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Effects of Corn Distillers Dried Grain with Solubles on Growth Performance and Economic Benefit of Meat Ducks

Xiaopeng Tang[1,*], Lei Chen[1], Kangning Xiong[1], Dun Deng[2] and Peng Peng[2,*]

[1]*State Key Laboratory Cultivation for Karst Mountain Ecology Environment of Guizhou Province, School of Karst Science, Guizhou Normal University, Guiyang, China*
[2]*Tangrenshen Group, Zhuzhou, China*

ABSTRACT

This study aims to investigate the effects of different levels of corn distillers dried grain with solubles (DDGS) on the growth performance of meat ducks. To this end, a total of 450 Shuanggui-tou meat ducks with comparable body weights were treated with increasing concentration of DDGS. Compared to mock-treated group, the average daily gain (ADG), average daily feed intake (ADFI) and feed to meat ratio (F:G) were measured. It was revealed that the addition of DDGS up to 24% in the diet remained ineffective for ADFI, ADG and F:G. However, there a tendency of decrease in ADG was observed when 32% DDGS was added in the feed. Taken together, our results demonstrate that the increase of DDGS in feed did not negatively affect the growth performance and subsequently can decrease the cost per unit weight gain. Therefore, the DDGS presents an alternative protein resource to meet ever-increasing demands of feed ingredients in poultry production sectors.

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Authors' Contribution
XT and PP designed and performed the experiments. XT and LC wrote the paper. KX and DD revised the paper.

Key words
Corn distillers dried grain with solubles, Economic benefit, Growth performance, Meat duck.

INTRODUCTION

With the continuous growth of livestock and poultry sectors, the shortage of feed ingredients (especially protein feed resources) is becoming a serious concern around the globe including China. To resolve this worldwide problem, development and utilization of unconventional and alternative protein resources have been considered (Xie *et al.*, 2016). One of such alternatives is distillers dried grains with solubles (DDGS) which is a by-product of dry-grind ethanol production from various cereal grains including corn, sorghum, wheat and rye (Xu *et al.*, 2010; Liu and Han, 2011; Villela *et al.*, 2017). Corn DDGS is one of the most abundant by-products in ethanol processing and has commonly been used as a replacement for soybean meal in animal feeds due to its high concentration of energy, protein, amino acids, phosphorus, and its relatively low market price (Fastinger *et al.*, 2006; Kowalczyk *et al.*, 2012; Villela *et al.*, 2017). Previous studies have demonstrated that corn DDGS can be satisfactorily used in broilers diets (Kim *et al.*, 2018; Shim *et al.*, 2018), and feed for laying hens (Wang *et al.*, 2018), rabbits (Alagón *et al.*, 2015), fishes (Diógenes, *et al.*, 2018), pigs (Kim *et al.*, 2017; Yang *et al.*, 2017; Huang *et al.*, 2018; Oczkowicz *et al.*, 2018), cattle (He *et al.*, 2014), cows (Testroet *et al.*, 2018), laying ducks (Ruan *et al.*, 2018) as well as meat ducks (Adamski *et al.*, 2011; Kowalczyk *et al.*, 2012).

However, the field application of corn DDGS in poultry is mainly limited to broilers and laying hens feed. The application of corn DDGS in meat duck feed has rarely been documented. Owing to differences in digestive tract characteristics between duck and chicken, the capacity and weight of the visceral organs of duck are larger than that of chicken. Therefore, we hypothesized that meat duck can tolerate higher levels of DDGS compared to chicken and we set to study the effect of different levels of corn DDGS on the growth performance and economic benefit in meat ducks. These understandings would guide the revised feed formulation and field application of alternative feed in meat ducks in enhancing productivity and performance.

MATERIALS AND METHODS

Corn DDGS

Corn DDGS used in this study was imported from the United States of America. The nutritional values of corn DDGS were measured before usage. The chemical composition of DDGS (air-dry basis) was as follows: crude protein (CP) 25.00%, crude fat (EE) 10.00%, lys 0.70%, met 0.50%, total phosphate 0.75%, available phosphate 0.40%, calcium 0.05%, and metabolic energy (ME) 2650 kcal/kg.

