Table 4). Hens fed the low-density diets were expected to have a greater feed intake than hens fed the commercial diet, but this was not observed. This could be partially due to the small difference of only 66 kcal TME/kg between the commercial and low-density diets. In addition, the experiment was initiated during hot summer conditions, which appeared to depress feed intake for all the hens. Under these conditions, it was observed that feed intake did not approach 95 g/bird per day until later in the study. Feed efficiency (kilogram per dozen) was slightly better when diets did not contain DDGS. However, there was no statistical difference ($P < 0.05$) in feed efficiency between the commercial-grade diets with 0 or 15% DDGS and the low-density control (0% DDGS) during the 22-wk period (Table 5). The depression in egg production when the low-density diet with 15% DDGS was fed resulted in the higher feed efficiency value observed. Body weights were measured throughout the experiment, and no difference was observed between the 4 treatments. The inclusion of 15% DDGS in the commercial or low-density diets had no effect on hen mortality.

There was no difference ($P < 0.05$) between the 4 treatments for specific gravity and shell-breaking strength (results not shown). A value of 1.08 or above is used by the laying hen industry as an indicator of good shell quality. Hens, fed

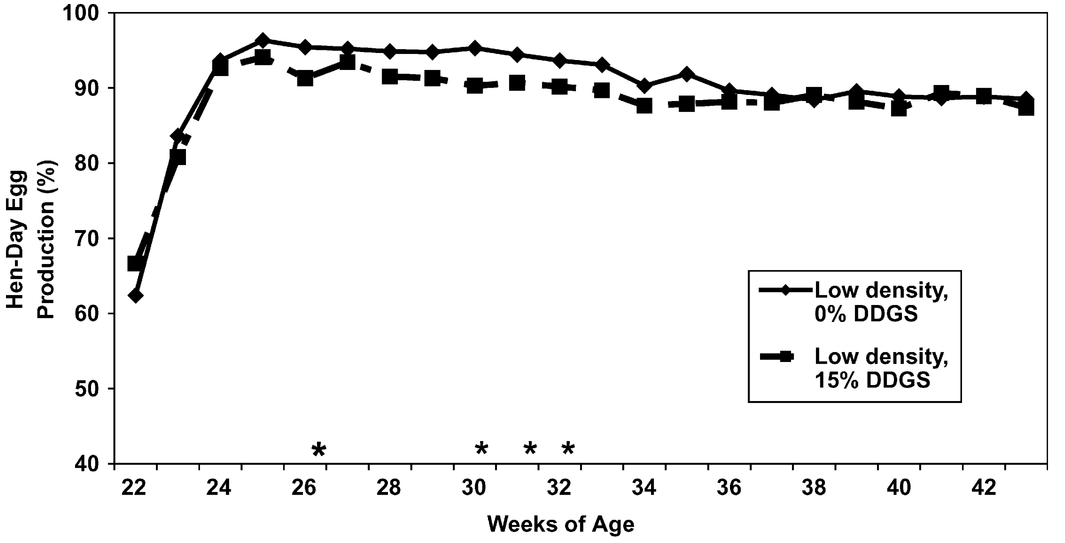

FIGURE 2. Effects of feeding distillers dried grains plus solubles (DDGS) in low-density diets to laying hens on hen-day egg production. *Denotes a significant ($P < 0.05$) difference between the 2 treatments.

either the commercial or low-density diet with 0 or 15% DDGS, resulted in a specific gravity value of 1.08 or above. When testing the interior quality of the eggs, there was no statistical difference in Haugh units at 25 and 31wk of age between any 4 of the dietary treatments (Table 6). At 43 wk of age, a statistical difference in Haugh units was observed between the hens fed the commercial and low-density diets containing 15% DDGS. However, the hens fed the commercial diet with 15% DDGS only had a numerically higher Haugh unit value at 43 wk of age compared with the commercial control diet. Hughes and Hauge [11] observed improvements in Haugh units when hens were fed diets consisting of 5 and 10% brewers dried grains. Lilburn and Jensen [12] reported that the incorporation of 20% corn fermentation solubles into laying hen diets resulted in a significant improvement of Haugh units. Jensen et al. [13] also observed improved egg quality with the

TABLE 3. Effects of feeding DDGS[1] to laying hens on egg weights[2]

	Commercial diets		Low-density diets		
Age (wk)	0% DDGS	15% DDGS	0% DDGS	15% DDGS	Pooled SEM
	(g)				
22	37.6	37.1	—	—	2.06
24	49.5	49.9	—	—	0.19
26	52.8	52.6	51.9	52.4	0.42
28	51.8^{b}	53.1^{a}	51.4^{b}	52.4^{ab}	0.47
30	54.6	54.7	53.5	54.6	0.41
32	56.2	56.0	55.2	55.9	0.33
34	57.1	56.8	56.1	56.8	0.31
36	57.9^{a}	58.3^{a}	56.8^{b}	57.6^{a}	0.28
38	59.4	59.3	58.4	58.7	0.34
40	60.3	60.2	59.6	59.6	0.35
42	61.3	60.0	60.0	61.2	0.65
Cumulative average	52.6	51.5	51.6	51.3	0.72

[a,b]Means within a row with no common superscript differ significantly ($P < 0.05$).
[1]DDGS = distillers dried grains plus solubles.
[2]Means represent 8 replications per treatment (16 hens per replication).

