Effect of wheat distillers dried grains with soluble on performance, carcass characteristics and immunity of broiler chicks

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Abstract

The study was performed to evaluate the effects of wheat- distillers dried grain with soluble (DDGS) levels on performance, carcass- characteristics, lymphoid organs and antibody titer against Avian Influenza and Newcastle Disease. A total of 144 day old broiler chicks (Ross 308) were randomly distributed between 3 treatments with 4 replicates and 12 chicks per each replication. The treatments included: control diet without wheat DDGS (A); 3, 4, 6 and 7% wheat-DDGS in starter, grower and finisher 1 and 2 phases respectively (B); 6, 8, 12 and 14% wheat-DDGS in starter, grower and finisher 1 and 2 phases respectively (C). Results showed that body weight at 50 d, daily weight gain at 25-39, 39-50 and 9-50 days significantly decreased C treatment ($P<0.05$). The feed intake at 16-25 d significantly decreased by C treatment ($P<0.05$). The feed conversion ratio at 25-39, 39-50 and 9-50 days in C treatment significantly decreased compare to control group ($P<0.05$). The percentage of carcass, heart, gizzard and ileum significantly decreased by C treatment ($P<0.05$). Also, jejunum weight percentage in B and C treatments compare to control group significantly increased ($P<0.05$). As a conclusion, using incremental levels of wheat-DDGS (3, 4, 6 and 7%) in starter, grower, finisher 1 and 2 phases did not make significant change on broilers; performance. On the other hand, inclusion high levels of wheat-DDGS (12 and 14%) in finisher 1 and 2 phases decreased broilers' performance ($P<0.05$).

Keywords: Broiler; Wheat-DDGS; Performance; Carcass; Immunity

Introduction

One of the by-products in ethanol and beverage production process is distillers dried grains with soluble (DDGS) which is produced after starch fermentation of cereals (Cozannet et al., 2010). In poultry industry, the information about chemical composition and nutritional values of DDGS in poultry nutrition is limited especially for wheat-DDGS, because a few number of studies have been performed (Widyaratne and Zijlstra, 2007).

After the fermentation process of corn and wheat to produce ethanol and fat extraction by centrifuge, the obtained by-product is dried distiller grain with soluble which can be a protein ingredient in poultry diet. Assessment of how much corn or wheat DDGS can be effectively fed to poultry varies (Shim et al., 2011). Lumpkins et al (2004) deduced that starter, grower and finisher diets of broilers should not contain more than 12 or 15% DDGS. Although, wheat DDGS contain high level of protein, there are concerns about the level and digestibility of amino acid, especially lysine (Cozannet et al., 2010; Bolarinwa and Adeola, 2012). Parsones et al (1983) found that up to 40% soy protein in broilers diet can be replace with DDGS, if the lysine level provided according to requirement. Waldroup et al (1981) reported that if metabolisable energy level provided constantly, the DDGS can included in broilers diet up to 25% without negative effect on body weight and feed conversion ratio. The objective of present study was to determine the effects of different levels of wheat DDGS on growth performance of chicks.

Materials and methods

The experiment was conducted at the experimental farm of Davoodi Commercial Group, with longitude 51.78, latitude 32.65 and altitude 1557. A total of 144 broiler chicks (Ross 308) were used in this experiment and were randomly allocated to 3 treatments with 4 replicates and 12 chicks per each replicate. The feed and water were provided by a hanging feeder and nipple drinker in each pen. Feed and water were provided *ad libitum* till the end of the trial. Body weight (BW), feed intake (FI), daily weight gain (DWG) and feed conversion ratio (FCR) were determined for each replicate at 15, 28, 43 and 50 days of age. The experiment was started from 9 days old. The 4 experimental periods included: starter (9-16 d), grower (17-25 d), finisher one (26-39 d), and finisher two (44-50 d).