* Corresponding authors: tangxiaopeng110@126.com; pp20130515@163.com
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Animals

All animal studies were approved by the Animal Care Committee of Guizhou Normal University Guiyang, China. The experimental procedures were conducted in accordance with the Chinese Guidelines for Animal Welfare. Shuanggui-tou meat ducks, a cross between Peking duck and Hemp duck, were provided by Tangrenshen Group (Zhuzhou, China).

Experiment design and diets

A total of 450 Shuanggui-tou meat ducks (fifteen-day-old) with similar weight (443.89±13.2 g) were divided into 5 treatments: T0 (control group, 0% DDGS), T1 (8% DDGS in the diet), T2 (16% DDGS in the diet), T3 (24% DDGS in the diet), and T4 (32% DDGS in the diet). Each treatment carried 6 replicates, and each replicate was composed of 15 ducks. The composition and nutrition level of the diets is shown in Table I. All diets were formulated to meet nutrient requirements of meat-type duck (NY/T 2122-2012). The ducks were housed in an environmentally controlled room with a 24 h constant light schedule and *ad libitum* access to water and feed. Ducks were weighted by pen, and feed consumption was recorded weekly. The average daily gain (ADG), average daily feed intake (ADFI) and feed to meat ratio (F:G) were measured. The regression relationship between DDGS and ADG, the regression relationship between DDGS and F:G were analyzed and the economic benefit of adding DDGS in duck diets was assessed. The experiment lasted for a total of 28 days.

Statistical analysis

All data were presented as mean ± standard deviation (SD). Results of growth performance were analysed by One-Way ANOVA using the SPSS 21.0 programs (SPSS, Inc., Chicago, IL, USA). Differences among treatment mean were determined using Duncan's multiple comparison tests. The regression relationship between DDGS and ADG, DDGS and F:G were analysed by quadratic regression analysis of SPSS 21.0 programs (SPSS, Inc., Chicago, IL, USA). A $P < 0.05$ was considered significant whereas $P < 0.1$ was considered as significant tendency.

RESULTS AND DISCUSSION

Effects of corn DDGS on growth performance of meat ducks

The growth performance analysis of DDGS in meat ducks showed a non-significant effect on the ADFI, ADG and F:G o ($P > 0.05$) (Table II). When DDGS was

Table I.- Diet composition and nutrient levels (on fed basis, %).

Ingredients	T0[1]	T1	T2	T3	T4
Corn	53.00	49.00	45.00	41.00	36.50
Corn DDGS	0.00	8.00	16.00	24.00	32.00
Soybean meal	4.00	0.00	0.00	0.00	0.00
Cottonseed meal	4.00	4.00	0.00	0.00	0.00
Rapeseed meal	8.00	8.00	8.00	3.50	0.00
Meat meal	2.00	2.00	2.00	2.00	1.50
Wheat middling	12.00	12.00	12.00	12.00	12.00
Oil bran	13.00	13.00	13.00	13.00	13.00
$CaHPO_4$	0.70	0.60	0.55	0.50	0.50
Salt	0.35	0.35	0.35	0.35	0.35
Limestone	0.20	0.20	0.20	0.25	0.35
Lysine	0.50	0.60	0.65	0.70	0.70
Methionine	0.07	0.06	0.05	0.04	0.04
Mildew preventive	0.05	0.05	0.05	0.05	0.05
Zeolite powder	1.13	1.14	1.15	1.61	2.01
Premix[2]	1.00	1.00	1.00	1.00	1.00
Total	100	100	100	100	100
Nutrient levels[3]					
ME (kcal/Kg)	2773	2767	2776	2781	2778
CP	15.40	15.41	15.45	15.49	15.50
Lys	0.85	0.85	0.86	0.86	0.86
Met	0.32	0.32	0.32	0.32	0.31
Met+Cys	0.61	0.62	0.62	0.61	0.61
Ca	0.83	0.82	0.82	0.83	0.82
Total Pi	0.72	0.72	0.73	0.72	0.70
Available Pi	0.35	0.35	0.35	0.35	0.35

[1]T0, control group: 0% DDGS; T1, 8% DDGS; T2, 16% DDGS; T3, 24% DDGS; T4, 32% DDGS. [2]The premix provided following per kilogram of diet: Cu 20 mg, Fe 90 mg, Mn 70 mg, Zn 60 mg, I 0.38 mg, Se 0.20 mg, VA 3000 IU, VE 10 mg, VD_3 500 IU, VK 0.5 mg, VB_1 2 mg, VB_2 5 mg, VB_6 4 mg, nicotinic acid 20 mg, VB_{12} 12 µg, D-pantothenic acid 15 mg, folic acid 550 µg. [3]nutrient levels were calculated values.

