CONJUGATED LINOLEIC ACID AND THE RATIO OF ω6:ω3 FATTY ACIDS ON THE LIPID METABOLISM OF BROILER CHICKENS

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Background

From the point of view of food safety it has been a growing concern of the poultry industry to improve not only the yield but also the composition of the poultry products, maximizing the deposition of protein and reducing the fat content. Quality and quantity of fat present in the food of animal origin has been an important criteria of nutritional evaluation. Conjugated linoleic acid (CLA) is a functional metabolite that has the potential of reducing carcass fat deposition (Akahoshi et al., 2003). This effect is related to the modification of gene expression of lipogenic enzymes (Bauman, 2001) showing that the hepatic lipogenisis and fat deposition may be reduced by the supplementation of CLA in the feed. CLA may reduce adipose tissue mass by minimizing accumulation of triglycerides in adipocytes. t10c12-CLA inibits activity of lipoprotein lipase in vivo (Park & Pariza, 2001). Also, there are reports of the effects of CLA in the increase of carnitine palmitoil transferase activity, a key enzyme on the β-oxidation (Akahoshi et al., 2003). Supplementation with CLA also reduced significantly the level of liver fat in broilers (Badinga et al., 2003) and total triglycerides and cholesterol in the plasma of rabbits (Corino et al., 2002). The use of CLA in association with oils rich in ω3 fatty acids or in diets that have a balanced ratio of ω6:ω3 has optimized the CLA effect (Aydin et al., 2001) showing that the CLA effect depend upon the amount of fatty acids ω6 and ω3 in the diet. Therefore, since CLA has the potential of alter the genetic expression of the lipogenic enzymes, 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 the carcass yield.

Objectives

The aim of these studies were to evaluate the dietary supplementation of CLA and the ratio of ω6:ω3 on the lipid metabolism of broiler chickens.

Materials and methods

Two studies were conducted simultaneously using 100 male or female Ross broiler chickens with 21 days of age at the start of the experiment. Birds were selected from a population of 300 animals so that, male or female birds used in the studies were within of 10% of the mean body weight of the population. The experimental design was a completely randomized in a factorial arrangement 2 x 5 (two oil source, i.e. soybean or canola oil and five levels of CLA supplementation, i.e. 0.0, 0.25, 0.50, 0.75 and 1.00). Oils used were supplied by Bunge Alimentos and CLA (Lucta – CLA 60) by BASF. The control diet had 4% of soybean or canola oil. CLA levels were obtained by isometrically replacing soybean or canola oil in the control diet. The ratio of ω6:ω3 fatty acids in the soybean and canola oil was 12:1 and 3.5:1 respectively. From 1 to 21 days of age chicks were raised in a corn-soy starter diet with 21% protein and 2,950 Kcal of metabolizable energy per Kg of diet. From 22 to 45 days of age the experimental diets were corn-soy diets formulated to at least reach nutrient levels recommended by the NRC (1994). The final body weight was determined individually at 45 days of age, when birds were killed by cutting the jugular vein. Blood samples were collected from all 10 birds. Abdominal fat pads and livers were collect from the five birds with body weight closest to the mean body weight of the treatment. Total serum cholesterol was measured using spectrometry (LABTEST – cholesterol liquiform). ANOVA and the F test (5% level) were used to compared results of the effect of oil sources and regression analysis for CLA levels.

Results and discussion

The effect of oil source on final body weight of males and females chickens is shown in Table 1. For both sexes, supplementation with canola oil resulted in heavier birds ($P < 0.05$) when compared to soybean oil.

