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Effect of Adding Different Dietary Levels of Distillers Dried Grains with Solubles (DDGS) on Productive Performance of Laying Hens

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Abstract: Adding distillers dried grains with solubles (DDGS) as a feed ingredient in poultry diets has lately been increased. This study was conducted to evaluate the effect of adding different dietary levels of DDGS on the productive performance of laying hens. Three hundred twenty with 30-week-old Hisex laying hens were randomly distributed among four dietary treatments with twenty replicates of four laying hens each. Laying hens were fed four iso-energetic and iso-nitrogenous layer diets containing 0.0, 5.0, 10.0 or 20.0% DDGS for 12-week trial period from 30 to 42 weeks of age. Results obtained from the present study showed that there were no significant effects of adding either 0.0, 5.0, 10.0 or 20.0% DDGS into laying hen diets on egg production, egg weight, egg mass, feed consumption, feed conversion ratio per egg mass (kg feed/kg egg/hen), egg specific gravity, Haugh unit and egg yolk color. However, laying hens fed a diet containing 20% DDGS exhibited significantly the highest body weight loss compared to all the other dietary treatments. Therefore, it can be concluded that DDGS can be safely added into diets as an alternative source of protein and energy up to 20% without negative effects on productive performance characteristics of Hisex laying hens from 30 to 42 weeks of age.

Key words: Distillers dried grains with solubles, laying hens, productive performance

INTRODUCTION

Corn will be not completely available in the next years for using as an energy source in poultry diets due to use it to produce biofuel ethanol production in the most produced countries. So, the shortage of high-quality conventional poultry feed ingredients considered as major problems facing poultry producers worldwide especially in the developing countries. Therefore, poultry nutritionist over the world have been focused intensively searching for suitable poultry unconventional poultry feed ingredient alternatives to replace partially with some of the expensive common feed ingredients such as corn and soybean in poultry diet to overcome traditional poultry feedstuffs shortage and to reduce poultry feed costs (Al-Harthi *et al*., 2009). In addition, several studies concluded that the distillers dried grains with solubles (DDGS) can be added into laying hen diets as an alternative source of protein and energy and source of xanthophyll (Swiatkiewicz and Korelski, 2008; Cuevasa *et al*., 2012). On the other hand, the use of DDGS as a conventional ingredient in poultry diets, continue to increase due to increasing high prices of protein sources such as soybean meal, which makes the diet more expensive, then DDGS will replace more often such protein sources (Wu-Haan *et al*., 2010).

DDGS is a byproduct of the ethanol production of cereal grain starch by fermentation process (Deniz *et al*., 2013). DDGS as an attractive poultry feed ingredient is a significant valuable, available unconventional source of protein, amino acids, energy, minerals such as phosphorus, water soluble vitamins and linoleic acid (Waldroup *et al*., 1981; Salim *et al*., 2010).

DDGS contains about 3-fold increase in crude protein, crude fiber, crude fat and minerals compared with corn (Liu, 2011). DDGS can be used in the poultry diets mainly as a source of crude protein (Belyea *et al.*, 2004). DDGS contains about 89.48 to 94% dry mater (NRC, 1994; Deniz *et al*., 2013; Hassan and Al Aqil, 2015), 23.0 to 53.39% crude protein (Cromwell *et al*., 1993; Spiehs, *et al*., 2002; Applegate *et al*., 2009; Hassan and Al Aqil 2015) and 2146 to 3554 kcal metabolizable energy (NRC, 1994; Batal and Dale, 2006; Fastinger *et al*., 2006; Hassan and Al Aqil, 2015). The amino acid profile of DDGS is very similar to that of corn. Therefore, DDGS was found mainly limiting for poultry nutrition in lysine and methionine contents (Spiehs *et al*., 2002; Fastinger *et al*., 2006) varying from 0.48 to 1.02% and 0.40 to 0.60%, respectively (Cromwell *et al*., 1993; NRC, 1994; Spiehs *et al*., 2002). Also, DDGS contains about 0.21% tryptophan; 0.20 to 0.30 tryptophan; 0.49 to 1.00% threonine and 0.24 to 0.41% cysteine (NRC, 1994; Deniz *et al*., 2013). In addition to crude protein, energy and amino acids, DDGS contains crude fat ranged from 2.0 to 14.1% (Cromwell *et al*., 1993; NRC, 1994; Spiehs