Table II.- Effects of corn DDGS on the performance of meat ducks (g, g/d).

Item	T0[1]	T1	T2	T3	T4	P-value
ADFI[2]	154.02±7.11	153.71±5.26	153.35±2.75	150.30±3.19	151.15±3.27	0.546
ADG	51.53±2.07	52.42±2.41	51.65±2.23	51.45±1.21	50.86±3.03	0.831
F:G	2.99±0.12	2.93±0.09	2.97±0.09	2.92±0.10	2.97±0.15	0.798

[1]T0, control group: 0% DDGS; T1, 8% DDGS; T2, 16% DDGS; T3, 24% DDGS; T4, 32% DDGS. [2]ADFI, average daily feed intake; ADG, average daily gain; F:G, feed to meat ratio.

supplemented up to 24%, there was no difference in ADG between the experimental group and the control group ($P > 0.05$), but there was a tendency of decrease in ADG when DDGS was added to 32% ($0.05 < P < 0.1$). Corn DDGS is a high-quality protein feedstuff for poultry. Previous studies in broilers showed that the recommend DDGS levels are non-identical. Dozier *et al*. (2016) have indicated that, addition of 8% DDGS in the starter, 10% DDGS in the grower, 12% DDGS in finisher 1 and 14% DDGS in finisher 2 periods did not affect cumulative growth and carcass characteristics of broilers from 1 to 50 days of age. On the other hands, Wang *et al*. (2007) have suggested that 20% corn DDGS could be used in broiler diets based on digestible amino acids. It have also been reported that 25% DDGS was acceptable in broiler diets. Addition of 10%, 20% or 30% corn DDGS in starter, grower and finisher diets would not affect the performance of Chinese yellow broiler, a typical broiler chicken from 1 to 63 days of age (Shim *et al*. (2011) and Ruan *et al*. (2017).

The digestive tract of duck is anatomically different than that of chicken. Therefore, the capacity and weight of the visceral organs of duck is larger than that of chicken. The results obtained from this study indicated that growth performance of meat ducks was not influenced by dietary DDGS added to 32%, further justifying the hypothesis. It is imperative to state that ducks are usually considered as a 'bioindicators' to feed quality, due to their sensitivity to any nutrient deficiency (Kowalczyk *et al.*, 2012). Results presented here indicate that addition of DDGS in diet was harmless for growth performance of ducks. This indicates that DDGS can be proposed as a good alternative for soybean meal in duck feeds. These results are consistent with the report of previous study which showed that DDGS supplementation up to 30% in Pekin diets did not negatively affect live body weight (Adamski *et al.*, 2011). However, corn DDGS contains high level of unsaturated fatty acids, particularly oleic acid and linoleic acid which are prone to oxidation. This may subsequently result in an acceleration of lipid oxidation in muscle and ultimately affecting the meat quality (Hanson *et al.*, 2015; Min *et al.*, 2015; Ruan *et al.*, 2018). In order to optimize a suitable level of DDGS for meat duck diets, the regression relationship between DDGS and ADG, DDGS and F:G was calculated. As shown in Figure 1, the regression relationship between DDGS and ADG was $y=-26.674x^2+5.6482x+51.70$ ($R^2=0.7543$, $P > 0.05$, y is ADG; x represents DDGS addition level) (Fig. 1A) and the regression relationship between DDGS and F:G was $y=1.4509x^2-0.5268x+2.9846$ ($R^2=0.414$, $P > 0.05$, y is F:G, x represents DDGS addition level) (Fig. 1B). According to the quadratic regression equation, it can be speculated that the maximum ADG would be 52.00 g/d when DDGS addition level was 10.58%, and the lowest F:G would be 2.93 when DDGS addition level was 18.15%.

