African Journal of Biotechnology Vol. 10(75), pp. 17379-17384, 28 November, 2011
Available online at http://www.academicjournals.org/AJB
DOI: 10.5897/AJB11.1704
ISSN 1684–5315 © 2011 Academic Journals

Full Length Research Paper

Effects of dietary conjugated linoleic acid (CLA), n-3 and n-6 fatty acids on performance and carcass traits of broiler chickens

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Accepted 28 October, 2011

An experiment was conducted on broiler chickens to study the effects of conjugated linoleic acid (CLA), fish oil, soybean oil or their mixtures (at 7% for single and 3.5% + 3.5% for mixtures) as well as up 12% dosage of palm oil, on the performance and carcass traits of broiler chickens. The chicks fed 7% fish oil or 7% CLA diets were found to have the most inferior weight gain in grower and finisher phases, respectively. A significant reduction in feed intake was observed with diets containing 7% fish oil. However, adding CLA to the diets regardless of the associated dietary fat, did not affect birds feed intake. The dietary fish oil and CLA adversely affected the feed conversion ratio as well as carcass yield. Dietary palm oil (at 12% level) and CLA (at 7% level) increased the abdominal fat pad and liver weights, respectively. The results of this study show that the high dosage of fish oil or CLA can reduce broiler chickens performance but their combination with soybean oil as n-6 fatty acid source can moderate these adverse effects.

Key words: Conjugated linoleic acid (CLA), polyunsaturated fatty acids (PUFA), performance, carcass traits, broiler chickens.

INTRODUCTION

Chicken has been considered an appropriate model in lipid nutrition studies, since it is highly sensitive to dietary fat modifications and many of the studies done with chickens deal with the degree of saturation or source type of the dietary replaced fat and how it influences the performance and carcass quality improvement of the animal (Rymer and Givens, 2005). If the poultry is expected to reach high performance, their high energy and protein requirements should be supplied. Providing their needs of high energy is an obligation to use different fat sources (López-Ferrer et al., 2001; Sanz et al., 2000; Senköylü, 2001). Specific fatty acids such as n-3 fatty acids and conjugated linoleic acid (CLA) were shown to improve performance and to decrease incidence of inflammatory response in the growing chicks (Cook et al., 1993; Korver and Klasing, 1997).

CLA is a naturally occurring substance in dairy products and meat from ruminant animals, as a result of bacterial biohydrogenation in the rumen (Ha et al., 1989). Dietary CLA was first shown to be effective in the prevention of growth depression induced by immune stimulation in chicks and mice (Cook et al., 1993). Dietary n-3 polyunsaturated fatty acids (PUFA) and in particular, eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), have well known effects on human health (Kinsella et al., 1990).

Suksombat et al. (2007) fed up to 1.5% doses of CLA

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to 3-week-old broilers and found no significant differences in average daily feed intake; however, average daily gain was significantly reduced. They showed a decrease in abdominal fat and drumstick and boneless drumstick percents but, percentages of liver weight were significantly increased with the increased CLA level in the broilers' diets. The increase in liver weight following dietary CLA intake was also reported by Leaflet (2004). Thiel-Cooper et al. (2001) verified a linear increase in average daily gain as the level of CLA increased in the diet.

Most of the previous reports indicated that inclusion of fish oil in the diets caused no adverse effects on the productive efficiency of the animals, either in terms of mortality, final body weight, or feed conversion ratios, compared with vegetable oils (Huang et al., 1990; Phetteplace and Watkins, 1990; Nash et al., 1995).

However, Hulan et al. (1988) observed that diets containing fish oil caused lower feed consumption and body weights and poorer feed conversion efficiency in broiler chickens. These authors attributed the reduced performance levels to lower palatability.

The objective of this study was to assess the effects of altering dietary fat type with inclusion of CLA, fish oil, soybean oil and their mixture as well as a palm oil containing diet as a saturated fatty acid source, on performance and various carcass characteristics of broiler chickens.

MATERIALS AND METHODS

A total of 560 Ross 308 male broiler chickens were used in this study. 20 day old chicks were placed randomly into each of 28 L pens (1.5 × 1.5 m^2). A lighting program of 23L:1D was used for the entire 42-days raring period. The birds were housed in an environmentally-controlled room and they had free access to feed (mash) and water.

