

## PROCEEDING

# Research on the nutritional characteristics of medium-chain fatty acids

Tosiaki Aoyama, Naohisa Nosaka, and Michio Kasai

*Central Research Laboratory, The Nisshin OilliO Group, Ltd., Kanagawa, Japan*

**Abstract :** Medium-chain fatty acids (MCFA) have attracted attention as part of a healthy diet, because they are absorbed and transported directly into the liver via the portal vein, metabolized rapidly by  $\beta$ -oxidation, and increase diet-induced thermogenesis. Because medium-chain triacylglycerols (MCT) containing only MCFA has a few weak points as frying oils, we have developed medium- and long-chain triacylglycerols (MLCT). MLCT is produced by lipase-catalyzed enzymatic transesterification. Recently, long-term clinical trials have demonstrated that MLCT and MCT result in less body fat-deposition. MLCT oil (Trade name : Healthy Resseta) is safe and can be substitute for common edible vegetable oils. Healthy Resseta has been approved as FOSHU (Food for Specified Health Use), by the Ministry of Health, Labour and Welfare of Japan in December 2002 for use as a cooking oil with a suppressing effect on body fat accumulation. Healthy Resseta is widely sold in Japan. *J. Med. Invest.* 54 : 385-388, August, 2007

**Keywords :** *edible oil, medium-chain fatty acids, nutrition*

## INTRODUCTION

Medium-chain triacylglycerols (MCT) were introduced into clinical nutrition in the 1950s for the dietary treatment of malabsorption syndromes because of their rapid absorption and solubility (1). MCT and long-chain triacylglycerols (LCT) are differently hydrolyzed and absorbed in the gastrointestinal system (Fig. 1). MCT are hydrolyzed rapidly to MCFA which are transported directly to the liver via the portal vein and oxidized to ketones. In contrast, LCT are absorbed via the intestinal lymphatic ducts and transported in chylomicrons through the thoracic duct into the systemic circulation (2, 3). It is probably due to this metabolic mechanism of MCT that makes them candidates for the dietary treatment of obesity (4).

Received for publication February 28, 2007 ; accepted March 20, 2007.

Address correspondence and reprint requests to Tosiaki Aoyama, Central Research Laboratory, The Nisshin OilliO Group, Ltd., Kanagawa, Japan and Fax : +046-837-2513.

## NUTRITIONAL CHARACTERISTICS OF MCFA

The dietary life of the Japanese has changed greatly with westernization, resulting in an increased fat-intake ratio and a higher incidence of lifestyle-related diseases and obesity. Obesity is closely related to lifestyle-related diseases such as hyperlipidemia, diabetes mellitus, and hypertension, and can cause heart failure or cerebrovascular disease (5, 6). A poor dietary life, particularly a high intake of fat, is considered to be an important causative factor of obesity and, thus, control of both the amount and type of dietary fat may help to prevent obesity.

Focusing on the metabolic properties of dietary fat, we have been investigating the effect of medium-chain fatty acids (MCFA), which have been researched since the 1950s, on preventing obesity. After absorption via the intestinal tract, MCFA are hydrolyzed more rapidly and metabolized more completely than long-chain fatty acids (2, 3). Because of these metabolic characteristics, MCFA have been considered to be less implicated in the accumulation of body fat (4). Until recently, however, suppression

