Effect of Triacylglycerols Containing Medium- and Long-Chain Fatty Acids on Body Fat Accumulation in Rats

Hiroyuki TAKEUCHI*, Fumie KUBOTA, Megumi ITAKURA and Nobuo TAGUCHI

Division of Food Science, Research Laboratory of Nisshin Oil Mills, Yokosuka, Kanagawa 239-0832, Japan
(Received November 3, 2000)

Summary Effect of triacylglycerols containing medium- and long-chain fatty acids (TML) on body fat accumulation was studied in rats. Male Wistar rats were fed an experimental diet containing 25% soybean oil or TML for 6 weeks. The food intake for 6 weeks did not significantly differ between the two diet groups. However, the perirenal and mesenteric adipose tissue weight and carcass fat content were significantly lower in the TML diet group than in the soybean oil diet group. The epididymal adipose tissue weight and liver triacylglycerol content did not significantly differ between the two diet groups. The digestibility of dietary fat did not significantly differ between the two diet groups. These results suggest that an intake of TML decreases body fat accumulation compared to an intake of soybean oil in rats.

Key Words body fat accumulation, triacylglycerols containing medium- and long-chain fatty acids, dietary fat, transesterification, rats

Medium-chain triacylglycerols (MCT) are edible oils that consist of C8 and C10 saturated fatty acids. MCT were introduced to clinical nutrition in the 1950s for dietary treatment of malabsorption syndromes caused by rapid absorption (1). MCT were metabolized differently from long-chain triacylglycerols (LCT). Quite a few animal experiment studies have provided evidence that MCT diets lead to less body fat deposition compared to LCT diets (2-7). These results suggest that substitution of MCT for LCT in dietary fat could reduce dietary obesity if energy intake remained constant (1). MCT may have such a strong point, but utilization of MCT as cooking oil is limited. MCT are not good for high-temperature cooking because of the lower smoking temperature.

Triacylglycerols containing medium- and long-chain fatty acids (TML) are lipids that contain medium- and long-chain fatty acids in the same triacylglycerol, and are made by transesterification of MCT and LCT. The smoking temperature of TML is higher than physical mixtures of MCT and LCT. TML are superior for high-temperature cooking to physical mixtures of MCT and LCT.

From the 1980s, studies have dealt with the effect of dietary TML on safety and whole body lipid oxidation. TML were rapidly oxidized compared with LCT in post-operative patients and were not associated with any side effects (8). Recently, we have demonstrated that total energy expenditure was higher after TML ingestion than after LCT ingestion in healthy young women (9). TML may have potential for dietary prevention of obesity. The present study, therefore, was designed to determine the effect of dietary TML on body fat accumulation in rats.

Materials and Methods

Soybean oil, MCT and rapeseed oil were purchased commercially (Nisshin Oil Mills, Tokyo, Japan). TML were prepared by transesterification of 200 g of MCT and 800 g of rapeseed oil (Fig. 1). Compositions of triacylglycerol and fatty acid of the test oils are given in Table 1. Smoking temperature of MCT, rapeseed oil, physical mixtures (MCT and rapeseed oil) and TML are 143, 230, 160 and 210°C, respectively.

The experimental plan was approved by the Laboratory Animal Care Committee of the Research Laboratory, Nisshin Oil Mills. Sixteen male 7-week-old Wistar rats were obtained from Japan SLC (Hamamatsu, Japan) and randomized into two groups. Rats were fed a purified high fat diet based on soybean oil or TML. Experimental diets contained the following ingredients (g/kg diet): corn starch, 250.944; casein, 254; sucrose, 100; soybean oil, 30; cellulose, 50; AIN-93 G mineral mix (10), 45; AIN-93 vitamin mix (10), 13; L-Cystine, 3.8; choline bitartrate, 3.2; tert-butylhydroquinone, 0.056 and test oil, 250. Rats were individually housed in stainless steel wire-cages and kept in a room at a controlled temperature (22±2°C) and humidity (50±10%), with light from 0800 to 2000 h. Each group of rats (n=8/group) was given free access to the experimental diet and water for 6 weeks. Feces were collected for the last 2 days of feeding. At the end of the feeding period, the rats were killed by decapitation after 5 h of food deprivation. Perirenal and mesenteric adipose tissue and epididymal adipose tissue were removed carefully using scissors and weighed. Carcass samples were...
Fig. 1. Preparation of triacylglycerols containing medium- and long-chain fatty acids (TML). After 800 g of rapeseed oil and 200 g of medium-chain triacylglycerols were mixed, TML were prepared by transesterification using sodium methoxide as a catalyst. TML were bleached by adding activated clay and deodorized by steam distillation. 

