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EFFECT OF FEEDING CORN DISTILLERS DRIED GRAINS WITH SOLUBLES ON GROWTH PERFORMANCE, NUTRIENTS DIGESTIBILITY, PLASMA METABOLITES, IMMUNOLOGICAL STATUS, AND INTESTINAL HEALTH OF BROILERS

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SUMMARY

The current study aimed to evaluate the effect of replacing soybean and corn with corn distillers dried grains with solubles (DDGS) in grower and finisher broiler diets on performance, nutrients digestibility, blood constituents, immune response, as well as intestinal health indications. A total of three hundred and sixty 21-day-old broiler chicks (Ross 308) were divided into four groups, each group included six replicates of 15 birds each. The control group (CON) was fed the basal diet, whereas the second (D5), third (D10), and fourth (D15) groups were fed diets with 5%, 10%, and 15% DDGS, respectively at the expense of corn and SBM. Birds fed 5% and 10% DDGS showed an improvement in body weight and feed conversion ratio than those fed 15% DDGS and CON groups.Also, relative economic efficiency records an increase with DDGS treatments. All DDGS levels showed significantly decrease in plasma cholesterol concentration, while increased HDL values compared to the control group. As well, crude protein digestibility is enhanced; while dry matter, ether extract, nitrogen-free extract digestibility, and AMEn were not affected by dietary treatments. Likewise, no variance in carcass characteristics, lymphoid organs (%), and ileal histomorphology were observed by the dietary treatments ($p< 0.05$). Increased the cecum content of *Escherichia coli* in birds fed 15% DDGS were observed. According to results observed in this work, it could be concluded that DDGS is a valuable ingredient and might be added in the broiler diet up to 15% without any processing or addition. Also, poultry nutrition experts should investigate the possibility of adding DDGS at higher rates or mixing some suitable bio-additives that might help to improve the nutritional value and increase the utilization of DDGS, as a cheap by-product.

Keywords: *DDGS, broilers, performance, digestibility, immunity.*

INTRODUCTION

A safe and cheaper alternative to petroleum-based fuels is ethanol production, especially ethanol from corn; as a result, large quantities of corn were planted for this purpose. The ethanol production process produces by-products in huge quantities, characterized by a high nutritional value that can be used in poultry feed (Singh *et al*., 2005), which is known as dried distillers' grains with solubles (DDGS), which can be used in poultry feed to reduce feed costs. The most important features of the dried distillers' grains with solubles (DDGS) are as a good source of energy, protein (digestible amino acids), fats, and available phosphorous (Parsons *et al*., 2006; Wang *et al*., 2007; Pederson *et al*., 2014). Where the DDGS contains about 3 times of protein, fat, and mineral elements found in raw corn (source). In addition to containing yeast protein (the product of the fermentation process), which may have a beneficial effect on birds. Accordingly, DDGS is a good partial substitute for corn and soybeans and saves the costs of some raw materials needed to balance the diet of poultry such as inorganic phosphorous (Belyea *et al*., 2010;Salim *et al*., 2010; Liu, K. 2011). These advantages motivated nutrition experts to study the possibility of using it in poultry feed formulation. Despite these previously mentioned advantages, it contains large amounts of crude fiber and some mycotoxins that are found in the exported grains (corn) that are harmful to the bird (Zhand *et al*., 2009; Loar *et al*., 2010). This study was planned to evaluate the effect of adding different DDGS levels to broiler chicks at the grower period on productive performance, nutrient digestibility, blood constituents, immune response, and cecum microbiota.