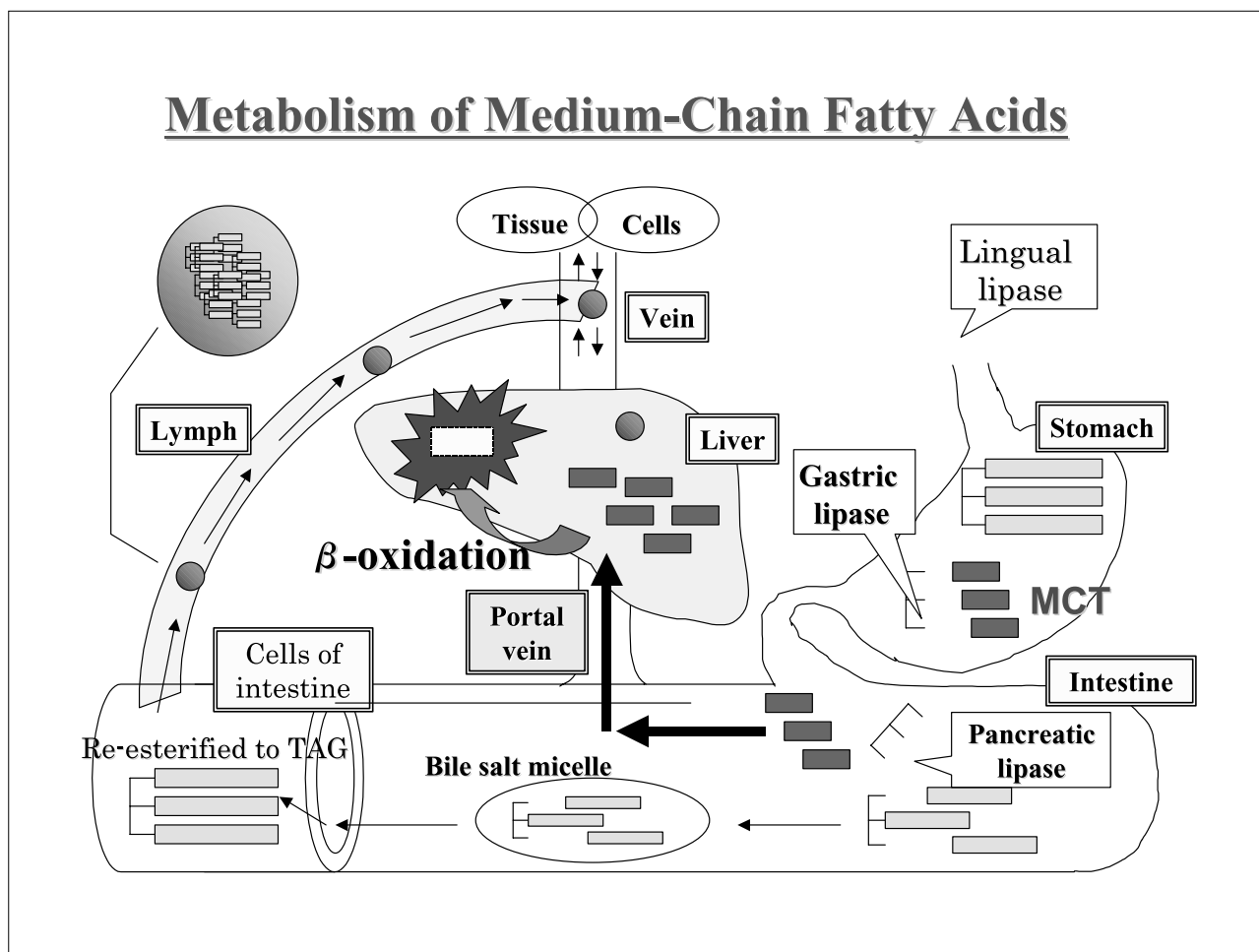


Fig. 1 The hydrolyzed and absorbed in the gastro-intestinal system of LCT and MCT.

of body fat accumulation by MCFA has not been proved in clinical studies. Therefore, we investigated (4) the effect of 12-week intake of MCT at a daily dose of 10 g on body fat accumulation and compared with those of an equivalent daily dose of LCT. There were no differences in the intake of total energy and fat before and during the study between a group receiving MCT and another receiving LCT. In subjects with a body mass index (BMI) of  $\geq 23$  kg/m<sup>2</sup>, body weight, body fat, abdominal subcutaneous fat, and waist and hip sizes were significantly reduced by MCT intake in comparison with LCT intake, suggesting that intake of MCT might be effective for preventing obesity in subjects with a high BMI.

