

Potential of Novel Oils for Health Benefits

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Despite the current attention on carbohydrates, fat remains an essential dietary component having important effects on cardiovascular health. Research accumulated over the past 40 or so years has revealed that most every class of fatty acids has effects on multiple cardiovascular risk factors such as blood lipids, hemostatic factors and platelet function, blood pressure, endothelial activation, and insulin secretion and activity.¹ This research has elicited specific diet recommendations not only for classes of fatty acids, such as saturated fatty acids, but also for individual fatty acids such as the *trans*, long-chain omega-3s, and for essential fatty acids, linoleic and linolenic acids, and their ratio.^{2,3}

In light of recent advances in oil and food technologies, there currently is great interest in understanding how modifying the structure of naturally occurring triglycerides can be used to improve its nutritional and health characteristics. Through controlled chemical and enzymatically catalyzed hydrolysis and reesterification, lipids can be custom-made with (and without) any fatty acid in any position on the glycerol backbone. These technologies provide the opportunity to replace conventional fats and oils in food products with fully functional and potentially healthier lipids. In fact, several food manufacturers have already developed and commercialized numerous fats and oils that are reduced in calories, have specific absorption characteristics, and/or provide optimum

levels of essential or bioactive fatty acids, while at the same time are reduced in total fat or saturated- or *trans*-fatty acid content. Because of the enormous potential for customization, only two examples of modified (or structured) lipids will be discussed: medium-chain triglycerides (MCT) and 1,3-diacylglycerol oils.

Historically, much of the interest in the use of modified and structured lipids has been in pre-term infant and parenteral and enteral nutrition to address metabolic disorders. For example, MCTs, which are synthesized lipids with fatty acids of 8 - 10 carbons derived from palm or coconut oils, have been developed for use as a source of rapid energy for patients with fat malabsorption-related diseases. These lipids are useful because effective absorption of MCTs—unlike typical long-chain triglycerides (LCTs)—does not depend on pancreatic lipases or bile salts; MCTs are thus more rapidly absorbed by the intestinal mucosa.⁴ After digestion, the bulk of MCTs are preferentially transported via the portal vein to the liver, where they are rapidly oxidized. In addition to being a useful dietary component for patients with fat malabsorption disorders, MCTs have been widely used clinically as a readily available source of energy for patients undergoing metabolic stress from burns, surgery, or trauma. Because they do not contribute to the formation of triglyceride-rich chylomicrons, they are also useful for patients with lipid disorders resulting from an inability to clear these postprandial lipoproteins.

Although MCT oils have been useful in nutritional modulation of metabolic diseases, they are rich in saturated fatty acids and deficient in essential fatty acids, which can limit their widespread use. To improve their nutritional profiles, novel structured triglycerides

combining both medium- and long-chain fatty acids have been developed. Of interest is that the digestion, absorption, and lymphatic transport of lipid and essential fatty acids from these structured lipids are observed to be improved when compared to a physical blend of oils having a similar fatty acid composition.⁵ The absorption of lipophilic compounds such as fat-soluble antioxidants also is enhanced, possibly because of a more efficient reesterification and packaging of chylomicrons. Based on these characteristics, these structured lipids could provide an opportunity to optimize the delivery of key essential or bioactive fatty acids and fat-soluble vitamins.

Currently, there is interest in understanding whether MCTs could be useful in the prevention or treatment of obesity. Although they provide a significant amount of calories (~8.4 kcal/g), the fatty acids from these triglycerides do not circulate in chylomicrons and are thus not available for hydrolysis and uptake directly into peripheral tissues or adipose. As a result of this metabolism, animal studies have shown that accumulation of body mass and body fat can be reduced during long-term feeding of MCT vs LCT without energy restriction.⁶ In humans, total energy expenditure and fat oxidation also has been shown to be substantially higher during the period after consumption of MCT vs LCT, and there also is data showing that chronic (4 week) feeding of MCTs may enhance the oxidation of other fatty acids present in the diet. However, the effects of chronic feeding of MCTs on body weight have been disappointing in longer-term feeding studies (4 weeks), although total energy expenditure or fat oxidation is demonstrably higher after subjects consumed diets rich in MCT compared to LCT.⁷ Because most of these studies were conducted with subjects

consuming diets designed to maintain weight, it is possible that the full utility of MCTs as adjuncts to weight-reducing diets has not yet been fully explored.

