Technical News Features

Medium Chain Length Fatty Acid Esters and Their Medical and Nutritional Applications

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ABSTRACT

Caprylic and capric acid esters and their applications in medical, nutritional and dietetic uses are described. Medium chain triglycerides (MCT) as a tool in the control of obesity, control in the cholesterol deposition in the tissues as well as a means of lowering serum cholesterol are cited as unique characteristics of such lipids. MCT as a source of quick energy and high energy is suggested as an alternative to the conventional fats and oils (LCT). Dietetic and nutritional application utilizing the unique characteristics of caprylic and capric acid esters is indicated as alternatives to conventional fats and oils. The mono-diglycerides of caprylic and capric acid as cholesterol dissolving agents in treating of patients having cholesterol gallstones is described to illustrate the unique solvency properties of such mono esters in medical applications. The possibility of such mono esters of di- and polyhydric alcohols to act as co-solvents for oil and water systems is suggested which can be applied in medical, pharmaceutical and allied fields. Structured lipids with a predominance of caprylic and capric acid to modify the properties of triglycerides is described for hyperalimentation uses as well as the special nutritional and dietetic needs.

A quarter of a century has passed since Hans Kaunitz (1) and coworkers began studies on tailor-made fats composed of essentially caprylic and capric acids. This team coined the terms MCT and LCT to differentiate between the medium chain length fatty acid triglycerides and the conventional fats and oils. Today, the terms have become accepted terminology in academic circles.

Much of the early history of the development work describing the human and animal studies on MCT has been discussed by Senior in his introductory remarks in the volume titled, *Medium Chain Triglycerides* (2) and by Babayan (3,4). Since then, the literature has proliferated to cover the various uses and applications of this unique lipid.

MCT has become an established treatment of a variety of malabsorption cases in which the patients are suffering from chyluria, steatorrhea, hyperlipoproteinemia and other related conditions. Greenberger and Skillman (5) and Kalser (6) have summarized contributions of many investigators who studied MCT. Many of the studies reconfirm and reiterate the initial findings of Kaunitz, Hashim, Van Itallie, Ahrens, Isselbacher, Kritchevsky and Iber and many other fine contributions both in animal and human studies.

In addition to the immediate medical application and success of its use for malabsorption cases, many applications of MCT developed because of its unique physical and chemical characteristics and the absorption, transport and metabolism differences of MCT from the conventional fats and oils. Patients of intestinal resection, coronary bipass, etc., are being given MCT for quick, easy caloric supplementation. Premature-infant feeding, childhood epilepsy and cystic fibrosis cases are being treated with MCT. The results have been most gratifying and establish MCT as a unique, unusual lipid which lends itself to many clinical uses. The significant features of MCT which have recently evolved appear to be the following: (a) MCT appears to be a useful tool in the control of obesity (7-10); (b) MCT appears to be a factor not only in the lowering of serum cholesterol, but also in the inhibition and/or limitation of cholesterol deposition in the tissues (11,12); (c) MCT appears to be a useful tool in providing quick energy, high energy, in both animals and humans (13-15); (d) MCT appears to be a useful tool in the feeding of newborn infants not only to assist their initial growth, but also to contribute to their physiological well being as they grow (16-19); and (e) MCT appears to be a useful tool in the treatment of childhood epilepsy (20-22).

The flurry of recent papers and the introduction of products for infant feeding and supplementation are all indicative of the great interest being generated in MCT as an ideal lipid in our diet. MCT appears to be a lipid which promises to have the favorable characteristics desired which are not found in conventional fats and oils. Caprylic and capric acid derivatives may well become the medical and nutritional specialties with the desirable requirements sought in good nutrition and good health.

Some MCT modifications hold promise for the future. Some years ago we suggested MCT be considered as the lipid for intravenous (I.V.) feeding solutions. The argument against its use that was presented at that time was that MCT would be absorbed too rapidly and cause a problem.

