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RESEARCH ARTICLE

Effects of Different Levels Distillers Dried Grains with Solubles on Growth Performance, Carcass Quality and Some Blood Parameters in Broilers [1]

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Summary

The objective of this study was to investigate the effects of different levels dried distillers grains with solubles (DDGS) on growth performance, carcass quality and blood parameters in broilers. In 42 d feeding trial, 1 day old broilers were allocated to 4 experimental groups with 4 replicates (22/pen): control, treatment 1 (5% DDGS), treatment 2 (10% DDGS) and treatment 3 (15% DDGS). In experiment 352 chicks were used. Feed and water are provided ad libitum. On day 42, 32 (16 male and 16 female) chicks per treatment were randomly chosen and slaughtered for determining the carcass yield. Blood samples were taken 8 (4 male and 4 female) chicks per treatment. At the conclusion of the trial, differences in terms of body weight, body weight gain, feed intake and feed conversion ratio were found between trial groups fed DDGS in different amounts ($P<0.05$). As a result of the slaughtering process at the conclusion of the trial, differences ($P<0.05$) were found in terms of slaughter weight and cold and hot carcass weight in the trial groups. No difference was found in terms of the weight of the heart and liver ($P>0.05$), but gizzard weights did vary ($P<0.05$). Differences also emerged between the groups in terms of total protein and total triglyceride levels in the blood samples taken during the slaughtering process ($P<0.05$), but there was no difference between the trial groups in terms of total cholesterol levels ($P>0.05$).

Keywords: *Blood parameters, Broilers, Carcass yield, Distillers dried grains with solubles*

Kurutulmuş Damıtma Çözünürlü Tanelerinin Farklı Düzeylerde Broyler Rasyonlarında Kullanılmasının Besi Performansı, Karkas Özellikleri ve Bazı Kan Parametreleri Üzerine Etkisi

Özet

Bu çalışma, farklı düzeylerde kurutulmuş damıtma çözünürlü tanelerinin (DDGS) broylerlerde besi performansı, karkas kalitesi ve kan parametreleri üzerine etkisini belirlemek için yapılmıştır. 42 günlük deneme süresinde, 1 günlük yaştaki civcivler 4 deneme grubu ve 4 alt grup olarak ayrılmıştır (22/adet): Kontrol, grup 1 (%5 DDGS), grup 2 (%10 DDGS) ve grup 3 (%15 DDGS). Denemede 352 adet civciv kullanılmıştır. Yem ve su ad- libitum olarak sağlanmıştır. 42. günde, her gruptan 32 adet broyler (16 erkek ve 16 dişi) rastgele seçildi ve karkas veriminin belirlenmesi için kesim işlemi uygulanmıştır. Kan örnekleri her deneme grubundan 8 adet broylerden (4 erkek ve 4 dişi) alınmıştır. Deneme sonunda, farklı düzeylerde DDGS ile beslenen deneme gruplarında canlı ağırlık, canlı ağırlık artışı, yem tüketimi ve yemden yararlanma oranı bakımından farklılıklar bulunmuştur ($P<0.05$). Kesim işlemi sonunda, kesim ağırlığı, sıcak ve soğuk karkas ağırlıkları bakımından farklılıklar tespit edilmiştir ($P<0.05$). Karaciğer ve kalp ağırlıklarında farklılık bulunmazken ($P>0.05$), taşlık ağırlığında farklılık olduğu tespit edilmiştir ($P<0.05$). Gruplar arasında toplam protein ve toplam trigliserit düzeyleri bakımından farklılık saptanırken ($P<0.05$), toplam kolesterol bakımından farklılık saptanmamıştır ($P>0.05$).

Anahtar sözcükler: *Kan parametreleri, Broyler, Karkas verimi, Kurutulmuş damıtma çözünürlü taneleri*

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INTRODUCTION

In recent years, the global production of ethanol and other bio-fuels has continued to increase rapidly. Distillers dried grains with solubles (DDGS) is defined as the product obtained after removal of ethyl alcohol by distillation from the yeast fermentation of a grain or grain mixture by condensing and drying at least 75% of resultant whole stillage by methods employed in the grain distilling industry [1]. The vast increase in ethanol production over the last 5 to 10 year has led to on increased supply of DDGS that is available for livestock feed [2,3].