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et al., 2002; Hassan and Al Aqil, 2015), 4 to 12% crude fiber (NRC, 1994; Hassan and Al Aqil, 2015), 4.11 to 4.49% crude ash (Deniz *et al*., 2013; Hassan and Al Aqil, 2015), 0.39 to 1.17% available phosphorus; 4.55% linolenic acid and 0.10 to 0.35% calcium (NRC, 1994; Deniz *et al*., 2013).

DDGS had been reported to contain a beneficial unidentified growth factor (Alenier and Combs, 1981). DDGS also recognize as a useful source of the water-soluble vitamins for poultry before chemical synthesis and commercialization of vitamins (Matterson *et al*., 1966).

There were many factors limited the using of DDGS in poultry nutrition for many years among them its considerable variability in nutrient content, low availability of some nutrients and digestibility (Spiehs *et al*., 2002; Batal and Dale, 2006; Pedersen *et al*., 2007; Swiatkiewicz and Korelski, 2008), high fiber containing about 35% insoluble and 6% soluble dietary fiber (Stein and Shurson, 2009), inconsistent supply and pricing (Waldroup *et al*., 1981) among different DDGS sources. Therefore, early studies recognized that DDGS can be added into poultry diets at low concentrations at less than 5% (Parsons *et al*., 1983). Recently, the increasing of DDGS supply from the modern ethanol plants and the high quality with low variability of DDGS nutrients encouraged the adding of DDGS into poultry diets at higher levels than has been used in the past (Deniz *et al*., 2013). Some studies reported that DDGS can be added successfully into diets up to 9 to 15% without negative effect on the productive performance of laying hens (Lumpkins *et al*., 2005; Robertson *et al*., 2005; Swiatkiewicz and Korelski, 2006, 2008; Shalash *et al*., 2010; Cuevasa *et al*., 2012; Deniz *et al*., 2013). Several studies noted that DDGS can be added at higher levels if lower energy and lysine content of DDGS were adjusted (Waldroup *et al*., 1981; Parsons *et al*., 1983).

Little research had conducted to investigate the effect of the adding DDGS into diets containing different levels of DDGS on the productive performance of laying hen. Therefore, this study was conducted to evaluate the effects of adding four levels (0.0, 5.0, 10.0 or 20.0%) of DDGS on the productive performance parameters of laying hens from 30 to 42 weeks of age.

MATERIALS AND METHODS

DDGS was obtained from a commercial feed mill in Al-Hassa, Saudi Arabia. Then, proximate chemical analysis including the moisture, crude fat, crude protein, crude ash and crude fiber of DDGS were determined using standard analytical procedures according to Association of Official Analytical Chemists (2004) before formulating the experimental diets. The energy content of DDGS as kcal ME/kg was calculated according to the following formula reported by Meloche (2013):

$$\text{ME (kcal/kg)} = 3673 - (121.35 \times \text{crude fiber}) + (51.29 \times \text{ether extract}) - 121.08 \times \text{ash}$$

Experimental design: This study was conducted from January till April 2014 at the Agriculture Research and Training Station belonged to King Faisal University, Al Hassa city, Kingdom of Saudi Arabia.

A total of 320 laying hens (Hisex White®, 30-week-old) with an average egg production rate of 74.63%±2.94 and 1452.50 g±17.80 initial live body weight over of 12-week trial period from 30 to 42 weeks of age were used. Laying hens were weighed and randomly distributed in battery group cages (50 x 30 x 30 cm^3) separated by a 1.0 m aisle, equipped with galvanized-iron trough feeders covering the entire front length of metal cages and nipple drinkers. Hens fed four different dietary treatments with four DDGS levels (0.0, 5.0, 10.0 or 20.0%) with twenty replicates of four laying hens each.

