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Research Article

Effect of Adding Dietary Conjugated Linoleic Acid to Broiler Diets on Production Performance and Fatty Acid Content in Meat

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Abstract

Background: Conjugated Linoleic Acid (CLA) is an essential polyunsaturated omega fatty acid that occurs naturally in vegetable oils. It also plays an important role in preserving meat for longer periods by preventing oxidation of other fats. Thus, it can be used in the production of functional foods with high biological value and low cholesterol levels by adding poultry diets. **Objective:** The aim of the present study was to evaluate the effect of adding CLA to broiler diets on production performance and fatty acid content in the meat. **Methodology:** One-day-old Ross-308 chicks were randomly distributed into four dietary treatment groups: control (0 g CLA kg^{-1} diet; A1), 0.5 g CLA kg^{-1} diet (A2), 0.75 g CLA kg^{-1} diet (A3) and 1 g CLA kg^{-1} diet (A4). Diets began at 1-day-old and continued for 6 weeks; each treatment was replicated thrice, with 30 birds/replicate (360 birds total). **Results:** Birds fed diets supplemented with CLA showed significantly higher average body weight and body weight gain (both $p\leq 0.05$). Compared to A1 birds, the A4 group showed a reduction in feed intake, increased feed conversion ratio and a significantly higher dressing percentage (all $p\leq 0.05$). Moreover, breast, thigh and drumstick percentages were significantly higher in all CLA treatment groups versus A1 (all $p\leq 0.05$). Overall, the A4 diet was superior to all other treatments (A1-A3). Furthermore, addition of CLA to broiler diets significantly affected meat quality ($p\leq 0.01$) by increasing its CLA content. **Conclusion:** Addition of 1 g CLA kg^{-1} to broiler diets is optimal for enhancing production performance and the fatty acid content of meat.

Key words: Conjugated linoleic acid, broilers, production performance, fatty acids in meat

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Presently, most broiler production research is focused on finding alternatives for drugs and vaccines frequently used for rearing. Many researchers have turned to use of natural food additives to improve the production performance (e.g., meat production and nutritive value) and physiological status of birds, encouraging toxin-/chemical-free functional food production[1]. Due to its low fat, sodium and cholesterol content, poultry meat is in high demand; therefore, any economical methods which increase broiler production and enhance meat quality are vital to this industry[2]. Supplementation of poultry feed is one way to increase meat production and quality. Among the various chemical-free food additives available, Conjugated Linoleic Acid (CLA) has been most commonly used in poultry diets[3,4]. The CLA is a polyunsaturated omega fatty acid with a conjugated double bond system[5,6] that is important for regulating fatty acid metabolism and fat deposition in animals. Park *et al.*[3] showed that addition of CLA to the diet improved growth performance and lipid metabolism in mice and pigs. Similarly, others have demonstrated that broilers fed a CLA-supplemented diet produced meat enriched with CLA[4,7]. Therefore, the purpose of this study was to add CLA to broiler diets and to study its effect on productive performance and quality of meat.

MATERIALS AND METHODS

Birds and diets: The current study was carried out at the Poultry Research Station at the Office of Agricultural Research of the Ministry of Agriculture (Iraq) from February 25th to April 6th, 2016. One-day-old Ross-308 broiler chicks were randomly distributed into four dietary treatment groups: control (0 g CLA kg^{-1}; A1), A2 (0.5 g CLA kg^{-1} diet), A3 (0.75 g CLA kg^{-1} diet) and A4 (1 g CLA kg^{-1} diet). Diets began at 1-day-old and continued for 6 weeks; each treatment was replicated thrice, with 30 birds per replicate (360 birds total). Feed and water were provided *ad-libitum* for the duration of the experiment. Birds were housed with continuous light with the lighting parts for 1 h to reorganize the birds to extinguish the electric current and heating controlled by gas incubators. All experimental diets were isonitrogenous, isocaloric and formulated to meet[8] (Table 1). Body Weight (BW) and feed intake, average daily BW Gain (BWG) and Feed Conversion Ratios (FCR) were recorded after 4 and 6 weeks. At the end of the study six birds were randomly selected from each treatment group to measure the carcass qualities characteristics.