Previous research has demonstrated that DDGS can be fed to poultry successfully [4-7]. Waldroup et al.[8] reported that when DDGS were included into broiler diets with the metabolisable energy (ME) content held constant up to 25% DDGS could be used without reduction in body weight (BW) or feed utilization. Dale and Batal [9] used to 0, 6, 12 and 18% DDGS in a 42 d grow out study and reported that 12% DDGS resulted in a slight decrease in performance during the starter period while 18% DDGS had a negative impact on BW and feed conversion ratio (FCR) over the 42 d period. Wang et al.[10] used 0, 5, 10, 15, 20 and 25% DDGS in broiler diets and found that 15-20% DDGS supplementation to be effective low level on performance. Similarly, Wang et al.[11] used similar levels in a 18 d and reported that DDGS can be used in broiler diets up to 30% levels. Lu and Chen [12] used 10-20% DDGS in 16 week growth study on domestic colored chickens and indicated that during the 14 week while 10-20% DDGS had no negative effects BW, body weight gain(BWG), FCR, carcass weight and yield, liver weight and plasma total cholesterol, protein and triglyceride.

Therefore, the objective of this study was to determine the effect of different levels DDGS on fattening performance, carcass yield and some blood parameters.

MATERIAL and METHODS

Experimental Diets

In 42 day feeding trial, one day old broilers were allocated to 4 experimental groups with 4 replicates (22/ pen): control, group 1 (5% DDGS), group 2 (10% DDGS) and group 3 (15% DDGS). The component of corn DDGS (CP Animal Feed Industry, Bursa, Karacabey, Turkey) were dry matter (DM) 89.77%, crude protein (CP) 23.70%, crude fiber 6.32%, ether extract 11.45%, crude ash 4.88% and ME 2310 kcal/kg. The diets based on corn and soybean meal and fed as mash throughout the experiment. The ME and CP levels of the diets from 0-14 d of age 3050 kcal/kg and 22%, 15-35 d of age 3150 kcal/kg and 20% and 36-42 d of age 3200 kcal/kg and 18%, respectively. The rations are formulated to meet NRC [13] nutrient requirements. All experimental rations were maintained isocaloric and isonitrogenous. The compositions of the basal rations are shown *Table 1*.

Table 1. *Composition and calculated analysis of experimental diets*
Tablo 1. *Deneme rasyonlarının bileşimi ve hesaplanan analiz değerleri*

Ingredients (%)	**Days 0-14**				**Days 15- 35**				**Days 36-42**			
Corn	53.1	51	48.6	46.6	57.6	55.3	53.1	50.9	62.6	60.4	58.1	55.9
Soybean meal	40.5	37.6	35	32	35	32.3	29.5	26.7	30	27.2	24.5	21.7
DDGS	-	5	10	15	-	5	10	15	-	5	10	15
Oil	4	4	4	4	4	4	4	4	4	4	4	4
Limestone	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
DCP	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Salt	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
DL-methionine	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Premix[a]	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Chemical Analyses (%)												
Dry matter	91.10	91.62	91.33	91.38	90.62	90.51	90.18	90.29	94.39	94.11	94.42	94.08
Crude protein	22.06	22.02	22.08	22.09	20.00	20.03	20.02	20.02	17.97	18.18	18.03	18.01
Crude fibre	3.35	3.42	3.15	3.48	3.50	3.01	3.64	3.68	3.27	3.76	3.07	3.17
Ether extract	7.18	7.60	7.95	8.15	7.34	8.03	7.90	8.38	7.03	7.77	7.80	8.59
Crude ash	5.29	5.24	5.53	5.17	5.59	5.38	5.73	5.35	4.98	5.30	5.20	4.96
N-free extract	53.22	53.34	52.62	52.49	54.19	54.06	52.89	52.86	61.14	59.10	60.32	59.35
Metabolisable Energy kcal/kg[b]	3169.9	3141	3109.4	3081.4	3185.4	3154.7	3124.9	3095.1	3230.4	3200.6	3169.9	3140.1