The effect of CLA supplementation on final body weight of female birds was significant and better explained by a cubic response. It decreased until the level of 0.20% of CLA and increased to a maximum between 0.75 and 0.80% of CLA (Figure 1). Research with growing swine have also shown that CLA supplementation improved feed efficiency, growth and carcass composition (Thiel-Cooper et al., 2001). On the other hand, Badinga et al. (2003) showed a reduction on the body weight of broilers receiving CLA supplementation. Abdominal fat pad content of females have shown a significant interaction between oil sources versus levels of CLA. A linear reduction in abdominal fat pad content was observed on females receiving canola oil and CLA (Figure 2). Probably, this effect of the CLA was due to a higher body fat content in the heavier females fed canola oil. The effect of CLA supplementation on reduction in body fat of heavier animals was also reported by Corino et al. (2003). Table 2 shows the effect of oil source on liver weight ($P < 0.05$). Canola oil fed male and female birds had a reduction in liver weight ($P < 0.05$) when compared to soybean oil fed birds. An interaction effect between canola oil and CLA was also verified on the liver weight of females ($P < 0.05$). The results follows a cubic response where liver weights were reduced to a minimum at 0.25% CLA supplementation and increased to a maximum at 0.80% of CLA (Table 2). There was effect of the oil source on the serum cholesterol levels of females ($P < 0.05$). Total serum cholesterol was lower (115,1 mg/dl) in females fed canola oil when compared to that of females fed soybean oil (131.8 mg/dl). In both sexes, the supplementation with CLA in association with two sources of oil influenced ($P < 0.05$) the lipid metabolism of birds (Figures 3, 4 and 5). Badinga et al. (2003) reported a significant reduction in liver lipids due to CLA supplementation of birds diets. Fatty acids production in birds occur mainly in the liver, therefore the lighter livers of male and female birds fed canola oil found in this study may be due to a reduction in the endogenous production of lipids as also shown by the reduced serum cholesterol levels in the females. The significant interaction effect between oil sources and levels of CLA on liver weight and serum cholesterol levels suggested that the CLA effect may be related to the ratio of omega 6 to omega 3 fatty acids in the diet. Brown et al., (2001) reported that culture of pre-adipocytes supplemented with CLA and sunflower oil (rich in omega 6 fatty acids) resulted in higher content of triglycerides when compared to the cultured treated with only CLA, showing that the anti-adipogenic effect of CLA on the pre-adipocytes can be reversed. Therefore, it is reasonable to think that in studying the CLA effect on the lipid metabolism is important to take in consideration the fatty acid composition of the diet as well as the ratio of omega 6 to omega 3 fatty acids. Zanini et al. (2003) reported a reduction in total fat, cholesterol and saturated fatty acids in the carcass of roosters fed canola oil. The ratio of omega 6 to omega 3 in theirs study was 6,6:1 that is within the range of 4:1 to 10:1 recommended to humans (British Nutrition Foundation, 1991). The results of this study suggest that effects of oil source and CLA levels on abdominal fat pad, liver weight and serum cholesterol of females may be related to a reduction in the hepatic lipogenesis.

Conclusions

The results of this study have shown that:

1. Canola oil fed birds were heavier than soybean oil fed birds.
2. The CLA response on abdominal fat deposition depend upon body weight, sex and the source of fat added to the diet.
3. The effect of CLA in reducing total serum cholesterol was dependent of oil source.
4. Liver weight in both sexes and serum cholesterol in the females were reduced in the canola oil diet.

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Table 1 - Final body weight of male and female birds fed diets supplemented with soybean or canola oil and CLA levels.

	FINAL BODY WEIGHT (g)		
	MALES		
CLA (%)	SOYBEAN OIL	CANOLA OIL	$\bar{x}$ CLA
0,0	2248,12	2637,50	2442,81
0,25	2200,00	2640,62	2429,31
0,50	2284,37	2635,62	2460,00
0,75	2404,37	2677,50	2540,94
1	2435,00	2586,23	2510,62
$\bar{x}$ OIL SOURCE	2314,37^{b}	2635,50^{a}	
	FEMALES		
CLA (%)	SOYBEAN OIL	CANOLA OIL	$\bar{x}$ CLA[1]
0,0	2055,00	2263,12	2159,06
0,25	1997,50	2163,75	2080,62
0,50	2148,75	2246,25	2197,50
0,75	2146,87	2341,25	2244,06
1	2116,87	2276,25	2196,56
$\bar{x}$ OIL SOURCE	2093,00^{b}	2258,12^{a}	

[a,b] Averages values within the same line with no common superscript differ significantly by the test F ($P<0.05$)
[1]Cubic effect ($P<0.05$)

Table 2 - Liver weight of male and female birds fed diets supplemented with soybean our canola oil and CLA levels.