The result of study on body fat accumulation using dietary MCT suggest that there is a difference in postprandial lipid metabolism between subjects with BMI  $\geq 23$  kg/m<sup>2</sup> and  $< 23$  kg/m<sup>2</sup>. Recently, the Japan Society for the Study of Obesity (JASSO) reported (7) a BMI 23 kg/m<sup>2</sup> indicates being overweight and can be used as an objective value in the treatment of obesity in Japan. In the light of these findings, the following study (8) was conducted to

clarify differences in the dynamics of postprandial serum lipids between two groups of subjects with BMI  $\geq 23$  kg/m<sup>2</sup> and  $< 23$  kg/m<sup>2</sup> after intake of MCT or LCT at a single dose of 10 g. We found that the response of triglyceride after LCT intake was greater for the subjects with BMI  $\geq 23$  kg/m<sup>2</sup> than for those with BMI  $< 23$  kg/m<sup>2</sup>. Furthermore, subjects with BMI  $\geq 23$  kg/m<sup>2</sup> showed a smaller triglyceride response after receiving MCT than after receiving LCT. Meanwhile, in the subjects with BMI  $< 23$  kg/m<sup>2</sup>, there was no difference in the triglyceride responses between the groups that received MCT and LCT. Furthermore, remnant-like lipoprotein cholesterol levels were lower in the subjects who received MCT than in those who received LCT (9). These results suggest that MCT intake is useful for treating diseases caused by lipid metabolism disorder, at least in subjects with a high BMI.

Although diet-induced thermogenesis (DIT) has been pointed out as a possible mechanism for the inhibition of body fat accumulation by MCT, the effects of MCT intake at daily doses of  $\leq 10$  g on postprandial thermogenesis have not yet been clari-

fied. Therefore, we also investigated (10) the difference in the response of DIT between subjects with BMI  $\geq 23$  kg/m<sup>2</sup> and  $< 23$  kg/m<sup>2</sup>, in view of difference in body fat accumulation between them. We found that MCT intake at a single dose of 5 - 10 g increased energy consumption more effectively than LCT intake. Thus, it is speculated that intake of MCT at a dose of 5 - 10 g enhances thermogenesis by activating the sympathetic nerves. On the other hand, there were no differences in the increase of energy consumption after intake of MCT between the groups with BMI  $\geq 23$  kg/m<sup>2</sup> and  $< 23$  kg/m<sup>2</sup>. Accordingly, it is suggested that there may be no differences in energy metabolism capacity resulting from MCT intake between obese and lean subjects. The change in energy consumption showed a characteristic time course in the subjects receiving MCT, reaching a peak 60 minutes after MCT intake, and being sustained for up to 300 minutes.

Our research group has also produced the new cooking oil, designed to solve problems such as smoke and foaming during deep frying. This oil has a structure consisting of triacylglycerol, which includes one or two molecules of MCFA. We investigated (11) whether a structured oil of medium- and long-chain triacylglycerols (MLCT) at a daily dose of 14 g could reduce the accumulation of body fat in healthy subjects. Subjects who received MLCT for 12 weeks were confirmed to show significant reductions in body weight, body fat weight, visceral fat, subcutaneous fat, and waist size, compared with subjects who received LCT. Intake of 14 g of MLCT results in digestion of 1.7 g of MCFA. Although this amount is small, it corresponds to about 8 times the mean daily-intake of MCFA, which is 0.2 g in Japanese people. Therefore, we consider that 2 g of MCFA might be an appropriate daily intake for improving lipid metabolism in Japanese. A daily intake of 14 g of MLCT is comparable to the daily amount used for cooking in Japanese households. Therefore, MLCT may be utilized as a special cooking oil for nutritional control in obese subjects.

