Dietary Conjugated Linoleic Acid (CLA) Effects Lipid Metabolism in Broiler Chicks

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Summary and Implications

Dietary CLA increased triglyceride, total cholesterol, and HDL cholesterol levels in plasma. The increased plasma triglyceride level could be caused by increased fatty acid synthesis in liver after CLA feeding, because the activity of fatty acid synthase in liver increased after dietary CLA treatment. Dietary CLA changed fatty acid composition of feces, but had no effect on fat content. Comparing to the linoleic and linolenic acids available in diets, ratios for their excretion into feces in CLA treated birds were significantly higher than those in control diet. Liver weight of broilers significantly increased after CLA feeding, but there was no difference in liver fat content among the different CLA treatments. CLA treatment did not influence total free fatty acid content in plasma, while there was significant difference in composition of free fatty acids. Dietary CLA reduced the content of linoleic and arachidonic acids in both plasma and liver.

Introduction

Feeding CLA at a low level produced a rapid, marked decrease in fat accumulation, but increased in protein content without any major effects on food intake. Rats fed 0.5% CLA in a diet had significantly reduced body fat, but increased whole body protein, water, and ash. Dietary CLA is also reported to improve feed efficiency in rats. The exact mechanism for the reduced fat accumulation by dietary CLA is not clear yet, but it can be related to the inhibition of lipid absorption and lipogenesis, and the promotion of lipid oxidation. In birds, liver is the principal site of lipid synthesis. Unlike mammals, fatty acids not glucose are the main energy source for birds, and liver of birds has a very high capacity for lipogenesis. Number of reports on the effect of dietary CLA on fatty acid metabolism in mammals are published, but few reports on birds are available. Therefore, the objective of this study was to determine the effect of dietary CLA on fatty acid status and key enzyme activities in liver of broiler chicks.

Materials and Methods

Total 120 3-week-old boiler chicks were assigned to one of the three dietary treatments containing 0%, 2%, or 3% CLA. Soybean oil and CLA source were substituted on a weight:weight basis in different diets. After 5 wk dietary treatment, birds were slaughtered and feces were collected the night before slaughter. Blood and whole liver were collected during slaughter. Sigma kit methods were used to analyze plasma cholesterol, HDL cholesterol and triglycerides levels. HDL cholesterol was measured after serum low density (LDL) and very low density (VLDL) lipoproteins were selectively precipitated and removed by centrifugation. Carnitine palmitoyltransferase I and II activities were analyzed by measuring the release of CoA catalyzed by carnitine palmitoyltransferases. Acetyl-CoA carboxylase and Fatty acid synthase were determined using [1-^{14}C] acetyl-CoA incorporation methods.

Results and Discussion

There was no difference in fat content among the diets (Table 1). The content of linoleic acid in diets decreased as the amount of CLA increased. The level of linolenic acid in CLA diets was lower, but that of oleic acid was higher than control. The major CLA isomers present in diets were *cis*-9, *trans*-11 and *trans*-10, *cis*-12 isomers. Triglyceride level in plasma significantly increased with CLA diets (Table 2). Dietary CLA also increased plasma cholesterol level in broiler, which was unexpected. Total cholesterol level in plasma increased from 126.3 mg/dL with control diet to 152.9 and 170.4 mg/dL with 2% and 3% CLA diets, respectively, and the increase was mainly due to the increase in VLDL- and LDL-cholesterol. Up to 1% of dietary CLA did not influence plasma triglyceride and cholesterol levels in broiler chicks.

A significant increase in fatty acid synthase activity and an increase (but not significant) in acetyl-CoA carboxylase activity in liver with CLA feeding were observed (Table 3). Acetyl-CoA carboxylase and fatty acid synthase are the main enzymes controlling fatty acid synthesis. The increase in the activity of fatty acid synthase could account in part for the increased triglyceride levels in plasma. These results indicate 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 overall fatty acid synthase and acetyl-CoA carboxylase measured in this study were quite low (Table 3) and this could be associated with high fat content in the diets due to 5% oil addition. There was no difference in the activity of carnitine palmitoyl-CoA transferases by CLA feeding (Table 3). Lipid content and fatty acid composition of liver are shown in Table 5. Liver weight increased as the level of dietary CLA increased (Table 4).

Dietary CLA decreased palmitoleic acid, linoleic acid, and arachidonic acid, while CLA isomers increased (Table 5). Significant difference in fatty acid composition of feces was found (Table 6). The content of CLA isomers in feces was much higher in CLA treated birds. While the content of linoleic acids in all treatments was similar, the linolenic acid was significantly higher in CLA treated groups. The content of linoleic and linolenic acids were more than 2 times lower in CLA diets than those in control diet (Table 1), but their contents in feces were similar for linoleic and even higher for linolenic acid in birds treated with CLA. This indicated that the ratio of excretion for linoleic and linolenic acids in birds of CLA diets could be much higher than those in control diet. This might be related to increased saturated fatty acid content in plasma and liver (Table 4).

In conclusion, this study showed that high level dietary CLA increased plasma triglyceride and cholesterol levels. The increase in triglyceride level could partially due to increased fatty acid synthase activity in liver. Dietary CLA decreased linoleic and arachidonic acid contents in liver and free fatty acids of plasma. There was no difference in crude lipid content of feces among chicken treated with different levels of dietary CLA. Despite the content of linoleic and linolenic acids in CLA diets were much lower than that of control diet, their content in feces was very similar or even higher than that of control.

