

TRIACYLGLYCEROL (TAG) COMPOSITION, MANUFACTURING, AND USES THEREOF

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of priority of Singapore application No. 10202103950S, filed 16 April 2021, the contents of it being hereby incorporated by reference in its entirety for all purposes.

FIELD OF THE INVENTION

[0002] The invention relates to the field of fat composition, more particularly compositions containing triacylglycerols, manufacturing and uses thereof.

BACKGROUND OF THE INVENTION

[0003] Traditionally, butter is the key ingredient in many baked goods. It is considered as the gold standard for fats used in bakery applications. Due to the rising costs of milk-derived fats such as butter and clarified butter, there is an ever-increasing demand for economic alternatives.

[0004] First discovered in 1869 by a French chemist, margarine is an alternative solution to the rising cost of butter. Margarine is predominantly a water-in-oil emulsion, with the water phase dispersed evenly across a fat phase (typically made from vegetable oils) arranged in stable crystalline forms. Additives like emulsifiers, colourants and flavourings are added to margarine to mimic the organoleptic characteristics of butter. Shortenings are essentially margarines without the water phase and are typically considered to be alternatives to lard. Shortenings are solid at room temperature, and upon addition to dough, they can result in the shortening of the gluten strands, allowing baked products to achieve certain attributes, such as flakiness in puff pastries, crumbly texture in cookies, tenderness in chiffon cakes.

[0005] Margarines and shortenings have been the contemporary replacement of butter as the fat ingredient for many bakery applications. The advantages of margarines and shortenings are not only limited to their economic benefits, but also include the improved shelf-life, consistency in quality, and the flexibility to be customized according to market requirements. However, there are a few naturally occurring phenomenon in vegetable-based fats that may limit the applicability of margarines and shortenings. Common challenges for using margarines and shortenings in bakery applications include post-hardening and textural changes due to polymorphic transformation of the crystalline structures. These physicochemical changes occur primarily during storage, and can result in poor appearance (e.g. brittleness, crumbly

appearance) of the fat, as well as their reduced functionality (e.g. low baked volume, poor product texture) in bakery applications.

[0006] Triacylglycerols (TAGs) are compounds composed of one glycerol molecule ester bonded to three fatty acids. TAGs are predominant in the composition of edible fats such as margarines and shortenings. In the solid state, fats are molecularly packed to manifest in crystalline forms due to the physicochemical bonds between the TAGs. Due to the polymorphic behaviour of these crystalline forms, there are three specific polymorphs that are predominant, i.e. α , β and β' . For margarines and shortenings, it is important to maintain a final product crystal profile that is predominantly β' , due to this particular crystal form imparting a smooth and workable texture to margarines and shortenings. Over time and storage, there is a tendency for conversion from the β' crystal form to the β crystal form which imparts undesirable properties such as brittleness, graininess, increased hardness and reduced functionality to the bakery fats.

[0007] Current state of the art in the industry with regards to modifying the crystal form tendency/crystallization rate of specialty fats revolves around the use of hydrogenation (either partial or full) or interesterification (either chemical or enzymatic). Partial hydrogenation has been used for decades to control the specific physical and chemical characteristics of specialty fats and generally gives a product of excellent functionality. However, partial hydrogenation of fatty acids leads to the production of trans fatty acids (TFAs), the consumption of which would impose multiple risk factors for chronic diseases, including the misregulation of numerous blood lipids and lipoproteins, systemic inflammation, endothelial dysfunction, and possibly insulin resistance, diabetes, and adiposity. Thus, the World Health Organization (WHO) is trying to globally eliminate the use of partially hydrogenated oils in food products by 2023 according to their REPLACE action package. Full hydrogenation has thus come to the fore as an acceptable modification technique for specialty fats as it generates none of the TFAs of partial hydrogenation. This process generates hardstock fats that can be used in the production of bakery specialty fats. However, the main issue is that fully hydrogenated fats tend towards the undesirable β crystal form which must be dealt with in subsequent formulation or processing. Interesterification involves the re-arrangements of fatty acid residues between different TAG species. It can be either chemical (catalyst mediated) or enzymatic (lipase mediated). The chemical method can be either directed or undirected, but both involve high temperatures and harsh reaction conditions that might cause damage to reactants and products. Enzymatic interesterification is a lot milder, causing less thermal and chemical damage to reactants and products. However, as enzymatic interesterification involves a biological system,

the reaction conditions must be extremely tightly regulated. Hydrogenation (whether partial or full) and interesterification (whether chemical or enzymatic) therefore both share the same requirements for significant investments to operate.

[0008] Therefore, there remains a need for alternative ways to prevent polymorphic transformation of the crystalline structures of oil-based fats.

SUMMARY

[0009] In one aspect, the present disclosure refers to a composition comprising at least one triacylglycerol (TAG), wherein the at least one triacylglycerol comprises at least one odd chain fatty acid (OCFA).

[0010] In another aspect, the present disclosure refers to a fat composition comprising the composition as described herein.

[0011] In another aspect, the present disclosure refers to a bakery specialty fat comprising the fat composition as described herein.

[0012] In another aspect, the present disclosure refers to an animal-based product comprising the fat composition as described herein.

[0013] In another aspect, the present disclosure refers to an edible product comprising the fat composition as described herein.

[0014] In another aspect, the present disclosure refers to a cosmetic product comprising the fat composition as described herein.

[0015] In another aspect, the present disclosure refers to a prophylactic product comprising the fat composition as described herein.

[0016] In another aspect, the present disclosure refers to a method of producing a composition comprising at least 80% TAG containing at least one OCFA, the method comprises the following steps: (a) adding at least one OCFA to glycerol in a reaction vessel; (b) adding between about 0.1% to about 0.3% activated carbon by total reaction mass; (c) flushing the atmosphere with nitrogen gas, thereby obtaining a nitrogen blanket; (d) increasing temperature of the reaction vessel consistently to between about 205°C to about 210°C; (e) incubating for about 7 to about 8 hours at between about 205°C to about 210°C; (f) allowing the reaction vessel to cool to about 80°C and subsequently filtering the reaction vessel content, thereby producing a composition comprising at least 80% TAG containing at least one OCFA.

[0017] In another aspect, the present disclosure refers to a method for obtaining a fat composition as described herein, the method comprising: (i) melting at least one TAG comprising at least one OCFA and melting a fat blend; (ii) mixing the melted at least one TAG

and the melted fat blend from step (i) to obtain a mixture; and (iii) solidifying the mixture from step (ii) to obtain the fat composition.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] **Fig. 1** shows a flowchart of an exemplary process flow for synthesizing shortenings with 1% or 2% C15 triacylglycerol (TAG) in pilot plant scale.

[0019] **Fig. 2** shows plots of solid fat content (SFC) profiles. **Fig. 2A** shows SFC vs. temperature curves of Wilshort 3639, C15 TAG (95% purity), C16 TAG (95% purity) and C17 TAG (95% purity) samples. The results show that C15 TAG and C17 TAG have a high SFC of at least 95% to at least 99% in the temperature range of 10°C to 40°C, and at least 98% to at least 99% at around 20°C. **Fig. 2B** shows SFC vs. temperature curves of samples of Wilshort 3639 (100%, 97%, 94%, 91%, 88%, 85%, 82%) mixed with 95% pure C15 TAG (0%, 3%, 6%, 9%, 12%, 15%, 18%). The results show that the higher the percentage of C15 TAG used in the sample, the higher the SFC profile.

[0020] **Fig. 3** shows results of Differential Scanning Calorimetry (DSC) profile analysis. As the percentages of C15 TAG or C17 TAG in the samples increased, the changes in the slip melting point and crystallization temperature of the samples can be predicted based on the thermal behaviour of the samples shown in the DSC curves. **Figs. 3A** and **3B** show the melting curves and crystallization curves of C15 TAG (95% purity), and samples of C15 TAG mixed with Wilshort 3639. **Figs. 3C** and **3D** show the melting curves and crystallization curves of C17 TAG (95% purity), and samples of C17 TAG mixed with Wilshort 3639. The results indicate that as the percentages of C15 and C17 TAG in the samples increased, the slip melting point and the crystallization temperature of the samples also increased.

[0021] **Fig. 4** shows results of the hardness profile analysis. The results show that shortenings with C15 TAG were softer with slower rate of change as compared to the control shortening.

[0022] **Fig. 5** shows results of the X-ray diffraction (XRD) analysis of the fat base stock Wilshort 3639. **Fig. 5A** shows that in the initial sample, there was a mix of β' and β peaks. As time progressed, there was an extensive conversion from prominent β' crystal form to almost entirely β crystal form, as shown in **Fig. 5B** (after 3 months at room temperature) and **Fig. 5C** (after 5 months at room temperature).

[0023] **Fig. 6** shows results of the XRD analysis of C16 TAG (95% purity), and samples of C16 TAG mixed with Wilshort 3639. **Fig. 6A₁** shows that initially, C16 TAG was predominantly α crystals with a minor component of β crystals. As time progressed, there was an extensive conversion from α crystal form to β crystal form, as shown by the appearance of

a prominent β peak at 6 months, in **Fig. 6A2**. **Fig. 6B1** shows that for 1% C16 TAG mixed with 99% Wilshort 3639, the resulting blend initially had an obvious β signal together with some β' signals. 3 months old sample showed extensive conversion of the β' signals in the initial sample to only the β signal. There were some remaining but much diminished β' signals in the 3 months old sample, as shown in **Fig. 6B2**. In **Fig. 6B3**, 4 months old sample also showed prominent β peak with almost complete loss of all β' peaks (only small β' peaks remaining). **Fig. 6C1** shows that for 2% C16 TAG mixed with 98% Wilshort 3639, the resulting blend initially had an obvious β signal together with some β' signals. 3 months old sample showed extensive conversion of the β' signals in the initial sample to only the β signal. There were some remaining but much diminished β' signals in the 3 months old sample, as shown in **Fig. 6C2**. In **Fig. 6C3**, 4 months old sample also showed prominent β peak with almost complete loss of all β' peaks (only small β' peaks remaining). **Fig. 6D1** shows that for 3% C16 TAG mixed with 97% Wilshort 3639, the resulting blend initially had an obvious β signal together with some β' signals. 3 months old sample showed extensive conversion of the β' signals in the initial sample to only the β signal. There were some remaining but much diminished β' signals in the 3 months old sample, as shown in **Fig. 6D2**. In **Fig. 6D3**, 4 months old sample also showed prominent β peak with almost complete loss of all β' peaks (only small β' peaks remaining). **Fig. 6E1** shows that for 6% C16 TAG mixed with 94% Wilshort 3639, the resulting blend initially had an obvious β signal together with some β' signals. 3 months old sample showed extensive conversion of the β' signals in the initial sample to only the β signal. There were some remaining but much diminished β' signals in the 3 months old sample, as shown in **Fig. 6E2**. In **Fig. 6E3**, 4 months old sample also showed prominent β peak with almost complete loss of all β' peaks (only small β' peaks remaining).

