Effects of Corn Distiller's Dried Grains with Soluble on the Productive Performance and Egg Quality of Brown Tsaiya Duck Layers

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INTRODUCTION

Corn distiller's dried grains with solubles (DDGS) is a co-product of the dry milling ethanol production. A recent increasing demand of fuel ethanol has resulted in the construction of many new ethanol plants. DDGS, therefore, is becoming available in large quantities to the animal production industry. A better fermentative process and a more gentle drying condition are new technology to improve the quality of DDGS from these new ethanol plants. The DDGS derived from corn in the ethanol production may have a better nutrient profile than the traditional DDGS produced as a by-product of the liquor production (Noll et. al., 2003).

With about 10% fat and 27% crude protein, the caloric value of DDGS for poultry was found to be 2820 kcal/kg in average using the TME_n assay (Dale & Batal, 2003). The amino acids of DDGS produced from these ethanol plants with new technology are highly digestible (Ergul et. al. 2003; Lumpkins et. al. 2003b). Ergul et.al. (2003) suggested that color of DDGS can be a quick and reliable method of determining the amino acids digestibility of corn DDGS. DDGS contains highly available phosphorous (Kalbfleisch and Roberson, 2005; Lumpkins, et. al., 2003a) and fermentative metabolites of yeast. Therefore, DDGS is a good feed ingredient for several areas of animal production.

Inclusion of marigold extract to increase the xanthophylls content of laying hen diet improved the yolk color of eggs without affecting production parameters (Troche, et. al., 2003). DDGS, containing 20 to 30 mg of xanthophylls per kilogram (Lu & Chen, 2005; Roberson, et. al., 2004), can be a natural feedstuffs that provides xanthophylls and nutrients for egg-producing poultry simultaneously. Roberson et. al., (2004) concluded that up to 15% of ethanol-derived DDGS can be used in the laying hen diet without reducing egg production and the yolk color was linearly improved as the amount of DDGS increased in the diets. Commercial feeding trial in Mexico proved that adding 10% DDGS significantly improved egg production and egg yolk color (Shurson, 2003). In contrast, Lumpkins et. al., (2003c) suggested that adding 15% DDGS in laying hen diet did not significantly influence yolk color and shell breaking strength. There is no study to test the feasibility of DDGS in the laying duck diet.

The objectives of this study are to investigate the effects of DDGS on the productive performance and egg quality in Brown Tsaiya duck layers.

MATERIAL AND METHODS

1. Facilities and management

The trial was conducted in the experimental barn of I-Lan Branch, Livestock Research Institute, Taiwan. The experimental barn was equipped with wet pad and forced ventilation cooling system. At 12 weeks of age, the ducks were randomly allocated into the individual cage. The dimension of the cage was 30 × 30 × 42 cm. There were 4 rows of cages for 4 diet treatments. Each row had 66 cages to hold the 3 replicates of the same treatment with 3 empty cages between the replicates. The automatic water nipples were used for water supply.

The DDGS was imported from the US in April, 2005 for this trial. DDGS from the same container was re-packed into 50kg bag and was stored in -20℃. Sufficient amount of DDGS was available in -20℃ freezer so that DDGS would not come from different sources during the trial. The diets were mixed according to the formulation (Table 1) and were refrigerated in 25kg bags. Ducks during laying period were raised in an individual cage with feed and water provided *ad libitum*.

2. Experimental animals and feeding program

Two hundred and forty Brown Tsaiya ducks were used in this study. They were randomly assigned into four treatments with three replicates in each treatment. There were 20 ducks in each replicate.

Ducks between 0-6 weeks of age were fed the diet with metabolizable energy (ME) 2900 kcal/kg and crude protein (CP) 19%. Between 6-14 weeks of age, ducks were provided the diet with 2750 kcal/kg ME and 15.5% CP. After 14 weeks of age up to 50 weeks of age, ducks were randomly assigned into four treatments and fed the isocaloric and isonitrogenous diet with 2750 kcal/kg ME and 19% CP. The four treatments were as follows (Table 1):

(1) Control diet without DDGS added.

