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Original Research

Effect of adding crude glycerol to broiler diets on the performance and yield characteristics of carcass

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ABSTRACT:

The present study was conducted to determine the effect of adding crude glycerol as an energy source to broiler's diets on growth performance, carcass yield and internal organ weights. Two Hundred-forty chicks, one-day-old (unsexed), were distributed in a completely randomized design that were divided to five treatments (0, 1.5, 3, 4.5 and 6% crude glycerol from 1 to 42 days), with four replicates (12 chick / replicate). All diets were formulated to meet the same requirements. Broiler were fed with water and food *ad libitum*. The data of Body Weight Gain (BWG), and Feed Consumption (FC) were recorded weekly and Feed Conversion Ratio (FCR) was also calculated. Birds fed diets with crude glycerol did not differ significantly in performance from those fed the control diet without crude glycerol. Birds receiving crude glycerol 3% for initially two weeks showed highest body weight gain and the better feed conversion ratio during all over the experimental period, whereas supplementation of 6% crude glycerol recorded lowest values of body weight gain and feed conversion ratio. Glycerol inclusion at 3% of diet can be used as an effective source of energy in broilers, especially from 0 to 21 days of age. Glycerol inclusion had no effects on the internal organ weights or carcass yield of broilers except for the abdominal fat weight.

Keywords:

Glycerol, Production performance, Internal organs, Broiler.

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INTRODUCTION

Glycerol is a by-product of biodiesel production, derived from vegetable oils and animal fats (Rivaldi *et al*., 2007). The gradually increasing biodiesel production poses a problem of the utilization of glycerol as a by-product of this technology, this production of crude glycerol above the market demand, which drives the researchers to seek new uses of this by-product. Due to the lack of legislation to dispose the crude glycerol produced in excess, this by-product can become in this way, an environmental problem, as crude glycerin may be considered a good source of dietary energy for poultry and pigs (Cerrate *et al*., 2006; Dozier *et al*., 2008). It is also possible to include in animal diet, which is a viable and environmentally sustainable alternative to allocate a part of this by-product on the market, as it may prevent the over production from having inadequate destinations and contaminating the environment.

Glycerol is a small molecule that plays a vital role in the metabolism. It is an important structural component of triglycerides and phospholipids. Glycerol is a precursor to glyceraldehyde 3-phosphate, an intermediate in the lipogenesis and gluconeogenesis pathways, and yields energy through the glycolytic and tricarboxylic-acid path-ways (Brisson *et al*., 2001). Krebs *et al*. (1966) mentioned that liver has the ability to convert glycerol component to glucose providing energy for metabolism. Also, Krebs and Lund (1966) reported that glycerol component could be converted to glucose by oxidization for energy. When the body uses body fat reserves as a source of energy, glycerol and fatty acids are released into the bloodstream.

During digestion, pancreatic lipase hydrolyzed triglycerides to free fatty acids and glycerol (Brody, 1994). Glycerol is water soluble and freely enters the blood portal and the residual glycerol enters the liver, which can be converted to glucose (Emmanuel *et al*., 1983) *via.* gluconeogenesis or oxidized for energy production *via* glycolysis and tricarboxylic acid cycle (Rosebrough *et al*., 1980). This study aimed to determine the effect of crude glycerol supplementation on the growth performance and internal organ weights of broiler chickens (Ross 308).

MATERIALS AND METHODS

Experimental design and feeding

This study was conducted at the poultry farm belonging to Animal production, College of Agriculture, University of Anbar from 20/9/2017 to 1/11/2017 (42 days). The objective of this study was to compare the effect of adding different levels of crude glycerol to broiler diets on productive performance and carcass characteristics. Two Hundred-forty broiler chicks (Ross 308) with an average body weight 38 gm were obtained from a commercial hatchery. At hatch, broilers were weighed, wing-banded, and allotted to pens and dietary treatments so that the initial mean weight was similar among the treatment groups and placed in 48 floor pens (12 birds/pen), and randomly assigned to five dietary treatments (four replicates/treatment). The experiment lasted for 42 days. Temperature was controlled and gradually decreased from 35°C on the first day to 22°C at 21 days of age. Broilers were fed a starter diet (0 to

