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A Review on Healthier Dietary Fats for Lower Calories in Take and Body Weight Control

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Authors' contributions

This work was carried out in collaboration among all authors. Author MAM designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors RSF and HAH managed the analyses of the study. Author AAN managed the literature searches. All authors read and approved the final manuscript.

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Review Article

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ABSTRACT

Obesity is a global problem and numbers are rising at a fast pace in developing countries and it becomes a major public health concern. Economic costs associated with obesity are high and increasing with the rate of obesity. Obesity is a state of body fat being accumulated in excess, and it is well known that many diseases including metabolic disorders, such as diabetes and hyperlipemia and diseases in circulatory organs Such as hypertension and ischemic cardiac diseases tend to follow obesity. The fat contained in meals is one of the nutrients most profoundly related to the accumulation of body fat, but the excessive ingestion of fat may result in obesity. However, fat has intrinsic taste, and meals of extremely reduced-fat are often insufficient to give Satisfaction. Further, when deep-fried food or fried food is made, edible oil is indispensable as a heating medium. The so-called fat substitutes were developed in the early 2000s for resolving such a situation. However, none of them are fully satisfactory in Safety, physical properties, cooking

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properties and flavor. This review will discuss the dietary fats that were developed for different food applications which are claimed as healthy oils with lower calorie intake than classical triglycerides oils which have a caloric content of average of 9 cal/gm and recommendations for optimum healthier and dietary for obesity and diabetic control and lower calories food.

Keywords: Dietary fats; body weight; hyperlipemia; diabetic control.

ABBREVIATIONS

FAs : Fatty acids
SFA C12–16 : Saturated fatty acids of carbon chain lengths, 12- 16 carbon atoms
TC : Total cholesterol, LDL-C: Low density Lipids- cholesterol
HDL-C : High density lipids
TFA : Trans fatty acids
MUFAs : Mono unsaturated fatty acids
PUFAs : POLY unsaturated fatty acids.
SCFAs : Short chain fatty acids (C4-6)
MCFAs : Medium chain fatty acids (C8-C14)
LCFAs : Long chain fatty acids (C16-C24).
MCTs : Medium-chain triacylglycerols
MLM : Medium-, long-, and medium-chain
MLCT : Medium, long chain triglycerides
N 435 : Novozym 435
RM IM : Lipozyme RM IM
TL IM : Lipozyme TL IM
PBR : Packed-bed reactor

1. INTRODUCTION

Fat is a major source of fuel energy for the body. It also aids in the absorption of the fat-soluble vitamins A, D, E, and K and carotenoids.

Dietary fat consists primarily (98 percent) of triacylglycerol, which is composed of one glycerol molecule esterified with three fatty acid molecules, and smaller amounts of phospholipids and sterols. Fatty acids are hydrocarbon chains that contain a methyl (CH3-) and a carboxyl (-COOH) end.

The fatty acids vary in carbon chain length and degree of unsaturation (number of double bonds in the carbon chain). The fatty acids can be classified into the following categories:

- Saturated fatty acids
- Cis monounsaturated fatty acids
- Cis polyunsaturated fatty acids
  — n-6 fatty acids
  — n-3 fatty acids
- Trans fatty acids

Since the 2008 Food and Agriculture Organization/ World Health Organization expert consultant report on fats and oils in human nutrition, of primary concern and importance was the potential relationship between total dietary fats and body weight (overweight and obesity), the metabolic syndrome and diabetes has emerged [1].

A lot of studies have been conducted on different edible oils either in pure form or in a simple blend form or chemical or enzymatic interesterified form or fractioned form or hydrogenated form. The target of those studies was either to reach a formula of higher oxidative stability during cooking and frying or to reach a formula with a most healthier effect on the human body compared to classical pure vegetable oils or oils blends.

Public concerns about obesity, cancer, and cardiovascular disease have increased our interest in minimizing the consumption of saturated fats and trans fats. These concerns have been a driving force in the lipid industry to develop fat-based ingredients that retain the physical, functional, and sensory features of traditional lipids and provide specific nutritional properties and health benefits.