Experimental diets were formulated to meet nutrients recommendation of laying hens based on Hisex management guide. The layer hen diets used in this study were calculated to be isocloric contained 2757 Kcal metabolizable energy and isonitrogenus contained 16.71% crude protein per kg of feed as shown in Table 1. At 30 week of age, each hen fed 120 g once daily at 8 h and water was provided *ad libitum* and subjected to a 16L:8D light program throughout the whole experimental period.

Measurements: Body weight, egg production, egg weight, egg mass, feed consumption, feed conversion ratio per egg mass (kg feed per kg egg), egg specific gravity, Haugh unit and egg yolk color were measured.

Initial body weight at the beginning and the final body weight at the end of the experiment for laying hens were measured and the average body weight gain was calculated by the differences between the two body weights.

The experimental period had duration of 12-week, divided into six sub-periods of 2-week each starting from 30 to 42 weeks of age. At the end of each sub-period, the egg production, egg weight, egg mass, feed consumption, feed conversion ratio per egg mass, egg specific gravity, Haugh unit and egg yolk color for each replicate were measured. Each 2-weeks, the feed leftovers from feeders were weighed and the feed consumption was measured. Feed consumption and overall egg produced per hen were recorded on daily basis. Egg weight, egg mass, egg specific gravity, Haugh units and egg yolk color for each replicate were calculated at the last three consecutive days of each sub-period. For egg mass calculation, the average daily egg production was multiplied by the average egg weight divided by 100. The feed conversion ratio per egg mass was obtained and calculated as kilogram by the ratio between total feed consumed per hen and total egg mass produced per hen.

Collected eggs were stored overnight in the same room before egg specific gravity was determined. Egg specific gravity was determined by using the saline flotation methods as described by Hempe *et al*. (1998) by immersing the eggs in graded saline solutions of density ranged from 1.065 to 1.120 g/cm^3 with interval incremental concentrations of 0.005 g/cm^3 between them. After determining egg specific gravity, the same eggs were subsequently broken, their components were separated and then albumen height was measured with an Ames micrometer (model S-6428, Ames, Waltham, MA) at a point halfway between the yolk and the edge of the widest expanse of albumen. Haugh units were calculated as follows:

$$\text{Haugh unit} = 100 \times \log (H+7.57-1.7W^{0.37})$$

Where, H is albumin height (mm) and W is egg weight (Panda, 1996). The egg yolk color was measured using a Roche colorimetric fan (DSM nutritional products Co.). Color scales ranged from 1 (pale yellow) to 15 (intense orange) according to Well (1968).

Statistical analysis: All data were subjected to one-way ANOVA using the GLM procedures of a statistical software package (SPSS 18.0, SPSS Inc., Chicago, IL). Treatment means were expressed as mean±standard error of means (SEM) and separated and compared by the F test ($p \leq 0.05$) using the Duncan's multiple range test (Duncan, 1955).

Table 1: Composition[1] of isocaloric and isonitrogenous laying hen diets containing 0.0, 5.0, 10.0, or 20.05 DDGS[2] from 30 to 42 weeks of age

	DDGS level (%) in laying hen diets			
Feed ingredients	0.0	5.0	10.0	20.0
Yellow corn	62.1	61.3	60.4	51.8
Barley	0.0	0.0	0.0	6.0
Corn oil	1.0	0.5	0.2	0.0
Dehulled soybean meal (44%CP)	26.0	22.5	18.6	11.3
Limestone	9.0	8.8	9.0	9.0
Dicalcium PO_4	1.0	1.0	9.0	8.0
Antioxidant	0.10	0.10	0.10	0.10
L-Lysine	0.10	0.10	0.10	0.10
Choline-chloride	0.10	0.10	0.10	0.10
DL-Methionine	0.10	0.10	0.10	0.10
Vitamin-mineral Premix[3]	0.25	0.25	0.25	0.25
Salt	0.25	0.25	0.25	0.25
Energy (Kcal ME/kg feed)	2757	2753	2756	2762
Crude protein (%)	16.72	16.77	16.64	16.69
Crude fat (%)	2.65	3.04	3.42	4.05
Crude fiber (%)	3.29	3.27	3.23	3.36
Linolenic acid (%)	1.57	1.77	1.96	2.24
Calcium (%)	3.73	3.65	3.70	3.66
Available phosphorus (%)	0.31	0.32	0.31	0.31