TABLE 4. Effects of DDGS[1] on feed intake of laying hens[2]

Treatments	Week 25	Week 31	Week 43
	(g/hen per day)		
Commercial, 0% DDGS	83	91	94
Commercial, 15% DDGS	84	91	94
Low density, 0% DDGS	—	90	95
Low density, 15% DDGS	—	92	95
Pooled SEM	0.65	0.73	0.68

[1]DDGS = distillers dried grains plus solubles.
[2]Means represent 8 replications per treatment (16 hens per replication).

TABLE 6. Effects of feeding DDGS[1] to laying hens on egg Haugh units[2]

Treatment	Week 25	Week 31	Week 43
	(Haugh units)		
Commercial, 0% DDGS	95.2	91.6	85.4[ab]
Commercial, 15% DDGS	96.4	94.5	87.2[a]
Low density, 0% DDGS	—	95.3	85.9[ab]
Low density, 15% DDGS	—	93.8	84.3[b]
Pooled SEM	0.89	1.66	0.66

[a,b]Means within a column with no common superscript differ significantly ($P < 0.05$).
[1]DDGS = distillers dried grains plus solubles.
[2]Means represent 8 replications per treatment (16 hens per replication).

addition of corn fermentables, and Waldroup and Hazen [14] reported a similar response in Haugh units with the use of corn-dried steep liquor concentrate. Based on previous studies, we expected to see improved Haugh units, and the trend toward improved interior egg may have been more pronounced if the experiment were carried out beyond 43 wk of age, when albumen quality usually declines.

A possible effect of DDGS on yolk color is of interest to researchers and producers, considering that DDGS is of corn origin and the xanthophylls in corn are a main contributor of yolk pigmentation. Researchers and producers are concerned that DDGS may supply additional pigment and create a darker yolk than what is desired. At the 3 periods tested there was no observable difference in yolk color between 0 and 15% DDGS for both diet densities (Table 7). The L* and b* values are the critical color indicators and are the colors that the human eye can differentiate. At 43 wk of age, there was a statistical difference ($P < 0.05$) for the a* value only. However, the differences detected were so minor that the human eye would not be able to detect any difference in yolk color.

Matterson et al. [15] performed 2 experiments with laying hens incorporating 0, 10, and 20% DDGS. The DDGS used came from the beverage industry, and the diets were formulated to contain an energy value of approximately 2,900 kcal of ME_n/kg. No difference in egg production was observed. Harms et al. [16] incorporated 0 and 10% DDGS (beverage industry) into laying hen rations to which various amounts of methionine were supplemented. No significant difference in egg production was observed regardless of the level of sulfur amino acids supplemented. Considering that our experiment was run during summer conditions with a decrease in feed intake and that the diets were lower in energy may have been the main contributing factor for the depression in egg production, since it can be speculated that the hens were not fully meeting their caloric intake.

TABLE 5. Effects of DDGS[1] on feed efficiency of laying hens[2]

Treatment	Week 25	Week 31	Week 43
	(kg/dozen)		
Commercial, 0% DDGS	1.18	1.15[b]	1.21[b]
Commercial, 15% DDGS	1.20	1.18[ab]	1.22[b]
Low density, 0% DDGS	—	1.14[b]	1.23[b]
Low density, 15% DDGS	—	1.21[a]	1.26[a]
Pooled SEM	1.369	0.013	0.008

[a,b]Means within a column with no common superscript differ significantly ($P < 0.05$).
[1]DDGS = distillers dried grains plus solubles.
[2]Means represent 8 replications per treatment (16 hens per replication).

TABLE 7. Effect of feeding DDGS[1] to laying hens on yolk color at 43 wk of age[2]

Treatment	L*,[3]	a*,[3]	b*,[3]
Commercial, 0% DDGS	55.16	–2.01[b]	45.46
Commercial, 15% DDGS	54.34	–0.11[a]	47.62
Low density, 0% DDGS	55.13	–1.75[b]	46.14
Low density, 15% DDGS	54.15	–0.19[a]	48.20
Pooled SEM	0.19	0.24	0.45

[a,b]Means within a column with no common superscript differ significantly ($P < 0.05$).
[1]DDGS = distillers dried grains plus solubles.
[2]Means represent 8 replications per treatment (16 hens per replication).
[3]L* = white and black, a* = red and green, and b* = yellow and blue.