MATERIALS AND METHODS

Birds, Experimental Design, and Diets:

A total of three hundred and sixty 21-day-old broiler chickens (Ross 308) were divided randomly into four groups, each group was divided into 6 replicates, and each replicate containing 15 birds (average LBW 766 ± 3 g at 21 days). The first group fed basal diet (CON) as the control group, the second, third, and fourth groups were fed diets that replaced soybean and corn with DDGS at 5%, 10%, and 15% respectively. The analysis of DDGS in the current study showed the presence of 30.2% crude protein, 0.71% methionine, 0.83% lysine, 7.3% ash, 9.05% fat, 0.27% calcium, 0.95% phosphorus and 3,307kcal metabolizable energy (ME). The experimental diets were formulated to be isonitrogenous and isocaloric (grower (21 to 29 D) and finisher (30 to 42 D) diets) based on the nutritional requirements of the NRC (1994) for broiler chicks and shown in Table (1). The diets (Pellet) and water were provided to the birds*ad libitum*. The ambient temperature was 25- 32 ◦C during the experimental period and the lighting was provided for 20 h and 4h dark.

Table (1): Composition and calculated analysis of the grower and finishing basal diets.

	Grower (21-29d)				Finisher (30-42d)			
Ingredient (%)	CON	D5	D10	D15	CON	D5	D10	D15
Yellow Corn	58.8	58.1	56.18	54.35	63.67	62.70	60.54	59.31
Soybean meal (44%)	29.4	26.0	23.01	19.95	23.91	20.57	17.60	14.45
DDGS	**0.00**	**5.00**	**10.0**	**15.0**	**0.00**	**5.00**	**10.0**	**15.0**
Corn gluten meal (60%)	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Soybean oil	2.50	1.55	1.43	1.15	3.10	2.41	2.25	1.60
Calcium carbonate	1.20	1.20	1.20	1.20	1.30	1.30	1.42	1.42
Di-Calcium Phosphate	2.20	2.20	2.20	2.20	1.95	1.95	1.95	1.95
Min and Vit Premix*	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
NaCl (salt)	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
L-Lysine HCl	0.10	0.15	0.18	0.30	0.25	0.25	0.38	0.41
DL-Methionine	0.20	0.20	0.20	0.25	0.22	0.22	0.26	0.26
Price / ton	6845	6765	6760	6730	6715	6640	6640	6585
Calculated analysis								
ME (kcal.kg)	3050	3050	3050	3050	3150	3150	3150	3150
CP (%)	21	21	21	21	19	19	19	19
Ca%	1.04	1.05	1.04	1.03	1.02	1.03	1.04	1.04
AP %	0.52	0.52	0.51	0.52	0.47	0.46	0.46	0.47

**Each 2.5 kg Vitamins and minerals premix contains :vitamin A, 7700,000 IU; vitamin D3, 3300,000 IU; vitamin E, 6,600 mg; vitamin K3, 550mg; thiamine, 2200 mg; riboflavin, 4400 mg; vitamin B , 4400 mg; Ca Pantothenate, 550 mg; nicotinic acid, 200 mg; folic acid, 110 mg; choline chloride, 6275,000 mg; biotin, 55 mg; vitamin B12, 8.8 mg; Trace mineral (milligrams per 2.5 kilogram of diet): Mn, 66000; Zn, 66000; Fe, 33000; Cu, 8800; Se,300; and I, 900.*
CON= basal diet (control); D5= 5% DDGS; D10= 10% DDGS; D15= 15% DDGS.

Performance and Digestibility:

Growth performance (Live body weight (LBW), body weight gain (BWG), feed intake (FI), and feed conversion ratio (FCR) were measured at 28 and 42 days) during the experimental period. At 42 days, 24 birds (6 chicks per group) were slaughtered to measure the carcass characteristics (dressing, carcass yield, liver, and abdominal fat) and lymphoid organs (Thymus, Spleen, and Bursa of Fabricius). On day 40, 3 chicks from each group were moved into individual cages (1 chicken/cage) for the collection of excreta samples, after fasting the chicks for 12 h to empty the digestive system. Excreta samples were collected from 40 to 43 days then the excreta samples (three times a day) were dried (at 60◦C for 72 h.) and ground.

Experimental diets and excreta samples were analyzed for dry matter (DM), crude protein (CP), ether extract (EE), according to AOAC (2006), while nitrogen free extract was obtained by difference. The apparent metabolizable energy corrected to zero nitrogen balance (AMEn) of diets and excreta were measured by a bomb calorimeter (Model 1261, Parr Instrument Co., Moline, IL), was estimated as described by Mountzouris *et al*. (2010).