Table 1. Characteristics of crude glycerol fed to broiler (as is basis)*

S. No	Characteristics	%
1	Glycerol	86.95
2	Dry matter (%)	73.68
3	Crude protein (%)	0.41
4	pH	5.33
5	FFA	0.29
6	Moisture (%)	9.63
7	Ash (%)	3.19
8	Methanol (%)	0.028
9	Crude fat (%)	0.12
10	Sodium (%)	1.26
11	Sodium chloride (%)	3.13
12	Metabolizable energy kcal/kg	3625

* Chemical analysis of crude glycerol, were determined according to the procedures outlined by Association of Official Analytical Chemists (AOAC, 2000).

Table 2. Ingredient and calculated analysis of the starter diets during 1-14 days

S. No	Ingredient %	Glycerol supplementation (%)				
		0	1.5	3	4.5	6
1	Yellow corn	59	57.19	55.4	53.5	51.65
2	Soybean meal, (48%)	32	32.3	32.6	33	33.36
3	Protein concentrate *	5	5	5	5	5
4	Glycerol	0	1.5	3	4.5	6
5	Plant oil	1.5	1.5	1.5	1.5	1.5
6	Limestone	1.4	1.4	1.4	1.38	1.38
7	Dicalcium phosphate	0.3	0.3	0.3	0.3	0.3
8	DL-methionine	0.53	0.53	0.53	0.55	0.55
9	L-lysine	0.15	0.16	0.16	0.16	0.16
10	Salt	0.12	0.12	0.11	0.11	0.1
11	Total	100	100	100	100	100
	Chemical composition (calculated)**					
12	ME, kcal/kg	2998	2998	2998	2998	2998
13	CP, %	22.4	22.4	22.4	22.4	22.4
14	Crude fibre	2.7	2.97	2.57	3.2	2.65
15	Met. + Cys.	1.02	0.88	0.86	1.01	1.01
16	Lysine	1.41	1.18	1.25	1.29	1.09
17	Ca	0.97	0.89	0.88	0.90	0.92
18	Available phosphorus	0.45	0.45	0.44	0.46	0.46

* Protein concentrate contains: 40% CP, 5% Ca,3.7% Methionine, 4.12% Methionine and Cystine, 3.85% Lysine, 4.68% AP, Metabolizable Energy 2107 Kcal kg^{-1}, 2.50 mg Sodium, 1.70 mg threonine, 0.42mg Tryptophan, 4.20 mg choline and each 1 kg of this concentrate contain: 100000 IU vitamin A, 33000; IU vitamin D3, 100 mg; vitamin E, 2.55 mg; vitamin K3, 25 mg; vitamin B1, 10 mg; B2, 50 mg; vitamin B6, 24 mg vitamin B12; 51 mg niacin; 1.5 mg folic acid; 15 mg; biotin,500 µg and 13.5 mg pantothenic acid.

**Calculated based on feed consumption Tables of NRC (1994).

14 d of age), grower diet (15 to 28 d of age) and a finisher diet (29 to 42 d of age). Diets were formulated to be adequate in all nutrients (NRC, 1994) for young broilers and were fed in mash form. The crude glycerol was obtained from a commercial facility (Turkey) that used plant oil as an primary substrate and is analyzed in a nutrition laboratory (commercial) to determine composition Table 1. Each pen was equipped with manual plastic feeder and an automatic nipple drinker. Water and experimental diets were provided *ad libitum.* The ingredients and chemical composition of the diets are presented in Table 2, 3 and 4. Crude glycerol used at the level 1.5, 3, 4.5 and 6% in diets. All chicks were individually weighed and Feed Intake (FI) was recorded at weekly intervals. Based on the recorded data, FI, Feed Conversion Ratio (FCR), and Body Weight Gain (BWG) were subsequently calculated based on the performance values. On day 42 of trial, eight birds representing treatment were randomly selected, allowed to fast for 12h and slaughtered. The weight of digestive organs proventriculus (empty), gizzard (empty), pancreas, liver, heart, spleen and abdominal fat were recorded and expressed as percentage of live weight according to Al–Fayadh *et al*. (2009).