(2) Diet with 6% DDGS added.

(3) Diet with 12% DDGS added.
(4) Diet with 18% DDGS added.

3. Measurements and data collection

Samples of DDGS and laying period diets of each treatment were collected and refrigerated for xanthophylls analysis.

During the laying period (14 to 50 weeks of age), egg production was recorded daily from the day of first egg. Feed intake and feed efficiency were determined for five consecutive days in a five-week interval. Egg weight and eggshell strength were determined for three consecutive days in a five-week interval. Egg yolk color was measured for three consecutive days using the Roche Color Fan in a five-week interval.

At the age of 20, 30, 40 and 50 week, six eggs from each replicate were randomly selected. The yolk was separated from albumin and pooled together by replicate, the pooled yolk were stored at -30℃ then was lyophilized. The lyophilized egg yolk was ground by mortar and stored at -30℃ until the analysis of cholesterol and fatty acid content of yolk. The yolk fat content was determined by AOAC (1990). For the analysis of cholesterol, 0.2 g of yolk was added with 5 mL chloroform, methanol and butylated hydroxytoluene mixture (chloroform : methanol : butylated hydroxytoluene = 2 : 1 : 0.002 v/v/w). The mixture was added with 2 mL 0.73% salt solution after shaking for 10 minutes. Then after further shaking for 5 minutes, the mixture was centrifuged at 3,000 rpm under 4 for 30 minutes to get the bottom layer fluid. The fluid was then evaporated at 40℃ with nitrogen gas then dissolved by 2 mL Ringer's solution. The content of cholesterol was determined using a kit (Cholesterol liquicolor, Human, Wiesbaden, Germany) with spectrophotometer. For the analysis of fatty acids, 0.2 g yolk was methylated according to the method of Sukhija and Palmquist (1988). The fatty acid methyl ester was injected to gas chromatography (Hitachi G-3000，Tokyo，Japan) and determined with silica capillary column (SP-2330, 30 m × 0.25 mm ID, Supelco). Oven temperature and injection temperature was 170-210℃ (2℃ / min) and 240℃, respectively. The flow rate of hydrogen, nitrogen and air was 20, 20 and 2.5 mL/min, respectively. Individual fatty acid was presented as percent of their sum.

4. Statistics

Data were statistically analyzed using the general linear models procedure of SAS. Differences among groups were determined using Duncan’s multiple-range test.

Table 1. The diet composition of laying Tsaiya ducks at 14-50 weeks of age.

Ingredients*	**Control**	**6% DDGS**	**12% DDGS**	**18% DDGS**
Yellow corn	52.69	50.44	47.94	45.94
Soybean meal	27.7	24.5	21.9	18.3
Fish meal	2	2	2	2
Wheat bran	4.85	4.3	3.4	3.0
Soybean oil	2.4	2.4	2.4	2.4
Dicalcium phosphate, 18%	1.8	1.8	1.8	1.8
Limestone, pulverized	6	6	6	6
Salt, iodized	0.3	0.3	0.3	0.3
Choline Chloride 60%	0.08	0.08	0.08	0.08
Vitamin premix[1]	0.03	0.03	0.03	0.03
Mineral premix[2]	0.1	0.1	0.1	0.1
DL-methionine	0.05	0.05	0.05	0.05
Yeast	2	2	2	2
DDGS	0	6	12	18
Total(kg)	100	100	100	100
Calculated value				
CP(%)	19.0	19.0	19.2	19.1
ME(kcal/kg)	2750.7	2750.4	2750.5	2751
Crude Fiber (%)	3.5	3.7	3.9	4.1
Crude Fat (%)	4.67	5.19	5.7	6.24
Total Phosphorus(%)	0.79	0.8	0.8	0.81

* Carophyll Red was added at a level of 2 g/ 100kg of feed.