Experimental diets were formulated according to the Ross 308 manual. All chicks were fed a commercial starter diet from 0 to 10 days and the experimental diets from 11 to 28 days (grower phase) and 29 to 42 days (finisher phase). Seven isocaloric and isonitrogenous diets were formulated so that they contained: 7% soybean oil (SO), 7% CLA (CLA), 7% fish oil (FO), 3.5% CLA + 3.5% soybean oil (CLA + SO), 3.5% fish oil + 3.5% soybean oil (FO + SO), 3.5% CLA + 3.5% Fish oil (CLA + FO) or up to 12% palm oil (PO). The CLA supplement used in this study was LUTA-CLA 60, prepared and supplied by BASF Company (Germany) and contained 30% isomer 9c, 11t and 30% isomer 10t, 12c of conjugated linoleic acid plus mostly oleic acid. So, the dietary inclusion of 7 and 3.5% CLA were supplied 4.2 and 2.1% CLA, respectively. The higher fat inclusion in palm oil diet was because of the lower metabolisable energy of palm oil (Table 1).

Group body weight, average daily gain (ADG), daily feed intake (DFI), and feed conversion ratio (FCR) per pen were calculated for grower (10 to 28 days) and finisher (29 to 42 days) phases. On day 42, two male birds per cage were weighed live, slaughtered after an overnight withdrawal period. The birds were slaughtered, and then bled for 2 min. After scalding (63°C) for 45 s, carcasses were mechanically defeathered and manually eviscerated. They were cut up after an internal carcass temperature of 4°C was reached (approximately 4 to 6 h). Sex was verified at processing, and carcass, breast (pectoralis major + pectoralis minor), and thigh weights were recorded on eight birds per treatment. Carcass yield was calculated as eviscerated carcass with neck, feet, and abdominal fat pad removed, as percentage of live BW at the time of feed withdrawal.

Data sets of completely randomized design whit seven treatments and four replicate, were compared across the treatments using the one-way analysis of variance (ANOVA) procedure. Pen was considered the experimental unit for performance traits and each chick was the experimental unit for carcass parameters data. Significant means were then elucidated using the Duncan multiple range tests. All statistical tests were conducted at 95% confidence level using the SAS program (SAS, 9.1, 2002).

RESULTS

The effects of experimental diets on performance traits of broiler chickens are demonstrated in Table 2. During the grower period, the body weight gain of the birds fed PO diet was higher than that of the other treatments ($P < 0.05$), however at finisher period, the birds fed SO, CLA + SO or PO diets had a comparable weight gain which was higher than other treatments ($P < 0.05$). FO and CLA diets was more effective to reduce weight gain at grower and finisher phases respectively ($P < 0.05$).

The feed intake of birds fed FO diet was lower ($P < 0.05$) in the grower and in the entire experimental period (days 10 to 42) when compared to the other groups. In grower period, the diets containing mixture of CLA + FO resulted in a higher feed intake than diets with CLA or fish oil separately ($P < 0.05$); however in finisher period, the difference was only observed in comparison with the 7% fish oil diet ($P < 0.05$).

The best FCR was absorbed for PO diet so that the difference was significant compared to all the CLA containing diets ($P < 0.05$). The CLA containing diets resulted in the worst FCR at both grower and finisher periods ($P < 0.05$), but in the entire experiment period, the FCR for CLA + SO diet was less affected.

Table 3 shows the carcass parameters of experimental birds. The birds fed PO or CLA + SO mixture had higher carcass percentage compared to the birds fed CLA, FO or the mixture of CLA + FO ($P < 0.05$). The birds fed CLA + SO diet had a higher breast yield compared with the birds fed CLA + FO diet, and significantly higher thigh yield than other treatments with the exception of PO diet ($P < 0.05$). The CLA diet significantly increased the liver weight ($P < 0.05$) and a significantly higher abdominal fat pad deposition was observed for broiler chickens fed PO diet ($P < 0.05$).

DISCUSSION

In this research, it seems that the negative effect of CLA on growth rate was modified by the dietary CLA level, age of birds and the fat composition of the experimental diets, so that the chicks fed diets containing 3.5% CLA in the finisher phases showed an acceptable body weight

Table 1. Ingredients and compositions of the experimental diets.