[0024] **Fig. 7** shows results of the XRD analysis of C15 TAG (95% purity), and samples of C15 TAG mixed with Wilshort 3639. **Fig. 7A1** shows that initially, C15 TAG only had β' signals. As time progressed, there was an extensive conversion from β' crystal form to β crystal form, as shown by the appearance of prominent β peaks at 6 months in **Fig. 7A2**. **Fig. 7B1** shows that for 0.125% C15 TAG mixed with 99.875% Wilshort 3639, the resulting blend initially had an obvious β signal together with some β' signals. The sample at 6 months had a slightly less prominent β peak than the initial sample, and slightly more prominent β' peaks than the initial sample, as shown in **Fig. 7B2**. **Fig. 7C1** shows that for 0.25% C15 TAG mixed with 99.75% Wilshort 3639, the resulting blend initially had an obvious β signal together with some β' signals. The sample at 6 months had a slightly less prominent β peak than the initial sample, and more prominent β' peaks than the initial sample, as shown in **Fig. 7C2**. **Fig. 7D1**

shows that for 0.5% C15 TAG mixed with 99.5% Wilshort 3639, the resulting blend initially had a β signal together with some prominent β' signals. The sample at 6 months had a slightly more prominent β peak than the initial sample, and more prominent β' peaks than the initial sample, as shown in **Fig. 7D₂**. **Fig. 7E₁** shows that for 1% C15 TAG mixed with 99% Wilshort 3639, the resulting blend initially had no obvious β signal but some prominent β' signals. The sample at 2 months had a slightly more obvious β peak than the initial sample. The β' peaks were still present as in the initial sample, as shown in **Fig. 7E₂**. **Fig. 7F₁** shows that for 3% C15 TAG mixed with 97% Wilshort 3639, the resulting blend initially only had β' signals. 3 months old sample showed a more prominent β signal with less pronounced β' signals as compared to initial sample, as shown in **Fig. 7F₂**. In **Fig. 7F₃**, 6 months old sample also showed similar β signal and β' signals. **Fig. 7G₁** shows that for 6% C15 TAG mixed with 94% Wilshort 3639, the resulting blend initially only had β' signals. 3 months old sample showed no β signal and still prominent β' signals, as shown in **Fig. 7G₂**. In **Fig. 7G₃**, 6 months old sample showed no β signal and still only β' signals. **Fig. 7H₁** shows that for 9% C15 TAG mixed with 91% Wilshort 3639, the resulting blend initially only had β' signals. 3 months old sample showed no β signal and still prominent β' signals, as shown in **Fig. 7H₂**. In **Fig. 7H₃**, 6 months old sample showed no β signal and still prominent β' signals. **Fig. 7I₁** shows that for 12% C15 TAG mixed with 88% Wilshort 3639, the resulting blend initially only had β' signals. 3 months old sample showed no β signal and still prominent β' signals, as shown in **Fig. 7I₂**. In **Fig. 7I₃**, 6 months old sample showed no β signal and still prominent β' signals. **Fig. 7J₁** shows that for 15% C15 TAG mixed with 85% Wilshort 3639, the resulting blend initially only had β' signals. 3 months old sample showed no β signal and still prominent β' signals, as shown in **Fig. 7J₂**. In **Fig. 7J₃**, 4 months old sample showed no β signal and still prominent β' signals. **Fig. 7K₁** shows that for 18% C15 TAG mixed with 82% Wilshort 3639, the resulting blend initially only had β' signals. 3 months old sample showed no β signal and still prominent β' signals, as shown in **Fig. 7K₂**. In **Fig. 7K₃**, 4 months old sample showed no β signal and still prominent β' signals.

[0025] **Fig. 8** shows results of the XRD analysis of C17 TAG (95% purity), and samples of C17 TAG mixed with Wilshort 3639. **Fig. 8A** shows that initially, C17 TAG only had α signal. At 6 months, C17 TAG still only showed mainly an α signal with a very minor β signal, as shown in **Fig. 8B**. **Fig. 8C** shows that for 1% C17 TAG mixed with 99% Wilshort 3639, the resulting blend initially only had β' signals. 3 months old sample showed emergence of a β signal. However, the β' signals were still prominent, as shown in **Fig. 8D**. In **Fig. 8E**, 6 months old sample still shows a β signal and prominent β' signals. There was almost no difference between the 3 months and 6 months samples. **Fig. 8F** shows that for 2% C17 TAG mixed with

98% Wilshort 3639, the resulting blend mostly had β' signals initially. 3 months old sample showed no β signal and still prominent β' signals, as shown in **Fig. 8G**. In **Fig. 8H**, 6 months old sample showed no β signal and still prominent β' signals. The pattern of signals almost remained unchanged since the initial sample. **Fig. 8I** shows that for 3% C17 TAG mixed with 97% Wilshort 3639, the resulting blend mostly had β' signals initially. 3 months old sample showed no β signal and still prominent β' signals, as shown in **Fig. 8J**. In **Fig. 8K**, 6 months old sample showed no β signal and still prominent β' signals. The pattern of signals almost remained unchanged since the initial sample. **Fig. 8L** shows that for 6% C17 TAG mixed with 94% Wilshort 3639, the resulting blend mostly had β' signals initially. 3 months old sample showed no β signal and still prominent β' signals, as shown in **Fig. 8M**. In **Fig. 8N**, 6 months old sample showed no β signal and still prominent β' signals. The pattern of signals almost remained unchanged since the initial sample.

[0026] **Fig. 9** shows results of the XRD analysis carried out at Week 2, 3, 4, 5, 6, 8, 10 18 and 30 for shortening samples obtained from pilot plant scale production. Two different storage temperatures (20°C and 30°C) were used after the samples were tempered for 5 days at 26°C. **Fig. 9A** shows that at Week 2, the control samples with 0% C15 TAG exhibited both β and β' crystal polymorphs at both storage temperatures, while the samples with 1% and 2% C15 TAG exhibited only β' crystal polymorph at both storage temperatures. **Fig. 9B** shows that at Week 3, the control samples with 0% C15 TAG exhibited both β and β' crystal polymorphs at both storage temperatures, and the sample stored at 30°C exhibited greater degree of β crystal polymorph than the sample stored at 20°C. The samples with 1% and 2% C15 TAG exhibited only β' crystal polymorph at both storage temperatures. **Fig. 9C** shows that at Week 4, at 20°C, only the control sample with 0% C15 TAG exhibited both β and β' crystal polymorphs; the samples with 1% and 2% C15 TAG exhibited only β' crystal polymorph. As the storage temperature increased to 30°C, all three samples exhibited β crystal polymorph, with the control sample exhibited almost exclusively β crystal polymorph. **Fig. 9D** shows that at Week 5, at 20°C, only the control sample with 0% C15 TAG exhibited both β and β' crystal polymorphs; the samples with 1% and 2% C15 TAG exhibited only β' crystal polymorph. At 30°C, the control sample still exhibited almost exclusively β crystal polymorph. The degree of β crystal polymorph in the samples with 1% and 2% C15 TAG increased as compared to Week 4. **Fig. 9E** shows that at Week 6, at 20°C, only the control sample with 0% C15 TAG exhibited both β and β' crystal polymorphs, the samples with 1% and 2% C15 TAG exhibited only β' crystal polymorph. At 30°C, the control sample still exhibited almost exclusively β crystal polymorph. The degree of β crystal polymorph in the samples with 1% and 2% C15 TAG

increased as compared to Week 5. The sample with 1% C15 TAG exhibited greater degree of β crystal polymorph than the sample with 2% C15 TAG. **Fig. 9F** shows that at Week 8, at 20°C, only the control sample with 0% C15 TAG exhibited both β and β' crystal polymorphs; the samples with 1% and 2% C15 TAG exhibited only β' crystal polymorph. At 30°C, the control sample still exhibited almost exclusively β crystal polymorph. The degree of β crystal polymorph in the samples with 1% and 2% C15 TAG increased as compared to Week 6. The samples with 1% and 2% C15 TAG exhibited similar degree of β crystal polymorph. **Fig. 9G** shows that at Week 10, at 20°C, only the control sample with 0% C15 TAG exhibited both β and β' crystal polymorphs; the samples with 1% and 2% C15 TAG exhibited only β' crystal polymorph. At 30°C, both the control sample and the sample with 1% C15 TAG exhibited almost exclusively β crystal polymorph. The degree of β crystal polymorph in the sample with 2% C15 TAG also increased as compared to Week 8. **Fig. 9H** shows that at Week 18, at 20°C, only the control sample with 0% C15 TAG exhibited both β and β' crystal polymorphs; the samples with 1% and 2% C15 TAG exhibited only β' crystal polymorph. At 30°C, all three samples exhibited almost exclusively β crystal polymorph. **Fig. 9I** shows that at Week 30, at 20°C, only the control sample with 0% C15 TAG exhibited both β and β' crystal polymorphs; the samples with 1% and 2% C15 TAG exhibited only β' crystal polymorph. At 30°C, all three samples exhibited almost exclusively β crystal polymorph.

[0027] **Fig. 10** shows results of the XRD analysis of samples of C15 TAG (95% purity) mixed with POL IV64. **Fig. 10A** shows that for 10% C15 TAG mixed with 90% POL IV64, the resulting blend initially only had β' signals. 2 months old sample showed no β signal and still prominent β' signals, as shown in **Fig. 10B**. **Fig. 10C** shows that for 15% C15 TAG mixed with 85% POL IV64, the resulting blend initially only had β' signals. 2 months old sample showed no β signal and still prominent β' signals, as shown in **Fig. 10D**. **Fig. 10E** shows that for 20% C15 TAG mixed with 80% POL IV64, the resulting blend initially only had β' signals. 2 months old sample showed no β signal and still prominent β' signals, as shown in **Fig. 10F**.

[0028] **Fig. 11** shows results of the XRD analysis of samples of MDG mixed with POL IV64. **Fig. 11A** shows that for 10% MDG mixed with 90% POL IV64, the resulting blend initially had a mix of β signals and β' signal. 1 month old sample showed no significant change, prominent β signals were still present, together with a minor β' signal, as shown in **Fig. 11B**. **Fig. 11C** shows that for 15% MDG mixed with 85% POL IV64, the resulting blend initially had a mix of β signals and β' signal. 1 month old sample showed no significant change, prominent β signals were still present, together with a minor β' signal, as shown in **Fig. 11D**. **Fig. 11E** shows that for 20% MDG mixed with 80% POL IV64, the resulting blend initially

had a mix of β signals and β' signal. 1 month old sample showed no significant change, prominent β signals were still present, together with a minor β' signal, as shown in Fig. 11F.

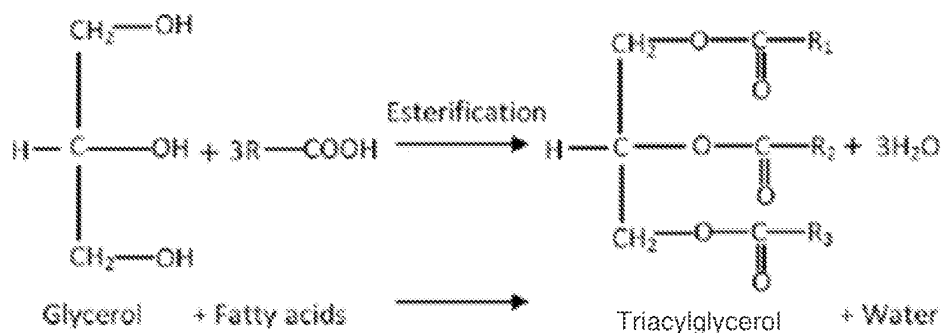
[0029] Fig. 12 shows results of the specific gravity (whipping ability) analysis carried out at 30°C over a period of 18 weeks. The results show that that shortenings with C15 TAG had lower specific gravity and thus better whipping ability, as compared to the control shortening.

DETAILED DESCRIPTION OF THE PRESENT INVENTION

[0030] For the purposes of promoting an understanding of the principles of the present invention, reference will now be made to preferred embodiments and specific language will be used to describe the same. It will nevertheless be understood that no limitation of the scope of the invention is thereby intended, such alteration and further modifications of the invention as illustrated herein, being contemplated as would normally occur to one skilled in the art to which the invention relates.