[1] vitamin premix (content per kg) : vitamin A, 50,000,000 IU; vitamin D3, 10,000,000 IU; vitamin E, 75gm;vitamin k_3 20gm; niacin, 200gm; pantothenic acid, 60gm; vitamin B2, 30gm; vitamin B1, 10gm; folic acid, 5gm;biotin, 100mg; vitamin B12, 100mg, vitamin B_6, 20gm.

[2] mineral premix (content per kg): Fe, 90000mg; Cu, 15000mg; Mn, 100000mg; Zn, 90000mg; I, 1000mg; Se, 150mg, Co, 250mg.

RESULTS AND DISCUSSION

Generally, the xanthophylls content of experimental diets was linearly increased as the amount of DDGS increased (Table 2). The exceptional high xanthophylls concentration of the Control diet at the week of 30 and the relative lower xanthophylls content of the 18% DDGS diet at the week of 20 were the result of mixing and sampling errors. The xanthophylls concentration of experimental diets in the current trial was consistent with the results of previous native chicken trial (Lu and Chen, 2005)

Table 2. The Xanthophylls content (mg/kg feed) of experimental diets.

Weeks of age	DDGS			
	0%	6%	12%	18%
20	3.43	3.78	4.47	3.76
30	4.82	3.52	5.90	4.86
40	2.07	3.45	4.86	5.17
50	3.34	3.39	5.15	6.18

From 14 to 34 weeks of age, adding DDGS in the Tsaiya duck layers diets did not significantly influence the egg production. However, the average egg production rate of 18% DDGS group tended to be slightly lower during this period of time compared to the Control group (Figure 1). Water deprival caused by typhoon resulted in dramatic drop of egg production during 25 to 26 weeks of age for all groups. The egg production rate dramatically decreased in all treatments when cold and chilly season started around 34 to 36 weeks. Interestingly, 18% DDGS treatment showed a consistent egg-producing advantage over the other treatments during the cold season (36 to 50 weeks of age). One of the possibilities was that 18% DDGS diet provided higher energy or higher heat increment to minimize the effects of cold stress. If this is a special phenomenon in the wet pad and forced ventilation cooling system remains in question. Roberson et. al. (2004) suggested that egg production was not decreased by DDGS levels in the diet up to 15% compared to the corn-soybean meal diet in laying hens trial. Lumpkins et. al. (2003c) had similar findings with Roberson et. al. (2004) when regular commercial diets were used. When low energy density diets were used, however, diet containing 15% DDGS showed a slight, but significant, depression in egg production (Lumpkins et. al., 2003c). In a commercial laying hens trial, Shurson (2003) found that average percentage of egg production was improved for laying hens fed with the sorghum-soybean meal basal diet containing 10% DDGS.

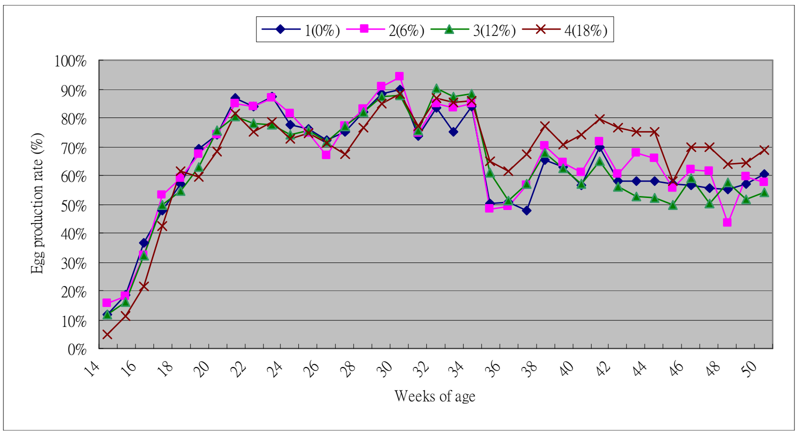

Figure 1. Effects of distillers dried grains with solubles on the egg production of Tsaiya ducks.