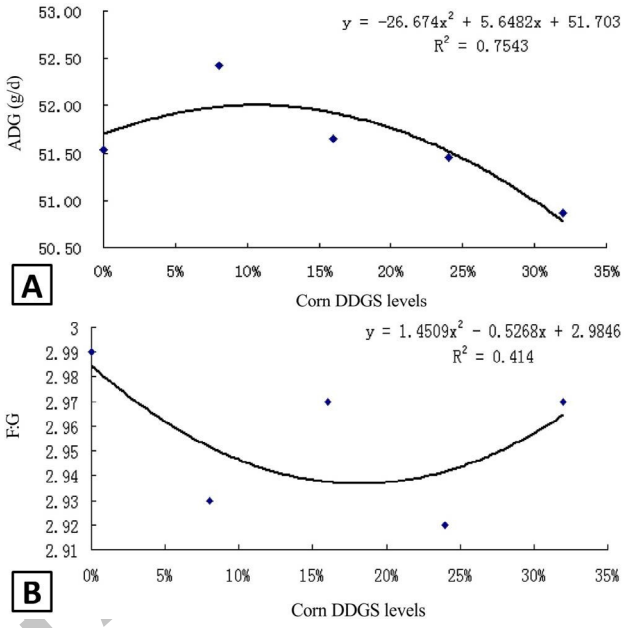

Fig. 1. Quadratic regression analysis: A, the regression relationship between DDGS and ADG; B, the regression relationship between DDGS and F:G.

Economic benefit analysis

In almost all poultry production systems, the feed costs accounted for 70-75% of producer expenses (Amerah *et al.*, 2007; Adamski *et al.*, 2011). For poultry production, reducing production costs is the key to profitability. On one hand, the nutritional value of corn DDGS is high that can be widely used in poultry (Abudabos *et al*., 2017; Shim *et al*., 2018; Wang *et al*., 2018; Ruan *et al.*, 2018). On the other hand, corn DDGS is much cheaper than corn and soybean meals. Thus an increase in DDGS inclusion in the diet can significantly reduce the feed cost. In the present study, the economic benefit of corn DDGS added to meat ducks was assessed. The results presented in Table III showed that cost per tonne of feed was decreased with the increase of DDGS addition level, which is in accordance with the study of Adamski *et al.* (2011) and Kowalczyk *et al*. (2012). With the increase of DDGS addition level, the unit weight gain cost was gradually decreased, namely, 0% DDGS > 8% DDGS > 16% DDGS > 24% DDGS > 32% DDGS. Owing to cheaper costs of DDGS compared to soybean meal, the results justify the addition of corn DDGS in diet which can significantly improve economic benefits. Moreover, addition of corn DDGS in meat duck diets did not influence the growth performance of ducks, therefore, the unit weight gain cost is correspondingly lower.

Table III.- Effects of corn DDGS on economic benefit of meat ducks.

Item	Costs[2]	F:G	UWGC[3]	Relative cost[4]	Relative economic benefit
T0[1]	2323	2.99	6.95	-	-
T1	2282	2.93	6.69	0.26*	3.79#
T2	2246	2.97	6.67	0.28*	4.02#
T3	2216	2.92	6.47	0.48*	6.90#
T4	2175	2.97	6.46	0.49*	7.05#

[1]T0, control group: 0% DDGS; T1, 8% DDGS; T2, 16% DDGS; T3, 24% DDGS; T4, 32% DDGS. [2]The cost of feed was calculated according to market price. [3]means unit weight gain cost. UWGC= F:G × feed unit price.[4]relative costs and relative economic benefits are compared with control group (T0). *, decrease; #, increase.

CONCLUSION

Taken together, our results demonstrate that the increase of DDGS in feed did not negatively affect the growth performance and subsequently can decrease the unit weight gain cost. In order to maintain a lower F:G conditions to minimize the cost of feed, the optimized DDGS added level is proposed to be 18.15%. However, a high level of corn DDGS in meat duck diets is also feasible and may warrant future investigations.

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Statement of Conflict of interest

The authors have declared no conflict of interest.

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