The experimental period lasted 50 days. At first broiler received commercial diet till 8 d, then 4 experimental periods included of: starter (9-16 d), grower (17-25 d), finisher one (26-39 d), finisher two (44-50 d). Composition and calculated energy and nutrient content of diets from day 8 to 50 are presented in Tables 1. Experimental diets as follow: control diet without wheat-DDGS (A); diets with incremental levels of 3, 4, 6 and 7% wheat-DDGS in starter, grower, finisher 1 and 2, respectively (B); diets with incremental levels of 6, 8, 12 and 14% wheat-DDGS starter, grower, finisher 1 and 2, respectively (C).

At 7 days all broiler chicks were intramuscularly immunized with a killed vaccine against Newcastle and Avian Influenza Viruses. The blood sample was taken from wing vein of two birds per each replicate. The blood serum was separated and antibody titer against Newcastle and Influenza Viruses were determined by haemaglutination inhibition (HI) test and expressed as the logarithm base 2 (Shahryari et al., 2019). The immune test was done at the Arian Dom Laboratory (an authorized with Iran Veterinary Organization).

At 50 days of age, two birds per replicate with body weight similar to the mean body weight of each pen were selected, slaughtered and after that carcass characteristics and lymphoid organs (spleen and bursa of fabricius) were collected, weighed and expressed as a percentage of live body weight.

Statistical analysis

Analysis was performed with the SAS software, using the general linear model procedure. Significant differences ($P<0.05$) among treatment means were defined using LSD test.

Results and Discussion

Growth performance

Effects of experimental diets on growth performance of broiler chickens is reported in Table 2. Inclusion low levels of wheat-DDGS (3, 4, 6 and 7% in starter, grower and finisher 1 and 2 periods, respectively) had no effect on performance parameters such as body weight, daily weight gain, feed intake and feed conversion ratio of broiler chicks. According to low price of wheat-DDGS than to corn and soybean meal and no negative effect of incremental levels of wheat-DDGS (3, 4, 6 and 7% in starter, grower, finisher 1 and 2 periods, respectively) on growth performance of broiler chicks can substitute corn and soybean meal with wheat-DDGS.

In starter phase (9-16 d) incremental levels of wheat DDGS (6, 8, 12 and 14 %) had no significant effect on BW, DWG and FCR of broiler chicks. In starter, grower, finisher 1 and 2 phases the FI of broilers significantly decreased by incremental levels of DDGS ($P<0.05$), but there was no significant difference between BW, DWG and FCR of broilers. In finisher 1 and 2 phases the FI was not affected by experimental diet, but BW at 50 day, DWG and FCR in finisher 1 and 2 phases adversely affected by incremental levels of wheat DDGS (6, 8, 12 and 14%) ($P<0.05$). In overall rearing phase the FI was not affected by experimental diets, the DWG and FCR significantly decreased by 6, 8, 12 and 14% wheat DDGS.