[0031] In one example there is provided a composition comprising at least one triacylglycerol (TAG), wherein the at least one triacylglycerol comprises at least one odd chain fatty acid (OCFA).

[0032] The terms “triacylglycerol”, “TAG” and “triglyceride” as used interchangeably herein refer to an ester which is typically non-polar and water-insoluble, derived from glycerol and three fatty acids. The glycerol molecule has three hydroxyl (HO-) groups and each of the three fatty acid molecules has a carboxyl group (-COOH). In triacylglycerol, the hydroxyl groups of the glycerol join the carboxyl groups of the fatty acid to form ester bonds, as illustrated by the following equation:



[0033] Each of the three carbons of the glycerol molecule allows for a stereochemically distinct fatty acid bond position: sn-1, sn-2, and sn-3. In the above equation, R₁, R₂ and R₃ are the exemplary fatty acid chains at the sn-1, sn-2 and sn-3 positions respectively.

[0034] The term “fatty acid” as used herein refers to a carboxylic acid with an aliphatic chain. Fatty acids can generally be classified as follows: (i) based on the number of carbon atoms in the aliphatic chain, a fatty acid can be classified either as an “even chain fatty acid” (i.e. a fatty acid having an aliphatic chain containing an even number of carbon atoms), or as an “odd chain fatty acid” (i.e. a fatty acid having an aliphatic chain containing an odd number of carbon atoms); (ii) based on the number of carbon-carbon double bonds present, a fatty acid can be classified either as a “saturated fatty acid” (i.e. a fatty acid that does not contain any carbon-carbon double bonds), or an “unsaturated fatty acid” (i.e. a fatty acid containing one or more carbon-carbon double bonds); (iii) based on the shape of the aliphatic chain, a fatty acid can be classified as either an unbranched chain fatty acid or a branched chain fatty acid.

[0035] In the present disclosure, the at least one triacylglycerol comprised in the composition as disclosed herein contains at least one odd chain fatty acid, i.e. at least one of the fatty acid chains R₁, R₂ and R₃ mentioned above is an odd chain fatty acid. In some examples, only one fatty acid chain of the triacylglycerol is an odd chain fatty acid, and the odd chain fatty acid chain is at the sn-1, sn-2, or sn-3 position. In some examples, two of the fatty acid chains of the triacylglycerol are odd chain fatty acids, and the odd chain fatty acid chains are at the sn-1 and sn-2 positions, or at the sn-2 and sn-3 positions, or at the sn-1 and sn-3 positions. In some other examples, all three fatty acid chains of the triacylglycerol are odd chain fatty acids.

[0036] In some examples, the at least one OCFA is present in an amount of at least about 50 wt% of the total composition. In some examples, the at least one OCFA is present in an amount of at least about 50, 55, 60, 65, 70, 75, 80, 85, 90 or 95 wt% of the total composition.

[0037] In some examples, the at least one OCFA comprised in the TAG is an unbranched OCFA. In some examples, the at least one OCFA comprised in the TAG is a saturated OCFA.

[0038] In some examples, the at least one OCFA comprised in the TAG is undecanoic acid (C11:0), or tridecanoic acid (C13:0), or pentadecanoic acid (C15:0), or heptadecanoic acid (C17:0), or nonadecanoic acid (C19:0), or heneicosanoic acid (C21:0), or tricosanoic acid (C23:0), or combinations thereof. In some specific examples, the at least one OCFA is pentadecanoic acid (C15:0), or heptadecanoic acid (C17:0), or combinations thereof.

[0039] In some examples, at least two fatty acid chains of the TAG are OCFA. The two OCFA can be the same or different, each of which can independently be undecanoic acid (C11:0), or tridecanoic acid (C13:0), or pentadecanoic acid (C15:0), or heptadecanoic acid (C17:0), or nonadecanoic acid (C19:0), or heneicosanoic acid (C21:0), or tricosanoic acid (C23:0).

[0040] In some examples, all three fatty acid chains of the TAG are OCFAs. The three OCFAs can be the same or different. For example, two out of the three OCFAs can be the same, with the third OCFA being different; or all three OCFAs can be different. Each of the three OCFAs can independently be undecanoic acid (C11:0), or tridecanoic acid (C13:0), or pentadecanoic acid (C15:0), or heptadecanoic acid (C17:0), or nonadecanoic acid (C19:0), or heneicosanoic acid (C21:0), or tricosanoic acid (C23:0). In some examples, all three fatty acid chains of the TAG are identical OCFAs. Examples of such TAGs include but are not limited to, triundecanoin, tritridecanoin, tripentadecanoin, triheptadecanoin, trinonadecanoin, triheneicosanoin, and tritricosanoin. In some specific examples, the TAG is tri-pentadecanoin or tri-heptadecanoin.

[0041] TAGs exist in three main crystalline forms: α , β , and β' . α form has the lowest density and stability. β form is the most stable crystal form with the highest melting point among the three polymorphs. The β' form is more stable than the α form but less stable than the β form.

[0042] In the composition of the present invention, the at least one TAG comprising at least one OCFA is in an α or a β' crystal form. In some specific examples, the at least one TAG has a crystal structure that is predominantly, or substantially, in the β' crystal form. In some other specific examples, there is more of the β' crystal form of the at least one TAG present in the composition than any other crystal form of the at least one TAG. For example, when the at least one TAG comprises one or more pentadecanoic acid chain, the at least one TAG is predominantly or substantially in the β' crystal form. In some other specific examples, the at least one TAG has a crystal structure that is predominantly, or substantially, in the α crystal form. In some other specific examples, there is more of the α crystal form of the at least one TAG present in the composition than any other crystal form of the at least one TAG. For example, when the at least one TAG comprises one or more heptadecanoic acid chain, the at least one TAG is predominantly or substantially in the α crystal form.

[0043] The composition of the present invention can also comprise a mixture of different TAGs having at least one OCFA. For example, the composition can comprise a mixture of TAGs having at least one undecanoic acid, and/or at least one tridecanoic acid, and/or at least one pentadecanoic acid, and/or at least one heptadecanoic acid, and/or at least one nonadecanoic acid, and/or at least one heneicosanoic acid, and/or at least one tricosanoic acid. In some examples, the composition comprises a mixture of TAGs such as triundecanoin, and/or tritridecanoin, and/or tripentadecanoin, and/or triheptadecanoin, and/or trinonadecanoin, and/or triheneicosanoin, and/or tritricosanoin. In some specific examples, the composition

comprises a mixture of TAGs having at least one pentadecanoic acid and at least one heptadecanoic acid. In some specific examples, the composition comprises a mixture of tripentadecanoin and triheptadecanoin.

[0044] The composition comprising the at least one TAG with at least one OCFA can contain impurities, such as free fatty acids, free glycerol, monoacylglycerol (also known as monoglyceride), and diacylglycerol (also known as diglyceride). The levels of such impurities are preferably minimized. Generally, the amount of impurities present in the composition is less than about 20, 19, 18, 17, 16, 15, 14, 13, 12, 11, 10, 9, 8, 7, 6, 5, 4, 3, 2 or 1 wt% of the composition. This means the composition contains at least 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98 or 99 wt% TAG with at least one OCFA. In some preferred examples, the composition contains at least 95 wt% TAG with at least one OCFA.

[0045] The inventors of the present invention found that the above-mentioned composition comprising at least one TAG with at least one OCFA can be used to enhance the crystal profile of a fat blend, by for example, increasing the percentage of β' crystals in the fat blend, and/or enhancing the stability of the β' crystals in the fat blend. This can help to prolong the shelf-life of the fat blend by preventing or delaying the onset of the post-hardening phenomenon. The composition comprising at least one TAG with at least one OCFA can also be used to structure a liquid fat blend to form a semi-solid or solid fat blend.

[0046] Thus, in one example, there is provided a fat composition comprising the composition (i.e. the composition comprising at least one TAG with at least one OCFA) as described herein, and a fat blend.

[0047] The term “fat composition” as used herein refers to a composition comprising at least 50% of fatty acids, said percentage being expressed by total weight of the fat composition. In some examples, the fat composition comprises at least about 51%, 52%, 53%, 54%, 55%, 56%, 57%, 58%, 59%, 60%, 61%, 62%, 63%, 64%, 65%, 66%, 67%, 68%, 69%, 70%, 71%, 72%, 73%, 74%, 75%, 76%, 77%, 78%, 79%, 80%, 81%, 82%, 83%, 84%, 85%, 86%, 87%, 88%, 89%, 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98% or 99% of fatty acids, said percentages being expressed by total weight of the fat composition. The fat composition may comprise any other constituent in accordance with the above-mentioned proportions of fatty acids.

[0048] In some examples, the fatty acids comprised in the fat composition are mainly in the form of TAGs. The expression “fatty acids mainly in the form of TAGs” is intended to mean that at least half of the fatty acids present in the fat composition are esterified on a TAG molecule. Thus, in some examples, the fat composition comprises at least about 51%, 52%, 53%, 54%, 55%, 56%, 57%, 58%, 59%, 60%, 61%, 62%, 63%, 64%, 65%, 66%, 67%, 68%,

69%, 70%, 71%, 72%, 73%, 74%, 75%, 76%, 77%, 78%, 79%, 80%, 81%, 82%, 83%, 84%, 85%, 86%, 87%, 88%, 89%, 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98% or 99% of fatty acids in the form of TAGs, these percentages being expressed by total weight of the fatty acids in the fat composition.

[0049] In some examples, in the fat composition comprising the at least one TAG comprising at least one OCFA as described herein, the total amount of the at least one TAG present in the fat composition is between about 0.4 wt% to about 20 wt%, or of at least about 0.5 wt%, at least about 0.8 wt%, at least about 1 wt%, at least about 1.5 wt%, at least about 1.8 wt%, at least about 2 wt%, at least about 3 wt%, at least about 6 wt%, at least about 9 wt%, at least about 12 wt%, at least about 15 wt%, or at least about 18 wt% of the total fat composition.

[0050] In some examples, the fat composition comprises a mixture of the composition comprising at least one TAG with at least one OCFA as described herein, and at least one TAG with at least one, at least two, or three even chain fatty acids. In some examples, the TAG with at least one even chain fatty acid comprises the same even chain fatty acid, while in some other examples, the TAG with at least one even chain fatty acid comprises different even chain fatty acids. Examples of even chain fatty acids include but are not limited to C8:0, C10:0, C12:0, C14:0, C16:0, C18:0, C18:1, C18:2, C18:3, C20:0, C20:1, C20:2, C22:0, and C22:1.

[0051] As described above, the fat composition is formed by mixing the fat blend with the composition comprising at least one TAG having at least one OCFA. In some examples, after mixing the composition comprising at least one TAG having at least one OCFA with the fat blend, the fat composition displays more β' crystal formation than the fat blend prior to mixing.

[0052] The term "fat blend" as used herein refers to a fat mixture or a fat base stock. The fat blend comprises at least 50% of fatty acids, said percentage being expressed by total weight of the fat blend. In some examples, the fat blend comprises at least about 51%, 52%, 53%, 54%, 55%, 56%, 57%, 58%, 59%, 60%, 61%, 62%, 63%, 64%, 65%, 66%, 67%, 68%, 69%, 70%, 71%, 72%, 73%, 74%, 75%, 76%, 77%, 78%, 79%, 80%, 81%, 82%, 83%, 84%, 85%, 86%, 87%, 88%, 89%, 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98% or 99% of fatty acids, said percentages being expressed by total weight of the fat blend. In some examples, majority (for example, at least 50, 55, 60, 65, 70, 75, 80, 85, 90, 95 or 99 wt%) of the fatty acids in the fat blend are present in the form of TAGs. The fat blend does not contain any substantial amount of TAG with OCFA. In some examples, the fat blend does not contain any TAG with OCFA.