Ingredient	Starter	Grower (11-28 days of age)							Finisher (29-42 days of age)						
	(1-10 days)	PO[2]	SO	FO	CLA	FO+SO	CLA+SO	CLA+FO	PO	SO	FO	CLA	FO+SO	CLA+SO	CLA+FO
Corn (%)	60.23	48.46	53.99	53.99	55.8	53.99	54.13	54	52.62	57.98	57.98	59.5	57.98	59.06	58.92
Soy meal (%)	30.81	30.56	32.27	32.27	28.6	32.27	31.96	32.26	27.76	30.27	30.27	26.38	30.27	28.3	28.6
Fish meal (%)	5.37	5	3	3	5	3	3.2	3.01	3	1	1	2.99	1	1.7	1.51
Soy bean oil (%)	-	-	7	-	-	3.5	3.5	-	-	7	-	-	3.5	3.5	-
Fish oil	-	-	-	7	-	3.5	-	3.5	-	-	7	-	3.5	-	3.5
Palm oil (%)	-	12.6	-	-	-	-	-	-	12.92	-	-	-	-	-	-
CLA(%)[1]	-	-	-	-	7	-	3.5	3.5	-	-	-	7.4	-	3.5	3.5
Oyster shell (%)	1.41	1.34	1.42	1.42	1.33	1.42	1.41	1.42	1.3	1.39	1.39	1.3	1.39	1.35	1.36
DCP (%)	0.51	0.48	0.66	0.66	0.52	0.66	0.64	0.66	0.69	0.84	0.84	0.71	0.84	0.81	0.82
Salt (%)	0.25	0.29	0.32	0.32	0.28	0.32	0.31	0.32	0.32	0.35	0.35	0.32	0.35	0.34	0.34
Vit-Min P (%)[3]	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
DL-Met (%)	0.26	0.23	0.25	0.25	0.23	0.25	0.25	0.25	0.17	0.18	0.18	0.16	0.18	0.18	0.18
L-Lys (%)	0.15	0.04	0.09	0.09	0.24	0.09	0.09	0.09	0.22	-	-	0.25	-	0.27	0.27
ME (Kcal/Kg)	2860	3175	3205	3211	3175	3208	3175	3175	3225	3235	3241	3225	3238	3225	3225
CP (%)	22.5	21	21	21	21	21	21	21	19	19	19	19	19	19	19
Crude Fat (%)	2.86	15	9.52	9.52	9.65	9.52	9.54	9.52	15.34	9.55	9.55	10.07	9.5	9.61	9.6
Linoleic a (%)	1.46	2.63	5.37	1.39	5.27	3.38	5.3	3.31	2.74	5.45	1.46	5.56	3.46	5.4	3.4
Ca (%)	0.95	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.85	0.85	0.85	0.85	0.85	0.85	0.85
Ava P (%)	0.475	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.425	0.425	0.425	0.425	0.425	0.425	0.425
Na (%)	0.152	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
Lys (%)	1.368	1.23	1.23	1.23	1.34	1.23	1.23	1.23	1.2	1.02	1.02	1.2	1.01	1.2	1.2
Met (%)	0.662	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.48	0.48	0.48	0.48	0.48	0.49	0.49
Met+Cys (%)	1.0355	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.8	0.8	0.8	0.8	0.8	0.8	0.8

CLA[1] used in this experiment was CLA LUTA60 which contains 60% CLA, then 7 and 3.5% dietary inclusion of CLA will be equal to 4.2 and 2.1%, respectively. PO[2] = diet containing palm oil; SO = diet containing 7% soybean oil; FO = diet containing 7% fish oil; CLA = diet containing 4.2% CLA; CLA + SO = diet containing 2.1% CLA + 3.5% soybean oil; CLA + FO = diet containing 2.1% CLA + 3.5% fish oil; FO + SO = diet containing 3.5% fish oil + 3.5% soybean oil. [3]Mineral premix provided per kg of ration with 50 mg Fe, 70 mg Mn, 50 mg Zn, 7 mg Cu, 0.4 mg Co, 0.17 mg Se, and 0.75 mg I. Vitamin premix provided per kg of ration with 6,000,000 IU vitamin A, 1.500,000 IU vitamin D3, 15,000 IU vitamin E, 2.5 mg vitamin K3, 0.02 mg vitamin B12, 3,000 mg riboflavin, 7000 mg pantothenic

gain and the combination of CLA + SO resulted in a more favorite effect on weight gain than the mixture of CLA + FO.