Economical traits

A production cost analysis and economical evaluation was carried out for all dietary treatments in an attempt to investigate effects of different levels of DDGS on relative economic efficiency. Where: Economic efficiency = net return/total feed cost X 100. Whereas net revenue= total return - total feed cost

Plasma Constituents and Immune Response:

At 42 days, blood samples from 24 chicks (6 chickens per group) were collected during slaughtering, gathered into heparinized test tubes, centrifuged (4500 rpm for 15 min) to separate the plasma, and stored at −10 °C till analysis. Plasma cholesterol (total, low-density lipoprotein (LDL), and high-density lipoprotein (HDL)), total protein, albumin, uric acid, aspartate aminotransferase (AST), and alanine aminotransferase (ALT) were spectrophotometrically assessed (Spectronic 1201; Milton Roy, Ivyland, PA, USA) using commercial kits. To determine the chicken's immune response, plasma samples were tested using chicken-specific IgA, IgM, and IgG ELISA quantitation commercial kits (Bethyl Laboratories Inc., Montgomery, TX, USA) to appreciate IgA, IgM, and IgG concentrations.

Intestinal Health Indications:

At end of the experiment, 24 chickens around the average body weight (6 birds per group) were slaughtered to evaluate ileum histomorphological, cecal microbiota, and gut pH trends. Ileum samples were collected (~3 cm) for histomorphological analysis and stored in 10% formalin saline solution. Ileum samples were processed into slides by cutting using a rotary microtome (4–5 μm thickness) and examined by optical microscopy. Villus height (VH) and crypt depth (CD) were measured as explained by Abdel- Moneim *et al*. (2020).

For the microbial estimate, the contents of the cecum were squeezed into sterile glass bottles. One gram from the three fresh samples/group was diluted and placed on the agar to enumerate *Lactobacillus*, *Coliforms*, and *Escherichia coli* (MacConkey agar, Rogosa, and deMan agar, respectively), and the number of microbial was converted to $\log^{10}$ as described by Czerwiński *et al*. (2012). One gram of digesta (from both duodenum, jejunum, ileum, and cecum) was taken and mixed with 10 ml of distilled deionized water to determine the pH directly according to Nisbet *et al*. (1993).

Statistical analysis:

Obtained data were analyzed using the one-way analysis of variance (ANOVA) by SPSS (Version 17.0, Chicago, IL, USA). Distinguishing the significant differences between groups means for each tested parameter was performed using Duncan's multiple (a significance level of 0.05) range test (Duncan, 1955).

RESULTS AND DISCUSSION

Performance:

The present study showed that replacing 5% and 10% of a broiler diet with DDGS at the expense of corn and SBM during the experimental period improved ($P < 0.05$) ADG and FCR compared to the control group, as shown in Table (2). Moreover, a 15% DDGS in the broiler diet did not affect ADG and FCR ($P<0.05$) compared to the control group. This is in agreement with the results of several studies, which indicated that only a small percentage of DDGS can be substituted in the broilers diet without influencing growth performance (Loar *et al*., 2010; Alizadeh *et al*., 2016). Likewise, Campasino *et al.* (2015) observed that feeding diets containing 15% DDGS decreased the BWG of broiler chickens. Nevertheless, the experimental treatments did not affect the ADFI in this study. The mortality rate was impacted by the experimental treatments, as it increased with the increase in the percentage of DDGS added in the broiler diets. Where the mortality rate increased in the D15 and D10 groups compared to the D5 and control groups. The reason may be due to the increase in the number of *E. coli* in the intestine (Table 6), which will appear later in the results of the current study. The higher levels may show significant negative effects on performance. Thus, some anti-nutritional factors in DDGS such as the high level of indigestible fiber content present that were can be blamed, which may lead to a negative effect on performance (Barekatain *et al*., 2013). Relative economic efficiency recorded an increasing ($P<0.05$) manner in D5 and D10 compared to the control group, in contrast, D15 recorded the lowest value. This is in agreement with the results of Roberts, (2009) who reported that economic analyses revealed lower feed cost per hen and per kilogram of egg production for the DDGS treatment.