[1]Calculated analysis of the diets was as follows: 16.71% crude protein; 2.757 kcal metabolizable energy; 3.29% crude fat; 3.29% crude fiber; 1.89% linolenic acid; 3.69% calcium; 0.32% available phosphorus; 0.44% methionine; 1.25% lysine; 0.77% threonine; 0.28% tryptophan/kg feed

[2]DDGS used was as follows: 33.262% crude protein; 2983 kcal metabolizable energy; 9.0% crude fat; 5.01 crude fiber; 4.55% linolenic acid; 4.49% ash; 0.10% calcium; 0.39% available phosphorus/kg

[3]Vitamin-mineral premix added at this rate yields: 149.60 mg Mn, 16.50 mg Fe, 1.70 mg Cu, 125.40 mg Zn, 0.25 mg Se, 1.05 mg I, 11,023 IU vitamin A, 46 IU vitamin E, 3,858 IU vitamin D_3, 1.47 mg minadione, 2.94 mg thiamine, 5.85 mg riboflavin, 20.21 mg pantothenic acid, 0.55 mg biotin, 1.75 mg folic acid, 478 mg choline, 16.50 µg vitamin B_{12}, 45.93 mg niacin and 7.17 mg pyridoxine per kg diet

RESULTS AND DISCUSSION

DDGS used in the present study contained about 93% dry matter, 33.262% crude protein, 2983 kcal metabolizable energy, 9.0% crude fat, 5.01% crude fiber, 4.55% linolenic acid, 4.49% crude ash, 0.10% calcium and 0.39% available phosphorus/kg. The nutrient composition of the experimental layer diets were shown in Table 1. These results were within the normal range reported by NRC (1994), Deniz *et al*. (2013), Hassan and Al Aqil (2015).

In the respect to the productive performance of laying hens, results obtained from the present study showed that there were no significant effects of adding either 0.0, 5.0, 10.0 or 20.0% DDGS into laying hen diets on egg production, egg weight, egg mass, feed consumption, feed conversion ratio per egg mass, egg specific gravity, Haugh unit and egg yolk color (Table 2). Also, no significant differences in mortality rate among all the dietary treatment groups during the entire course of the study were recorded and the values were within the normal range (data not shown). However, laying hens fed a diet containing 20% DDGS exhibited significantly the highest body weight loss compared to all the other dietary treatments (Table 2).

These results were in agreement with the findings of some studies which showed that DDGS can be incorporated up to 20% into laying hen diets without negative effect on egg production and egg weight (Matterson *et al*., 1966; Harms *et al*., 1969). Also, Lilburn and Jensen (1984) reported no effect on productive performance parameters, but significantly decreased the body weight of laying hens fed diet containing 20% DDGS than those fed control diet. Similarly, Robertson *et al*. (2005) concluded that the inclusion of 15% DDGS had no negative effects on productive performance for Hy-Line W-36. Lumpkins *et al*. (2005) found no significant differences in egg production, egg weight, feed consumption and feed conversation ratio between hens fed diets containing 0 or 15% DDGS. Swiatkiewicz and Korelski (2006) noted that reported that adding 20% of DDGS into Lohmann Brown laying hen diets had no effects on egg production, egg mass, feed consumption and feed conversion ratio from 26 to 43 weeks of age. Roberts *et al*. (2007) indicated that a diet containing 10% DDGS had no effect on egg production, egg weight, feed consumption and feed conversion ratio. In another study, Swiatkiewicz and Korelski (2008) observed that adding DDGS at the level of 15% into laying hens did not affect most of their productive performance parameters. Loar *et al*. (2010) reported that increasing graded levels of DDGS from 0 to 32% for Bovans White laying hens had no negative effect on the performance parameters.