Dietary fats intake has a major influence on the body weight and calories intake of the human body through the fats metabolism process. Fat and Fatty Acids Intake has the main impact on hypercholesterolemia and bad cholesterol levels in the bloodstream [2]. Decreasing the intake of SFA C12–16 and their replacement with oleic and linoleic acids lowers TC and LDL-C without lowering HDL-C and has a more favorable effect on the TC: HDL-C ratio than replacement with carbohydrate, particularly in overweight or obese populations. Also, it is recommended to replace the SFA rich oils like palm oil with vegetable oils rich in cis unsaturated fatty acids like soft oils (like Canola, High oleic Sunflower, soybean oil), which result in modest reductions in TC and LDL-C TFA have adverse effects on the TC: HDL-C ratio.

Some food applications require high-melting-point fats, so TFA containing fats has been replaced by Stearic acid-containing fats which appear to not affect the LDL-C or TC: HDL-C ratio. Thus, this need could be met by the use of fully hydrogenated vegetable oils interesterified with unhydrogenated fat, which results in the production of TAG with a significant proportion of stearic acid in the sn–2 position, or by blending with fats that have high melting points, such as palm oil.

There is possible evidence to suggest that long-chain n–3 fatty acids from fish origin like DHA may influence arterial stiffening and have favorable effects on endothelial function, Dietary fat intake has no clear effect on blood pressure, inflammation, fibrinolysis, or insulin sensitivity, whereas these risk factors are strongly influenced by obesity. Meals high in fat, however, cause postprandial lipaemia and may `promote atherosclerosis as well as having a potentially adverse influence on the risk of thrombotic events by way of effects on procoagulant activity and endothelial function.

- Concerning obesity, The association between total fat intake and saturated fat intake, and body weight remain inconclusive [3]. Interventional randomized studies comparing the Atkin's diet to other regimes – with a percentage of fat being the primary difference and similar overall intensity of intervention – tend to show a greater weight loss than lower-fat diets. Larger intervention studies suggest that lower dietary fat is associated with weight loss; Systemic studies of trials and meta-analyses suggest that diets lower in fat and with calorie restriction are associated with greater weight loss, but these interventions have typically been of limited duration or involved additional lifestyle changes (e.g. an increase in physical activity). Although many prospective cohort studies show a positive relationship between dietary fat intake and weight gain, these data are also inconclusive. There is insufficient evidence – due to the small number of studies – to determine whether there is a relationship between intake of MUFAs or PUFAs and body weight. There is insufficient evidence to determine the association between diabetes risk and intake of total fat or any particular type of fat. However, there are a sufficient number of studies that suggest that total fat and saturated fat intakes increase the risk of having components of the metabolic syndrome and that higher intakes of MUFAs and PUFAs have a beneficial effect in reducing this risk.

The medium-chain triglycerides (MCT) has been recommended as an edible oil for domestic uses with a suppressing effect on body fat accumulation has been proven clinically [4].

The mechanism of MCT is rapidly digested and absorbed and suppresses body fat accumulation.

The justification for that is that Medium-chain fatty acids (MCFA) with C6-C12 carbon chain length is more rapidly metabolized than LCFA(Long-chain fatty acids), due to its small size and greater solubility compared to long-chain fatty acid (LCFA), MCFA is transported directly to the liver via the portal vein to undergo beta-oxidation process producing ketones, thus providing a rapid source of energy [5].

However, MCT has disadvantages, low smoking point, and foaming in deep frying.

MLCT (medium &long chain fatty acids) have been developed to solve these problems.

MLCT also suppressed body fat accumulation by increasing energy expenditure.

The study of the impact of MLCT oils to reduce Body Fat and Blood Triacylglycerols in Hyper-triacylglycerolemic, Overweight but not Obese, Chinese Individuals showed that Intake of MLCT might help reduce body fat and levels of fasting blood TAG and LDL-C in hyper triacylglycerol emic and overweight Chinese subjects under an appropriate dietary regimen [6]. MLCT might be useful for the control of abnormal TAG metabolism and body fat accumulation in overweight subjects. However, a longer-term and larger sample size clinical trial is needed to confirm the substantial effects of MLCT in overweight and hyper triacylglycerol emic individuals.