	LIVER WEIGHT (%)		
	MALES		
CLA (%)	SOYBEAN OIL	CANOLA OIL	$\bar{x}$ CLA
0,0	1,87	1,66	1,76
0,25	1,89	1,57	1,73
0,50	2,00	1,71	1,85
0,75	1,91	1,81	1,86
1	1,93	1,68	1,81
$\bar{x}$ OIL SOURCE	1,92^{a}	1,68^{b}	
	FEMALES		
CLA (%)	SOYBEAN OIL	CANOLA OIL[1]	$\bar{x}$ CLA
0,0	1,79^{a}	1,86^{a}	1,82
0,25	1,93^{a}	1,61^{b}	1,77
0,50	1,90^{a}	1,73^{b}	1,82
0,75	1,95^{a}	1,82^{a}	1,89
1	1,90^{a}	1,74^{b}	1,82
$\bar{x}$ OIL SOURCE	1,89^{a}	1,75^{b}	

[a,b] Averages values within the same line with no common superscript differ significantly by the test F ($P<0.05$)
[1]fCubic effect ($P<0.05$, R^2 0.97)

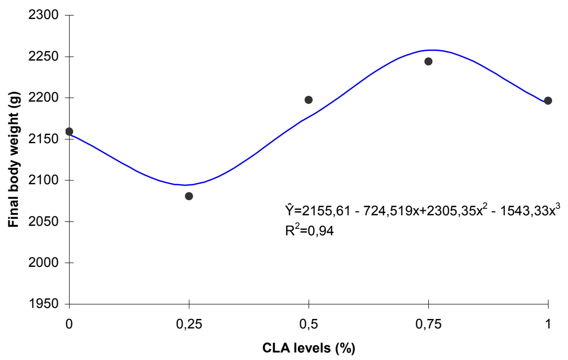

Figure 1. Final body weight of female birds supplemented with CLA

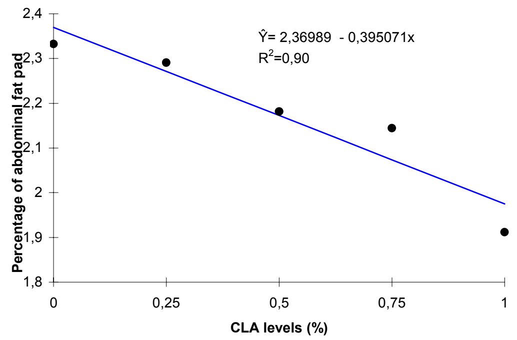

Figure 2. Percentage of abdominal fat pad of female birds fed canola oil diets and supplemented with CLA.

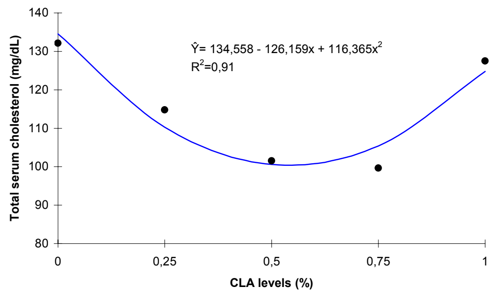

Figure 3. Total serum cholesterol (mg/dl) of female birds fed canola oil and supplemented with CLA.

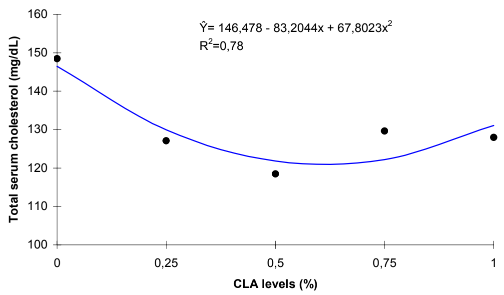

Figure 4. Total serum cholesterol (mg/dl) of male birds fed canola oil and supplemented with CLA.

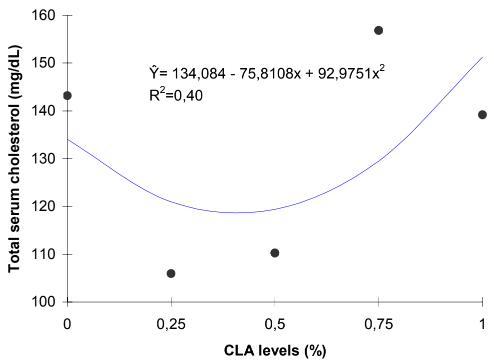

Figure 5. Total serum cholesterol(mg/dl) of male birds fed soybean oil and supplemented with CLA.