Table (2): Effect of dietary DDGS level on the productive performance of broiler chicks.

Item	CON	D5	D10	D15	SEM	P value
			Days 21-29			
ADG (g/day)	76.91	77.85	78.40	77.14	0.172	0.094
ADFI (g/day)	138.4	137.8	138.8	137.1	0.244	0.233
FCR	1.80[a]	1.77[b]	1.76[b]	1.78[ab]	0.012	0.012
			Days 30-42			
ADG (g/day)	75.3[b]	83.8[a]	82.2[a]	73.6[b]	0.351	0.037
ADFI (g/day)	172.8	175.2	173.1	172.5	0.219	0.308
FCR	2.291[a]	2.093[b]	2.106[ab]	2.342[a]	0.018	<0.001
			Overall (days 21-42)			
ADG (g/day)	75.82[b]	81.84[a]	81.01[a]	74.85[b]	0.282	<0.001
Relative ADG#	100.00	107.94	106.85	98.72	-	-
ADFI (g/day)	161.3	162.8	161.7	160.7	0.175	0.215
Relative ADFI#	100.00	100.93	100.25	99.63	-	-
FCR	2.128[b]	1.981[a]	1.993[a]	2.147[b]	0.016	0.014
Relative FCR#	100.00	93.09	93.66	100.89	-	-
Mortality rate (%)	0.00	0.00	1.11	2.22	-	-
Relative Economic Efficiency*	100.00	118.32	103.36	82.76	-	-

a,b, Means in the same row with different superscripts are significantly different significantly (P<0.05).
ADG, average daily gain; ADFI, average daily feed intake; FCR, feed conversion rate (ADFI/ADG), SEM standard error of means.
CON= basal diet (control); D5= 5% DDGS; D10= 10% DDGS; D15= 15% DDGS.
 # Relative to control group.
**Assuming that the relative economic efficiency of control group equals 100*

Carcass Traits:

No variable responses to carcass traits (dressing, carcass yield, liver, and abdominal fat) were observed (P<0.05) at the end of the experiment as a result of including DDGS, as shown in Table 3. Similar results were published by Foltyn *et al*. (2013). However, variable results to some studies have shown that the addition of DDGS (60 g/kg) led to a lower abdominal fat content (Shim *et al*., 2011), and some others noticed a decrease in relative liver weight (Loar *et al*., 2010). The reason for the difference in the carcass traits results of adding DDGS may be due to the amount of DDGS that was replaced or to the chemical composition of DDGS.

Table (3): Effect of dietary DDGS level on carcass traits (%), and nutrients digestibility (%) of broiler chicks.

Parameter	CON	D5	D10	D15	SEM	P value
			Carcass traits			
Dressing	69.81	70.71	71.02	70.51	0.431	0.095
Carcass yield	74.67	75.43	75.31	74.83	0.388	0.162
Liver	2.011	1.955	2.142	2.087	0.074	0.118
Abdominal fat	0.641	0.592	0.677	0.612	0.151	0.201
			Nutrients digestibility			
Dry matter	71.25	70.55	71.09	71.41	0.855	0.115
Crude protein	67.01^{b}	69.40^{a}	69.12^{a}	66.38^{b}	0.905	0.031
Ether extract	67.70	66.65	67.29	67.05	2.074	0.257
Nitrogen-free extract	70.41	71.55	70.90	69.21	1.992	0.165
AMEn (kcal/kg)	3096	3067	3105	3082	25.88	0.514

a,b, Means in the same row with different superscripts are significantly different significantly (P < 0.05),SEM standard error of means.
CON= basal diet (control); D5= 5% DDGS; D10= 10% DDGS; D15= 15% DDGS.