[0053] The fat blend can be in the form of a liquid, semi-solid, or solid, at room temperature. Room temperature generally refers to a temperature in the range of about 20°C to about 30°C, or about 20°C to about 25°C.

[0054] In some examples, the fat blend comprises a vegetable oil and/or a fractionated product of vegetable oil. A vegetable oil is usually in the form of a liquid at room temperature. Examples of vegetable oil include but are not limited to, soybean oil, rapeseed oil, coconut oil, palm kernel oil, palm oil, peanut oil, shea nut oil, corn oil, cottonseed oil, rice bran oil, olive oil, canola oil, and combinations thereof. A fractionated product of vegetable oil can be in the form of a liquid, a semi-solid, or a solid at room temperature. Examples of fractionated product of vegetable oil include but are not limited to, palm stearin, palm soft stearin, palm hard stearin, palm mid fraction, palm olein, palm super olein, palm kernel stearin, palm kernel olein, shea stearin, and shea olein. In some specific examples, the vegetable oil comprised in the fat blend is palm oil, and the fractionated product of vegetable oil comprised in the fat blend is palm stearin.

[0055] In some specific examples, the fat blend comprises a mixture of vegetable oil and a fractionated product of vegetable oil. The amount of vegetable oil present is usually predominant, for example, at least about 50%. In some examples, the vegetable oil present is at least about 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, 95% or 99%, and the amount of the fractionated product of vegetable oil present is at most about 50%, 45%, 40%, 35%, 30%, 25%, 20%, 15%, 10%, 5%, or 1%. In some specific examples, the fat blend is a palm-based fat blend. In one specific example, the palm-based fat blend comprises a mixture of about 95% palm oil and 5% palm stearin. An example of such a fat blend is Wilshort 3639 from Wilmar International Limited.

[0056] In some examples, the fat blend comprises a fractionated product of a vegetable oil but does not comprise a vegetable oil. In some examples, the fractionated product of a vegetable oil is in the form of a liquid. In some specific examples, the fractionated product of a vegetable oil is palm-based, such as palm olein. A non-limiting example of such a fat blend is POL IV64 (palm olein of Iodine Value 64).

[0057] Numerous commercially available fat blends can be used for the purpose of forming the fat composition as described in the present application.

[0058] In some examples, the vegetable oil and/or the fractionated product of vegetable oil comprised in the fat blend is/are chemically modified. Examples of suitable chemical modification include, but are not limited to, chemical interesterification, enzymatic interesterification, partial hydrogenation and full hydrogenation. In some examples, the vegetable oil and/or the fractionated product of vegetable oil comprised in the fat blend is not modified by hydrogenation (full or partial). In some specific examples, the vegetable oil and/or the fractionated product of vegetable oil comprised in the fat blend is not modified by partial

hydrogenation, so the fat composition being formed does not contain, or at least does not substantially contain, any trans fatty acids.

[0059] In some examples, the vegetable oil and/or the fractionated product of vegetable oil comprises TAGs with at least one, at least two, or at least three saturated fatty acid chains, or TAGs with at least one, at least two, or at least three monounsaturated or polyunsaturated fatty acid chains. Examples of saturated fatty acids include but are not limited to, lauric acid (C12:0), myristic acid (C14:0), palmitic acid (C16:0), stearic acid (C18:0), and arachidic (C20:0). Examples of monounsaturated fatty acids include, but are not limited to oleic acid (C18:1), paullinic acid (C20:1), erucic (C22:1). Examples of polyunsaturated fatty acids include, but are not limited to linoleic acid (C18:2) and α -linolenic acid (C18:3). In some specific examples, the vegetable oil and/or the fractionated product of vegetable oil comprises TAGs with C16:0 and/or C18:1 fatty acid.

[0060] In some examples, the fat composition as described herein further contains oils and/or fractionated products of oils derived directly or indirectly from animal sources. In some other examples, the fat composition as described herein does not contain oils and/or fractionated products of oils derived directly or indirectly from animal sources.

[0061] In some examples, the fat composition as described herein does not, or at least does not substantially, contain trans fatty acids. The trans fatty acid content in the fat composition is preferably about 10 wt% or less, more preferably about 5 wt% or less, more preferably about 2 wt% or less, more preferably about 1 wt% or less, or even more preferably about 0.1 wt% or less.

[0062] In some examples, the fat composition as described herein is suitable for bakery purposes, for examples, as a margarine, a shortening, a fat spread, other butter substitutes, or part thereof. The fat composition can be a mixture of various fats, wherein the explicit combinations depend on the intended use of the fat composition. The term “margarine” as used herein refers to a spread used for flavouring, baking, and cooking, and is often used as an inexpensive butter substitute. It is noted that based on jurisdiction, a food administrative definition of the term “margarine” may imply a certain percentage of some of the components of said margarine. The term “shortening” as used herein refers to a fat that is a solid at room temperature. Shortening is typically used to make crumbly pastry and other food products, by preventing or reducing cross-linkage between gluten molecules.

[0063] The fat composition as described herein can further comprise an emulsifier. An emulsifier is a substance that stabilizes an emulsion by increasing its kinetic stability. Any food emulsifiers commonly used in fat compositions can be used, such as lecithin, propylene glycol

esters of fatty acids, sodium stearyl lactylate, diacetyl tartaric acid esters of monoacylglycerols, and lactic acid esters of mono- and diacylglycerols.

[0064] Since the fat composition as described herein can comprise at least one TAG comprising at least one OCFA, any health benefits associated with the consumption of OCFA can also be associated with the consumption of the fat composition.

[0065] The fat composition as described herein has an x-ray diffraction (XRD) signature showing at least one β' crystal signal. In some examples, the XRD signature of the fat composition shows predominantly (i.e. at least about 50%) β' crystal form. In some examples, the XRD signature of the fat composition shows that at least about 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, 95% or 99% of the TAGs are of the β' crystal form. In some examples, the XRD signature of the fat composition shows that there are more TAGs of the β' crystal form present in the fat composition, as compared to TAGs of the other crystal forms, such as β crystal form and α crystal form.

[0066] Other characteristics of the fat composition disclosed herein can be expressed using various parameters known in the art, including but not limited to, texture, heat stability, shelf-life/storage stability. These parameters can be measured using methods known in the art.

[0067] In one example, there is provided a bakery specialty fat comprising the fat composition as described herein. In some examples, the bakery specialty fat is puff pastry margarine, puff pastry shortening, general purpose shortening, general purpose margarine, spread margarine, low fat spread, butter oil substitute, or liquid shortening. The present disclosure also provides a bakery food comprising the bakery specialty fat as described herein. The bakery food can be prepared by methods known in the art. For example, the bakery specialty fat as described herein can be mixed with components typically used in the preparation of bakery food, such as flour, water, sugar, sugar alcohol, egg, egg processed product, starch, common salt, emulsifier, foaming agent, cheese, cream, yoghurt, milk, yeast, cacao mass, cocoa powder, and flavourings.

[0068] In another example, an animal-based product comprising the fat composition as described herein is disclosed. In another example, an edible product comprising the fat composition as described herein is disclosed. In yet another example, a cosmetic product comprising the fat composition as described herein is disclosed. In yet another example, a prophylactic product comprising the fat composition as described herein is disclosed.

[0069] The present disclosure also describes a TAG for use in a fat composition, wherein the TAG comprises at least one OCFA. Examples of the TAGs and the at least one OCFA are described above. In some examples, the TAG is in an α or a β' crystal form.

[0070] In another example, there is described a method of producing a composition comprising at least 80% TAG containing at least one OCFA, the method comprises the following steps: (a) adding at least one OCFA to glycerol in a reaction vessel; (b) adding between about 0.1% to about 0.3% activated carbon by total reaction mass; (c) flushing the atmosphere with nitrogen gas, thereby obtaining a nitrogen blanket; (d) increasing temperature of the reaction vessel consistently to between about 205°C to about 210°C; (e) incubating for about 7 to about 8 hours at between about 205°C to about 210°C; (f) allowing the reaction vessel to cool to about 80°C and subsequently filtering the reaction vessel content, thereby producing a composition comprising at least 80% TAG containing at least one OCFA.

[0071] The term “consistent” as used herein means the increase in temperature was carried out at about the same rate until the reaction vessel has reached the desired temperature.

[0072] In some examples, the ratio of OCFA to glycerol used is between about 2.9:1 to about 3.2:1, or between about 3:1 to about 3.1:1, or at about 3.05:1.

[0073] In some examples, the activated carbon is added in an amount of about 0.2% of the total reaction mass.

[0074] In some examples, the above-mentioned method of producing the composition further comprises the following steps: (g) adding at least about 0.1% tetrabutyl titanate (TBT; functions as an esterification catalyst) by total reaction mass to the reaction vessel **after** step (e) (but before step (f)); (h) incubating the reaction vessel for about 4 to about 5 hours under negative pressure at between about 205°C to about 210°C after step (g) (but before step (f)); (i) (after step (f)) alkali washing, dehydrating and decolorising the filtered reaction vessel content from step (f), to obtain the composition.

[0075] Tetrabutyl titanate can be replaced by other catalyst suitable for esterification of glycerol and free fatty acids, such as methyl ester sulfonate acid (MESA), sulfuric acid, $\text{AlCl}_3 \cdot 6\text{H}_2\text{O}$, Al_2O_3 , $\text{CdCl}_2 \cdot 2\text{H}_2\text{O}$, $\text{FeCl}_3 \cdot 6\text{H}_2\text{O}$, FeO , HgCl_2 , $\text{MgCl}_2 \cdot 6\text{H}_2\text{O}$, MgO , $\text{MnCl}_2 \cdot \text{H}_2\text{O}$, MnO_2 , NaOH , Ni , $\text{NiCl}_2 \cdot 2\text{H}_2\text{O}$, PbCl_2 , PbO , SbCl_2 , $\text{SnCl}_2 \cdot 2\text{H}_2\text{O}$, $\text{SnCl}_4 \cdot 5\text{H}_2\text{O}$, SnO_2 , ZnCl_2 , and ZnO .

[0076] Alkali washing, dehydrating and decolorising are common techniques used in the industrial production of TAGs. A person skilled in the art would be able to decide on the suitable reagents and/or reaction conditions to be used for alkali washing, dehydrating and decolorising, without undue experimentations.

[0077] In some examples, the esterification catalyst in (g) is added in an amount of at least about 0.2%, 0.3%, 0.4%, 0.5%, 0.6%, 0.7%, 0.8%, 0.9%, 1.0%, 1.1%, 1.2%, 1.3%, 1.4%, 1.5%, 1.6%, 1.7%, 1.8%, 1.9%, or 2% by total reaction mass. In some specific examples, the

esterification catalyst is added in an amount of about 1.0% of the total reaction mass. It is understood that suitable concentration of the catalyst used in the reaction can be determined by a person skilled in the art without undue experimentation.

[0078] In some examples, the composition being produced using the above-mentioned method comprises at least 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98 or 99 wt% TAG containing at least one OCFA. In some specific examples, the composition comprises at least 95% TAG containing at least one OCFA, in particular when the method comprises the usage of an esterification catalyst, as described herein.