The benefits of MLCT oil as functional oil that can prevent fat accumulation in our body. MLCT From the health benefits point of view, not only can provide us with nutritional properties from the essential fatty acids incorporated in the MLCT molecule but most importantly it can also help to reduce body weight and body fat accumulation in the body [6]. However, at least 12% of MCFA must be present in the product to see the beneficial effects. As such, including MLCT in our diet is one way to curb the increasing rise of worldwide obesity. Among the 3 enzymatic processes discussed, to produce structured MLCT fats which are interesterification, esterification, and acidolysis, esterification gave the highest yield of MLCT. Though it may be costly when produced on large scale due to the substrates used [6].

2. DISCUSSION

2.1 Low Calories Cooking Oils for Obesity Control Based on Structured Lipids

A high-fat diet where fats produce a relatively large amount of energy when metabolized, nine calories per gram, compared with four calories per gram for carbohydrates and proteins [7].

In humans, short-chain fatty acids (SCFAs) contribute to 3% of total energy expenditure, and these are more easily absorbed in the stomach and provide fewer calories than medium-chain fatty acids (MCFAs) and long-chain fatty acids (LCFAs) [8]. Thus, acetic, propionic and butyric acids have caloric values of 3.5, 5.0, and 6.0 kcal/g, respectively.

MCT does not accumulate in the fatty tissue and does not form a reserve fat and, unlike other triacylglycerols, they have lower caloric values. Thus, MCT is used as a source of easily available energy and a low-calorie product [9].

Although MCTs provide fewer calories than absorbable long-chain triacylglycerols (LCTs), need to be used with MCTs to provide balanced nutrition in enteral and parenteral products [10, 11].

The first MLCT that was produced and released to the market was produced by transesterification of canola oil and medium-chain TAG, and has been on the market in Japan as a ‘‘Food for specified health uses” since 2003 [12]. The typical Triacylglycerol composition of this MLCT oil is in Table 3.

Structured lipids are generally defined as triacylglycerols (TAGs) that have been modified by the incorporation of new fatty acids, restructured to change the positions of fatty acids, or synthesized to yield novel TAGs aiming at obtaining some desirable properties (Fig. 1) [13,14].

The structured lipids (SLs) are triacylglycerols (TAGs) that have been modified from their native form either biologically with enzymes such as lipase or chemically with sodium methoxide as a catalyst. They are designed for obtaining TAGs with improved functional properties with specific physical properties for food applications or medical and nutritional applications, especially to meet the growing need for healthier foods.

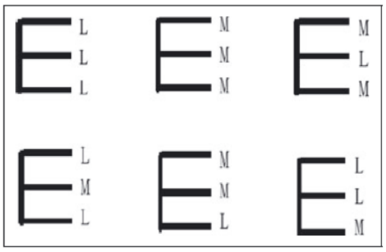

Fig. 1. Individual triacylglycerol molecules of MLCT conisists of glycerol backbone attached with long chain fatty acids (L)like linoleic (C18:2)acid or lenolinic acid (C18:3)and medium chain fatty acids (M) like capric fatty acid(C8) or capryic fatty acid (C10)

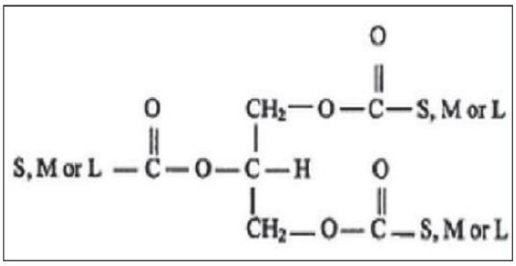

Fig. 2. General structure of structured lipids – S,M, L are referring to short chain fatty acids like butyric acid(C4) , medium chain fatty acids like capric/caprylic / lauric (C8/C10/C12) and long chain fatty acids like Stearic/Oleic / linoleic /linolenic fatty acids (C18/C18:1/C18:2/ C18:3)