Statistical analysis

Data generated from the present experiment was subjected to statistical analysis using the GLM procedure of Statistical Software Package SAS (2001). Pens were treated as the experimental unit. Significant differences among treatment groups were further analyzed using Duncan's multiple-range test (Duncan, 1955). A significant level of ($P<0.05$) was implemented.

Table 3. Ingredient and calculated analysis of the grower diets during 15-28 days

S. No	Ingredient %	Glycerol supplementation (%)				
		0	1.5	3	4.5	6
1	Yellow corn	64.78	63	61.17	59.37	57.5
2	Soybean meal, (48%)	26	26.26	26.6	26.9	27.27
3	Protein concentrate *	5	5	5	5	5
4	Glycerol	0	1.5	3	4.5	6
5	Plant oil	2.1	2.1	2.1	2.1	2.1
6	Limestone	1.35	1.32	1.32	1.32	1.32
7	Dicalcium phosphate	0.1	0.1	0.1	0.1	0.3
8	DL-methionine	0.35	0.4	0.4	0.4	0.4
9	L-lysine	0.17	0.17	0.17	0.17	0.18
10	Salt	0.15	0.15	0.14	0.14	0.13
11	Total	100	100	100	100	100
	Chemical composition, Calculated**					
12	ME, kcal/kg	3100	3100	3100	3100	3100
13	CP, %	20.0	20.0	20.0	20.0	20.0
14	Crude fibre	2.5	2.57	2.65	2.97	3.02
15	Met. + Cys.	0.98	1.01	1.01	0.88	0.86
16	Lysine	1.25	1.09	1.27	1.20	1.09
17	Ca	0.89	0.89	0.88	0.90	0.92
18	Available phosphorus	0.41	0.42	0.44	0.44	0.45

* Protein concentrate contains: 40% CP, 5% Ca, 3.7% Methionine, 4.12% Methionine and Cystine, 3.85% Lysine, 4.68% AP, Metabolizable Energy 2107 Kcal kg^{-1}, 2.50 mg Sodium, 1.70 mg Threonine, 0.42mg Tryptophan, 4.20 mg Choline and each 1 kg of this concentrate contain: 100000 IU vitamin A, 33000; IU vitamin D3, 100 mg; vitamin E, 2.55 mg; vitamin K3, 25 mg; vitamin B1, 10 mg; B2, 50 mg; vitamin B6, 24 mg vitamin B12; 51 mg niacin; 1.5 mg folic acid; 15 mg; biotin,500 µg and 13.5 mg pantothenic acid.

**Calculated based on feed consumption Tables of NRC (1994).

RESULTS

The effects of the dietary treatments on production performance are shown in Table 5. Results showed that at 14 days of age, the birds fed the diets with 3% crude glycerol has significantly increased in the body weight and body weight gain than birds in the control treatment. Also the results showed birds fed diets with 1.5% crude glycerol, recorded the highest values of feed intake compared with the bird fed diet with 4.5 and 6% crude glycerol at 28 days of age. However, at 42 days of age birds fed diets with 3% crude glycerol showed best values in feed conversion ratio compared with birds fed diets 1.5, 4.5 and 6% crude glycerol. No significant differences in average values of body weight gain or feed conversion ratio were noted at 28 days of age between birds fed diets with different levels of glycerol. Moreover, the inclusion of 1.5% crude glycerol in broiler dies recorded highest feed intake compared to control or the other treatments during 28 days of age. The high levels of feed intake for birds feeding diets containing glycerol may be due to the sweet taste of the glycerol, which is easily and efficiently absorbed in the gastrointestinal tract of animals (Min *et al*., 2010). In addition, glycerol could affect the passage rate of feed in gastrointestinal tract by interfering with other nutrients and reducing nutrient utilization (Barteczko and Kaminski, 1999). Birds could compensate the lack of energy uptake by increase feed intake. Also, at 42 days of age it is noticed that body weight gain , feed intake and feed conversion ratio for treatments were almost comparable. The present findings are analogous with the findings of Waldroup (2007) also with Abd-Elsamee *et al.* (2010) who found that the crude glycerin content of the rations did not affect body weight gain or feed conversion ratio.