Table 1. Triacylglycerol and fatty acid compositions of the test oils.

| Triacylglycerol composition (g/100 g) | Soybean oil | TML |
|--------------------------------------|-------------|-----|
| L, L, L                              | 100         | 38.4|
| L, L, M                              | —           | 44.2|
| L, M, M                              | —           | 15.9|
| M, M, M                              | —           | 1.5 |

| Fatty acid composition (g/100 g) | Soybean oil | TML |
|---------------------------------|-------------|-----|
| 8:0                             | —           | 14.4|
| 10:0                            | —           | 4.8 |
| 16:0                            | 10.5        | 3.2 |
| 18:0                            | 3.8         | 1.6 |
| 18:1                            | 23.6        | 49.2|
| 18:2                            | 54.2        | 17.9|
| 18:3                            | 7.6         | 8.9 |
| Others                          | 0.3         | —   |

Table 2. Effect of dietary triacylglycerols containing medium- and long-chain fatty acids (TML) on body weight, food intake, carcass, adipose tissue and liver.

| Measurement                                      | Dietary group |
|--------------------------------------------------|---------------|
| Initial body weight (g)                          | Soybean oil   | TML |
| Final body weight (g)                            | 167±3         | 167±3|
| Food intake (g/6 wk)                             | 316±6         | 306±5|
| Carcass weight (g)                               | 526±5         | 514±8|
| Carcass fat (g)                                  | 205±3         | 198±4|
| Carcass protein (g)                              | 32.2±1.5      | 26.0±1.1|
| Perirenal and mesenteric adipose tissue weight (g)| 42.6±0.6      | 41.8±0.9|
| Epididymal adipose tissue weight (g)              | 15.0±1.0      | 12.1±0.6|
| Liver weight (g)                                 | 10.7±0.3      | 11.6±0.4|
| Liver triacylglycerols (mg/g wet)                | 24.1±3.2      | 31.3±4.4|

*a Values are means±SE (n=8).

Results and Discussion

Many studies reported that body fat accumulation was lower in animals fed MCT diets than in those fed LCT diets (2-7). However, there is little known concerning the effect of dietary TML on body fat accumulation. This study, therefore, was undertaken to examine the effect of dietary TML on body fat accumulation in rats.

Body weight, food intake, carcass weight, carcass protein content, carcass fat content and adipose tissue weight of the rats are shown in Table 2. The initial body weight, final body weight and food intake for 6 weeks did not significantly differ between the two diet groups. However, the carcass fat content was significantly lower in the TML diet group than in the soybean oil diet group. The carcass weight and carcass protein content were not affected by dietary fat. The perirenal and mesenteric adipose tissue weight was significantly lower in the TML diet group than in the soybean oil diet group. The carcass weight and carcass protein content were not affected by dietary fat. The epididymal adipose tissue weight was not affected by dietary fat. This results suggests that TML has a differential effect on fat accumulation between the perirenal and mesenteric adipose tissues and epididymal adipose tissue. Liver weight and liver triacylglycerol content of the rats are shown in Table 2. The liver weight and triacylglycerol content did not significantly differ between the two diet groups.

The feces weight and apparent digestibility of dietary fat in rats fed the soybean oil or TML diet are presented in Table 3. The feces weight and digestibility of dietary fat did not significantly differ between the two diet groups. These results indicate that the lower body fat accumulation in rats fed the TML diet may result from higher energy expenditure rather than lower energy in-
Table 3. Effect of dietary triacylglycerols containing medium- and long-chain fatty acids (TML) on feces weight and apparent digestibility of dietary fat.

| Measurement                        | Dietary group |
|------------------------------------|---------------|
|                                    | Soybean oil   | TML            |
| Feces dry weight (mg/d)             | 950±30        | 850±60         |
| Apparent digestibility of dietary fat (%) | 98.6±0.1      | 98.8±0.1       |

*Values are means±SE (n=8).

take. Sandström et al. reported that TML are associated with a higher fat oxidation than LCT in postoperative patients (8). Medium-chain fatty acids pass from mucosal cells of the intestine into the portal vein and are directly transported to the liver (14). Most medium-chain fatty acids are catabolized by mitochondrial beta-oxidation (15). Activity of beta-oxidation in mitochondria might be related to the mechanism of lower body fat accumulation in rats fed the TML diet (16, 17).