Table 1. Ingredient and composition of the starter diet

Diet composition	Starter			Grower			Finisher 1			Finisher 2		
	A	B	C	A	B	C	A	B	C	A	B	C
Corn seed	50.65	49.1	48	52.3	50.8	49.2	56.5	54.7	52.9	57.7	55.4	53.3
Soybean meal	24	22.5	20.5	22.8	20.3	17.8	18.6	14.4	10.2	15.5	10.7	5.9
Oil	0.9	1	1	1	1	1	1.3	1.3	1.3	1.5	1.5	1.5
Salt	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.25	0.2	0.1
MCP	1.05	1	1	0.85	0.81	0.79	0.73	0.67	0.62	0.55	0.5	0.44
$CaCo_3$	1.715	1.695	1.755	1.585	1.585	1.645	1.45	1.46	1.49	1.36	1.45	1.4
Lysine	0.39	0.42	0.46	0.33	0.39	0.44	0.3	0.39	0.48	0.31	0.42	0.52
Methionine	0.28	0.27	0.26	0.2	0.19	0.19	0.2	0.18	0.18	0.16	0.15	0.14
Threonine	0.13	0.14	0.15	0.1	0.11	0.13	0.07	0.09	0.12	0.06	0.09	0.11
$NaHCo_3$	0.13	0.13	0.13	0.13	0.13	0.13	0.15	0.15	0.15	0.15	0.15	0.15
Mineral premix[1]	0.14	0.14	0.14	0.12	0.12	0.12	0.1	0.1	0.1	0.1	0.1	0.1
Vitamin premix[2]	0.14	0.14	0.14	0.12	0.12	0.12	0.1	0.1	0.1	0.1	0.1	0.1
Choline chloride	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Toxin binder	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Canola meal	6	6	6	6	6	6	7	7	7	9	9	9
DDGS	0	3	6	0	4	8	0	6	12	0	7	14
Sesame meal	2	2	2	2	2	2	2	2	2	2	2	2
Corn gluten	2	2	2	2	2	2	1	1	1	1	1	1
Wheat	10	10	10	10	10	10	10	10	10	10	10	10
Phytase	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Multi enzyme	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Metabolizable energy (Kcal/Kg)	2912	2913	2910	2942	2941	2936	3003	3003	3002	3031	3026	3028
Crude protein%	21.06	21.16	21.10	20.52	20.51	20.49	18.0	18.0	18.0	17.43	17.47	17.51
Digestible lysine%	1.15	1.15	1.15	1.08	1.08	1.08	0.96	0.96	0.96	0.93	0.93	0.93
Digestible Met+Cys%	0.9	0.9	0.9	0.82	0.82	0.82	0.77	0.77	0.77	0.73	0.73	0.73
Digestible Thr%	0.78	0.78	0.78	0.73	0.73	0.73	0.64	0.64	0.64	0.61	0.61	0.61
Calcium%	0.96	0.96	0.96	0.87	0.87	0.87	0.8	0.8	0.8	0.74	0.74	0.74
Available phosphorous%	0.48	0.48	0.48	0.435	0.435	0.435	0.39	0.39	0.39	0.35	0.35	0.35
Na %	0.17	0.17	0.17	0.17	0.17	0.17	0.18	0.18	0.18	0.19	0.19	0.19
Cl %	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21

[1]Vitamin premix per kg of diet : Vitamin A: 9000 IU؛ Vitamin D3: 4000 IU؛ Vitamin E: 63 mg؛ Vitamin K 2.3 mg؛ Vitamin B1: 2.6 mg؛ Vitamin B2: 6.5 mg؛ Vitamin B3: 48 mg؛ Vitamin B5: 15 mg؛ Vitamin B6: 3 mg؛ Vitamin H2: 0.16 mg؛ Vitamin B9: 1.7 mg؛ Vitamin B12: 0.013mg; [2] Mineral premix per kg of diet : Zn 126 mg ؛Mn 105 mg ؛Fe 38 mg ؛Cu 16 mg ؛I 1.3 mg ؛Se 0.38 mg