Table 4. Ingredient and calculated analysis of the finisher diets during 29-42 days

S. No	Ingredient %	Glycerol supplementation (%)				
		0	1.5	3	4.5	6
1	Yellow corn	65.9	63.85	62.05	60.25	58.4
2	Soybean meal, (48%)	23.8	24.05	24.35	24.65	25
3	Protein concentrate *	5	5	5	5	5
4	Glycerol	0	1.5	3	4.5	6
5	Plant oil	3.4	3.5	3.5	3.5	3.5
6	Limestone	1.25	1.25	1.25	1.25	1.25
7	Dicalcium phosphate	0.1	0.3	0.3	0.3	0.3
8	DL-methionine	0.35	0.35	0.35	0.35	0.35
9	L-lysine	0.11	0.11	0.12	0.12	0.12
10	Salt	0.09	0.09	0.08	0.08	0.08
11	Total	100	100	100	100	100
	Chemical composition, Calculated**					
12	ME, kcal/kg	3200	3200	3200	3200	3200
13	CP, %	19.0	19.0	19.0	19.0	19.0
14	Crude fibre	2.2	2.4	2.5	2.5	2.6
15	Met. + Cys.	0.89	0.90	0.90	0.91	0.92
16	Lysine	1.11	1.14	1.15	1.16	1.17
17	Ca	0.85	0.86	0.87	0.87	0.88
18	Available phosphorus	0.40	0.43	0.44	0.45	0.47

* Protein concentrate contains: 40% CP, 5% Ca,3.7% Methionine, 4.12% Methionine and Cystine, 3.85% Lysine , 4.68% AP, Metabolizable Energy 2107 Kcal kg^{-1} , 2.50 mg Sodium, 1.70 mg threonine, 0.42mg Tryptophan, 4.20 mg choline and each 1 kg of this concentrate contain: 100000 IU vitamin A, 33000; IU vitamin D3, 100 mg; vitamin E, 2.55 mg; vitamin K3, 25 mg; vitamin B1, 10 mg; B2, 50 mg; vitamin B6, 24 mg vitamin B12; 51 mg niacin; 1.5 mg folic acid; 15 mg; biotin,500 µg and 13.5 mg pantothenic acid.

**Calculated based on feed consumption tables of NRC (1994).

Also, they showed that using five or 10% crude glycerol in broiler diets instead of corn starch had no adverse effects**.** The economic evaluation of the use of glycerol is rather problematic due to the varying prices of individual feed components. The price of crude glycerol is likely to decrease with the over production of glycerol generated in the production of methyl-ester. The use of crude glycerol in diets will therefore become very interesting from an economic point of view. It follows from our results data that the optimum level of crude glycerol in feed for broiler is 3%. If the diet programmed is designed properly, it is possible to use 6% of crude glycerol in a diet without a negative effect on the performance indicators of animals. However, there are still many issues associated with the use of glycerol in the nutrition of poultry that have to be addressed in future research studies. The inclusion of crude glycerol in the diets did not affect the internal organ weights of broiler, except for the abdominal fat Table 6. The current study concluded that adding 1.5, 3, 4.5 and 6% of crude glycerol to the broiler's diet had no negative effects on the weights of liver, proventriculus, gizzard and spleen of birds**.** Studies reported that the relative weights of some internal organs such as heart may be related to the weight of the live body. Therefore, the significant differences between different treatments in the relative weight are not based on feeding glycerol. Abd-Elsamee *et al*. (2010) observed that broilers consuming feeds with different levels of crude glycerol did not differ significantly from birds fed the control diet for percentage of most internal organs, or weight of immune organs. Similar results were reported by Topal and

Table 5. Effect of crude glycerol on body weight gain, feed intake and feed conversion ratio of broilers+ *