One of the objectives of this trial was to evaluate the potential interactions between dietary CLA and other fatty acids on growth parameters of broiler chickens. Because of the CLA and PUFAs effects on lipid metabolism, it is believed that the use of CLA in association with different sources of fat in the diet may improve the productive efficiency as well as body fat deposition (Zanini et al., 2006). In a previous study, it was observed that the use of CLA in combination with oils rich in n-3 fatty acids or in diets with a balanced ratio of n6:n3 optimized the

Table 2. Effects of dietary fat type on performance traits of broiler chickens.

Treatment	Grower phase (10-28 days)				Finisher phase (29-42 days)				Total experiment (10-42 days)		
	BW (g)	DWG (g/b/d)	DFI (g/b/d)	FCR	BW (g)	DWG (g/b/d)	DFI (g/b/d)	FCR	DWG (g/b/d)	DFI (g/b/d)	FCR
PO[1]	1080^{a}	54.27^{a}	80.40^{a}	1.49^{d}	2260^{a}	72.4^{a}	139.5^{ab}	1.92^{c}	51.3^{a}	83.7^{ab}	1.63^{d}
SO	970^{b}	46.81^{bc}	77.22^{ab}	1.65^{cd}	2078^{b}	67.7^{ab}	132.2^{abc}	1.95^{c}	47.1^{b}	80.6^{ab}	1.71^{cd}
FO	590^{e}	24.16^{e}	52.52^{c}	2.17^{a}	1554^{c}	58.8^{c}	114.9^{c}	1.95^{c}	34.5^{c}	63.8^{c}	1.85^{c}
CLA	790^{d}	35.87^{d}	72.42^{b}	2.02^{ab}	1650^{c}	50.9^{d}	141.9^{ab}	2.79^{a}	36.2^{c}	81.3^{ab}	2.24^{a}
CLA+SO	980^{b}	47.12^{bc}	78.56^{a}	1.67^{c}	2086^{b}	69.1^{ab}	149.7^{a}	2.17^{b}	47.0^{b}	86.1^{a}	1.83^{c}
CLA+FO	900^{c}	43.79^{c}	82.98^{a}	1.90^{b}	1982^{b}	63.1^{bc}	148.2^{a}	2.36^{b}	43.6^{b}	87.3^{a}	2.01^{b}
FO+SO	1020^{b}	49.6^{b}	78.16^{ab}	1.57^{cd}	2018^{b}	62.3^{bc}	122.5^{bc}	1.97^{c}	45.7^{b}	75.6^{b}	1.66^{d}
SEM	7.5	0.45	0.71	0.02	17	0.93	3.4	0.02	0.5	1.11	0.02

$^{a-d}$ Means with different superscripts within column differ significantly at $P<0.05$. CLA used in this experiment was CLA LUTA60 which contains 60% CLA, then 7% and 3.5% dietary inclusion of CLA will be equal to 4.2 and 2.1%, respectively; PO[1] = diet containing palm oil; SO = diet containing 7% soybean oil; FO = diet containing 7% fish oil; CLA = diet containing 4.2% CLA; CLA+SO = diet containing 2.1% CLA + 3.5% soybean oil, CLA + FO = diet containing 2.1% CLA + 3.5% fish oil, FO+SO = diet containing 3.5% fish oil + 3.5% soybean oil. BW, body weight; DWG, daily weight gain; DFI, daily feed intake; FCR, feed conversion ratio.

CLA effect (Aydin et al., 2001.

The results of this study demonstrated that the effects of CLA on performance traits in broilers depend on oil source as demonstrated by more favorable body weight gain when soybean oil was used with CLA but, this effect was not showed when fish oil was added. Brown et al. (2001) have also shown that the CLA effect can be modified by the oil supplement; therefore, the association of CLA with another fat should be considered.

Obviously, in this study, the CLA + SO diet resulted in more favorite effects on the carcass traits, a result that is in accordance with the body weight gain data but the only previous report on the positive effect of CLA on carcass yield is related to Buccioni et al. (2009) study in which broiler chickens were fed with 1% dietary CLA.