[0079] Examples of the TAGs comprised in the composition being produced, as well as the at least one OCFA, are described in the preceding paragraphs.

[0080] The present disclosure also describes a composition as obtained using the method as described herein, wherein the composition comprises at least one TAG comprising at least one OCFA.

[0081] In one example, there is described a method for obtaining a fat composition as described herein. The method comprises: (i) melting at least one TAG comprising at least one OCFA and melting a fat blend; (ii) mixing the melted at least one TAG and the melted fat blend from step (i) to obtain a mixture; and (iii) solidifying the mixture from step (ii) to obtain the fat composition.

[0082] Melting the at least one TAG comprising at least one OCFA and melting the fat blend can be carried out at appropriate temperatures, which can be determined by a person skilled in the art using conventional methods and without undue experimentation. For example, the melting step can be carried out at a temperature that is higher than both the melting point of the at least one TAG comprising at least one OCFA, and the melting point of the fat blend. In some specific examples, the melting step is carried out at a temperature between about 30°C to about 80°C, or between about 35°C and about 80°C, or between about 40°C and about 75°C, or between about 45°C and about 70°C, or between about 50°C and about 65°C, or between about 55°C and about 60°C.

[0083] In some alternative examples, there is provided a method for obtaining a fat composition as described herein, the method comprises: (i) melting a fat blend; (ii) mixing the melted fat blend from step (i) and the at least one TAG comprising at least one OCFA to obtain a mixture; and (iii) solidifying the mixture from step (ii) to obtain the fat composition. Such alternative method can be used when the melted fat blend is sufficient to melt the TAG comprising at least one OCFA, such that the TAG comprising at least one OCFA does not have to be melted separately.

[0084] In some other examples, the fat blend is a liquid. For such examples, the method for obtaining a fat composition as described herein comprises the following steps: (i) adding the at least one TAG comprising at least one OCFA to the fat blend; (ii) heating and blending the at least one TAG and the fat blend to obtain a homogenous mixture; and (iii) cooling the homogenous mixture from step (ii) to obtain the fat composition.

[0085] Examples of the fat blend used in the method are described in the preceding paragraphs.

[0086] In some examples, the at least one TAG comprising the at least one OCFA is added in an amount of between about 0.4 wt% to about 20 wt%, or in an amount of at least about 0.5%, at least about 0.8 wt%, at least about 1 wt%, at least about 1.5 wt%, at least about 1.8 wt%, at least about 2 wt%, at least about 3 wt%, at least about 6 wt%, at least about 9 wt%, at least about 12 wt%, at least about 15 wt%, or at least 18 wt%, of the total fat composition. Pure TAG comprising at least one OCFA, or a composition comprising the at least one TAG comprising at least one OCFA, can be used in the above-mentioned method to produce the fat composition. When a composition comprising the at least one TAG comprising at least one OCFA is used, it is preferred that the composition contains a high purity of the at least one TAG comprising at least one OCFA, such as at least 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98 or 99 wt% TAG comprising at least one OCFA. When such compositions are used, the amount of TAG comprising the at least one OCFA used in the method of producing the fat composition can be calculated accordingly. For example, when the composition used is of about 95% purity of the TAG comprising at least one OCFA, and 3% of the composition is mixed with the fat blend, the resulting fat composition comprises about 2.85% of the TAG comprising at least one OCFA.

[0087] When more than one TAGs comprising at least one OCFA are used in the production of the fat composition, the more than one TAGs can be mixed with the fat blend simultaneously or sequentially. For example, when two TAGs comprising at least one OCFA are mixed with the fat blend simultaneously, the method for obtaining the fat composition comprises: (i) melting the first and the second TAGs comprising at least one OCFA and melting a fat blend; (ii) mixing the melted first and second TAGs and the melted fat blend from step (i) to obtain a mixture; and (iii) solidifying the mixture from step (ii) to obtain the fat composition. In another example, when two TAGs comprising at least one OCFA are mixed with the fat blend sequentially, the method for obtaining the fat composition comprises: (i) melting the first TAG comprising at least one OCFA and melting a fat blend; (ii)(a) mixing the melted first TAG and the melted fat blend from step (i) to obtain a first mixture; (ii)(b) melting the second TAG comprising at least one OCFA; (ii)(c) mixing the melted second TAG and the first mixture

from step (ii)(a) to obtain a second mixture; and (iii) solidifying the second mixture from step (ii)(c) to obtain the fat composition. It is understood that the first and second TAGs are different. [0088] In some examples, step (ii) of the method as described herein further comprising interesterification after mixing.

[0089] The term “interesterification”, or its grammatical variants as used herein, refers to a process that rearranges the fatty acids of a mixture of TAGs. The process involves breaking and reforming the ester bonds C–O–C that connect the fatty acid chains to the glycerol. Interesterification can be performed by inorganic catalysts via chemical interesterification (CIE), or by enzymes via enzymatic interesterification (EIE). In one specific example, enzymatic interesterification is carried out.

[0090] In some examples, step (ii) of the method as described herein further comprises fractionating after mixing or interesterification.

[0091] The term “fractionation”, or its grammatical variants as used herein, refers to a separation process in which a certain quantity of a mixture is divided during a phase transition, into a number of smaller quantities (fractions) in which the composition varies according to a gradient. Various fractionation processes have been developed for oils and fats. Solvent fractionation processes use solvents such as acetone, nitropropane or hexane. Dry fractionation processes customarily involve heating the fat to be fractionated to a temperature above its melting point, then cooling slowly to below its melting point, whereupon crystals are formed and grow. When a sufficient degree of crystallisation has been attained, the crystal slurry is separated by filtration into a filter cake (the stearin), and a filtrate (the olein). Crystallisation vessels that are fitted with heat exchangers and/or an agitator are often used in fractionations for industrial scale productions. In some preferred examples, dry fractionation is used in the method of the present application.

[0092] In some examples, the method as described herein further comprises step (iv) texturizing the solidified mixture from step (iii).

[0093] The term “texturize” or its grammatical variants as used herein refers to a process of providing a particular texture to the substance being texturized. Texture typically encompasses a number of desired characteristics such as viscosity, plasticity, solid fat content (SFC) versus temperature, and melting point. Texturization processes typically involves the use of heating, cooling, pressure, and/or mechanical forces. Known texturization methods used in the treatment of oil or fat, in particular edible oil or fat, can be used in the method of the present application. In some examples, texturizing the solidified mixture comprises melting at about 50°C, 55°C, 60°C, 65°C, 70°C, 75°C, and/or cooling at less than about 5°C, 10°C, 15°C, 20°C,

25°C, or 30°C. In some specific examples, texturizing the solidified mixture comprises melting at about 70°C, and cooling at less than about 10°C. In some examples, texturizing the solidified mixture comprises traditional margarine or shortening processing, including chilling, and working.

[0094] The term "solid fat content (SFC)" as used herein refers to a measure of the percentage of fat in crystalline (solid) phase to total fat (the remainder being in liquid phase) across a temperature gradient. The resulting SFC/temperature curve is related to melting qualities and flavour of a fatty food. The SFC of shortenings typically varies between 15% and 30% and retain these solids in the usage temperature (usually in the range of about 15°C to about 35°C, or about 20°C to about 30°C, or about 25°C to about 30°C).

[0095] In one example, there is described a fat composition as obtained by the method as described herein. The fat composition typically comprises a β' polymorph of a TAG.

[0096] The invention illustratively described herein may suitably be practiced in the absence of any element or elements, limitation or limitations, not specifically disclosed herein. Thus, for example, the terms "comprising", "including", "containing", etc. shall be read expansively and without limitation. Additionally, the terms and expressions employed herein have been used as terms of description and not of limitation, and there is no intention in the use of such terms and expressions of excluding any equivalents of the features shown and described or portions thereof, but it is recognized that various modifications are possible within the scope of the invention claimed. Thus, it should be understood that although the present invention has been specifically disclosed by preferred embodiments and optional features, modification and variation of the inventions embodied therein herein disclosed may be resorted to by those skilled in the art, and that such modifications and variations are considered to be within the scope of this invention.

[0097] As used in this application, the singular form "a", "an", and "the" include plural references unless the context clearly dictates otherwise. For example, the term "a triacylglycerol" includes a plurality of triacylglycerols, including mixtures and combinations thereof.

[0098] As used herein, the term "about", in the context of concentrations of components of the formulations, typically means +/- 5% of the stated value, more typically +/- 4% of the stated value, more typically +/- 3% of the stated value, more typically, +/- 2% of the stated value, even more typically +/- 1% of the stated value, and even more typically +/- 0.5% of the stated value.

[0099] Throughout this disclosure, certain embodiments may be disclosed in a range format. It should be understood that the description in range format is merely for convenience and brevity and should not be construed as an inflexible limitation on the scope of the disclosed ranges. Accordingly, the description of a range should be considered to have specifically disclosed all the possible sub-ranges as well as individual numerical values within that range. For example, description of a range such as from 1 to 6 should be considered to have specifically disclosed sub-ranges such as from 1 to 3, from 1 to 4, from 1 to 5, from 2 to 4, from 2 to 6, from 3 to 6 etc., as well as individual numbers within that range, for example, 1, 2, 3, 4, 5, and 6. This applies regardless of the breadth of the range.

[0100] Certain embodiments may also be described broadly and generically herein. Each of the narrower species and sub-generic groupings falling within the generic disclosure also form part of the disclosure. This includes the generic description of the embodiments with a proviso or negative limitation removing any subject matter from the genus, regardless of whether or not the excised material is specifically recited herein.

[0101] The invention has been described broadly and generically herein. Each of the narrower species and sub-generic groupings falling within the generic disclosure also form part of the invention. This includes the generic description of the invention with a proviso or negative limitation removing any subject matter from the genus, regardless of whether or not the excised material is specifically recited herein.

[0102] Other embodiments are within the following claims and non-limiting examples. In addition, where features or aspects of the invention are described in terms of Markush groups, those skilled in the art will recognize that the invention is also thereby described in terms of any individual member or subgroup of members of the Markush group.

EXPERIMENTAL SECTION

[0103] Synthesizing triacylglycerol (TAG) samples

[0104] Materials used

[0105] Purified samples of odd chain fatty acid (OCFA) free fatty acid were purchased from Tokyo Chemical Industry Co., Ltd. (TCI).

[0106] Synthesizing TAG samples (Tri-Pentadecanoin (C15 TAG), Tri-Palmitin (C16 TAG) or Tri-Heptadecanoin (C17 TAG)) with >80% purity

[0107] Combine 3.05M (Moles) of purified free fatty acid (C15, C16 or C17) for every 1M of Glycerol in four-necked flask. Activated carbon (2% w/w) was added. The temperature was

gradually raised to 205 – 210°C under nitrogen blanketing, maintained for 7 – 8h, then cooled to 80°C. The TAG sample of >80% purity was then obtained after filtering.

[0108] Synthesizing TAG samples (C15 TAG, C16 TAG or C17 TAG) with >95% purity

[0109] Combine 3.05M (Moles) of purified free fatty acid (C15, C16 or C17) for every 1M of Glycerol in four-necked flask. Activated carbon (2% by total reaction mass) was added. The temperature was gradually raised to 205 – 210°C under nitrogen blanketing, maintained for 7 – 8h, and TBT catalysis (1% w/w) was added. The reaction was continued under negative pressure for 4 – 5h, then cooled to 80°C. The crude sample was obtained after filtered. The TAG sample of >95% purity was then obtained after alkali washing, dehydration and decolourization.