S. No	Items	Glycerol Supplementation (%)					SEM	*P*-value
		0	1.5	3	4.5	6		
								BW (g)
1	14 day	339.92[b]	356.25[ab]	368.29[a]	357.12[ab]	353.02[ab]	8.37	0.4836
2	28 day	1290.50	1312.21	1327.10	1339.25	1327.04	28.24	0.3096
3	42 day	2435.46	2398.29	2482.88	2507.15	2443.27	36.34	0.0510
				BWG (g)				
4	0-14 day	301.91[b]	318.25[ab]	330.29[a]	319.12[ab]	315.02[=]	8.41	0.4714
5	15-28 day	950.57	955.95	958.80	982.12	974.02	26.67	0.2417
6	29-42 day	1144.96	1086.08	1155.76	1167.89	1116.23	36.05	0.5217
7	0-42 day	2397.46	2360.29	2444.88	2469.15	2405.27	36.31	0.0514
				FI (g)				
8	0-14 day	400.85[c]	422.58[b]	436.29[a]	431.45[a]	425.79[ab]	6.92	0.0621
9	15-28 day	1526.2[ab]	1544.23[a]	1520[ab]	1510.08[b]	1491.08[b]	17.88	0.6269
10	29-42 day	2260.54	2267.51	2223.09	2334.17	2297.83	23.27	0.7858
11	0-42 day	4187.65	4234.31	4179.46	4275.71	4214.71	35.72	0.7262
				FCR				
12	0-14 day	1.32	1.33	1.32	1.35	1.35	0.03	0.4532
13	15-28 day	1.60	1.61	1.59	1.54	1.53	0.03	0.1634
14	29-42 day	1.97[ab]	2.09[a]	1.92[b]	2.00[a]	2.06[a]	0.04	0.5430
15	0-42 day	1.75	1.79	1.71	1.73	1.75	0.01	0.0172

* Data represent mean values of 4 replicates per treatment; a–c means in the same row with different superscripts differ (P<0.05).

Ozdogan (2013) who observed that inclusion of glycerol 40 or 80 g of glycerol/kg in the diets did not affect the internal organ weights of broilers (females or males).

Our results in this study differed with the finding of Coşkun *et al.* (2007), who observed that relative weights of liver, gizzard, and heart of broilers fed a diet with 50 g of glycerol/kg were lower than those for control group. Furthermore, the researchers reported that broilers fed 100 g of glycerol in the diets recorded liver weights higher than control group. Also, the results in Table 6 showed that birds fed diets with different levels of crude glycerol recorded significant differences with an increase in the dietary crude glycerol that may be due with the rate of fatty acid synthesis and lipogenic enzyme activities in the liver (Lin *et al*., 1976). Moreover, in rats when glycerol and fat are fed together, they can reduce plasma cholesterol and liver lipids and the esterification of fatty acids in rat fat tissue (Narayan and Ross, 1987).

CONCLUSION

From the present study it can be concluded that inclusion of glycerol at 3% in the broiler diet can be an effective source of energy especially from 0-21 days

Table 6. Effect of adding crude glycerol to diets on carcass yield and internal organ weights (%) of broiler *

S. No	Organs (weight in percent)	Glycerol Supplementation (%)					SEM	*P*-value
		0	1.5	3	4.5	6		
1	Hot carcass	2024.0[b]	2166.6[ab]	2298.0[a]	2086.6[b]	2178[a]	0.73	0.239
2	Liver	3.02	2.61	2.43	3.01	2.51	0.13	0.828
3	Proventriculus	0.428	0.430	0.405	0.417	0.397	0.06	0.907
4	Gizzard	1.848	1.900	1.771	1.947	1.620	0.12	0.924
5	Heart	0.427[ab]	0.429[ab]	0.463[a]	0.350[b]	0.457[a]	0.03	0.998
6	Pancreas	0.261[a]	0.214[ab]	0.202[ab]	0.191[b]	0.183[b]	0.061	0.935
7	Abdominal fat	1.27 [b]	1.52[ab]	1.98 [ab]	2.25 [a]	2.29 [a]	0.29	0.36
8	Spleen	0.099	0.124	0.087	0.129	0.092	0.05	0.68

* Data represent mean values of 4 replicates per treatment; a–c: means in the same row with different superscripts differ (P<0.05).

old chicks. Glycerol inclusion in the broiler diets, did not show any negative impact on carcass yield as well as internal organs weight.

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