Table 2: Productive performance parameters of Hisex white egg laying hens fed diets containing either 0.0, 5.0, 100, or 20.0% from 30 to 42 weeks of age

	DDGS level (%) in laying hen diets			
Parameters	0.0	5.0	10.0	20.0
IBW (g/hen)	1452.50±17.80	1476.00±33.21	1420.00±19.89	1512.50±40.71
FBW (g/hen)	1428.67±31.39	1442.33±46.37	1416.00±32.53	1351.00±35.67
BWG (g/hen)	-65.00±27.57[b]	-62.17±19.60[b]	-52.50±25.49[b]	-184.50±46.68[a]
FC (kg feed/hen)	7.80±0.21	7.43±0.24	8.14±0.56	8.34±0.52
FCR (kg feed/kg egg)	2.22±0.08	2.17±0.15	2.25±0.16	2.80±0.28
EW(g/egg)	56.81±1.54	58.76±2.12	58.91±0.99	56.43±3.56
EM (kg egg/hen)	3.54±0.13	3.54±0.22	3.76±0.30	3.27±0.35
EPN/hen	62.69±2.47	60.29±3.20	63.63±4.74	57.07±4.27
EPP/hen	74.63±2.94	71.78±3.81	75.74±5.65	67.94±5.08
ESG (g/cm^3)	1.089±00.001	1.089±0.001	1.088±0.001	1.087±0.001
HU	4.92±0.16	5.48±0.25	5.28±0.19	4.87±0.31
EYC	7.46±0.47	7.89±0.30	8.10±0.32	7.29±0.52

Means±standard error of mean within a row that do not share a common superscript are significantly different ($p \leq 0.05$)

DDGS: Distillers dried grains with solubles (%) into diet, IBW: Initial body weight, FBW: Final body weight, BWG: Body weight gain, FC: Feed consumption, FCR: Feed conversion ratio, EW: Egg weight, EM: Egg mass, EPN: Egg production number, EPP: Egg production percentage, ESG: Egg specific gravity, HU: Huagh unit, EYC: Egg yolk color

Wu-Haan *et al*. (2010) noted that the supplementation DDGS up to 20% into diets did not affect negatively the productive performance of laying hens. Tangendjaja and Wina (2011) noted that adding DDGS up to 16% into laying he diets did not affect egg production, egg weight and egg mass, but decreased feed consumption. Cuevasa *et al*. (2012) showed that adding DDGS into laying hen diets up to 9% from 35 to 43 weeks did not affect the productive performance of laying hens. Deniz *et al*. (2013) noted that feeding up to 15% DDGS had no negative effects on egg production, egg weight, feed consumption and feed conversion ratio. However, Alenier and Combs (1981) reported that adding 10% DDGS into diet increased feed consumption for laying hens.

In contrast, Allen *et al*. (1979) noted that 14.9% DDGS into diets decreased laying performance in Leghorn white egg strain laying hens, but they found no negative effect in brown egg strain laying hens. Lumpkins *et al*. (2005) reported that adding 15% DDGS into diets negatively affected egg production. Robertson *et al*. (2005) noted that adding DDGS at 0, 5, 10 or 15% into laying diet from 48 to 56 and 58 to 67 weeks of age had occasional effects for adding DDGS into laying hen diets during certain experimental periods and, as DDGS level increased, linear decreases were observed for egg production (52 to 53 weeks of age), egg weight (63 week of age), egg mass (51 week of age) and specific gravity (51 week of age). Swiatkiewicz and Korelski (2006) reported that adding 20% of DDGS into laying hen diets negatively affected the egg production, feed conversion ratio, egg weight and gg mass. Masa'deh *et al*. (2011) noted that egg weigh was negatively affected by adding DDGS into Bovan Single Comb White Leghorn laying hen diets from 24 to 46 weeks of age without effects from 46 to 76 weeks of age. Also, Deniz *et al*. (2013) noted that adding 20% of DDGS into laying hen diets significantly was negatively affected the feed conversion ratio (g feed/g egg mass) and decreased feed consumption, egg mass, egg production and egg weight compared to those fed control diets.