Also, some structured lipids are studied to prevent obesity, cancer and cardiovascular diseases. Chemical and enzymatic interesterification modification methods are used for the development of those structured lipids which can be useful for diabetics, people who are trying to lose weight, and others concerned about maintaining a healthy diet. Modification of lipid can also be done to produce either zero or low calories lipid to cater to the growing consumers' interest in healthier food and to control the worldwide obesity problem.

These modifications will result in changes in fatty acid composition, fatty acid position in a TAG molecule, physicochemical properties such as melting properties, solid fat content (SFC), oxidative stability, iodine value, viscosity, and saponification number to enhance its functionality.

FDA had approved the use of different SLs, however EFSA (European Food Safety Authority) restricted the use of some SLs such as Olestra because of the potential health risks for some people who may be allergic to such products and may develop other health problems by using them.

The structured lipids are produced by either chemical or enzymatic reactions and different commercial products examples of structured lipids for different nutritional, medical uses and industrial applications have been produced on a commercial level and launched in the global market [15]. The first Low calories structured lipids MLCT oils were produced can be produced via the enzymatic process in 3 routes [6]:

(1) Interesterification
(2) Acidolysis
(3) Esterification

- Interesterification is the reaction between esters or TAG molecules. Different triglycerides oils.
- Acidolysis involved the exchange reaction between acyl moiety of acylglycerol and a free carboxylic acid.
- In the esterification process, the desired fatty acid (such as oleic acid, stearic acid, capric acid, and so on) is made to react with glycerol in the presence of the enzyme lipase.

The first commercialized MLCT was produced by Nisshin Oillio Group Ltd. (Japan) and is sold widely as cooking oil in Japan and United States with the name Resetta. It is stable for 30 min in 200 ◦C. which was not enough stability for shallow and deep frying applications for longer times [6].

The Enzymatic interesterification technique was used to prepare the first position-specific Low-Calorie Structured Lipids. By using immobilized sn-1,3-specific lipase from Rhizomucor miehei (IM 60) to catalyze the interesterification of tristearin (C18:0) and tricaprin (C10:0). Maximum Product yields were obtained from a 1:1 mole ratio of both triacylglycerols with 10% (w/w of reactants) of IM 60 in 3 mL hexane [16].

MLCT when blended with soybean or palm olein, can be used for cooking purposes especially frying. This is because, the presence of long-chain fatty acid from soybean oil and palm oleins such as oleic acid (C18), linoleic acid (C18:1), and linolenic acid (C18:3) increases the blended MLCT oil's smoke point. For example, the smoke point of MLCT blended with palm olein (225 ± 1.41^0 C) and soybean oil (229 ± 1.41^0 C) at a ratio of 1: 1 was much higher compared to the control, which is the unblended MLCT oil (210 ± 0^0 C) [17].

MLCT was less in heat stability for frying applications than normal cooking oils as palm olein, However, when MLCT was stabilized by adding with antioxidants m it has a higher thermal resistant oxidative strength (above 180^0 C) than RBD palm olein, lighter in color and lower free fatty acid content, thus having the characteristic required for deep frying oil. A sensory test showed that there is no difference in terms of taste and rancidity assessment in potato chips fried with MLCT oil and those with palm olein [8]. Rice bran oil structured lipid (RBOSL) consisting primarily of CA at the sn-1,3 position and oleic and linoleic acid at the sn-2 position can be used in frying sweet potato chip (SPC) at 165 to 185^0 C for 20 to 60 s. The color variable, smoke point, foaming ability, and γ -oryzanol concentration showed no significant difference between RBOSL and RBO after frying. However, RBOSL tends to have a lower viscosity and oil uptake compared to RBO after frying [18].

Enzymatic acidolysis of canola oil through caprylic acid was investigated to produce certain medium-chain Ttriacyliglycerol (TAG) structured lipids (SLs) [19].