Nutrients digestibility:

In this study, results cleared that the digestibility of dry matter, Ether extract, NFE, and AMEn in broilers were not affected (P<0.05) by the inclusion of different levels of DDGS, as shown in Table (3). These results are similar to those obtained by Shalash *et al*. (2010) who found that no significant effects were observed on nutrient digestibility when including different levels of DDGS in feeding laying hens. Nevertheless, there were significant differences among experimental groups in digestibility of CP, where D5 and D10 had the highest CP digestibility (P<0.05) than control and D15 which may be related to high nutritive components of DDGS such as protein, fat, and minerals (Pederson *et al*., 2014; Kim *et al*., 2018). However, the nutrient digestibility of fed birds by 15% DDGS was not affected. These observations may explain that an increase in the level of DDGS in the diet may have a negative effect on the utilization of nutrients. In this connection, Kim *et al*., (2018) noticed that, the replacement of the diet with 20% of the DDGS, which led to less CP digestion.

Blood biochemical indices:

The effect of dietary treatments on plasma hepatic biomarkers and lipid profile of birds at day 42 are shown in Table (4). The plasma concentrations of total protein, albumin, LDL-cholesterol, glucose, uric acid, AST, and ALT were not affected (P < 0.05) by the DDGS replaced in the diet. While total plasma concentrations of cholesterol were found to decrease significantly (p<0.05) when replaced DDGS in the diets of broilers. Moreover, broilers fed a diet including the DDGS had higher HDL levels (P<0.05). Similar results were noticed by Wickramasuriya *et al*. (2020) who reported that there were no effects of inclusion levels of DDGS in diets of laying hens on plasma concentrations of total protein, ALT, and AST as indicators of liver health. Furthermore, plasma total cholesterol concentrations were found to decrease significantly, while increasing (P<0.05) HDL concentrations by the inclusion of DDGS in the diets of broilers. This may be due to the composition of the fatty acids contained (saturated and unsaturated fatty acids) in DDGS.

Table (4): Effect of dietary DDGS level on plasma hepatic biomarkers, and lipid profile of broiler chicks.

Parameter	CON	D5	D10	D15	SEM	P value
Total Proteins (g dl^{-1})	4.14	3.76	3.81	4.05	0.041	0.125
Albumin (g dl^{-1})	2.51	2.46	2.49	2.53	0.032	0.094
Cholesterol (mg dl^{-1})	216^{a}	174^{c}	180^{c}	191^{b}	3.042	0.002
HDL-cholesterol (mg dl^{-1})	53.8^{b}	68.1^{a}	66.9^{a}	58.3^{ab}	1.921	0.011
LDL-cholesterol (mg dl^{-1})	121	118	115	123	2.430	0.223
Glucose (mg dl^{-1})	91.41	92.20	88.95	91.06	1.736	0.304
Uric acid (mg dl^{-1})	6.28	6.16	6.44	6.52	0.231	0.514
AST (U L^{-1})	362	254	260	259	3.480	0.099
ALT (U L^{-1})	29.25	30.20	29.61	28.87	0.664	0.455

a,b, Means in the same row with different superscripts are significantly different significantly (P < 0.05), SEM standard error of means.
CON= basal diet (control); D5= 5% DDGS; D10= 10% DDGS; D15= 15% DDGS.

Plasma immunoglobulins and lymphoid organs:

In this study, we aimed to get a picture of the immune response of broilers via the determination of relative weights of lymphoid organs and plasma IgA, IgM, and IgG, concentrations. The results showed different responses to the addition of DDGS in the diets, as shown in Table (5). It was found that DDGS inclusion levels did not significantly affect ($P < 0.05$) the immune status of the broilers. Where, the lymphoid organs (thymus, spleen, and bursa of Fabricius) were not significantly affected ($P<0.05$) as well as the concentration of IgG too. However, increasing the level of DDGS in broiler diets had an opposite effect on the concentration of IgM. In addition to increased ($P < 0.05$) concentration of IgM in broilers fed 5 and 10 % DDGS. These results agree with Min *et al*, (2015) who found an increase in IgG and IgA in broilers fed DDGS. This explains some of the immune changes due to DDGS by the effect of yeast existing in DDGS (Lim *et al*., 2009; Fathi *et al*., 2017). Dietary inclusion of yeast could improve serum immunoglobulin in the broiler chickens (Ding *et al*., 2019), which justified our current finding for some of the immune responses.