Although the feed intake of 12% DDGS group was significantly lower at 30 and 50 weeks of age, the feed intake and feed efficiency were not consistently influenced by including up to 18% of DDGS in the diet during the whole trial (Table 3, Table 4). The reason that feed intake of 12% DDGS group dropped at certain period of time was unknown. Adding DDGS in the diets of duck layers increased both the crude fat and crude fiber content of the diets (Table 1). With the same energy content between treatments, higher fat of diets did not improve the feed efficiency. Increased fiber content of diet by adding 18% DDGS did not decrease the feed intake. These findings were consistent with the results from laying hen trial (Lumpkins, et. al. 2003c; Shurson, 2003).

Table 3. Effects of distillers dried grains (DDGS) with solubles on feed intake (g/day/duck) of Tsaiya ducks

Weeks of age	DDGS			
	0%	6%	12%	18%
20	166.7±8.5	156.8±5.8	154.7±10.4	163.7±12.2
25	171.7±13.2	167.8±7.1	164.9±3.1	171.8±3.0
30	177.1±9.2[a]	176.3±11.4[a]	160.2±7.0[b]	170.7±0.89[ab]
35	157.8±17.5	165.1±8.9	155.9±11.5	176.0±2.6
40	202.0±7.4	215.9±11.9	197.9±23.4	212.0±3.1
45	211.6±10.1	214.6±18.5	203.7±18.5	209.8±18.9
50	231.8±12.4[a]	213.1±7.3[ab]	198.6±5.8[b]	227.7±12.9[a]

[abc] values within the same row with different superscripts differ significantly (P<0.05).

Table 4. Effects of distillers dried grains (DDGS) with solubles on feed efficiency of Tsaiya ducks

Weeks of age	DDGS			
	0%	6%	12%	18%
20	4.60±0.60	4.27±0.18	4.14±0.40	4.55±0.41
25	4.18±0.87	4.02±0.19	4.07±0.46	3.91±0.12
30	3.41±0.29	3.15±0.18	3.09±0.19	3.09±0.18
35	7.11±3.46	6.48±1.25	4.92±0.34	4.96±1.14
40	6.06±1.24	6.10±0.70	5.88±0.53	4.76±0.68
45	6.44±1.66	6.72±1.42	6.85±0.40	5.56±1.69
50	6.00±0.64	5.65±0.21	5.47±0.10	5.00±0.76

[abc] values within the same row with different superscripts differ significantly (P<0.05).

Adding DDGS in the laying duck diets tended to improve the egg weight, especially when higher amount (12 or 18%) of DDGS was used in the diets (Table 5). In the other studies, the egg weight of laying hens was not impacted by the inclusion of DDGS in the diets (Lumpkins et. al. 2003c; Roberson, et. al. 2004; Shurson, 2003). The eggshell strength measured during different stage of age was diverse (Table 6) and no conclusive result was noticed. Lumpkine et. al. (2003c) did not find the influence of DDGS on the shell breaking strength of laying hens. Shurson (2003) reported that broken eggs percentage was significantly higher by adding 10% of DDGS in the commercial laying hen trial.

Table 5. Effects of distillers dried grains (DDGS) with solubles on the egg weight of Tsaiya ducks

Weeks of age	DDGS			
	0%	6%	12%	18%
20	51.11±4.64	51.42±4.13	51.74±4.78	51.73±5.98
25	56.16±3.77[b]	57.43±3.64[ab]	56.70±5.37[ab]	58.24±4.53[a]
30	59.75±3.78[b]	60.64±3.93[ab]	60.34±4.25[ab]	61.78±4.31[a]
35	60.33±5.68	60.43±5.28	62.29±4.11	61.74±4.62
40	61.26±5.46[b]	62.85±3.68[ab]	64.37±4.04[a]	63.59±3.99[a]
45	63.04±5.27	64.27±3.93	64.23±5.19	65.15±4.38
50	66.21±4.82	66.36±4.24	66.48±5.14	67.91±4.52

[abc] values within the same row with different superscripts differ significantly ($P<0.05$).