The recent studies on the enzymatic synthesis of medium- and long-chain triacylglycerols has been summarized (in Table 1) [20].

Table 2 summarizes also the last studies on the enzymatic synthesis of low calories fat in the period of 2010-2014.

Structured lipid has been produced by a direct method from lauric based oil which is coconut oil through directed interesterification in two solvents, cellosolve, and acetone at 24% yield [21].

The physicochemical Properties and Sensory Attributes of Medium- and Long-Chain Triacylglycerols (MLCT)-Enriched Bakery Shortening was studied for six binary formulations of medium- and long-chain triacylglycerols (MLCT) fat and palm stearin and four ternary formulations of MLCT fat, palm stearin, and palm olein were produced.

Table 1. Recent studies (published between 2010 and 2014) on the enzymatic synthesis of medium and long-chain triacylglycerols (MLCTs)

Study	Product type	Reaction scheme	Reaction type	Enzyme	Reactor type
Caballero and others (2014)	MLM-type	Avocado oil + 8:0	Acidolysis	RM IM or TL IM	Cylindrical glass vessel
Ifeduba and Akoh (2014)	MLM-type	High-stearidonic soybean oil + 8:0	Acidolysis	*Rhizomucor miehei* lipase (immobilized on Celite powder, prepared in the laboratory)	Batch (undefined)
Qin and others (2014)	MLM-type	Soybean oil + 8:0	Acidolysis	*Geobacillus* sp. T1 lipase (free)	Batch (undefined)
Silroy and others (2014)	MLM-type	Mustard oil + 10:0	Acidolysis	TL IM	Batch (undefined)
Gokce and others (2013)	MLM-type	Echium oil + 12:0	Acidolysis	RM IM	30-mL reactor flask
Chen and others (2012)	MLM-type	Tricaprin + marine *n*-3 FA ethyl ester concentrate	Interesterification	RM IM	100-mL round bottom flask
Chnadhapuram and Sunkireddy (2012)	MLM-type	Palm olein + 8:0 and [illegible]	Acidolysis	RM IM	Batch (undefined; vacuum)
Choi and others (2012)	MLM-type	Step 1: Redistribution of FAs in pine nut oil Step 2: FAs-redistributed pine nut oil + 10:0	Interesterification (for step 1) Acidolysis (for step 2)	N 435 (for step 1) RM IM (for step 2)	50-mL Erlenmeyer flask (for step 1) PBR (column dimension: 7.62 cm × 4.8 mm i.d.; for step 2)
Nunes and others (2012)	MLM-type	Case 1: Olive oil + [illegible] Case 2: Olive oil + [illegible]	Acidolysis (for both cases)	*Rhizopus oryzae* heterologous lipase (immobilized on Eupergit C or Lewatit VP OC 1600, prepared in the laboratory)	Cylindrical glass vessel
Savaghebi and others (2012)	MLM-type	Canola oil + 8:0	Acidolysis	TL IM	Flask
Wang and others (2012)	MLM-type	Canola oil + 8:0	Acidolysis	RM IM	25-mL round bottom flask
Sengupta and Ghosh (2011)	MLM-type	Mustard oil + 10:0	Acidolysis	TL IM	PBR (column dimension: 50 cm × 10 mm i.d.)
Silroy and Ghosh (2011)	MLM-type	Case 1: Rice bran oil + [illegible] Case 2: Ground nut oil + 10:0 Case 3: Mustard oil + [illegible]	Acidolysis (for all cases)	N 435	Stirred-tank reactor
Foresti and Ferreira (2010)	MLM-type	Tripalmitin + 10:0	Acidolysis	RM IM	10-mL vial
Hamam and Budge (2010)	MLM-type	Fish oil + 10:0	Acidolysis	RM IM	PBR (column dimension: 16.2 × 2.5 cm^2 i.d.)
Jennings and others (2010)	MLM-type	Rice bran oil + 8:0	Acidolysis	RM IM	PBR (column dimension: 50 × 4.7 cm^2 i.d.)
Kim and others (2010)	MLM-type	Borage oil + 8:0	Acidolysis	RM IM or lipase from *Pichia lynferdii* NRRL Y-7723 (free)	25-mL Erlenmeyer flask
Ozturk and others (2010)	MLM-type	Corn oil + 8:0	Acidolysis	TL IM	30-mL Reaction flask
Yang and others (2014a)	Non-MLM-type	Soybean oil + MCTs	Interesterification	TL IM	50-mL round bottom flask PBR (column dimension: 20 cm × 11.5 mm i.d.)
Yang and others (2014b)	Non-MLM-type	Glycerol + 8:0, 10:0, and 18:1*n*-9	Direct esterification	N 435	250-mL three necked round bottom flask (vacuum)
Khodadadi and Kermasha (2014a)	Non-MLM-type	Flaxseed oil + tricaprylin	Interesterification	TL IM	30-mL reactor flask
Khodadadi and Kermasha (2014b)	Non-MLM-type	Flaxseed oil + tricaprylin	Interesterification	N 435	30-mL reactor flask
Bai and others (2013)	Non-MLM-type	Tricaprylin+	Interesterification	RM IM or N 435	50-mL Erlenmeyer flask