Analysis of broiler meat fatty acid profiles: Fatty acid profile analysis of the collected meat samples was carried out on a Shimadzu gas chromatograph (Model 17, made in Japan)[9].

Table 1: Percent composition of broiler diets

	Diets	
Ingredients	Starter (%)	Finisher (23-42 days, %)
Yellow corn (%)	45	40.04
Wheat (%)	14	26
Soybean meal[1] (%)	30	22.5
Meat meal[2] (%)	5	5
Hydrogenated vegetable fat (%)	3.5	4.3
Dicalcium phosphate (%)	0.7	0.4
NaCl (%)	0.1	0.1
Limestone (%)	1.2	1.1
Methionine (%)	0.25	0.13
Lysine (%)	0.25	0.13
Calculated Values[3]		
M.E. (kcal kg^{-1} diet)	3132	3229
Crude protein	22.6	19.9
Crude fiber	2.7	2.7
Lysine	1.43	1.14
Methionine+Cystine	0.99	0.79
Calcium	0.87	0.82
Available phosphorus	0.8	0.78

M.E.: Metabolizable energy, [1]Soybean cake used was from an Argentine source of crude protein content by 48% and 2440 kcal kg^{-1}, [2]Protein meal used was of Netherlands origin) Brocon(and contains 40% crude protein, 0.2107 kcal kg^{-1} protein, 0.5% M.E., 2.20% crude fat, 5% crude fiber, 4.68% calcium, 3.85% phosphorus, 4.12% lysine, 4.12% methionine, 0.42% methionine+cystine, 0.38% tryptophan and 1.70% threonine. This protein meal also contained a mixture of vitamins and minerals [3]Based on National Research Council recommendations[8]

Statistical analysis: A completely randomized design was used to examine the effect of each treatment on the different production parameters. Significance was set at $p<0.05$ for performance comparisons and $p<0.01$ for fatty acid analysis[10]. A multiple range test was used to compare significant differences between groups. Data are presented as the means unless specified otherwise. The data were analyzed using Statistical Analysis System (SAS)[11].

RESULTS AND DISCUSSION

Effect of CLA on production performance of broilers: Supplementation of CLA in broiler diets had a significant effect on average BW ($p\leq0.05$, Table 2). The highest average BW was observed for birds fed A3 and A4 diets at 4 weeks and both groups were significantly higher than A1 and A2 birds at 6 weeks ($p\leq0.05$, Table 2). After 4 weeks, A4 birds had a significantly higher BWG than A1-A3 groups ($p\leq0.05$) and by 6 weeks, both A3 and A4 BWG were significantly greater than that of A1 and A2 groups ($p\leq0.05$, Table 2). The A1 and A2 birds did not differ significantly in average BW or BWG at either time point. Overall, the A4 treatment produced the highest average BW and BWG at all time points, followed by A3, A2 and A1 treatments. Feed intake for birds fed diets supplemented with CLA (A2-A4) was significantly lower than A1 birds at all time points ($p\leq0.05$, Table 3). Furthermore, the FCRs (g feed g^{-1} BWG) of A2-A4 groups were significantly higher than that of A1 birds at all time points ($p\leq0.05$, Table 3). Taken together, these results demonstrate CLA supplementation leads to significant improvements in production performance parameters (average BW, BWG, feed intake and FCR), which is likely due to the biological activity of this fatty acid's system of conjugated double bonds [12]. In addition, Qasim[13] reported that improvements in broiler production performance were associated with increased production of growth hormones in liver cells stimulated by CLA. The CLA works to increase primer (i.e., amino acid) synthesis of growth hormones that are then transported to the pituitary gland. Moreover, CLA works as a genetic expression and gene receptor of growth hormone.