Table 6. Effects of distillers dried grains (DDGS) with solubles on the eggshell strength of Tsaiya ducks

Weeks of age	DDGS			
	0%	6%	12%	18%
20	4.94±0.80[ab]	5.23±0.74[a]	4.87±0.76[b]	4.69±0.93[b]
25	5.07±0.88	4.87±0.87	5.06±0.37	4.96±0.85
30	4.67±0.90	4.86±0.79	4.91±0.82	4.90±0.86
35	4.26±1.02	4.30±1.08	4.49±1.00	4.57±0.96
40	4.57±0.90	4.63±1.02	4.87±0.88	4.98±0.85
45	4.54±1.24[b]	4.62±1.13[ab]	5.08±0.90[a]	4.78±0.88[a]
50	4.80±0.95	4.58±0.96	4.67±1.05	4.70±1.04

[abc] values within the same row with different superscripts differ significantly ($P<0.05$).

Yolk color was significantly improved by the introduction of DDGS into the diets of duck layers (Table 7 & Figure 2) during the whole trial. Yolk color tended to be linearly improved by the increased amount of DDGS in the diets. Even the lowest including rate (6% DDGS) can significantly improved the yolk color compared with the Control treatment. This result indicated that the xanthophylls of DDGS was effectively absorbed and utilized by the duck layers. Using DDGS in the laying duck diet can be a good alternative to enhance the yolk color and save the cost of supplementing artificial pigments. Similar result was reported in the laying hen trial by Shurson (2003) and Roberson et. al. (2004). However, Lumpkins, et. al. (2003c) did not observe significant difference of yolk color when 15% of DDGS was used in the laying hen diet.

Table 7. Effects of distillers dried grains (DDGS) with solubles on yolk color of Tsaiya ducks

Weeks of age	DDGS			
	0%	6%	12%	18%
20	11.08±0.82[c]	11.95±0.69[b]	12.81±0.86[a]	13.07±0.80[a]
25	11.73±0.66[c]	12.75±0.65[b]	12.96±0.79[b]	13.56±0.71[a]
30	10.73±0.70[c]	12.36±0.58[b]	12.58±0.58[b]	13.26±0.50[a]
35	11.50±0.78[d]	12.50±0.83[c]	12.99±0.59[b]	13.44±0.51[a]
40	11.72±0.81[c]	12.50±0.65[b]	13.12±0.56[a]	13.25±0.52[a]
45	11.86±0.76[d]	12.32±0.70[c]	12.92±0.56[b]	13.26±0.71[a]
50	11.97±0.69[c]	12.51±0.63[b]	13.01±0.61[a]	13.04±0.42[a]

[abcd] values within the same row with different superscripts differ significantly ($P<0.05$).

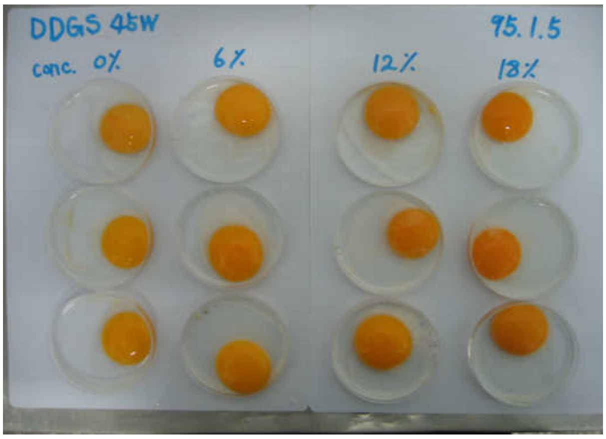

Figure 2. Effects of distillers dried grains (DDGS) with solubles on yolk color of Tsaiya ducks