[a] KAVİMİX VM 214: Vit A: 12.000.000 IU; Vit D_3: 1.500.000 IU; Vit E: 30.000 mg; Vit K_3: 5.000 mg; Vit B_1: 3.000 mg; Vit B_2: 6.000 mg; Vit B_{12}: 30 mg; Folic Acid: 750 mg; Cal. D.Panth: 10.000 mg; D Biotine: 75 mg; Choline Chloride: 375.000 mg; Nicotine Amid: 40.000 mg; Mangan: 80.000 mg; Fe: 40.000 mg; Zn: 60.000 mg; Cu: 5.000 mg; Co: 100 mg; I: 400 mg; Se: 150 mg; Antioxidant: 10.000 mg (Per 2.5 kg.), [b] Calculated (TSE 1991)

Broiler Management

Three hundred and fifty-two one day old male and female Ross- 308 chicks were obtained local hatchery where they had been vaccinated in ovo for Marek's disease and had received vaccinations for New Castle Disease and Infectious Bronchitis post hatch via a coarse spray. The treatment was set up in a completely randomized design where 22 chicks (11 male and 11 female) randomly assigned to each of four treatments with four replicates. The experiment lasted for 42 days and the chicks were fed the experimental diets throughout the experimental period. Chicks had free access to feed and water. The lighting regime was 23 h/d. The temperature was maintained at 32°C for the first week and then reduced until a temperature of 22°C was achieved by the fourth week, gradually.

Measurements

The DDGS sample and experimental rations were analyzed by the methods of AOAC [14]. The ME levels of rations were calculated according to TSE [15]. The BWG of the chicks were determined at the beginning (0) and 7, 14, 21, 28, 35 and 42th d of study. At the same time all the replicates feed residues were weekly weighed to define the feed intake (FI) levels and FCR. At the end of the study thirty-two chicks (16 male and 16 female) per treatment were randomly chosen and slaughtered for determining the carcass yield. During slaughter, individual blood samples were taken *vena subcutena ulnaris* within each treatment and collected into dry clean centrifuge tubes containing drops of heparin and centrifuged for 15 min (3.500 rpm) to obtain plasma. Then, total protein, total cholesterol and total triglycerides were determined by DDS commercial kits.

Statistical Analysis

The importance's of the difference between the mean values of groups were evaluated by analysis of variance technique. Duncan multiple range test was used determine difference between treatment groups. The statistical analyses were performed of SPSS 16.0.

RESULTS

At the beginning of the study, there was no statistically significant difference between the groups in terms of body weight (P>0.05). The average BW obtained at the end of the trial in the control and trial groups were 1763.0, 1991.1, 2102.1 and 2060.1 g respectively, and this difference between the groups was found to be statistically significant (P<0.05). The highest BWG value was found in the trial group with a supplement of 10% DDGS. The highest FI was also found to occur in the same trial group. The lowest FCR in the 14-28 day period was found in the trial group that included 5% DDGS while in the other periods it was in the trial group supplemented with 15% DDGS. Broiler performance is provided in *Table 2* and *3*.

Carcass weights were higher in the trial groups and in the control group. Warm and cold carcass weights were highest in the trial group with DDGS added at a rate of 15%. It was also determined that the addition of DDGS in different amounts had no effect on carcass yield. Broiler carcass weight performance and carcass yields are provided in *Table 4*.

Supplementing broiler rations with different amounts of DDGS had no effect (P>0.05) on the weight of the liver or heart, but the groups did vary in terms of the weight of the gizzard (P<0.05). The addition of DDGS in differing amounts created a statistically significant difference (P<0.05) between the total protein and triglyceride values in blood serum, but it did not result in a difference (P>0.05) in total cholesterol values. Broiler performance regarding internal organ weight and blood parameters is provided in *Table 5*.

DISCUSSION

The BW values obtained on day 14 of this study were lower than the values of the control group in Oryschak et al.[16] but higher than the values they reported in groups supplemented with 5% and 10% DDGS. However, it was found to be lower than values obtained in other similar studies [10,11,17,18]. Body weight values on d 28 of the trial were lower than the values obtained in the control group and groups supplemented with 5 and 10% DDGS in the study by Oryschak et al.[16]. Results for BW were lower than those reported for the control group in the study by Loar et al.[19] and higher than the BW values found in the group supplemented with 15% DDGS. The numbers obtained in the study by Min et al.[17] with a supplement of 0 and 15% DDGS were lower than the values