We subsequently suggested the use of lipids based on MCT and linoleate in varying ratios (23,24). One can insure the presence of essential fatty acid for supplying nutritional needs while slowing down the rate of absorption of the balance of the triglyceride molecule. The varying ratios of MCT to linoleate allows for the proper selection of the modification which best suits the application contemplated. Such tailor-made lipid structures composed of MCT and linoleate not only should serve as innovation in I.V. fat emulsions, but also be ideal for enteric hyperalimentation and allied applications. Typical compositions are given in Table I, illustrating the choice open to the physician and clinical investigator. Alternatives are possible using fatty

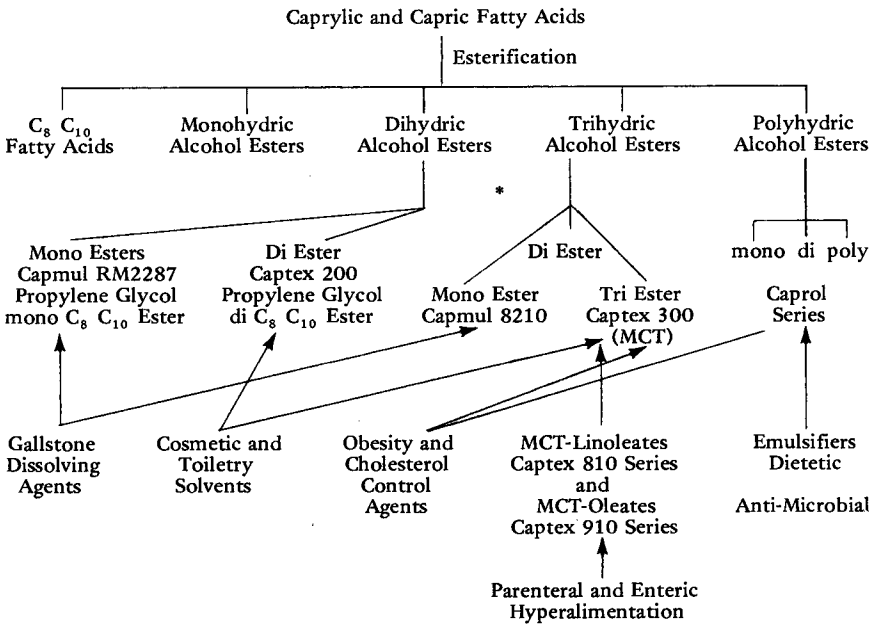
TABLE I

Captex 810 Series[a]

	Intravenous Injectable Oil Bases			
Typical data:	810A	810B	810C	810D
Linoleic %	10	25	35	45
Caprylic and capric %	80	60	46	32
Other fatty acids %	10	15	19	23
Free fatty acid %	0.04	0.04	0.04	0.04
Iodine value	20	51	71	91
Color (Gardner)	1	1	1	1
Flavor and odor	bland	bland	bland	bland

[a]Capital City Products, Columbus, Ohio

TABLE II



*Captex, Capmul and Caprol are products of Capital City Products, Columbus, Ohio

acids other than linoleic acid.

As another offshoot of MCT modifications, some years ago products were suggested which were essentially monoglycerides of medium chain length fatty acids (25). Such monoglycerides were capable of solubilizing both oil and water components. MCT monoglycerides are ideal for ampule work and could serve as a solubilizer and carrier for both oil and water soluble components. The product being germastatic and bacteriostatic enhanced the opportunities for preparing ampules which were sterilized easily and quickly and at lower temperatures. Such monoglycerides were also ideal solvents for aromatics, steroids, dyes and perfume bases. As such, they found applications and uses in the cosmetics and toiletries industries as well as the pharmaceutical field (26). Other mono esters such as the propylene glycol and polyglycerol derivatives have similar properties.

In recent years the mono-diglycerides of caprylic and capric acid (27) have found use in the dissolving of cholesterol gallstones in humans. The findings at Mayo Clinic (28) and at the University Hospital of the University of Wisconsin (29) have demonstrated the safe and efficient manner in which such products effectively dissolve gallstones. Much more needs to be done to explore the full possibilities of such edible products possessing unique medical applications. Extension of the use of such mono esters will no doubt occur not only in medical applications, but in other allied fields as well.

Table II schematically presents the groups of compounds which are presently being investigated in the edible, dietetic, medical and health care areas. Note that their functional versatility also makes them useful products for a host of applications in allied industrial areas. Antimicrobial agents, emulsifiers and solubilizers of oil and water systems are but a few of the areas in question.

Physicians, food scientists and clinical nutritionists must seriously consider the caprylic and capric acid esters and the modifications thereof as a real opportunity to find solutions for problems they face in such areas as obesity, artherosclerosis and health care. Such esters and the modifications thereof offer such an opportunity. MCT and MCT modifications cannot and must not be considered in the same parameters as conventional fats and oils (LCT), but as a unique class which behaves differently from such conventional lipids.