Table 1. Crude fat content and fatty acid composition of diets (4 to 5 week).

Fatty acid	0% CLA	2% CLA	3% CLA
Crude fat content	8.72	8.68	8.45
Fatty acid composition			
Palmitoleic	0.32[b]	0.34[a]	0.37[a]
Palmitic	13.71[a]	9.43[b]	8.12[c]
Stearic	4.62[a]	2.76[b]	2.39[c]
Linoleic	46.45[a]	21.47[b]	15.14[c]
Oleic	30.96[b]	33.02[a]	33.37[a]
Linolenic	3.77[a]	1.67[b]	1.34[c]
CLA (*cis9, trans11*)	0[c]	9.20[b]	11.23[a]
CLA *(trans10, cis12*)	0[c]	11.69[b]	14.02[a]
CLA *(trans9, trans11)*	0[c]	4.88[b]	5.87[a]
Other CLA isomers	0[c]	5.04[b]	7.14[a]

Table 2. Plasma triglyceride, total cholesterol, and HDL cholesterol content of broilers .

	0% CLA	2% CLA	3% CLA
Triglyceride	42.1[b]	49.8[a]	50.2[a]
Total cholesterol	126.3[c]	152.9[b]	170.4[a]
HDL cholesterol	38.2[b]	46.8[a]	48.3[a]
Calculated LDL+VLDL chol.	88.2	106.8	122.1

Table 3. The activities of selected enzymes related to fatty acid metabolism in livers.

Enzymes	0% CLA	2%CLA	3% CLA
Fatty acid synthase	0.38[b]	0.46[a]	0.46[a]
Acetyl-CoA carboxylase	2.97	3.46	3.84
Carnitine palmitoyl-CoA transferase	11.41	11.99	12.24

Table 4. Weight, crude fat content, cholesterol content, and fatty acid composition of liver.

Fatty acid	0% CLA	2% CLA	3 % CLA
Liver weight	62.1[b]	64.2[b]	70.9[a]
Crude fat content	3.8	3.6	4.2
Fatty acid composition			
Myristic	0.23	0.19	0.19
Palmitoleic	0.65[a]	0.32[b]	0.55[a]
Palmitic	18.02[c]	21.46[b]	24.34[a]
Margaric	0.23[a]	0.20[b]	0.18[b]
Linoleic	25.47[a]	18.97[b]	15.02[c]
Oleic	21.29[a]	18.57[b]	15.84[c]
Stearic	12.56[c]	19.39[b]	25.05[a]
Linolenic	1.40[a]	1.22[b]	0.81[c]
CLA (*cis9, trans11*)	0[c]	1.28[b]	2.01[a]
CLA *(trans10, cis12*)	0[c]	1.86[b]	2.58[a]
CLA *(trans9, trans11)*	0[b]	0.59[a]	0.71[a]
Other CLA isomers	0[c]	0.81[b]	1.12[a]
Arachidonic	11.07[a]	8.78[b]	6.01[c]
Eicosapentaenoic	0.52[a]	0.45[a]	0.25[b]
Docosahexaenoic	2.80[a]	2.01[b]	0.95[c]
Unconfirmed	4.21	4.59	3.55

Table 5. The composition of free fatty acids in plasma (µg/mL plasma).

Fatty acid	0% CLA	2% CLA	3% CLA
Free fatty acid content	501.7	592.1	552.3
Individual Fatty acid content (µg/ml)			
Capric	3.1	2.9	3.0
Lauric	4.1	4.8	7.2
Myristic	2.7	3.6	3.8
Palmitic	133.8	163.9	163.0
Palmitoleic	10.8[a]	6.6[b]	6.0[b]
Stearic	78.3	105.4	99.6
Oleic	156.6	164.0	141.6
Linoleic	91.3[a]	90.1[a]	64.3[b]
CLA (*cis9, trans11*)	0[c]	13.2[b]	18.6[a]
CLA *(trans10, cis12*)	0[c]	13.8[b]	19.0[a]
CLA *(trans9, trans11)*	0[c]	4.7[b]	9.6[a]
Other CLA isomers	0[c]	5.8[b]	10.0[a]
Arachidonic	20.4[a]	13.3[b]	6.7[c]

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Table 6. Crude fat content and fatty acid composition of feces from broilers .

Fatty acid	0% CLA	2% CLA	3% CLA
Crude fat content	5.34	5.55	5.28
Fatty acid composition			
Myristic	0.17	0.12	0.16
Palmitoleic	0.21	0.27	0.26
Palmitic	14.08[a]	12.23[b]	11.44[c]
Margaric	0.20	0.13	0.10
Stearic	4.21[a]	3.06[b]	3.21[b]
Oleic	21.37	22.86	26.92
Linoleic	52.30[a]	45.47[b]	41.13[b]
Linolenic	0.90[b]	1.16[a]	1.33[a]
CLA (*cis9, trans11*)	0[c]	2.86[b]	4.85[a]
CLA *(trans10, cis12*)	0[c]	2.88	5.00[a]
CLA *(trans9, trans11)*	0[c]	1.48[b]	2.77[a]
Other CLA isomers	0[c]	1.23[b]	2.89[a]

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