DIETARY MEDIUM CHAIN TRIGLYCERIDE INCREASES LIVER PROTEIN SYNTHESIS IN CHICKS

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Summary

This influence of dietary medium chain triglyceride on liver protein synthesis in chicks was investigated using a large dose injection of L-[4-³H] phenylalanine. Dietary medium chain triglyceride increased liver weight and liver fat content of chicks compared to the long chain triglyceride group. Fractional synthesis rate of liver protein was increased by dietary medium chain triglyceride, which was accounted for not by elevating protein synthesized per unit RNA but by enhancing RNA: protein ratio.

(Key Words: Medium Chain Triglyceride, Protein Synthesis, Liver, Chicken)

Introduction

Some recent evidence provided that dietary medium chain triglyceride (MCT) affected growth, protein and energy utilization, and feeding behavior in the chicken (Furuse et al., 1992; Mabayo et al., 1992, 1993). Under the *ad libitum* feeding condition, dietary MCT reduced body weight gain, protein retention and energy retention in young chicks compared to dietary LCT, but the decrease in these performances was attributed to reduced food intake (Furuse et al., 1992). To eliminate the influence of reducing food intake by dietary MCT, Mabayo et al. (1993) applied equalized-feeding technique and showed that dietary MCT had the potency to improve protein retention and efficiency of protein utilization.

When chicks were given an equal amount of dietary energy, liver weight was increased by MCT supplemented in the diet at the expense of dietary LCT, and the increment was associated with an increase in both protein accumulation and fat deposition in the liver (Mabayo et al., 1993). However, there has been little evidence on the relationship between dietary MCT and liver

protein synthesis. In the present study, therefore, the experiment was conducted to investigate the influence of dietary MCT on liver protein synthesis in chicks.

Materials and Methods

Thirty day-old Single Comb White Leghorn male chicks from a local hatchery (Hattori Yokei Ltd., Nagoya, Japan) were maintained on a commercial chick mash diet (CP 21.5%, ME 12.1 kJ/g; Marubeni Siryoku Ltd., Tokyo, Japan) until 7 days of age in electrically-heated brooders. At this stage, eighteen birds of similar body weights were selected, and distributed into two experimental groups of nine birds each so that mean body weight, 76.4 (SE 0.37) g, was as uniform as possible. The birds were kept individually in metabolism cages under continuous illumination and ambient temperature was controlled at 29±2°C. Table 1 gives the composition of experimental diets. Corn oil and glyceryl tri-caprylate (Coconado RK®) from Kao Corporation, Wakayama, Japan, were used as the source of LCT and MCT, respectively. According to our previous reports (Furuse et al., 1992), food intake of chicks fed on an experimental diet containing MCT was decreased compared to LCT. Therefore, to eliminate the influence of the difference in food intake, chicks were given experimental diets under the equalized-feeding condition at the level of 120 g/10 days, which conditions were described previously (Mabayo et al., 1993).

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On day 10 (17 days of age), the birds were used for the measurement of liver protein synthesis, fractional synthesis rate of protein was measured using a large dose injection (Garlick et al., 1980) of L-[4-³H] phenylalanine via a wing vein (1 ml/100 g BW: 120 mM-phenylalanine, 1.48 MBq/ml in 0.15 M-NaCl). At 2 and 10 min after the isotope injection four and five birds in each treatment were killed by cervical dislocation, respectively. The livers were quickly removed from opened abdominal cavities and were placed in

ice-cold 0.15 M-NaCl. Liver samples were blotted, weighed, plunged into liquid N₂ for freezing and stored at -20°C.

The details of analytical procedures for the determination of protein synthesis were described by Garlick et al. (1980). Protein content in the liver was determined by the method of Lowry et al. (1951). Liver fat was extracted by the procedure of Folch et al. (1957) and measured gravimetrically. Liver RNA content was analyzed by the modified Schmidt-Thannhauser method as described by Munro and Fleck (1969).

The results were analyzed by ANOVA to determine the effect of MCT (SAS Institute Inc., 1985).

Results

Body weight gain, food intake and contents of protein, fat and RNA in the liver are shown in table 2. Body weight gain was affected by the difference in dietary triglyceride sources. Dietary MCT increased liver weight compared to dietary LCT. There was no significant difference in protein contents of the liver between MCT and LCT groups. Liver fat retained in chicks fed the MCT diet was greater than that of LCT group.

Fractional and absolute protein synthesis rates, RNA: protein ratio and protein synthesized per unit RNA are presented in table 3. Fractional synthesis rate of liver protein in the MCT group was significantly higher than that in the LCT group. Absolute synthesis rate of liver protein tended to increase similarly to fractional synthesis rate without significant difference between both

TABLE 1. COMPOSITION OF EXPERIMENTAL DIETS

Ingredient	Long chain	Medium chain
	triglyceride	triglyceride
	(g/kg)	
Isolated soybean protein	226	
Mineral mixture ¹	58.8	
Vitamin mixture ¹	2	
Choline chloride	1.5	
L-Methionine	2.9	
Inositol	1	
Glycine	4.2	
L-Threonine	1.2	
Cellulose	100	
Corn starch	435.4	380.4
Corn oil	167 ³	42
Coconado RK ^{®2}		180 ³
Calculated ME (kJ/g)	16.4	16.4

¹ Furuse and Okumura (1989).