Table 1 continued…..

Study	Product type	Reaction scheme	Reaction type	Enzyme	Reactor type
Casas-Godoy and others (2013)	Non-MLM-type	Case 1: Olive oil + 8:0 Case 2: Olive oil + 10:0	Acidolysis (for both cases)	*Yarrowia lipolytica* lipase 2 (immobilized on Accurel MP1000, prepared in the laboratory)	Cylindrical glass tube
Khodadadi and others (2013)	Non-MLM-type	Flaxseed oil + tricaprylin	Interesterification	RM IM, TL IM, N 435 or Amano DF (free *Rhizopus oryzae* lipase, Amano, Japan)	30-mL reactor flask
Perignon and others (2013)	Non-MLM-type	Tricaprylin + trimyristin	Interesterification	*Thermomyces lanuginosus* lipase (immobilized on Immobead 150, Sigma–Aldrich, U.S.A.) or *Candida antarctica* lipase B (immobilized on macroporous resin, Sigma–Aldrich, U.S.A.)	Batch (undefined)
Kocak and others (2011)	Non-MLM-type	Terebinth fruit oil + 8:0 and 18:0			

Table 1 continued…..

Study	Product type	Reaction scheme	Reaction type	Enzyme	Reactor type
Casas-Godoy and others (2013)	Non-MLM-type	Case 1: Olive oil + 8:0 Case 2: Olive oil + 10:0	Acidolysis (for both cases)	*Yarrowia lipolytica* lipase 2 (immobilized on Accurel MP1000, prepared in the laboratory)	Cylindrical glass tube
Khodadadi and others (2013)	Non-MLM-type	Flaxseed oil + tricaprylin	Interesterification	RM IM, TL IM, N 435 or Amano DF (free *Rhizopus oryzae* lipase, Amano, Japan)	30-mL reactor flask
Perignon and others (2013)	Non-MLM-type	Tricaprylin + trimyristin	Interesterification	*Thermomyces lanuginosus* lipase (immobilized on Immobead 150, Sigma–Aldrich, U.S.A.) or *Candida antarctica* lipase B (immobilized on macroporous resin, Sigma–Aldrich, U.S.A.)	Batch (undefined)
Kocak and others (2011)	Non-MLM-type	Terebinth fruit oil + 8:0 and 18:0	Acidolysis	RM IM	Batch (undefined)

Table 2. Recent studies (published between 2010 and 2014) on the enzymatic synthesis of low-calorie fats / oils