Table 2. *Effects of dried distillers grains with solubles on the body weight of broilers. (g)*
Tablo 2. *Kurutulmuş damıtma çözünürlü tanelerinin broylerlerin canlı ağırlığı üzerine etkisi (g)*

Days	Control (X±Sx)	Group I (X±Sx)	Group II (X±Sx)	Group III (X±Sx)	P
1	47.78±0.37 (n=88)	47.16±0.36 (n=88)	47.60±0.35 (n=88)	46.50±0.32 (n=88)	-
14	305.82±4.98^{c} (n=88)	346.39±4.97^{b} (n=88)	351.68±4.53^{b} (n=86)	372.30±4.37^{a}	*
28	922.1±1.20^{c} (n=86)	1063.5±13.20^{b} (n=88)	1099.2±11.9^{a} (n=86)	1095.4±11.4^{ab} (n=86)	*
42	1763.0±13.9^{c} (n=83)	1991.1±15.9^{b} (n=86)	2102.1±16.4^{a} (n=83)	2060.1±18.1^{a} (n=86)	*

a,b,c: *Means on the same row followed by different letters differ significantly (P<0.05),* ***-:*** *Differences among the groups were not statistically significant (P>0.05),* ***n:*** *Deneme gruplarındaki hayvan sayıları*

Table 3. *Effects of dried distillers grains with solubles on the growth performance of broilers*
Tablo 3. *Kurutulmuş damıtma çözünürlü tanelerinin broylerlerin performansı üzerine etkisi*

Days	Parameters	Control (X±Sx)	Group I (X±Sx)	Group II (X±Sx)	Group III (X±Sx)	P
1-14	FI	415.55±1.93^{c}	483.51±10.03^{a}	478.21±10.11^{a}	449.26±9.53^{b}	*
	BWG	258.04±0.36^{c}	299.23±3.83^{b}	304.31±7.61^{b}	325.79±1.92^{a}	*
	FCR	1.61±0.008^{a}	1.61±0.04^{a}	1.57±0.02^{a}	1.38±0.02^{b}	*
14-28	FI	1223.9±8.15^{d}	1302±14.77^{c}	1392.3±11.96^{a}	1345.5±8.83^{b}	*
	BWG	616.37±4.08^{c}	717.12±9.11^{b}	747.56±7.89^{b}	723.01±2.90^{a}	*
	FCR	1.98±0.01^{a}	1.81±0.006^{c}	1.86±0.005^{b}	1.86±0.006^{b}	*
28-42	FI	1758±22.47^{c}	1890.1±27.75^{b}	2020±34.9^{a}	1928±25.93^{b}	*
	BWG	841.26±5.62^{d}	927.45±7.06^{c}	1003.1±9.42^{a}	964.47±10.56^{b}	*
	FCR	2.09±0.02^{a}	2.03±0.02^{b}	2.01±0.02^{b}	2.00±0.009^{b}	*
0-42	FI	3397.4±24.9^{c}	3675.8±41.8^{b}	3890.60±31.3^{a}	3722.7±32.7^{b}	*
	BWG	1715.7±8.89^{c}	1943.7±16.3^{b}	2055±15.8^{a}	2013.3±14.9^{a}	*
	FCR	1.98±0.007^{a}	1.89±0.009^{b}	1.89±0.009^{b}	1.84±0.004^{c}	*

a,b,c,d: *Means on the same row followed by different letters differ significantly. (P<0.05),* ***FI:*** *Feed Intake (g/chick),* ***BWG:*** *Body Weight Gain (g),* ***FCR:*** *Feed Conversion Ratio*

Table 4. *Effects of dried distillers grains with solubles on the slaughter weight (g), carcass weight (g) and yield (%) of broilers (n=32)*
Tablo 4. *Kurutulmuş damıtma çözünürlü tanelerinin broylerlerde kesim ağırlığı (g), karkas ağırlığı (g) ve verimi (%) üzerine etkisi (n=32)*