Table (5): Effect of dietary DDGS level on the immune response of broiler chicks.

Parameter	CON	D5	D10	D15	SEM	P value
			Lymphoid organs (%)			
Thymus	0.263	0.28.0	0.274	0.259	0.071	0.144
Spleen	1.09	1.15	1.12	1.20	0.262	0.181
Bursa of Fabricius	0.231	0.227	0.245	0.239	0.095	0.206
			Immunoglobulins (mg/mL)			
IgA	0.39^{b}	0.51^{a}	0.54^{a}	0.46^{ab}	0.052	0.012
IgG	4.20	3.85	4.16	4.49	0.033	0.099
IgM	0.62^{ab}	0.77^{a}	0.59^{ab}	0.43^{c}	0.041	0.003

a,b, Means in the same row with different superscripts are significantly different significantly (P < 0.05), SEM standard error of means.
CON= basal diet (control); D5= 5% DDGS; D10= 10% DDGS; D15= 15% DDGS.

Intestinal health indications:

In this study, the focus also was on the health status of the gut (microbial content, histomorphological features, and acidity) to clarify the effect of increasing the inclusion rate of the DDGS of the broiler diet. As far as we know, there have been no detailed investigations related to the effect of dietary DDGS on gut microbial installation in broiler chickens. No effect of inclusion of DDGS on the histological status and microbial population of Lactobacillus and total coliform was observed (Table 6). However, the addition of low levels of DDGS (D5 and D10) tends to reduce the number of *E. coli* and pH compared to the control group. Where the *E. coli* population was increased significantly (P < 0.05) in the D15 group compared to the other groups fed diets containing DDGS (D5 and D10 groups). The Escherichia coli population was in a similar manner between D15 and the control group. Also, it was noticed that including 5 and 10% of DDGS in a diet has a reduction (P<0.05) in the pH value of duodenum and jejunum contents compared to the other groups. Likewise, our findings agree with previous studies that have indicated that the source of feed and feed composition can significantly impact gut microbial communities, histomorphology, and pH (Apajalahti *et al*., 2001).

Table (6): Effect of dietary DDGS level on intestinal health indications of broiler chicks.

Parameter	CON	D5	D10	D15	SEM	P value
			Microbial enumeration *			
Escherichia coli	3.82^{a}	3.06^{b}	3.20^{b}	3.72^{a}	0.201	0.011
Total coliform	2.43	2.60	2.18	2.54	0.128	0.128
Lactobacillus	4.06	4.28	4.50	4.18	0.155	0.135
			Histomorphological features			
Villus height (VH, µm)	481	456	470	448	7.422	0.281
Crypt depth (CD, µm)	84.3	81.8	85.2	79.8	1.601	0.155
VH/CD	5.72	5.56	5.52	5.64	0.119	0.095
		pH				
Duodenum	6.27^{a}	5.61^{b}	5.74^{b}	6.32^{a}	0.034	0.021
Jejunum	6.38^{a}	6.04^{b}	5.99^{b}	6.19^{ab}	0.027	0.040
Ileum	7.12	7.06	7.16	7.25	0.033	0.081
cecum	6.20	6.18	6.22	6.19	0.068	0.405

*a,b, Means in the same row with different superscripts are significantly different significantly (P<0.05), *(Log10 CFU g−1), SEM standard error of means.*
CON= basal diet (control); D5= 5% DDGS; D10= 10% DDGS; D15= 15% DDGS.