Study	Product type	Reaction scheme	Reaction type	Enzyme	Reactor type
Bebarta and others (2013)	SLs containing MCFA and VLCFA	Case 1: Kokum fats + 10:0, 12:0, and 22:0 Case 2: Sal fats + 10:0, 12:0, and 22:0 Case 3: Mango fats + 10:0, 12:0, and 22:0	Acidolysis (for all cases)	RM IM	Batch (undefined, vacuum)
Cao and others (2013)	SLs containing SCFA	Triacetin + camellia oil FA methyl esters	Interesterification	RM IM or N 435	5-L round bottom flask
Kanjilal and others (2013)	SLs containing VLCFA	Case 1: Sunflower oil + 22:0 ethyl ester Case 2: Soybean oil + 22:0 ethyl ester	Interesterification (for both cases)	TL IM	Batch (undefined)
Lei and others (2013)	SLs containing SCFA and MCFA(MSM-type)	Step 1: glycerol + 8:0 → 1,3-dicapryloylglycerol Step 2: 1,3-dicapryloylglycerol + acetic anhydride (under reflux)	Direct esterification (for both steps)	RM IM (for step 1)	Round bottom flask (vacuum, for step 1) 5-mL round bottom flask (for step 2)

Table 3. Typical Triacylglycerol composition of first commercial MLCT oil

Fatty acid	Percent (%)
L-L-L	55.1
L-L-M or L-M-L	35.2
L-M-M or M-L-M	9.1
M-M-M	0.6

Table 4. Some commercial MLCT products

Brand name	Fatty acid profile	Application	Company
Caprenin	8:0-10:0-22:0	Candy bars and confectionary coating	Procter & Gamble
Captex	8:0-10:0 -18:2	Clinical application and cosmetic industry .	Abitec Corp.
Neobee	8:0-10:0-LCFA	Pharmaceutical in medical beverages or bars.	Stepan company
Impact	Randomized 12:0 and 18:2	Pharmaceutical	Novartis nutrition .
Laurical	12:0 and 18:1 ,18:2 , 18:3	Confectionery coating, coffee, whitener, whipped toppings and entrée fat.	Calgene Inc.
Structolipid	Mixture of 8:0 ,10:0,16:0, 18:0,18:1,18:2 and 18:3.	As rapid source of energy for critically ill patients.	Fresenius Kabl Parental nutrition
Resetta oil	8:0,10:0 and canola oil	Cooking oil and salad dressing	Nisshin Oillio

The fatty acid composition of the MLCT-enriched shortening formulations had a great influence on solid fat content and heating behaviors. Also, all MLCT based shortening formulations showing a high likability in sensory evaluation of the cake made by it and it had good sensory properties [22].

The short-chain triglycerides (SCT) were prepared on a pilot scale [23], to produce the low-calorie oil by transesterification of soybean oil and glycerol triacetate using sodium methoxide as the catalyst. The reaction conditions were optimized, and the yield reached 73.14% under these conditions. The calorific values of the soybean oil and the product were measured and the value for the latter was 32 450 J/g which was approximately 71% of the normal oil.

This method was the simplest and cost-effective published method for preparing low calories MLCT structured oil for bodyweight control. However, this work has the following drawbacks:

1- When it was repeated by the author of this review did not shows replications in results.
2- The 30% less caloric content claim has not yet been verified through any clinical studies.

Last, Table 4 summarizes the commercially launched MLCT with the fatty acid profile for low calories applications in a cooking application [24].

3. CONCLUSION

International concerns about the obesity and cardiovascular diseases have had driven all researchers and food scientist in last two decades to develop a new category of structural lipids which are not naturally present but its produced either through simple blending process of normal long-chain triglycerides oils (LCT) with Medium-chain triglycerides or synthesized through chemical or enzymatic interesterification between LCT and MCT oils or LCFA and MCFA, others examples to produce MLCT oils structured lipids of health benefits and lower in calories than normal triglycerides oils.

However, still, those efforts have not yet reached to the cost-effective healthier oil formula that can be used as healthier dietary cooking fats for lower calories in taking and body weight control. Further researches are still required to reach this cost-effective formula that can be used by domestic users for multipurpose cooking applications and can be commercialized in mid-tier cooking oil market consumers in the middle east.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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