[0110] Synthesizing shortenings with TAGs

[0111] Laboratory scale using solid fat base stock

[0112] TAG sample (C15, C16 or C17 TAG) of 95% purity was blended with palm-based fat base stock (Wilshort 3639 – 95% palm oil and 5% palm stearin) for lab scale analysis using the following methodology:

[0113] 1. Melt Wilshort 3639 in microwave until sample is liquid and clear (about 2+ mins) and blend with C15/C16/C17 TAG by respective mass (0.5% - 18%, depending on experimental setting),

[0114] until Wilshort 3639 and C15/C16/C17 TAG were completely incorporated with no solid particles.

[0115] 2. Solidify at room temperature for use in future experiments.

[0116] Pilot plant scale using fat base stock

[0117] A pilot plant scale production of Wilshort 3639 incorporating 0%/1%/2% C15 TAG was carried out using the following methodology:

[0118] 1. Melt down Wilshort 3639 and blend with 0%/1%/2% C15 TAG by respective mass.

[0119] 2. Texturize oil blend in pilot plant using similar parameters to that of commercial bakery margarine/shortening. **Table 1** below shows exemplary process parameters used.

[0120] 3. Samples were tempered for 5 days at 26°C (tempering refers to storing at specific temperature to encourage appropriate crystal development). All shortening samples were filled and stored in 500g plastic containers and subsequently stored at 20°C and 30°C.

[0121] A flowchart of an exemplary process flow for synthesizing shortenings with 1% or 2% C15 TAG is shown in **Fig. 1**.

Process Conditions	Shortening A (2% C15 TAG)	Shortening B (1% C15 TAG)	Shortening C (Control)
High Pressure Pump (Litre/Hour)	101	101	101
System Pressure (Bar)	5.6	4.2	4.3
Nitrogen	0	0	0
Oil Temperature (°C)	48.7	52.5	51.0
Mixing Tank			
Setting Temperature (°C)	70	70	70
Oil Temperature (°C)	65	65	65
Perfector Chilling Tube 1			
Chiller Temperature (°C)	1.5	0.6	1.1
Oil Temperature (°C)	23.1	22	22.9
Agitation Speed (RPM)	603	603	603
Water Heater Temperature (°C)	50	50	50
Perfector Chilling Tube 2			
Chiller Temperature (°C)	2.3	2.2	2.4
Oil Temperature (°C)	18.5	16.0	17.4
Agitation Speed (RPM)	603	604	604
Water Heater Temperature (°C)	50	50	50
Filling Nozzle Temperature (°C)	22.3	22.5	21.3
Pin Rotor Machine			
Hot Water Temperature (°C)	23.9	23.0	22.5
Oil Temperature (°C)	22.0	22.0	21.5
Agitation Speed (RPM)	906	906	906

Table 1. Exemplary process parameters used for a pilot plant scale production of shortenings with 0%/1%/2% C15 TAG

[0122] Laboratory scale using liquid fat base stock (e.g. liquid oil)

[0123] C15 TAG of 95% purity was blended with a liquid fat base stock POL IV64 (palm olein of Iodine Value 64) for lab scale analysis using the following methodology:

[0124] 1. Add C15 TAG at dose 10-20% and POL IV64 at dose 90% - 80% (depending on experimental setting) into storage container of total blend volume.

[0125] 2. Melt the sample in a glass beaker using microwave, until sample is liquid and clear (about 2 mins). Blend the sample

[0126] on magnetic stirrer (with stirring rod) to a temperature of about 75°C.

[0127] 3. Continue stirring for further 30 mins to ensure proper homogenization.

[0128] 4. Remove homogenous liquid oil mixture from magnetic stirrer and place in fridge overnight.

[0129] Methods used for the analysis of samples

[0130] The following analysis were conducted on a regular (e.g. weekly or monthly) schedule to assess the performance of the OCFA TAGs:

[0131] 1. Solid Fat Content (SFC) profile

[0132] Samples were filled into SFC tubes and tempered at respective temperatures (10°C, 20°C, 25°C, 30°C, 35°C, 40°C, 45°C) in Julabo 200F waterbaths. Upon tempering, samples were loaded into Bruker Minispec MQOne NMR and SFC data were obtained in accordance with the American Oil Chemists' Society (ACOS) Official Method Cd 16b-93 (i.e. Solid Fat Content (SFC) by Low-Resolution Nuclear Magnetic Resonance, Direct Method, Revised 2017).

[0133] 2. Differential Scanning Calorimetry (DSC) profile

[0134] Samples were transferred into sample pans and analysed using Perkin Elmer DSC 6000 for the DSC analysis. The DSC profiles of the samples were obtained based on the following parameters in accordance with the ACOS Official Method Cj 1-94 (i.e. DSC Melting Properties of Fats and Oils, Reapproved 2017): I. Heat from 25°C to 80°C at 5°C/min; II. Hold at 80°C for 5 min; III. Cooled from 80°C to -30°C at 5°C/min; IV. Hold at -30°C for 5 min; V. Heat from -30°C to 80°C at 5°C; VI. Hold at 80°C for 5 min.

[0135] 3. Hardness profile

[0136] Shortening samples were filled into containers and subjected to texture analysis to evaluate the hardness profile (Stable Micro Systems TA.XT texture analyser, cylindrical probe P/6 6ø). Analytical test parameters: (i) Pre-test speed 1.00 mm/s; (ii) test speed 2.00 mm/s; (iii) post-test speed 2.00 mm/s; (iv) test distance 20 mm; (v) trigger force 5.0g. Hardness of each sample was then derived from the highest point of the software-generated curve (force over time).

[0137] Samples (20°C & 30°C) were analysed in triplicates on a weekly basis for the first 4 weeks, then on a fortnightly basis for subsequent weeks, for a total of 6 months.

[0138] 4. X-Ray Diffraction (XRD) analysis

[0139] XRD analysis was conducted in accordance with AOCS Official Method Cj 2-95 (i.e. X-Ray Diffraction Analysis of Fats, Reapproved 2017) using the Bruker D8 Advance XRD platform (from Bruker Corporation). For the XRD analysis of lab-scale produced shortenings containing OCFA TAG, the initial samples of all the shortenings were tempered as follows: 1. 20 mins at 70°C to completely melt sample and remove remaining crystals (leave for longer if sample is not clear); and 2. 20 mins in fridge to solidify sample. Samples at subsequent time points were not tempered. The XRD analysis conditions were based on Cu Anode, working voltage 40 kV, current 40 mA, antiscatter slit 8.0 mm, divergence slit 0.6 mm, light tube power

2.2 kW, room temperature 25°C. Scanning angle: $12^\circ < 2\theta < 30^\circ$, scanning speed is 1.2°/min, step size is 0.02°. For the XRD analysis of lab-scale produced POL IV64 containing OCFA TAG, the initial samples were tempered by placing in 25°C – 27°C incubator for two days.

[0140] According to the short spacing (defined as all spacings below 5Å): α crystal form – single line or peak at $4.15\text{Å} \pm \text{S.D.}$; β' crystal form – two main lines or peaks at 3.8Å and $4.2\text{Å} \pm \text{S.D.}$, with or without the presence of a minor peak at 4.3Å to $4.4\text{Å} \pm \text{S.D.}$; β crystal form – a strong $4.60\text{Å} \pm \text{S.D.}$ line or peak and several other lines or peaks.

[0141] 5. Specific gravity (Whipping ability)

[0142] The samples were first tempered at 25°C for 24 hours. Samples were blended with sugar in the ratio of 1:1 and subsequently mixed using Hobart mixer (speed 2) for 5 minutes. The sample was then filled into a sample cup and weighed. Specific gravity of sample was measured as per the following equation:

[0143] Specific gravity (%) = $(W_t - W_o)/W$, where W_t is the weight of the weighing cup filled with the sample; W_o is the weight of the empty weighing cup; and W is the weight of water when filled in the weighing cup.

[0144] The above procedure was repeated for 10, 15, 20, 25 and 30-minute intervals.

[0145] Results of analysis

[0146] 1. SFC profile analysis for laboratory scale production

Sample	Wilshort 3639 (COA)	C15 TAG (95%)	C16 TAG (95%)	C17 TAG (95%)
SMP (°C)	36.6	52.45	65.05	70.1
SFC				
N10	52.5	99.0	99.1	99.3
N20	28.2	98.8	98.8	99.2
N25	17	98.7	98.6	99.2
N30	10.6	98.1	97.0	99.0
N35	7.1	97.2	97.0	98.8
N40	3.9	95.7	96.3	97.0
N45	-	90.2	94.9	95.7
N50	-	63.3	88.7	93.1

Table 2. SFC profile of Wilshort 3639, C15 TAG (95% purity), C16 TAG (95% purity) and C17 TAG (95% purity). The slip melting point (SMP) of the samples are also included.

[0147] The SFC of Wilshort 3639, C15 TAG (95% purity), C16 TAG (95% purity) and C17 TAG (95% purity) at 10, 20, 25, 30, 35, 40, 45 and 50°C are listed in Table 2. Fig. 2A shows a line graph of the SFC vs. temperature curves of the different samples. The results show that

OCFA TAGs such as C15 TAG and C17 TAG have a high SFC of at least 95% to at least 99% in the temperature range of 10°C to 40°C, and at least 98% to at least 99% at around 20°C. Such an SFC profile ensures that the OCFA TAG stock (before mixing with any fat base stock) can be easily packaged and stored at storage temperature with no significant softening.

Wilshort 3639	100%	97%	94%	91%	88%	85%	82%
C15 (95%)	0%	3%	6%	9%	12%	15%	18%
SMP (°C)	36.6	37.4	38.4	38.7	39.7	41.3	41.7
SFC							
N10	52.5	55.5	59.3	61.5	63.6	66.1	67.8
N20	28.2	29.7	34.6	37.9	41.2	44.8	47.7
N25	17	18.2	22.7	25.7	29.1	32.8	36.1
N30	10.6	11.0	14.5	17.0	19.8	23.0	26.0
N35	7.1	5.9	8.2	10.1	12.6	13.6	18.3
N40	3.9	2.5	1.9	2.6	4.2	6.7	9.0
N45	0	0.3	0.2	0.2	0.3	0.0	0.3
N50	0	0.2	0.1	0.0	0.2	0.0	0.2

Table 3. SFC profile of samples of Wilshort 3639 (100%, 97%, 94%, 91%, 88%, 85%, 82%) mixed with 95% pure C15 TAG (0%, 3%, 6%, 9%, 12%, 15%, 18%). The slip melting point (SMP) of the samples are also included.

[0148] The SFC of samples of Wilshort 3639 (100%, 97%, 94%, 91%, 88%, 85%, 82%) mixed with 95% pure C15 TAG (0%, 3%, 6%, 9%, 12%, 15%, 18%) at 10, 20, 25, 30, 35, 40, 45 and 50°C are listed in Table 3. Fig. 2B shows a line graph of the SFC vs. temperature curves of the different samples. The results show that the higher the percentage of C15 TAG used in the sample, the higher the SFC profile. Also, at 25°C, samples with 0% to 12% C15 TAG have an SFC in the range of about 15% to about 30%; and at 30°C, samples with 6% to 18% of C15 TAG have an SFC in the range of about 15% to about 30%. SFCs in the range of about 15% to about 30% are desirable for baking specialty fats at usage temperatures.