Table 2. Effect of wheat DDGS levels on performance of broiler chicks

Items	A	B	C	P-value
9-16 d				
FI	51.44^{a}±0.32	52.01^{a}±0.47	51.69^{a}±0.36	P<0.59
BW	518.65^{a}±4.30	530.00^{a}±4.51	522.00^{a}±2.43	P<0.14
DWG	47.77^{a}±0.22	48.57^{a}±0.64	47.42^{a}±0.34	P<0.21
FCR	1.06^{a}±0.008	1.07^{a}±0.009	1.07^{a}±0.007	P<0.43
16-25 d				
FI	93.71^{a}±0.70	93.97^{a}±1.02	90.92^{b}±0.74	P<0.04
BW	1096.20^{a}±12.33	1099.43^{a}±2.25	1107.20^{a}±13.72	P<0.76
DWG	64.17^{a}±1.66	63.26^{a}±0.52	65.02^{a}±1.43	P<0.64
FCR	1.46^{a}±0.03	1.48^{a}±0.01	1.40^{a}±0.03	P<0.19
25-39 d				
FI	142.58^{a}±0.39	141.74^{a}±0.20	142.31^{a}±0.74	P<0.49
BW	2169.6^{a}±21.80	2160.0^{a}±4.28	2137.8^{a}±10.04	P<0.29
DWG	76.67^{a}±0.85	75.75^{ab}±0.35	73.61^{b}±0.78	P<0.02
FCR	1.86^{b}±0.02	1.87^{ab}±0.01	1.94^{a}±0.02	P<0.05
39-50 d				
FI	170.23^{a}±2.42	174.58^{a}±0.64	173.30^{a}±0.73	P<0.15
BW	3092.40^{a}±22.80	3113.40^{a}±22.80	2962.04^{b}±16.66	P<0.002
DWG	83.89^{a}±2.54	86.63^{a}±2.97	74.93^{b}±2.31	P<0.02
FCR	2.03^{b}±0.06	2.02^{b}±0.07	2.32^{a}±0.06	P<0.01
9-50				
FI	119.97^{a}±0.73	120.54^{a}±0.29	119.69^{a}±0.36	P<0.49
DWG	69.10^{a}±0.54	69.59^{a}±0.82	66.00^{b}±0.39	p<0.002
FCR	1.73^{b} ±0.01	1.73^{b}±0.02	1.81^{a}±0.01	P<0.005

a-b Means within the row with no common superscripts differ significantly. A: Control diet without wheat DDGS; B: 3, 4, 6 and 7% wheat-DDGS in starter, grower, finisher 1 and 2, respectively. C: 6, 8, 12 and 14% wheat-DDGS in starter, grower, finisher 1 and 2, respectively. FI: Feed intake; BW: Body weight; DWG: Daily weight gain; FCR: Feed conversion ratio.

Table 3. Effect of wheat DDGS levels on carcass characteristics of broiler chicks (Live wt. %)

Items	A	B	C	P-value
Carcass	66.09^{a}±0.53	66.60^{a}±0.18	63.62^{b}±0.64	P<0.002
Heart	0.49^{b}±0.01	0.48^{b}±0.01	0.60^{a}±0.01	P<0.0002
Liver	1.74^{a}±0.04	1.79^{a}±0.05	1.85^{a}±0.02	P<0.18
Pancreas	0.15^{a}±0.02	0.15^{a}±0.02	0.16^{a}±0.02	P<0.96
Proventriculus	0.33^{a}±0.01	0.36^{a}±0.02	0.37^{a}±0.01	P<0.27
Gizzard	1.21^{b}±0.03	1.35^{ab}±0.05	1.38^{a}±0.03	P<0.04
Deudenum	0.52^{a}±0.04	0.54^{a}±0.03	0.59^{a}±0.03	P<0.39
Jejunum	0.77^{b}±0.05	1.02^{a}±0.06	1.13^{a}±0.02	P<0.0009
Ileum	0.65^{b}±0.04	0.72^{ab}±0.03	0.86^{a}±0.06	P<0.03
Cecum	0.93^{a}±0.07	0.94^{a}±0.07	0.93^{a}±0.16	P<0.99
Abdominal fat	1.85^{a}±0.09	1.93^{a}±0.04	2.05^{a}±0.07	P<0.19

a-b Means within the row with no common superscripts differ significantly. A: Control diet without wheat DDGS; B: 3, 4, 6 and 7% wheat-DDGS in starter, grower, finisher 1 and 2, respectively. C: 6, 8, 12 and 14% wheat-DDGS in starter, grower, finisher 1 and 2, respectively.