Another explanation for the initial depression in egg production may be due to the amino acid profile of DDGS. Hughes and Hauges [11] observed that when DDGS was used as the sole source of protein in a broiler diet, there was a slight deficiency in lysine and tryptophan, causing a decrease in performance. The diets herein were formulated on a total amino acid basis, which could have resulted in a lysine or AA deficiency. Also, soybean meal (SBM) has a more preferable amino acid pattern for poultry production than corn. In a normal corn-SBM diet, SBM contributes 75% of the protein. However, when using 15% DDGS (whose protein is of corn origin), SBM only contributes 50% of the total protein. The differences in amino acid levels and its availability could affect production performance.

An early numeric depression in egg production was observed when 15% DDGS was included in both the commercial and low-density diets. Based on egg production, it could be concluded that the inclusion of 15% DDGS in a standard layer diet may be above a recommended maximum inclusion level especially during peak production.

CONCLUSIONS AND APPLICATIONS

1. Hens fed a commercial density diet with 15% DDGS had no statistical difference in egg production. Fifteen percent DDGS inclusion in the low-density diet was excessive for this level of sensitivity, which lead to an obvious depression in egg production.
2. Feeding 15% DDGS to laying hens had no affect on egg weight, yolk color, and exterior or interior egg quality.
3. The maximum inclusion level is suggested to be 10 to 12% for DDGS in a standard (commercial) laying hen diet, based on these data and findings from other researchers.
4. The DDGS have proven to be an acceptable feed ingredient in laying hen diets and might be advantageous to nutritionists in formulating a laying hen diet at a lower cost.

REFERENCES AND NOTES

1. Reilly, P. J. 1979. Gashol-future prospects. Distillers Feed Conference 34:4–14.

2. Shurson, J. 2003. Subject: The value and use of distillers dried grains with solubles (DDGS) in livestock and poultry rations. http://www.ddgs.umn.edu/. Accessed Nov. 2003.

3. Hy-line International, West Des Moines, IA.

4. Batal, A. B., and N. M. Dale. 2003. University of Georgia, Poultry Science building, Athens, GA. Personal communication.

5. TA.XT Plus Texture Analyzer, Texture Technologies Corp., Scarsdale, NY.

6. TSS QCD System. Technical Services and Supplies, Chessingham Park, Dunnington, York, England.

7. Minolta CR300 Colorimeter, Minolta Corporation, Ramsey, NJ.

8. Cromwell, G. L., K. L. Herkelman, and T. S. Stahly. 1993. Physical, chemical, and nutritional characteristics of distillers dried grains with solubles for chicks and pigs. J. Anim. Sci. 71:679–686.

9. Steel, R. G. D., and J. H. Torrie. 1980. Principles and Procedures of Statistics. A Biometrical Approach. 2nd ed. McGraw-Hill Book Co., Inc., New York.

10. SAS Institute. 2001. SAS User's Guide: Statistics. Version 8 ed. SAS Institute Inc., Cary, NC.

11. Hughes, C. W., and S. M. Hauge. 1945. Nutritive value of distillers' dried solubles as a source of protein. J. Nutr. 30:245–258.

12. Lilburn, M. S., and L. S. Jensen. 1984. Evaluation of corn fermentation solubles as a feed ingredient for laying hens. Poult. Sci. 63:542–547.

13. Jensen, L. S., C. H. Chang, and S. P. Wilson. 1978. Interior egg quality: improvement by distillers feeds and trace elements. Poult. Sci. 57:648–654.

14. Waldroup, P. W., and K. R. Hazen. 1979. Examination of corn dried steep liquor concentrate and various feed additives as potential sources of a Haugh unit improvement factor for laying hens. Poult. Sci. 58:580–586.

15. Matterson, L. D., J. Tlustohowicz, and E. P. Singsen. 1966. Corn distillers dried grains with solubles in rations for high-producing hens. Poult. Sci. 45:147–151.

16. Harms, R. H., R. S. Moreno, and B. L. Damron. 1969. Evaluation of distiller's dried grain with solubles in diets of laying hens. Poult. Sci. 48:1652–1654.

Acknowledgments

The authors thank Land O'Lakes for their support, which made this research possible. We also thank L. Jones for her help and the gracious aid from Deana Jones and Patsy Mason at the USDA Russell Research Center, Athens, GA.