Parameters	Control (X±Sx)	Group I (X±Sx)	Group II (X±Sx)	Group III (X±Sx)	P
Slaughter weight	1757.90±31.5^{c}	2052.60±39.7^{b}	2114.50±32.0^{a}	2122.40±31.5^{a}	*
Warm carcass	1272.60±25.40^{c}	1480.0±30.10^{b}	1524.90±25.10^{ab}	1534.0±25.90^{a}	*
Cold carcass	1258.50±24.90^{a}	1463.40±28.90^{b}	1501.10±23.40^{ab}	1511.10±26.10^{a}	*
Warm carcass yield	72.37±0.23	72.90±0.17	72.09±0.15	72.35±0.20	-
Cold carcass yield	71.58±0.21	71.29±0.13	70.98±0.12	71.27±0.19	-

a,b,c: *Means on the same row followed by different letters differ significantly. (P<0.05),* ***-:*** *Differences among the groups were not statistically significant (P>0.05)*

Table 5. *Effects of dried distillers grains with solubles on the internal organ weights (g/ 100 BW) and some blood parameters (g/dl) of broilers*
Tablo 5. *Kurutulmuş damıtma çözünürlü tanelerinin broylerlerde iç organ ağırlıkları (g/ 100 CA) ve bazı kan parametreleri (g/ dl) üzerine etkisi*

Parameters	Control (X±Sx)	Group I (X±Sx)	Group II (X±Sx)	Group III (X±Sx)	P
Heart	13.26±0.45	12.53±0.49	13.14±0.57	13.62±0.49	-
Liver	39.87±1.21	40.76±1.37	41.48±1.22	39.78±1.15	-
Gizzard	28.78±1.22^{b}	31.46±1.38^{ab}	33.73±1.11^{a}	29.89±0.64^{b}	*
Total cholesterol	132.08±0.59	130.60±0.61	132.05±0.65	131.23±0.63	-
Total protein	2.95±0.02^{a}	3.22±0.01^{c}	3.39±0.01^{a}	3.32±0.01^{b}	*
Total triglyceride	86.77±0.67^{a}	84.66±0.36^{b}	82.32±0.31^{c}	81.23±0.20^{c}	*

a,b,c: *Means on the same row followed by different letters differ significantly (P<0.05),* ***-:*** *Differences among the groups were not statistically significant (P>0.05)*

found in this trial. The study conducted by Shalash et al.[20] found BW values in the control group and the group supplemented with 12% DDGS which were similar to those in this study. The BW values for day 35 were lower than the values reported by Wang et al.[10] for day 35. The values found in this study were higher than the values obtained as a result of supplementing with DDGS at the same rate in the study conducted by Wang et al.[18]. The BW findings obtained in the study were lower than the values found by Wang et al.[11] in the control group and the group supplemented with 10% DDGS. The BW values at the end of the trial were lower than those obtained by Min et al.[17] on day 42. These values were also lower than the BW values in the results obtained by Wang et al.[11] in the control group and the group supplemented with 10% DDGS and results in the control group as well as the group given 15% DDGS in Wang et al.[18]. The numbers in this study were lower than the BW values reported by Oryschak et al.[16] in the control group and the groups given 5% and 10% DDGS.

The BWG values obtained in days 14-28 as a result of this study were lower than the BWG values found by Loar et al.[19] for the same period in the control group and the trial groups given a DDGS supplement of 5%, 7.5% and 15%. The BWG values on days 28-42 of the trial were similar to those reported by Shalash et al.[20] during the same period in the control group and the group fed rations including with 12% DDGS. The body weight gains obtained in this study at the

conclusion of the trial were lower than the BWG values found during the same period by Lumpkins et al.[21] in a study supplementing 0, 6, 12 and 18% DDGS.

The FI values obtained in days 1-14 in this study were lower than the FI values found by Wang et al.[18] for days 1-14. Similarly, they were lower than the values found by Wang et al.[11] in the control group and the 10% DDGS group in their study. The values obtained in this study were similar to those found by Min et al.[17]. The FI values obtained in days 14-28 of the trial were lower than the values found by Loar et al.[19] in the control group and the trial groups given a 7.5% and 15% DDGS supplement. FI values from days 28-42 were found to be lower than the FI values found by Shalash et al.[20] during a similar period in the control group and that given 12% DDGS. At the conclusion of the trial, FI values in days 0-42 were found to be lower than the values obtained by Min et al.[17] in the control group and that given a supplement of 15% DDGS. Similarly, the results of this study were lower than the numbers obtained in the control groups and trial groups of Wang et al.[18] which received a 15% DDGS supplement. The results of this study were similar to those reported by Shalash et al.[20] in the control group and those obtained from adding 12% DDGS.