[0149] 2. Differential Scanning Calorimetry (DSC) profile

[0150] Fig. 3 shows results of DSC profile analysis. Figs. 3A and 3B show the melting curves (with endotherm peaks) and crystallization curves (with exotherm peaks) of C15 TAG (95% purity), and samples of C15 TAG mixed with Wilshort 3639. Figs. 3C and 3D show the melting curves (with endotherm peaks) and crystallization curves (with exotherm peaks) of C17 TAG (95% purity), and samples of C17 TAG mixed with Wilshort 3639. The predicted slip melting point and crystallization temperatures of the samples are listed in Tables 4A and 4B.

Wilshort 3639 percentage	C15 TAG percentage	Predicted slip melting point (°C)	Predicted crystallization temperature (°C)
0	100	53.86	34.15
100	0	38.01	17.19
97	3	38.30	18.50
94	6	39.22	19.42
91	9	39.55	19.84
88	12	40.21	20.53
85	15	41.29	21.01
82	18	41.71	21.54

Table 4A. DSC profile of samples of Wilshort 3639 (100%, 97%, 94%, 91%, 88%, 85%, 82%) mixed with 95% pure C15 TAG (0%, 3%, 6%, 9%, 12%, 15%, 18%). Both the slip melting point and the crystallization temperature predicted for each sample are included.

Wilshort 3639 percentage	C17 TAG percentage	Predicted slip melting point (°C)	Predicted crystallization temperature (°C)
0	100	51.18; 61.43	44.55
100	0	38.01	17.19
99	1	39.31	19.48
98	2	40.80	20.41
97	3	41.73	21.65
94	6	44.48	23.99

Table 4b. DSC profile of samples of Wilshort 3639 (100%, 99%, 98%, 97%, 94%) mixed with 95% pure C17 TAG (0%, 1%, 2%, 3%, 6). Both the slip melting point and the crystallization temperature predicted for each sample are included.

[0151] The results indicate that as the percentages of C15 TAG and C17 TAG in the samples increased, the slip melting point and the crystallization temperature of the samples also increased. The results also show that when the percentages of C15 TAG and C17 TAG are the

same, the samples with C17 TAG have higher slip melting point and crystallization temperature than the samples with C15 TAG.

[0152] 3. Hardness profile analysis for laboratory scale production

[0153] Hardness profile analysis was conducted for samples of Wilshort 3639 base stock (control), Wilshort 3639 mixed with 1% C15 TAG, and Wilshort 3639 mixed with 2% C15 TAG, stored at 20°C and 30°C respectively. As shown in **Fig. 4A**, results of the hardness profile analysis showed that overall, the samples ranked from the hardest to the softest are: Control > 2% C15 TAG > 1% C15 TAG, at both temperatures. The above results showed that shortenings with C15 TAG were softer with slower rate of change as compared to the control shortening. It was also observed that at 20°C, the increase in hardness plateaued for all samples from Week 22 onwards, while at 30°C, samples with C15 TAGs continued to increase in hardness (data not shown). Without being bound by theory, it is thought that this phenomenon was likely attributed to the higher content of saturated fatty acids in the fat formulation, which was more evident at a higher storage temperature, and also at a higher content of C15 TAG.

[0154] 4. XRD analysis for laboratory scale production of shortening using solid fat base stock

[0155] Wilshort 3639

[0156] The fat base stock Wilshort 3639 was included as a first negative control to study the effects of OCFA TAG on the XRD pattern of the fat base stock after mixing. As shown in **Fig. 5A**, the fat base stock Wilshort 3639 sample showed a mix of β and β' peaks initially. As time progressed, there was an extensive conversion from prominent β' crystal form to almost entirely β crystal form, as shown in **Fig. 5B** (after 3 months at room temperature) and **5C** (after 5 months at room temperature).

[0157] C16 TAG

[0158] C16 TAG which is a TAG that does not contain any OCFA chains, was included as a second negative control to study the effect of OCFA TAGs on the XRD pattern of the fat base stock after mixing. As shown in **Fig. 6A₁**, C16 TAG sample (without mixing with any fat base stock) showed that initially, C16 TAG was predominantly α crystals with a minor component of β crystals. As time progressed, there was an extensive conversion from α crystal form to β crystal form, as shown by the appearance of a prominent β peak at 6 months, as shown in **Fig. 6A₂**.

[0159] As shown in **Fig. 6B₁**, XRD of 1% C16 TAG mixed with 99% Wilshort 3639 showed that the resulting blend initially had an obvious β signal together with some β' signals. 3 months old sample showed extensive conversion of the β' signals in the initial sample to only the β signal. There were some remaining but much diminished β' signals in the 3 months old sample,

as shown in **Fig. 6B₂**. 4 months old sample also showed prominent β peak with almost complete loss of all β' peaks (only small β' peaks remaining), as shown in **Fig. 6B₃**.

[0160] As shown in **Fig. 6C₁**, XRD of 2% C16 TAG mixed with 98% Wilshort 3639 showed that the resulting blend initially had an obvious β signal together with some β' signals. 3 months old sample showed extensive conversion of the β' signals in the initial sample to only the β signal. There were some remaining but much diminished β' signals in the 3 months old sample, as shown in **Fig. 6C₂**. 4 months old sample also showed prominent β peak with almost complete loss of all β' peaks (only small β' peaks remaining), as shown in **Fig. 6C₃**.

[0161] As shown in **Fig. 6D₁**, XRD of 3% C16 TAG mixed with 97% Wilshort 3639 showed that the resulting blend initially had an obvious β signal together with some β' signals. 3 months old sample showed extensive conversion of the β' signals in the initial sample to only the β signal. There were some remaining but much diminished β' signals in the 3 months old sample, as shown in **Fig. 6D₂**. 4 months old sample also showed prominent β peak with almost complete loss of all β' peaks (only small β' peaks remaining), as shown in **Fig. 6D₃**.

[0162] As shown in **Fig. 6E₁**, XRD of 6% C16 TAG mixed with 94% Wilshort 3639 showed that the resulting blend initially had an obvious β signal together with some β' signals. 3 months old sample showed extensive conversion of the β' signals in the initial sample to only the β signal. There were some remaining but much diminished β' signals in the 3 months old sample, as shown in **Fig. 6E₂**. 4 months old sample also showed prominent β peak with almost complete loss of all β' peaks (only small β' peaks remaining), as shown in **Fig. 6E₃**.

[0163] Comparing the XRD patterns of the base stock Wilshort 3639 with the XRD patterns of Wilshort 3639 mixed with different percentages (1%, 2%, 3% and 6%) of C16 TAG, it was observed that mixing C16 TAG with Wilshort 3639 did not have any significant effect in preventing the conversion of β' crystals to β crystals over time.

[0164] C15 TAG

[0165] As shown in **Fig. 7A₁**, XRD of C15 TAG showed that initially, C15 TAG (without mixing with any fat base stock) only had β' signals. As time progressed, there was an extensive conversion from β' crystal form to β crystal form, as shown by the appearance of prominent β peaks at 6 months, as shown in **Fig. 7A₂**.

[0166] As shown in **Fig. 7B₁**, XRD of 0.125% C15 TAG mixed with 99.875% Wilshort 3639 showed that the resulting blend initially had an obvious β signal together with some β' signals. The sample at 6 months had a slightly less prominent β peak than the initial sample, and slightly more prominent β' peaks than the initial sample, as shown in **Fig. 7B₂**.

[0167] As shown in **Fig. 7C₁**, XRD of 0.25% C15 TAG mixed with 99.75% Wilshort 3639 showed that the resulting blend initially had an obvious β signal together with some β' signals. The sample at 6 months had a slightly less prominent β peak than the initial sample, and more prominent β' peaks than the initial sample, as shown in **Fig. 7C₂**.

[0168] As shown in **Fig. 7D₁**, XRD of 0.5% C15 TAG mixed with 99.5% Wilshort 3639 showed that the resulting blend initially had a β signal together with some prominent β' signals. The sample at 6 months had a slightly more prominent β peak than the initial sample, and more prominent β' peaks than the initial sample, as shown in **Fig. 7D₂**.

[0169] As shown in **Fig. 7E₁**, XRD of 1% C15 TAG mixed with 99% Wilshort 3639 showed that the resulting blend initially had no obvious β signal but some prominent β' signals. The sample at 2 months had a slightly more obvious β peak than the initial sample. The β' peaks were still present as in the initial sample, as shown in **Fig. 7E₂**.

[0170] As shown in **Fig. 7F₁**, XRD of 3% C15 TAG mixed with 97% Wilshort 3639 showed that the resulting blend initially only had β' signals. 3 months old sample showed a more prominent β signal with less pronounced β' signals as compared to initial sample, as shown in **Fig. 7F₂**. 6 months old sample also showed similar β signal and β' signals, as shown in **Fig. 7F₃**.

[0171] As shown in **Fig. 7G₁**, XRD of 6% C15 TAG mixed with 94% Wilshort 3639 showed that the resulting blend initially only had β' signals. 3 months old sample showed no β signal and still prominent β' signals, as shown in **Fig. 7G₂**. 6 months old sample showed no β signal and still only β' signals, as shown in **Fig. 7G₃**.

[0172] As shown in **Fig. 7H₁**, XRD of 9% C15 TAG mixed with 91% Wilshort 3639 showed that the resulting blend initially only had β' signals. 3 months old sample showed no β signal and still prominent β' signals, as shown in **Fig. 7H₂**. 6 months old sample showed no β signal and still prominent β' signals, as shown in **Fig. 7H₃**.

[0173] As shown in **Fig. 7I₁**, XRD of 12% C15 TAG mixed with 88% Wilshort 3639 showed that the resulting blend initially only had β' signals. 3 months old sample showed no β signal and still prominent β' signals, as shown in **Fig. 7I₂**. 6 months old sample showed no β signal and still prominent β' signals, as shown in **Fig. 7I₃**.

[0174] As shown in **Fig. 7J₁**, XRD of 15% C15 TAG mixed with 85% Wilshort 3639 showed that the resulting blend initially only had β' signals. 3 months old sample showed no β signal and still prominent β' signals, as shown in **Fig. 7J₂**. 4 months old sample showed no β signal and still prominent β' signals, as shown in **Fig. 7J₃**.

[0175] As shown in **Fig. 7K₁**, XRD of 18% C15 TAG mixed with 82% Wilshort 3639 showed that the resulting blend initially only had β' signals. 3 months old sample showed no β signal and still prominent β' signals, as shown in **Fig. 7K₂**. 4 months old sample showed no β signal and still prominent β' signals, as shown in **Fig. 7K₃**.

[0176] Comparing the XRD patterns of Wilshort 3639 mixed with C15 TAG against the XRD patterns of the base stock Wilshort 3639, as well as the XRD patterns of Wilshort 3639 mixed with C16 TAG, it was observed that mixing C15 TAG with Wilshort 3639 significantly reduced the conversion of β' crystals to β crystals over time. In addition, comparing the Wilshort 3639 mixed with different percentages (0.125%, 0.25%, 0.5%, 1%, 3%, 6%, 9%, 12%, 15% and 18%) of C15 TAG, it was observed that when the concentration of C15 TAG in the blend was 6% or more, the effect of C15 TAG in preventing the conversion of β' crystals to β crystals was especially prominent.

[0177] C17 TAG

[0178] As shown in **Fig. 8A**, XRD of C17 TAG showed that initially, C17 TAG (without mixing with any fat base stock) only had α signal. At 6 months, C17 TAG still only showed mainly an α signal with a very minor β signal, as shown in **Fig. 8B**.

[0179] As shown in **Fig. 8C**, XRD of 1% C17 TAG mixed with 99% Wilshort 3639 showed that the resulting blend initially only had β' signals. 3 months old sample showed emergence of a β signal. However, the β' signals were still prominent, as shown in **Fig. 8D**. 6 months old sample still showed a β signal and prominent β' signals, as shown in **Fig. 8E**. There was almost no difference between the 3 months and 6 months samples.