In the majority of such studies, carcass traits were not affected by dietary CLA sources. Bolukbasi (2006) could not show any difference in carcass yield, and leg weight of chicks fed 0 to 3% CLA in combination with sunflower oil, but they found an increase in the breast percent of birds fed CLA which is in agreement with our finding using the CLA + SO diet. In the study of Szymczyk et al. (2001), the relative proportion of breast and leg muscles (% of carcass weight) responded differently to increasing levels of dietary CLA. The former variable was not affected by the treatment and the latter was significantly increased.

Buccioni et al. (2009) found that increase in dressing out percentage in CLA fed animals was related to the significant decrease in abdominal separable fat and attributed it to the ability of CLA to reduce body fat deposition. This conclusion is not in accordance with our observation because the abdominal fat pad content of birds fed PO diet (one of the treatments with the best carcass yield) was higher than the treatments with unfavorable carcass yield (CLA, FO and CLA+FO). Szymczyk et al. (2001) showed a decrease in abdominal fat pad with an increase in thigh percent; however, in the study of Suksombat et al. (2007), the reduced abdominal fat pad in birds fed dietary CLA was not associated with any increase in carcass, breast or thigh percents. These controversies show that there may be a more complicate mechanism for the effects of CLA on body parameters than simply just the abdominal fat pad alteration.

In this study, the abdominal fat pad weight percentage in birds fed palm oil was higher than in the other treatments but the fat deposit in the birds fed CLA, fish oil, soybean oil or their combinations were not different. There are conflicting reports on the effects of CLA on increase or decrease of abdominal fat pad in chickens. Du and Ahn (2002) found that feeding a diet containing 0·5% CLA to broilers at three weeks of age, for a period of three weeks, resulted in an increase in abdominal fat content. Javadi et al. (2007) reported same observation using 1% dietary CLA. It is reported that dietary CLA reduces lipogenesis in adipose tissues and mammary glands, but not in liver. This could be the reason for the ineffectiveness of CLA in reducing fat accumulation in birds, in which lipogenesis is concentrated in liver. The increase

Table 3. Carcass parameters as a percent of live weight of the experimental birds.
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Parameter	Carcass	Breast	Thigh	Liver	Fat pad
PO[1]	59.6[a]	22.1[ab]	19.5[ab]	2.1[c]	2.4[a]
SO	58.1[ab]	20.9[ab]	18.9[bc]	2.3[bc]	1.9[b]
FO	54.5[c]	18.1[c]	18.1[c]	2.6[b]	2.0[b]
CLA	56.3[bc]	20.3[b]	18.3[c]	3.3[a]	2.1[b]
CLA+SO	60.3[a]	22.6[a]	20.0[a]	2.4[bc]	2.1[b]
CLA+FO	56.3[bc]	21.2[ab]	18.4[c]	2.6[b]	2.1[b]
FO+SO	58.5[ab]	20.8[ab]	18.2[c]	2.3[bc]	2.1[b]
SEM	*0.31*	*0.25*	*0.13*	*0.04*	*0.08*

[a-d] ,Means with different superscripts within column differ significantly at $P<0.05$. CLA used in this experiment was CLA LUTA[60] which contains 60% CLA, then 7 and 3.5% dietary inclusion of CLA will be equal to 4.2 and 2.1% respectively. PO[1] = diet containing palm oil; SO = diet containing 7% soybean oil; FO = diet containing 7% fish oil; CLA = diet containing 4.2% CLA; CLA+SO = diet containing 2.1% CLA+3.5% Soybean oil; CLA+FO = diet containing 2.1% CLA + 3.5% fish oil; FO + SO = diet containing 3.5% fish oil + 3.5% soybean oil.

in triglyceride level could partially be due to increased fatty acid syntheses activity in liver (Leaflet, 2004).

The increase in liver weight of broiler chickens following dietary CLA intake was reported by Du and Ahn (2003), Leaflet (2004) and Suksombat et al. (2007) as well. The effect of dietary oils on liver weight is apparently independent of oil source interactions, so that in this study, there was no significant difference in liver weight of birds fed mixtures of CLA, fish oil and soybean oil. However in a different report, Zanini et al. (2006) showed a reduction in the relative liver weight in female's broiler chickens supplied with CLA and canola oil. They found an interaction between oil source and CLA so that supplementation of CLA produced lower relative of liver in birds fed canola oil when compared to that of birds receiving soybean oil diets. The results of this study show that the high dosage of fish oil or CLA can reduce broiler chickens performance but their combination with soybean oil as a well known n-6 fatty acid source can moderate these adverse effects.

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