In conclusion, the perirenal and mesenteric adipose tissue weight and carcass fat content were significantly lower in rats fed the TML diet than in those fed the soybean oil diet. These results in this study suggest that an intake of TML decreases body fat accumulation compared to an intake of soybean oil in rats.

REFERENCES

1) Seaton TB, Well SL, Warenko MK, Campbell RG. 1986. Thermic effect of medium-chain and long-chain triglycerides in man. *Am J Clin Nutr* 44: 630–634.

2) Geliebter A, Torbay N, Bracco EF, Hashim SA, Van Itallie TB. 1983. Overfeeding with medium-chain triglyceride diet results in diminished deposition of fat. *Am J Clin Nutr* 37: 1–4.

3) Lavau MM, Hashim SA. 1978. Effect of medium chain triglyceride on lipogenesis and body fat in the rat. *J Nutr* 108: 613–620.

4) Schemmel R. 1976. Physiological consideration of lipid storage and utilization. *Am J Clin Nutr* 16: 661–670.

5) Travis D, Minenna A, Frier H. 1979. Effect of medium chain triglyceride on energy metabolism and body com-

6) Babu N, Bracco EF, Hashim SA. 1982. Enhanced thermogenesis and diminished deposition of fat in response to overfeeding with diet containing medium chain triglyceride. *Am J Clin Nutr* 35: 678–682.

7) Bray GA, Lee M, Bray TL. 1980. Weight gain of rats fed medium-chain triglycerides is less than rats fed long-chain triglycerides. *Int J Obes* 4: 27–32.

8) Sandström R, Hyltander A, Kornèr U, Lundholm K. 1995. Structured triglycerides were well tolerated and induced increased whole body fat oxidation compared with long-chain triglycerides in postoperative patients. *J Parenter Enteral Nutr* 19: 381–386.

9) Matsuo T, Oh-iwa M, Taguchi M, Takeuchi H. 1999. Effect of medium and long chain triacylglycerols (structured lipids) on post-ingestive energy expenditure in healthy young women. *EASEB J* 13: A901.

10) Reeves PG, Nielsen FH, Fahey GC Jr. 1993. AIN-93 purified diets for laboratory rodents: Final report of the American Institute of Nutrition ad hoc writing committee on the reformulation of the AIN-76A rodent diet. *J Nutr* 123: 1939–1951.

11) Mickelesen O, Anderson AA. 1959. A method for preparing intact animals for carcass analysis. *J Lab Clin Med* 53: 282–290.

12) Murui T, Yoshikawa M, Takeuchi H, Fujii S, Mizobuchi H, Takeuchi H. 1994. Effects of sterolglycosides from soybean on lipid indices in the plasma, liver, and feces of rats. *Biosci Biotech Biochem* 58: 494–497.

13) Takeuchi H, Nishioya Y, Fujishiro M, Muramatsu K. 1987. Physiological effects of nondialyzable melanoidin in rats. *Agric Biol Chem* 51: 969–976.

14) Bach AC, Babayan VK. 1982. Medium-chain triglycerides: an update. *Am J Clin Nutr* 36: 950–962.

15) Papamandjaris AA, MacDougall DE, Jones PJH. 1998. Medium chain fatty acid metabolism and energy expenditure: obesity treatment implications. *Life Sci* 62: 1203–1215.

16) Surette ME, Whelan J, Broughton KS, Kinsella JE. 1992. Evidence for mechanisms of the hypotriglyceridemic effect of n-3 polyunsaturated fatty Acids. *Biochim Biophys Acta* 1126: 199–205.

17) Seydoux J, Giacobino J-P, Girardier L. 1986. Effect of nafenopin, a peroxisome proliferator, on energy metabolism in the rat as a function of acclimation temperature. *Pflügers Arch* 407: 377–381.