² Coconade RK[®], glyceryl tricaprilate (Donated by Kao Corp., Wakayama, Japan).

³ ME, LCT 37.5 kJ/g (Scott et al., 1982); MCT 30.7 kJ/g (Furuse et al., 1992).

TABLE 2. INFLUENCE OF DIETARY MEDIUM CHAIN TRIGLYCERIDE ON BODY WEIGHT GAIN, LIVER WEIGHT AND CONTENTS OF PROTEIN, FAT AND RNA IN THE LIVER OF CHICKS

	Diet		Pooled SEM
	Long chain triglyceride	Medium chain triglyceride	
Body weight gain (g/10 d)	73.0 ^a	76.0 ^b	0.81
Liver weight (g)	3.62 ^a	4.72 ^b	0.13
Liver protein (mg)	743	779*	36.5
Liver fat (mg)	169 ^a	228 ^b	13.1
Liver RNA (mg)	27.8 ^a	37.0 ^b	1.97

^{a,b} Means not sharing a common superscript letter within the same row are significantly different at $p < 0.05$.

* One missing value.

MEDIUM CHAIN TRIGLYCERIDE AND LIVER PROTEIN SYNTHESIS

TABLE 3. INFLUENCE OF DIETARY MEDIUM CHAIN TRIGLYCERIDE ON PROTEIN SYNTHESIS, RNA:PROTEIN RATIO AND PROTEIN SYNTHESIZED PER UNIT RNA IN THE LIVER OF CHICKS

Diet	Long chain triglyceride	Medium chain triglyceride	Pooled SEM
Fractional protein synthesis rate (%/day)	83.1 ^{a*}	113.7 ^{b*}	7.2
Absolute protein synthesis rate (mg/day)	622*	824**	71
RNA: protein ratio	37.4 ^a	46.5 ^{b*}	2.0
Protein synthesized per unit RNA (mg/day/mg RNA)	22.0*	23.9**	2.5

^{a,b} Means not sharing a common superscript letter within the same row are significantly different at $p < 0.05$.

* One missing value.

** Two missing values.

groups. There was significant increase in RNA:protein ratio in chicks fed the MCT diet. However, dietary MCT did not affect protein synthesized per unit RNA in the liver of chicks.

Discussion

It has been well known that liver is the main site of fatty acid synthesis in the chicken (Leveille et al., 1968; O'Hea and Leveille, 1969), and liver fat content is regulated by both fat synthesis and fat degradation, including fat transport from liver to other tissues. Kritchevsky and Tepper (1965) have reported increased fatty acid synthesis in liver slices of MCT fed rats. The present increase in fat accumulation in the liver could either have been due to increased fatty acid synthesis or to decreased fat outflow from the liver.

It has been reported that dietary MCT improved efficiency of protein utilization in chicks (Furuse et al., 1992; Mabayo et al., 1993). As shown in table 3, liver protein content of chicks given dietary MCT was slightly higher, but not significantly, than that of LCT, which was in line with the previous study by Mabayo et al. (1993). Fractional synthesis rate of liver protein in chicks given LCT (83 %/day), was similar to our previous results (Muramatsu et al., 1983; Kita and Okumura, 1993). When chicks fed the MCT diet, however, fractional synthesis rate of liver protein, (114 %/day), was significantly higher than that of LCT. It has been observed that medium chain fatty acids were absorbed better than long chain fatty acids in the chicken (Renner and Hill,

1961), and Greenberger et al. (1966) reported that MCT can be easily hydrolyzed and absorbed from the intestine in the rat. Kita et al. (1989) reported that whole-body protein synthesis in the chicken given normal energy intake was higher than that under the energy-restricted condition, since protein synthesis is known as an energy-required process (Buttery and Boorman, 1976). In the present study, therefore, the effect of MCT diet to increase the fractional synthesis rate may be the result of increased energy availability due to higher absorption (Rennie and Hill, 1961) as Kita et al. (1989) showed protein synthesis in the chicken was related to energy intake. However, The detailed mechanism of the enhanced protein synthesis by dietary MCT remained to be elucidated.

To explain the alteration of fractional synthesis rate of protein, the parameter can be divided into two other parameters, i.e. RNA:protein ratio and protein synthesized per unit RNA (Waterlow et al., 1978). As shown in table 3, however, the increase in fractional synthesis rate by MCT treatment was not mainly accounted for by the change in protein synthesized per unit RNA but by the increase in RNA:protein ratio. The increased fractional synthesis rate of liver protein due to enhanced RNA:protein ratio was also observed in chicks fed diets containing various levels of dietary protein (Kita et al., unpublished results).

Net protein accumulation is definitely regulated by both protein synthesis and degradation. Furthermore, it has been well known that proteins

present in the liver consisted of two types of protein; one is fixed protein and the other is exported protein, and the outflow of protein from liver can become the regulator of liver protein mass. In the present study, as dietary MCT increased liver protein synthesis but did not affected net protein accumulation, dietary MCT would lead to the concomitant increase in protein degradation and/or outflow from liver. However, in the present study, this issue has not been clarified, and this remains to be studied in the future.

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