The FCR for d 1-14 of the study were 1.61, 1.61, 1.57 and 1.38 for the control group and trial groups supplemented with 5, 10 and 15% DDGS. The findings in this study were higher than those of the control group in the study by Min et al.[17] and similar to the findings in the study group receiving a 15% DDGS supplement. While the numbers in this study were higher than those Wang et al.[18] found in the control group at the conclusion of their study, they were similar to the group that received 15% DDGS. The FCR values obtained in this study were found to be higher than those in the control group and the groups given 10% DDGS in Wang et al.[11]. The FCR values for days 28-42 in the study that was conducted were similar to the FCR values found by Shalash et al.[20] during the same time in both the control group and the groups given a 12% DDGS supplement. FCR results for days 0-42 were higher than those found in the control group and the trial groups given 10% DDGS in Wang et al.[11]. Similarly, the FCR values obtained by Wang et al.[18] in the control group and the trial group given 15% DDGS were higher than the results of this study. The FCR values for the study were higher than those found by Shalash et al.[20] in the control group, but similar to the FCR values they found as a result of supplementing with 12% DDGS.

The reason for the differences seen at different times as a result of adding varying amounts of DDGS to broiler rations could be due to the composition of the ration, differences in the method used to obtain the DDGS added to the ration, or a difference in the composition of nutrients.

Slaughter weights in the study were higher than the live finishing weights reported by Lu and Chen [12] in their control group and the groups given 10% DDGS. The hot carcass values obtained in the trial were similar to those in the control group in the study by Lu and Chen [12] but higher than those obtained in the group supplemented with 15% DDGS. The numbers in this study were lower than those reported by Lumpkins et al.[21] in their control group and the trial groups given DDGS supplements of 6, 12 and 18%.

The hot carcass yields obtained in the study's control group and the trial groups that included 5, 10 and 15% DDGS were found to be lower than the yields that Min et al.[17] found in their control group and the trial group supplemented with 15% DDGS. The hot carcass yields reported by Wang et al.[11] in their control group and that which received 10% DDGS supplements were higher than the hot carcass yield results obtained in this study.

Liver weights from this study's control group and the trial groups supplemented with 5, 10 and 15 %DDGS were higher than those reported by Loar et al.[19] in their control group and trial groups receiving 7.5% and 15% DDGS. The liver weights reported by Shalash et al.[20] in the control group and trial group given a DDGS supplement of 12% were found to be lower than the results in this study. The values obtained in this study were higher than the liver weights reported by Lu and Chen [12] in their control group and the research groups given 10% DDGS. The heart weights obtained in the study's control and trial groups, on the other hand, were higher than those found by Shalash et al.[20] in their control group and the research group given 12% DDGS.

In this study, total blood cholesterol values in the control group and the trial groups receiving 5, 10 and 15% DDGS were 132.08, 130.6, 132.05 and 131.23 mg/dl respectively. The results of this experiment were higher than the values found by Shalash et al.[20] in their control group, but lower than the values reported for the research group supplemented with 12% DDGS. Total blood cholesterol values found in the trial were lower than the total blood cholesterol values reported by Awad et al.[22] as a result of supplementing with DDGS (0, 6, 12 and 18%) in ducks.

Total blood protein values in the study were lower than those found by Lu and Chen [12] in their control group and the research group given a 10% DDGS supplement. The total blood protein values found by Awad et al.[22] in trial groups where duck rations were supplemented with 0, 6, 12 and 18% DDGS were higher than the total protein values in this study.

The results for total triglycerides in samples of blood serum taken from broilers in the control group and those fed rations that included 5, 10 and 15% DDGS were higher than the total triglycerides in blood serum found by Lu and Chen [12] in their control group and trial groups given a 10% DDGS supplement. The values obtained in the study were lower than the total triglyceride values found in the blood serum of ducks fed a ration supplemented with 0, 6, 12 and 18% DDGS by Awad et al.[22].

It was concluded that supplementing broiler rations with up to 15% DDGS does not have a negative effect on performance, carcass yield or blood parameters and that it can be safely used in broiler rations.

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