Based on the previous results, the reason for the decreased numbers of *E. coli* may be due to the reduction in pH. Where, some studies have shown that low acidity leads to the inhibition of harmful microbes and the activation of beneficial microbes (Asahara *et al*., 2004), which may reduce pathogens and enhance broiler performance. In addition, lowering the pH improves the digestibility and absorptive value of most nutrients (Boling *et al*., 2001). However, including DDGS in the diet had no significant impact ($P < 0.05$) on ileum villus height, crypt depth, and VH/CD ratio compared to the control group, as shown in Table 6. These results may explain the reasons for the improved growth performance when low levels of DDGS were added (D5 and D10 groups). Although the performance of broilers fed the D5 and D10 groups improved, the performance did not improve in the D15 group. Therefore, it is necessary to track the effect of replacing higher levels of DDGS and how to treat the negative effects that may appear, whether with treatment or with some feed additives in future studies.

CONCLUSION

In conclusion, the replacement of 5 - 10% of the diet with DDGS at the expense of corn and SBM is suitable for growing broiler diets, resulting in improved growth performance, digestibility of CP, decreased plasma cholesterol, as well as enhanced immune status and economic efficiency.

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تأثير اضافة النواتج الثانوية لتقطير الذرة على الأداء الإنتاجي ، معاملات الهضم ، مكونات البلازما ، الحالة المناعية والحالة الصحية للأمعاء لدجاج التسمين

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تهدف الدراسة إلى تقييم تأثير استبدال كسب فول الصويا والذرة بالنواتج الثانوية لتقطير الذرة مع المواد القابلة للذوبان (DDGS) في علائق كتاكيت التسمين على الأداء الإنتاجي، ومعامل هضم العناصر الغذائية ، ومكونات الدم ، والاستجابة المناعية ، وكذلك الحالة الصحية للأمعاء . تم تقسيم ثلاثمائة وستين كتكوت تسمين (روس 308) عمرها 21 يومًا إلى أربع مجموعات تجريبية ، تضمنت كل مجموعة ستة مكررات بكل منها 15 طائرًا. تم تغذية المجموعة الأولى (CON)على عليقة مقارنة ، بينما تم تغذية المجموعة الثانية (D5) ، والثالثة (D10) ، والرابعة (D15) بنسبة 5٪ ، و 10٪ ، و 15٪ من الـ DDGSعلى التوالي. أظهرت الكتاكيت التي تم تغذيتها بـ 5٪ و 10٪ DDGS تحسنًا في وزن الجسم ومعدل التحويل الغذائي مقارنة بتلك التي تم تغذيتها على15٪ DDGS والكنترول علاوة على حدوث زيادة في الكفاءة الإقتصادية النسبية مقارنة بعليقة الكنترول. أظهرت جميع مستويات DDGS انخفاضًا معنويًا في تركيز الكوليسترول في البلازما ، بينما زادت قيم HDL مقارنة بمجموعة الكنترول. كذلك حدث تحسن معنوي في معاملات هضم البروتين ، بينما لم تتأثر معاملات هضم كل من المادة الجافة ومستخلص الإثيروالمستخلص الخالي من الأزوت و الطاقة الممثلة الظاهرية بالمعاملات الغذائية. وبالمثل ، لم يلاحظ أي إختلاف في خصائص الذبيحة ، والأعضاء اللمفاوية (٪) ، والشكل النسيجي للأمعاء من خلال المعاملات الغذائية لوحظ زيادة محتوى الأعور ($P < 0.05$) من بكتيريا E. Coliفي الطيور المغذاة على 15٪ DDGS. وفقًا للنتائج التي تمت ملاحظتها في هذا العمل ، يمكن الإستنتاج أن DDGS هو مكون ذو قيمة ويمكن إضافته في علائق دجاج التسمين بنسبة تصل إلى 15 ٪ دون أي معالجة أو إضافة، والأمر يتطلب إجراء مزيد من الدراسات على إمكانية إستخدام DDGS بمعدلات أعلى أو خلط بعض الإضافات المناسبة التي قد تساعد في تحسين القيمة الغذائية وزيادة استخدام DDGS كمنتج ثانوي رخيص نسبيا.