Effect of CLA on major carcass traits: The effects of CLA supplementation on major carcass traits of birds are given in Table 4. Dressing percentages increased due to CLA

Table 2: Effect of adding conjugated linoleic acid to the diets on the average body weight and body weight gain of broiler

Age (weeks)	Treatments A_1 Control	A_2 (0.5 g CLA kg^{-1} diet)	A_3 (0.75 g CLA kg^{-1} diet)	A_4 (1 g CLA kg^{-1} diet)	Significance
Average body weight (g)					
4	1122.67±2.08^{C}	1119.09±0.57^{C}	1164.06±2.84^{B}	1223.50±0.57^{A}	*
6	2123.19±1.15^{B}	2099.81±1.15^{C}	2121.14±37.65^{B}	2212.57±0.70^{A}	*
Body weight gain (g)					
0-4	647.28±0.57^{B}	640.23±0.75^{B}	588.36±0.75^{C}	684.56±0.50^{A}	*
4-6	1438.41±0.57^{B}	1422.80±0.75^{B}	1495.28±0.57^{A}	1490.51±0.57^{A}	*
0-6	2085.69±1.15^{B}	2062.31±1.15^{B}	2083.64 B ±1.00^{B}	2175.09±1.07^{A}	*

CLA: Conjugated linoleic acid, values within treatments are Means±SEM. Means in the same row with different superscripts were significantly different ($p<0.05$)

Table 3: Effect of adding conjugated linoleic acid to the diets on feed intake and food conversion ratio

Age (weeks)	Treatments A_1 Control	A_2 (0.5 g CLA kg^{-1} diet)	A_3 (0.75 g CLA kg^{-1} diet)	A_4 (1 g CLA kg^{-1} diet)	Significance
Feed intake					
0-4	1178.06±8.52^{A}	1062.71±37.98^{B}	966.86±4.24^{C}	1131.83±16.77^{AB}	*
4-6	2977.51±21.77^{A}	2635.57±28.22^{B}	2601.78±8.17^{B}	2633.22±16.93^{B}	*
0-6	4056.68±19.29^{A}	3622.71±75.23^{BC}	3524.82±7.60^{C}	3719.38±19.39^{B}	*
Feed conversion ratio					
0-4	1.82±0.01^{A}	1.66±0.06^{B}	1.64±0.08^{B}	1.65±0.07^{B}	*
4-6	2.07±0.02^{A}	1.85±0.02^{B}	1.74±0.05^{C}	1.76±0.01^{C}	*
0-6	1.94±0.08^{A}	1.75±0.03^{B}	1.69±0.04^{B}	1.71±0.05^{B}	*

Values within treatments are Means±SEM, Means in the same row with different superscripts were significantly different ($p<0.05$)

Table 4: Effect of adding conjugated linoleic acid to the diets on the major carcass traits of slaughtered birds

	Treatments				
Major carcass traits (%)	A_1 Control	A_2 (0.5 g CLA kg^{-1} diet)	A_3 (0.75 g CLA kg^{-1} diet)	A_4 (1 g CLA kg^{-1} diet)	Significance
D.P.	72.25 ± 0.41^{B}	75.08 ± 0.21^{A}	74.73 ± 0.11^{AB}	77.15 ± 0.02^{A}	*
Breast	36.89 ± 0.39^{C}	39.67 ± 0.57^{B}	40.19 ± 0.03^{AB}	42.42 ± 0.28^{A}	*
Thigh	13.66 ± 0.60^{B}	14.73 ± 0.62^{AB}	14.22 ± 0.19^{AB}	16.40 ± 0.05^{A}	*
Drumstick	11.75 ± 0.57^{B}	11.81 ± 0.57^{B}	12.48 ± 0.13^{AB}	13.25 ± 0.02^{A}	*
Liver	2.37 ± 0.11^{B}	2.94 ± 0.02^{A}	2.58 ± 0.05^{B}	3.12 ± 0.01^{A}	*
Abdominal fat	2.06 ± 0.004^{A}	1.14 ± 0.001^{B}	11.17 ± 0.005^{B}	0.85 ± 0.005^{C}	*