The percentage of fat in yolk was lower in the early laying stage (20 weeks of age) compared with the later laying stages (Table 8, 9, 10, 11). A tendency of higher fat percentage in yolk was found in DDGS-containing treatments. At 50 weeks of age, the fat percentage in yolk was significantly increased by using 12% and 18% of DDGS in the diets and the cholesterol was increased in 18% DDGS treatment. The effect of DDGS on the cholesterol content in yolk was inconsistent and inconclusive in the current trial. Using DDGS in the laying duck diets tended to increase the percentage of unsaturated fatty acids (linoleic acid, C18:2). This effect was significant for 12% and 18% DDGS treatments over the whole laying period. The influence of

DDGS on the other fatty acids percentage was not consistent in different laying stages. The fat of DDGS contains large amount of unsaturated fatty acids and about 56% of the fatty acids are linoleic acid (C18:2) (Schingoethe, et. al., 1999). Therefore, the change of fatty acids composition of yolk should be reasonable when DDGS was used in the laying duck diets.

Table 8. Effects of distillers dried grains (DDGS) with solubles on the fat, cholesterol and fatty acids contents in yolk of 20 weeks of age in Tsaiya ducks

	Treatments (% of DDGS)				
Composition	0%	6%	12%	18%	MSE
Fat in yolk, %	23.72	24.73	25.00	24.80	0.90
Cholesterol					
in yolk fat, mg/g	43.08	36.94	38.94	43.89	2.86
in yolk, mg/100g of yolk	1019.5	917.0	967.8	1088.7	70.76
Fatty acids[1], %					
Myristic acid (14 : 0)	0.39	0.39	0.41	0.38	0.01
Palmitic acid (16 : 0)	25.98	26.43	26.26	25.92	0.32
Palmitoleic acid (16 : 1)	1.87[a]	0.92[b]	1.67[a]	1.55[a]	0.18
Stearic acid (18 : 0)	8.99[a]	7.88[ab]	7.20[b]	7.71[ab]	0.43
Oleic acid (18 : 1)	39.03	39.23	38.22	37.78	0.53
Linoleic acid (18 : 2)	13.65[c]	15.33[b]	16.69[a]	16.57[a]	0.31
Linolenic acid (18 : 3)	0.79	0.83	0.88	0.76	0.03
Others	9.30	9.00	8.67	9.33	0.22

[1] Individual fatty acid was presented as per cent of their sum.
[a,b,c] Means within a row with different letters are significantly different ($P < 0.05$).

Table 9. Effects of distillers dried grains (DDGS) with solubles on the fat, cholesterol and fatty acids contents in yolk of 30 weeks of age in Tsaiya ducks

	Treatments				
Composition	0%	6%	12%	18%	MSE
Fat in yolk, %	32.99	33.02	32.90	32.45	0.17
Cholesterol					
in yolk fat, mg/g	28.61	28.56	28.11	28.52	0.53

in yolk, mg/100g of yolk	943.9	943.2	924.2	925.4	14.89
Fatty acids[1], %					
Myristic acid (14 : 0)	0.44	0.47	0.50	0.46	0.01
Palmitic acid (16 : 0)	30.00	29.31	29.11	29.52	0.21
Palmitoleic acid (16 : 1)	1.96	2.03	1.77	1.79	0.06
Stearic acid (18 : 0)	11.32^{b}	16.38^{a}	12.47^{b}	13.06^{b}	0.37
Oleic acid (18 : 1)	39.56^{a}	33.94^{b}	37.06^{a}	34.36^{b}	0.40
Linoleic acid (18 : 2)	15.27^{d}	16.42^{c}	17.50^{b}	19.23^{a}	0.16
Linolenic acid (18 : 3)	1.20	1.20	1.28	1.30	0.03
Others	0.25	0.26	0.31	0.27	0.01

[1] Individual fatty acid was presented as per cent of their sum.
[a,b,c,d] Means within a row with different letters are significantly different (P < 0.05).