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Chemical and Physical Effects of Processing Fats and Oils[1]

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ABSTRACT

Soybean oil is processed for a variety of food uses, salad/cooking oil, margarine and shortening. Crude soybean oil is composed mainly of triglycerides but also contains measurable amounts of minor constituents that may have beneficial or detrimental effects on oil characteristics. The nature of these minor constituents, the role they play in oil stability or deterioration and their fate during processing are subjects of this review. Iodine value, fatty acid composition, solid fat index and congeal point are chemical and physical characteristics of oil that are affected by the hydrogenation process. Techniques and effects of degumming, alkali refining, bleaching, hydrogenation, winterization and deodorization are discussed. Utilization or disposal of by-products or wastes from each processing step is reviewed.

INTRODUCTION

In many countries, the major edible oils traditionally are consumed in a clean but unrefined form. Apart from hydrolysis, which releases free fatty acids, and oxidation, which causes rancidity, these oils are unaltered and any materials naturally present remain in the product. Examples of vegetable oils that are consumed in the unrefined state are peanut, coconut, rapeseed, mustard seed, palm, olive and sesame seed oils. However, processing crude oils to finished edible food products is practiced worldwide and is dictated by several factors: (a) consumer preferences, (b) flavor and stability characteristics of particular oils, and (c) preparation of hardened products from liquid vegetable oils, i.e., margarines and shortenings. These factors have lead to development of technological processes for treatment of crude oils to make them as bland and colorless as possible and for modification of the physical characteristics of the oils. The refining techniques consist of water or acid degumming, alkali refining, bleaching and deodorization. The refined oils and fats may be further processed by hydrogenation and winterization for different food uses. Each of these technological processes affects the nature of the oil; the character of these effects forms the basis of the current discussion.

In the United States soybean oil is the major vegetable oil used for production of edible food products. Significant quantities of cottonseed, corn, peanut, safflower and sunflower seed oils also are utilized in our domestic market. In general, the same technological processes are applied for the refining of all these oils with minor modifications based on the characteristics of the particular oil. Therefore, this paper will be directed to a consideration of processing soybean oil.

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Composition of Soybean Oil

The typical compositions of crude and refined soybean oils are given in Table I (1). The refining process does not affect the fatty acid composition of the glyceride but does essentially remove phosphatides and free fatty acids and lower the contents of some lesser constituents such as the tocopherols, the sterols and squalene (2). Also present in very small quantities are a number of other materials including waxes, pigments and minerals. Waxes are the esters of long chain fatty alcohols and acids that originate from seed coats. Although waxes are a minor consideration with soybean oil, other oils such as sunflower seed, corn, safflower and sesame contain sufficient amounts of waxes (0.2-3.0%) to require their removal by a special dewaxing (3). One of the more prevalent pigments is β-carotene, which is the most important of the provitamins A. When present in higher concentration, β-carotene is also responsible for the red color of palm oil. Hydrogenation and high-temperature deodorization destroy the chromophore groups of β-carotene. Chlorophyll is also present and gives a greenish cast to soybean oil after the removal of the yellow color of β-carotene during hydrogenation. If immature or freeze-damaged soybeans are used for oil extraction, the content of chlorophyll can be sufficient to cause color problems in producing a finished oil (4). Minerals present in trace amounts include phosphorus, sodium, iron and copper. Iron and copper have been shown to be active catalysts for the oxidation of soybean oil (5) and their removal or inactivation is essential for oil stability.

PROCESSING

The processing techniques employed to produce a finished edible oil from crude oils are outlined in the flowsheet shown in Figure 1.

TABLE I

Average Compositions for Crude and Refined Soybean Oil (1)

Component	Crude oil	Refined oil
Triglycerides, %	95-97	>99
Phosphatides, %	1.5-2.5	0.003-0.015
Unsaponifiable matter, %	1.6	0.3
Plant sterols, %	0.33	0.13
Tocopherols, %	0.15-0.21	0.11-0.18
Hydrocarbons (squalene),%	0.014	0.01
Free fatty acids, %	0.3-0.7	<0.05
Trace metals		
Iron, ppm	1-3	0.1-0.3
Copper, ppm	0.03-0.05	0.02-0.06