Table 4. Effect of wheat DDGS levels on antibody titer production against avian influenza and Newcastle diseases and lymphoid organs of broiler chicks

Treatments	Antibody titer		Lymphoid organs (Live weight percentage)	
	AI	ND	Spleen	Bursa of fabricus
A	5.42^{a}±0.29	4.00^{a}±0.30	0.12^{a}±0.00	0.06^{a}±0.00
B	5.28^{a}±0.28	4.00^{a}±0.30	0.12^{a}±0.00	0.06^{a}±0.01
C	5.57^{a}±0.20	4.28^{a}±0.18	0.11^{a}±0.01	0.06^{a}±0.00
P-value	P<0.75	P<0.7	P<0.80	P<0.99

a-b Means within the row with no common superscripts differ significantly. AI: Avian Influenza; ND: Newcastle Disease. A: Control diet without wheat DDGS; B: 3, 4, 6 and 7% wheat-DDGS in starter, grower, finisher 1 and 2, respectively. C: 6, 8, 12 and 14% wheat-DDGS in starter, grower, finisher 1 and 2, respectively.

Oryschak et al (2010) reported that inclusion of 5 and 10% wheat DDGS in broilers diet had no significant effect on BW and DWG of broilers in different rearing phases, but FI and FCR of broilers at 28-42 d significantly decreased by 10% wheat DDGS (P<0.05). Therefore, they proposed that 10% wheat DDGS can be used in broilers diet without adverse effect on growth performance. The poor growth performance in broilers fed on diet containing high wheat DDGS can be because of low digestibility of branched chain amino acid and low lysine content.

According to mentioned issue, it can be concluded that till the wheat DDGS included in broilers diet lower than 10% (starter and grower phases) had no adverse effect on growth performance, but in finisher one and two phases 12 and 14% wheat DDGS inclusion decreased growth performance. Oryschak et al (2010) and Lumpkins et al (2004) suggested that decrease broilers performance by using high DDGS is probably because of overestimation

of lysine in DDGS that is cause to marginal shortage of this amino acid. Also, they suggested that 6% DDGS in starter phase, 12 to 15% in grower and finisher phases is acceptable. Similar to obtained results, Wen et al (2013) reported that using 10% DDGS with 200 mg/kg vitamin E in layer diet had no adverse effect on their production.

Lumpkins et al (2004) performed two experiments to evaluate new generation of DDGS in broilers diet. In first experiment two starter diets (high and low density) contain 0 and 15% DDGS formulated. There was no significant difference between two levels of DDGS on broilers' growth performance. The broilers received diet low density and 15% DDGS had low feed efficiency (gain/feed) in 7 and 14 days.

In second experiment the iso-caloric and iso-nitrogenous diet with 0, 6, 12, and 18% DDGS formulated for starter, grower and finisher phases, respectively. The results showed no differences in performance and carcass characteristics of broilers, except that daily weight gain and feed conversion ratio of broilers at starter phase decreased by 18% DDGS ($P<0.05$).

Zhang et al (2013) showed that diets contain 20% DDGS cause to decrease growth performance of broilers. Also, adding DDGS up to 10% of diet had no negative effect on growth performance, carcass characteristics and immune organs development of broilers (ICAR-CARI, 2015). In confirming to obtained results, Ibrahim et al (2008) stated that using 15% DDGS in 12-35 days of broilers age had no significant effect on DWG, but the FCR significantly increased compare to control group ($P<0.05$). Also, they observed no significant difference in FCR of broilers fed on diet contain 5 and 10% compare to control group.

In contrast to results of present study, Lumpkins et al (2004) and Wang et al (2008) expressed that using 20% corn DDGS had no significant effect on broilers performance, although the discrepancy between results can be because of different DDGS sources. Another reason in broilers performance reduction might be because of 10% higher soluble NSP in wheat DDGS than other DDGS sources. The soluble NSP in wheat is more than corn (Hetland et al., 2004), so inclusion of wheat DDGS in diet cause to increase NSP content of diet. The difference in NSP content might be difference in wheat and corn DDGS usage.