Table 10. Effects of distillers dried grains (DDGS) with solubles on the fat, cholesterol and fatty acids contents in yolk of 40 weeks of age in Tsaiya ducks

	Treatments				
Composition	0%	6%	12%	18%	MSE
Fat in yolk, %	31.68	32.03	32.76	32.64	0.27
Cholesterol					
in yolk fat, mg/g	18.69^{ab}	19.78^{a}	19.41^{ab}	17.33^{b}	1.75
in yolk, mg/100g of yolk	592.3	633.2	636.1	565.6	20.07
Fatty acids[1], %					
Myristic acid (14 : 0)	0.47	0.48	0.45	0.51	0.01
Palmitic acid (16 : 0)	29.48	30.13	28.72	28.93	0.04
Palmitoleic acid (16 : 1)	1.89^{b}	2.14^{a}	2.16^{a}	2.15^{a}	0.03
Stearic acid (18 : 0)	14.66^{b}	20.69^{a}	19.27^{a}	18.61^{ab}	0.68
Oleic acid (18 : 1)	35.83^{a}	27.82^{b}	29.98^{b}	29.50^{b}	0.82
Linoleic acid (18 : 2)	16.23^{c}	17.23^{bc}	17.99^{ab}	18.84^{a}	0.38
Linolenic acid (18 : 3)	1.17	1.19	1.20	1.17	0.03
Others	0.28	0.33	0.24	0.30	0.01

1 Individual fatty acid was presented as per cent of their sum.
a,b Means within a row with different letters are significantly different (P < 0.05).

Table 11. Effects of distillers dried grains (DDGS) with solubles on the fat, cholesterol and fatty acids contents in yolk of 50 weeks of age in Tsaiya ducks

	Treatments				
Composition	0%	6%	12%	18%	MSE
Fat in yolk, %	31.82^{b}	32.08^{b}	33.03^{a}	33.00^{a}	0.10
Cholesterol					
in yolk fat, mg/g	19.44^{b}	22.28^{ab}	23.07^{ab}	23.67^{a}	0.58

in yolk, mg/100g of yolk	617.72^{b}	714.95^{ab}	762.26^{ab}	780.91^{a}	18.84
Fatty acids[1], %					
Myristic acid (14 : 0)	0.50	0.47	0.49	0.48	0.01
Palmitic acid (16 : 0)	29.56^{ab}	28.92^{b}	29.86^{a}	29.66^{ab}	0.13
Palmitoleic acid (16 : 1)	2.50	2.31	2.30	2.19	0.08
Stearic acid (18 : 0)	15.73	16.38	12.72	14.51	0.63
Oleic acid (18 : 1)	34.61	36.08	35.53	33.63	0.84
Linoleic acid (18 : 2)	15.88^{b}	14.74^{b}	17.84^{a}	18.27^{a}	0.33
Linolenic acid (18 : 3)	1.03	0.93	0.99	1.00	0.02
Others	0.18	0.17	0.27	0.26	0.03

1 Individual fatty acid was presented as per cent of their sum.
a,b,c Means within a row with different letters are significantly different ($P < 0.05$).

CONCLUSION

Results from this study suggested that adding DDGS up to 18% in the diets of laying duck did not significantly influence the feed intake, feed efficiency and quality of eggshell. Higher inclusion rate of DDGS (18%) increased the egg production rate in the cold season. Egg weight tended to be higher by including 12% or 18% of DDGS in the diets. Yolk color was linearly improved by the increased amount of DDGS in the laying duck diets. The xanthophylls in DDGS can be well utilized by the laying ducks. When DDGS was used in the laying diets of duck, fat percentage of yolk and linoleic acid content of yolk was increased. DDGS can be efficiently used in the diets of duck layer to improve the yolk characteristics without influencing the productive performance.

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