Values within treatments are Means±SEM. Means in the same row with different superscripts were significantly different ($p<0.05$), D.P: Dressing percentage, CLA: Conjugated linoleic acid

Table 5: Effect of adding conjugated linoleic acid to the diets on fatty acid composition of broiler meat

	Treatments				
Fatty acid composition (%)	T_1 Control	T_2 (0.5 g CLA kg^{-1} diet)	T_3 (0.75 g CLA kg^{-1} diet)	T_4 (1 g CLA kg^{-1} diet)	Significance
C 16	27.26 ± 0.72^{A}	21.23 ± 0.13^{B}	19.21 ± 0.17^{C}	17.30 ± 0.40^{D}	**
C16:1	4.92 ± 0.57^{B}	4.33 ± 0.66^{B}	6.26 ± 0.33^{A}	4.09 ± 0.17^{B}	**
C 18	6.53 ± 0.33^{A}	6.56 ± 0.06^{A}	5.50 ± 0.24^{B}	6.76 ± 0.33^{A}	**
C 18:1	43.50 ± 0.76^{A}	41.10 ± 0.10^{B}	41.80 ± 0.20^{B}	41.09 ± 0.32^{B}	**
C 18:2	17.80 ± 0.10^{C}	21.60 ± 0.22^{AB}	22.43 ± 0.12^{A}	20.00 ± 0.20^{B}	**
CLA	0.00 ± 0.00^{D}	5.16 ± 0.02^{C}	6.69 ± 0.29^{B}	8.83 ± 0.25^{A}	**

Values within treatments are Means±SEM. Means in the same row with different superscripts were significantly different ($p<0.01$), CLA: Conjugated linoleic acid

supplementation and were significantly higher in A2-A4 group of birds compared to control group (A1) ($p\leq0.05$). Thigh and drumstick weight percentages were highest for A4 birds and significantly different from the control group (A1) ($p\leq0.05$), while breast percentages increased significantly in A2 and A4 compare to control group (A1) (all $p<0.05$, Table 4). The breast percentage was significantly different between A4 and A2 treatments but not between A2 and A3 or A3 and A4. Similar improvement was noted for liver percentages in A2 and A4 birds, which were both significantly different from that of A1 and A3. In addition, a reduction in separable abdominal fat was found in all CLA treated groups (A2-A4) compared to controls (A1). The positive effect of CLA supplementation on carcass and meat yield reported herein may be related to the role of this fatty acid in increasing amino acid uptake and utilization, which ultimately increases protein deposition, muscle synthesis, and, therefore, meat yield[13]. These effects could also be attributed to the ability of CLA to reduce body fat accretion. Previous studies have reported that CLA is able to reduce lipoprotein lipase activity in rats and pigs [3,14], as well as increase lipolysis, which leads to reduced fat deposition and altered body composition[15,16].

Fatty acid content of broiler meat: Table 5 shows the effects of adding CLA to broiler diets on the fatty acid composition of their meat. Current results reveal that the concentration of linoleic acid in broiler meat increased with increasing concentration of dietary CLA. The highest linoleic acid concentration was found in A4 group, followed by A3, A2 and A1 groups and all treatments with added CLA were significantly different from A1. This suggests that CLA supplementation increased the linoleic acid content of the broiler meat, which ultimately enhanced its fatty acid composition. The CLA plays an important role in fat metabolism in general, particularly in liver cells. It is posited that these cells worked to increase the deposition of CLA through the replacement and translocation of fatty acids in the meat, producing a functional food with high nutritional value[16,17]. In contrast, control birds fed 0 g CLA kg^{-1} (A1) did not have significant CLA deposition in their meat because they were unable to extract it from the base diet. Moreover, because poultry are monogastric animals, they do not have the linoleate isomerase required to synthesize CLA from available precursors in their body[16].

CONCLUSION

The results of the present study showed that addition of CLA powder in broiler feed improves production performance parameters, carcass quality and fatty acid composition in the meat. Furthermore, CLA supplementation also improved the nutritional value of broiler meat, producing a functional food.

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