Another example of a modified lipid with potential to help in weight-controlled diets is 1,3-diacylglycerol. Diacylglycerols are lipids having 2 fatty acids on a glycerol backbone, in contrast to 3 fatty acids for a triglyceride. Although they are found in small quantities in most edible oils, oils containing an increased level of 1,3-diacylglycerols have been produced commercially. Because the primary structure of the 1,3- diacylglycerol lacks a key single fatty acid in the glycerol backbone (specifically, the SN-2 position), a portion of the ingested fatty acids are shunted away from reassembly into TG-rich chylomicrons and are directed through the portal blood system to the liver where they are oxidized.⁸ In this regard, 1,3- diacylglycerol is metabolized in part like MCTs.

Studies with animals and humans have demonstrated reductions in post-meal blood triglycerides after consumption of 1,3-diacylglycerol oil when compared to an equivalent level of dietary triacylglycerol,^{9,10} which is consistent with a non-lymphatic transport metabolism. However, the magnitude of the reduction in blood triglycerides has been ~25 % of that of triglycerides, thus, a portion of the long-chain fatty acids do circulate systemically. However, like MCTs, studies in animals and humans have also demonstrated modest increases in fat oxidation and reductions in body weight gain and/or fat accumulation after chronic consumption of 1,3-diacylglycerol oil compared to triglyceride oil. Most importantly, long-term consumption of this oil has been demonstrated to provide added benefit to a weight-reducing diet in which obese subjects who consumed diets in which diacylglycerol oil replaced a portion of triglyceride had

greater total body weight and body fat reductions compared to a control group consuming similar diets with no diacylglycerol oil.¹¹ Although the difference in body weight in the two was modest, the results do suggest that this oil could be useful as an adjunct to diet therapy in the management of obesity.

These are just a few examples of novel lipids that are already being designed to replace conventional fats and oils in food products, to give functionality with health benefits. With current and emerging technologies, there is great opportunity to customize dietary lipids based on the requirements for individual fat components by different segments of the population and to meet a specific nutritional need. It is also clear that because these alterations may also alter a triglyceride's functional and physical properties, it is important to be able to fully understand their potential to significantly alter the process of digestion, absorption, and lymphatic transport and the subsequent health benefits of the new lipid.

References

1. Kris-Etherton, et al: Summary of the scientific conference on dietary fatty acids and cardiovascular health. Conference summary from the nutrition committee of the American Heart Association. *Circulation* 1002;103:1034-1039.
2. Kris-Etherton PM, Harris WS, Appel LJ, et al: Omega-3 fatty acids and cardiovascular disease: new recommendations from the American Heart Association. *Arterioscler Thromb Vasc Biol* 2003 Feb 1;23(2):151-152.
3. Food and Nutrition Board, Institute of Medicine. Dietary Reference Intakes for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids (Macronutrients). Washington, D.C: National Academy Press, 2002.
4. Guillot E, Lemarchal P, Dhorne T, et al: Intestinal absorption and liver uptake of medium-chain fatty acids in non-anaesthetized pigs. *Br J Nutr* 1993;69:431-442.
5. Tso P, Lee T, DeMichele, SJ: Lymphatic absorption of structured triglycerides vs physical mix in a rat model of fat absorption. *Am J Physiol* 1999;277:G333-340.
6. St-Onge MP, Jones PJH: Physiological effects of medium-chain triglycerides: potential agents in the prevention of obesity. *J Nutr* 2002;132:329-332.
7. St-Onge M-P, Bourque C, Jones PJH, et al: Medium- versus long- chain triglycerides for 27 days increases fat oxidation and energy expenditure without resulting changes in body composition in overweight women. *Int J Obes* 2003;27:95-102.
8. Murata M, et al: Alteration by diacylglycerols of the transport and fatty acid composition of lymph chylomicrons in rats. *Biosci Biotech Biochem* 1994;58;1416-1419.

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9. Taguchi et al. Double-blind controlled study on the effects of dietary diacylglycerol on postprandial serum and chylomicron triacylglycerol responses in healthy humans. *J Am Coll Nutr* 2000;19:789-796.
 10. Tada N, et al. Dynamics of postprandial remnant-like lipoprotein particles in serum after loading of diacylglycerols. *Clinica Chimica Acta* 2001;311:109-117.
 11. Maki K, Davidson MH, Tsushima R, et al: Consumption of diacylglycerol oil as part of a reduced-energy diet enhances loss of body weight and fat in comparison with consumption of a triacylglycerol control oil. *Am J Clin Nutr* 2002; 76:1230-1236.