In the respect to the interior egg quality, the effect of DDGS on egg yolk color also was conflicting. While, Lumpkins *et al*. (2005) reported no effects on egg yolk color of laying hens fed diets containing 15% DDGS, coinciding with the results obtained from the present study. Roberts *et al*. (2007) found that a diet containing 10% DDGS had no effect on egg yolk color. Deniz *et al*. (2013) noted that feeding up to 15% DDGS had no negative effects on Haugh units and egg yolk color.

The lack of the effect of adding DDGS on the egg yolk color in the present study compared to the other studies might be attributed to the lower xanthophyll content or the heat destruction effect for xanthophyll content during drying of DDGS used. Robertson *et al*. (2005) found in different two DDGS samples the xanthophyll content was 30 ppm in one sample and only 3 ppm in the other dark-colored one explained the lowest xanthophyll content due to the overheating damaged the xanthophyll.

Conversely, a positive effect of DDGS on egg yolk color was observed by Jensen *et al*. (1978) and Robertson *et al*. (2005), who found that the egg yolk color increased rapidly within one month for laying hens fed 10% DDGS and more slowly (more than two months) for those fed 5% DDGS. Swiatkiewicz and Korelski (2006) noted that egg yolk color significantly increased with increasing DDGS supplemented into laying hen diets. Shalash *et al*. (2010) found that adding DDGS to 15 or 20% into laying hen diets significantly increased egg yolk color. Also, Cuevasa *et al*. (2012) showed that adding DDGS into laying hen diets up to 9% from 35 to 43 weeks increased the egg yolk color compared to the control treatment. Masa'deh *et al*. (2011) noted that egg yolk color increased with increasing DDGS levels from 5 to 25% into Bovan Single Comb White Leghorn laying hen diets from 24 to 76 weeks of age.

On the other hand, Lumpkins *et al*. (2005) and Robertson *et al*. (2005) observed that Haugh unit value was not affected by the presence of DDGS in the diet. Also, Swiatkiewicz and Korelski (2006) reported that adding 20% of DDGS into laying hen diets had no effect on Haugh units. In contrast, other studies reported that DDGS exhibited a positive effect on Haugh unit value (Jensen *et al*., 1978; Jensen and Maurice, 1980).

Deniz *et al*. (2013) noted that as the level of DDGS increased in the diet, the level of dicalcium phosphate gradually decreased, which might be resulted in a reduction in the diet costs. These findings were in agreement with the results obtained in the present study (Table 1).

It has been suggested that DDGS with Hunter L values higher than 55 to 57 should be selected to obtain better quality feedstuffs for monogastric animals (Batal and Dale, 2003). Cromwell *et al*. (1993) found that DDGS color was highly related to its nutritional properties of DDGS, where dark-colored DDGS was lower in nutritional value than light-colored DDGS. A number of researchers (Batal and Dale, 2003; Fastinger *et al*., 2006) reported that DDGS with a lighter and more yellow color tend to have greater amino acid digestibility, particularly lysine.

The variations or the inconsistent responses of laying hens fed diets containing different levels of DDGS among several studies might be possibly attributed to the differences in physical, chemical, properties and nutrients digestibility resulted from the variation in the agronomic and geographical effects, oil extraction and ethanol processing procedures, source or genetic variation in the original grain source (NRC, 1994; Belyea *et al*., 1998; Swiatkiewicz and Korelski, 2008; Liu, 2011), drying temperature and duration (Spiehs *et al*., 2002; Kingsly *et al*., 2010) among different DDGS used.

Finally, the results obtained from the present study indicated that there were shortages in the nutrients requirements among all the dietary treatments, which resulted in the lack of the differences among all the dietary treatments on productive performance of laying hens.

Conclusions: Therefore, it can be concluded that DDGS can be added safely into diets as an alternative source of protein and energy up to 20% without negative effects on productive performance characteristics of Hisex laying hens from 30 to 42 weeks of age. Further research on the effects of adding higher levels of DDGS supplemented with different levels of enzymes, lysine and methionine at different ages on productive performance and eggshell quality parameters for laying hens are required to attain the optimal results.

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