Thacker and Widyaratne (2007) used 0, 10, 15 and 20% wheat DDGS in broilers diet, they observed no significant difference in DWG, FI and FCR of broilers; although, the growth performance of broilers received 20% wheat DDGS tend to decrease. Guney et al (2013) reported that corn DDGS inclusion up to 20% compare to diets based on corn-soybean meal had no negative effect on broilers performance. Olofintoye and Bolu (2013) observed that using 20% corn DDGS in layer diet improved their production compare to control group.

Carcass characteristics

The effect of wheat-DDGS on carcass characteristics of broilers are presented in Table 3. The 6, 8, 12 and 14% wheat-DDGS in starter, grower, finisher 1 and 2 phases respectively, significantly decreased carcass percentage, and significantly increased percentage weight of heart, gizzard, jejunum and ileum of broilers ($P<0.05$). Use of 3, 4, 6 and 7% wheat-DDGS in starter, grower, finisher 1 and 2 phases respectively, significantly increased jejunum percentage of broilers ($P<0.05$), but had no significant effect on other carcass characteristics. Presumably, because of increases of percentage weight of heart, gizzard, ileum and jejunum of broilers feed on incremental levels of wheat-DDGS (6, 8, 12 and 14%) the carcass percentage decreased ($P<0.05$). On the other hand, the weight percentage reduction in broilers received diets contain 6, 8, 12 and 14% wheat-DDGS could be because of low amount of lysine and arginine and low digestibility of branched chain amino acids. The highest protein ratio of wheat-DDGS is from wheat (95%) and the residual is from yeast (5%) (Ingledew, 1993). So, it is expected that DDGS amino acids profile approximately equal to wheat amino acid profile. However, remarkable reduction in lysine (1.9 v.s 2.9 g lysine in 100 g protein) and arginine (3.8 v.s 5.1 in 100 g protein) in DDGS probably is affected broiler performance. Probably, these two amino acids are affected in maillard reaction during wheat DDGS production (Pederson et al., 2007). The increase of digestive organs such as gizzard, jejunum and ileum could be because of high fiber content of diets that is contain high level of DDGS.

The relative weight of digestive organs in broilers fed on diet contain high fiber significantly increased ($P<0.05$). According to results present study, Ibrahim et al (2008) showed that wheat-DDGS contain more soluble NSP (35.61% DM) that is presumably hemicellulose. Spiehs et al (2002) reported that hemicellulose content in DDGS is higher than usual.

Immune response

The effect of different levels of wheat-DDGS on lymphoid organs and antibody titer against Avian Influenza and Newcastle Disease Viruses are summarized in Table 4. The results show that wheat-DDGS levels had no significant effect on immune responses of broilers. Barekatain et al (2013) showed that the necrotic enteritis in broilers fed on 20% sorghum with and without protease and zylanase enzymes improved; while, IgA and IgM titer of broilers challenged with necrotic enteritis in 21 and 35 days of age respectively, decreased ($P<0.05$). Min et al (2015) reported that super oxid dismutase and total antioxidant activity in blood serum of broilers in 21 days decreased by DDGS inclusion; so, IgA, IgG and MDA in blood serum increased.

Alizadeh et al (2016) reported that diets contain 10% DDGS cause increase in cell mediated immune response, this increase represents the immune activity stimulation due to face to non-inflammatory antigens in broilers. Accordance with obtained results Gupta et al (2016) reported that 5, 7 and 10% Rice-DDGS in broiler diet had significant effect on cellular mediate immunity and hemagglutination antigen.

Conclusion The results showed that using incremental levels of wheat-DDGS till 7% (3, 4, 6 and 7% in starter, grower, finisher 1 and 2, respectively) had no significant effect on growth performance and immune responses. Therefore, above mentioned levels can be used to decrease diet price.

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