From these results, we conclude that MCFA suppress body fat accumulation in Japanese with a high BMI of  $\geq 23$  kg/m<sup>2</sup>. In addition, it is suggested that intake of MCFA at a daily dose of 2 g is useful for suppressing body fat accumulation in Japanese people. With regard to the mechanism responsible for the suppressive effect on body fat accumulation, we found a detectable difference in the change of serum triglyceride levels between subjects with BMI  $\geq 23$  kg/m<sup>2</sup> receiving MCT and those receiving LCT.

Furthermore, intake of MCT at a daily dose of 5 - 10 g led to higher DIT compared with intake of LCT, irrespective of BMI value. Accordingly, the decreases in body weight and body fat weight following MCT intake in subjects with BMI  $\geq 23$  kg/m<sup>2</sup> might be due largely to the difference in LCT metabolism between these subjects and those with BMI  $< 23$  kg/m<sup>2</sup>. We consider that the difference in BMI greatly affects the oxidation and synthesis of fat in the liver and other tissues, thus, explaining the observed difference in the body fat accumulation.

## REFERENCES

- 1 Seaton TB, Welle SL, Wareko MK, Campbell RG : Thermic effect of medium-chain and long-chain triglycerides in man. *Am J Clin Nutr* 36 : 43-51, 1986
- 2 Babayan VK : Medium chain triglycerides and structured lipids. *Lipids* 22 : 417-420, 1987
- 3 Bach AC, Babayan VK : Medium-chain triglycerides : an update. *Am J Clin Nutr* 36 : 950-962, 1992
- 4 Tsuji H, Kasai M, Takeuchi H, Nakamura M, Okazaki M, Kondo K : Dietary medium-chain triglycerides suppress accumulation of body fat in a double-blind, controlled trial in healthy men and women. *J Nutr* 131 : 2853-2859, 2001
- 5 Abbasi F, Brown BW Jr, Lamendola C, McLaughlin T, Reaven GM : Relationship between obesity, insulin resistance, and coronary heart disease risk. *J Am Coll Cardiol* 40 : 937-943, 2002
- 6 Manson JE, Colditz GA, Stampfer MJ, Willett WC, Rosner B, Monson RR, Speizer FE, Hennekens CH : A prospective study of obesity and risk of coronary heart disease in women. *N Engl J Med* 322 : 882-889, 1990
- 7 Japan Society for the Study of Obesity, The Asia-Pacific perspective : redefining obesity and its treatment. *J Jap Soc Study Obesity* 6 : 15-20, 2000
- 8 Kasai M, Maki H, Nosaka N, Aoyama T, Ooyama K, Uto H, Okasaki M, Igarashi O, Kondo K : Effect of medium-chain triglycerides on postprandial triglyceride concentrations in healthy men. *Biosci Biotechnol Biochem* 67(1) : 46-53, 2003
- 9 Kasai M, Maki H, Suzuki Y, Nosaka N, Aoyama T, Inuzaka H, Okazaki M, Igarashi O, Kondo K : Effect of medium-chain triglycerides on postprandial concentrations of remnant-like particles

- (RLP) in healthy men. *J Oleo Sci* 52(4) : 197-204, 2003
- 10 Kasai M, Nosaka N, Maki H, Suzuki Y, Takeuchi H, Aoyama T, Ohra A, Harada Y, Okazaki M, Kondo K: Composition of diet-induced thermogenesis of foods containing medium-versus long-chain triacylglycerols. *J Nutr Sci and Vitaminol* 48(6) : 536-540, 2003
- 11 Kasai M, Nosaka N, Maki H, Negishi S, Aoyama T, Nakamura M, Suzuki Y, Tsuji H, Uto H, Okazaki M, Kondo K: Effect of dietary medium- and long-chain triacylglycerols (MLCT) on accumulation of body fat in healthy humans. *Asia Pacific J Clin Nutr* 12(2) : 151-160, 2003