[0180] As shown in **Fig. 8F**, XRD of 2% C17 TAG mixed with 98% Wilshort 3639 showed that the resulting blend mostly had β' signals initially. 3 months old sample showed no β signal and still prominent β' signals, as shown in **Fig. 8G**. 6 months old sample showed no β signal and still prominent β' signals, as shown in **Fig. 8H**. The pattern of signals almost remained unchanged since the initial sample.

[0181] As shown in **Fig. 8I**, XRD of 3% C17 TAG mixed with 97% Wilshort 3639 showed that the resulting blend mostly had β' signals initially. 3 months old sample showed no β signal and still prominent β' signals, as shown in **Fig. 8J**. 6 months old sample showed no β signal and still prominent β' signals, as shown in **Fig. 8K**. The pattern of signals almost remained unchanged since the initial sample.

[0182] As shown in **Fig. 8L**, XRD of 6% C17 TAG mixed with 94% Wilshort 3639 showed that the resulting blend mostly had β' signals initially. 3 months old sample showed no β signal and still prominent β' signals, as shown in **Fig. 8M**. 6 months old sample showed no β signal

and still prominent β' signals, as shown in **Fig. 8N**. The pattern of signals almost remained unchanged since the initial sample.

[0183] Comparing the XRD patterns of Wilshort 3639 mixed with C17 TAG against the XRD patterns of the base stock Wilshort 3639, as well as the XRD patterns of Wilshort 3639 mixed with C16 TAG, it was observed that mixing C17 TAG with Wilshort 3639 significantly reduced the conversion of β' crystals to β crystals over time. In fact, mixing C17 TAG with Wilshort 3639 almost (i.e. other than when the concentration of C17 TAG in the blend was 1%) completely prevented the formation of any β crystals within 6 months. Comparing the XRD patterns of Wilshort 3639 mixed with C17 TAG against the XRD patterns of Wilshort 3639 mixed with C15 TAG, it was observed that C17 TAG was more effective than C15 TAG in preventing the conversion of β' crystals to β crystals, when the concentrations of C15 TAG and C17 TAG used were the same. In addition, comparing the Wilshort 3639 mixed with different percentages (1%, 2%, 3% and 6%) of C17 TAG, it was observed that when the concentration of C17 TAG in the blend was 2% or more, the effect of C17 TAG in preventing the conversion of β' crystals to β crystals was especially prominent.

[0184] 5. XRD analysis for pilot plant scale production of shortening using solid fat base stock

[0185] XRD crystal profile analysis of shortenings samples obtained from pilot plant scale production was carried out at Week 2, 3, 4, 5, 6, 8, 10 18 and 30. As stated above, two different storage temperatures (20°C and 30°C) were used after the samples were tempered for 5 days at 26°C.

[0186] As shown in **Fig. 9A**, at Week 2, the control samples with 0% C15 TAG exhibited both β and β' crystal polymorphs at both storage temperatures, while the samples with 1% and 2% C15 TAG exhibited only β' crystal polymorph at both storage temperatures.

[0187] As shown in **Fig. 9B**, at Week 3, the control samples with 0% C15 TAG exhibited both β and β' crystal polymorphs at both storage temperatures, and the sample stored at 30°C exhibited greater degree of β crystal polymorph than the sample stored at 20°C. The samples with 1% and 2% C15 TAG exhibited only β' crystal polymorph at both storage temperatures.

[0188] As shown in **Fig. 9C**, at Week 4, at 20°C, only the control sample with 0% C15 TAG exhibited both β and β' crystal polymorphs; the samples with 1% and 2% C15 TAG exhibited only β' crystal polymorph. As the storage temperature increased to 30°C, all three samples exhibited β crystal polymorph, with the control sample exhibited almost exclusively β crystal polymorph.

[0189] As shown in **Fig. 9D**, at Week 5, at 20°C, only the control sample with 0% C15 TAG exhibited both β and β' crystal polymorphs; the samples with 1% and 2% C15 TAG exhibited

only β' crystal polymorph. At 30°C, the control sample still exhibited almost exclusively β crystal polymorph. The degree of β crystal polymorph in the samples with 1% and 2% C15 TAG increased as compared to Week 4.

[0190] As shown in **Fig. 9E**, at Week 6, at 20°C, only the control sample with 0% C15 TAG exhibited both β and β' crystal polymorphs; the samples with 1% and 2% C15 TAG exhibited only β' crystal polymorph. At 30°C, the control sample still exhibited almost exclusively β crystal polymorph. The degree of β crystal polymorph in the samples with 1% and 2% C15 TAG increased as compared to Week 5. The sample with 1% C15 TAG exhibited greater degree of β crystal polymorph than the sample with 2% C15 TAG.

[0191] As shown in **Fig. 9F**, at Week 8, at 20°C, only the control sample with 0% C15 TAG exhibited both β and β' crystal polymorphs; the samples with 1% and 2% C15 TAG exhibited only β' crystal polymorph. At 30°C, the control sample still exhibited almost exclusively β crystal polymorph. The degree of β crystal polymorph in the samples with 1% and 2% C15 TAG increased as compared to Week 6. The samples with 1% and 2% C15 TAG exhibited similar degree of β crystal polymorph.

[0192] As shown in **Fig. 9G**, at Week 10, at 20°C, only the control sample with 0% C15 TAG exhibited both β and β' crystal polymorphs; the samples with 1% and 2% C15 TAG exhibited only β' crystal polymorph. At 30°C, both the control sample and the sample with 1% C15 TAG exhibited almost exclusively β crystal polymorph. The degree of β crystal polymorph in the sample with 2% C15 TAG also increased as compared to Week 8.

[0193] As shown in **Fig. 9H**, at Week 18, at 20°C, only the control sample with 0% C15 TAG exhibited both β and β' crystal polymorphs; the samples with 1% and 2% C15 TAG exhibited only β' crystal polymorph. At 30°C, all three samples exhibited almost exclusively β crystal polymorph.

[0194] As shown in **Fig. 9I**, at Week 30, at 20°C, only the control sample with 0% C15 TAG exhibited both β and β' crystal polymorphs; the samples with 1% and 2% C15 TAG exhibited only β' crystal polymorph. At 30°C, all three samples exhibited almost exclusively β crystal polymorph.

[0195] The degree of β and β' crystal polymorphs exhibited are summarized in **Table 5** below. It can be seen that at the storage temperature of 30°C, addition of 1% or 2% C15 TAG to the shortening base stock can delay the onset of β crystals for at least 4-6 weeks.

Week	Polymorph	30C storage			20C storage		
		Control	1% C15	2% C15	Control	1% C15	2% C15
2	β'	++++	+++++	+++++	++++	+++++	+++++
	β	+	-	-	+	-	-
4	β'	-	++++	++++	+++	+++++	+++++
	β	+++++	+	+	++	-	-
6	β'	-	++	+++	+++	+++++	+++++
	β	+++++	+++	++	++	-	-
8	β'	-	+	+	+++	+++++	+++++
	β	+++++	++++	++++	++	-	-
10	β'	-	-	+	+++	+++++	+++++
	β	+++++	+++++	++++	++	-	-
18	β'	-	-	-	+++	+++++	+++++
	β	+++++	+++++	+++++	++	-	-
30	β'	-	-	-	+++	+++++	+++++
	β	+++++	+++++	+++++	++	-	-

Table 5. The degrees of β and β' crystal polymorphs exhibited by the three samples (with 0%, 1% and 2% C15 TAG) at storage temperatures of 20°C and 30°C through Weeks 2 to 30. +: Slightly exhibited; ++: Moderately exhibited; +++: Significantly exhibited; ++++: Greatly exhibited; +++++: Fully exhibited

[0196] 6. XRD analysis for laboratory scale production of shortening using liquid fat base stock (e.g. liquid oil)

[0197] As shown in **Fig. 10A**, XRD of 10% C15 TAG mixed with 90% POL IV64 showed that the resulting blend initially only had β' signals. 2 months old sample showed no β signal and still prominent β' signals, as shown in **Fig. 10B**.

[0198] As shown in **Fig. 10C**, XRD of 15% C15 TAG mixed with 85% POL IV64 showed that the resulting blend initially only had β' signals. 2 months old sample showed no β signal and still prominent β' signals, as shown in **Fig. 10D**.

[0199] As shown in **Fig. 10E**, XRD of 20% C15 TAG mixed with 80% POL IV64 showed that the resulting blend initially only had β' signals. 2 months old sample showed no β signal and still prominent β' signals, as shown in **Fig. 10F**.

[0200] Comparing the POL IV64 mixed with different percentages (10%, 15% and 20%) of C15 TAG, it was observed that mixing C15 TAG with POL IV64 prevented the conversion of β' crystals to β crystals over time. In addition, as the concentration of C15 TAG increased, the β' signals became more prominent. It could therefore be concluded that OCFA TAGs such as C15 TAG could be used to structure liquid oil to produce a shortening with stable β crystal polymorph.

[0201] The inventors of the present application were aiming to compare the effect of OCFA TAG on the conversion of β' crystals to β crystals with the effect of a commercially available emulsifier Trancendim. Trancendim is an emulsifier used to structure liquid oils, marketed by Corbion N.V., a Dutch food and biochemicals company headquartered in Amsterdam, Netherlands. According to the disclosure in the patent application covering the Trancendim emulsifier (WO/2011/071999 published on 16 June 2011), Trancendim contains at least about 50% by weight diglycerides and less than about 25% by weight monoglycerides, based upon the total weight of glycerides in the composition taken as 100% by weight. As there were some difficulties in obtaining a sample of the Trancendim emulsifier on time for this study, an in-house mimic of Trancendim, named MDG (mono-di glyceride composition with about 40% monoglyceride, 60% diglyceride and a small amount of triglyceride), was prepared and used for the analysis.

[0202] As shown in **Fig. 11A**, XRD of 10% MDG mixed with 90% POL IV64 showed that the resulting blend initially had a mix of β signals and β' signal. 1 month old sample showed no significant change, prominent β signals were still present, together with a minor β' signal, as shown in **Fig. 11B**.

[0203] As shown in **Fig. 11C**, XRD of 15% MDG mixed with 85% POL IV64 showed that the resulting blend initially had a mix of β signals and β' signal. 1 month old sample showed no significant change, prominent β signals were still present, together with a minor β' signal, as shown in **Fig. 11D**.

[0204] As shown in **Fig. 11E**, XRD of 20% MDG mixed with 80% POL IV64 showed that the resulting blend initially had a mix of β signals and β' signal. 1 month old sample showed no significant change, prominent β signals were still present, together with a minor β' signal, as shown in **Fig. 11F**.

[0205] As can be seen from the XRD results, for all samples of MDG mixed with POL IV64, the most prominent peak was that of the β crystal polymorph and not the β' crystal polymorph desirable for bakery specialty fat.

[0206] 7. Specific gravity (whipping ability) analysis for laboratory scale production

[0207] Specific gravity (whipping ability) analysis was conducted for samples of Wilshort 3639 base stock (control), Wilshort 3639 mixed with 1% C15 TAG, and Wilshort 3639 mixed with 2% C15 TAG at 30°C over a period of 18 weeks. The results in **Fig. 12** show that that shortenings with C15 TAG had lower specific gravity and thus better whipping ability, as compared to the control shortening.

Claims:

1. A composition comprising at least one triacylglycerol (TAG), wherein the at least one triacylglycerol comprises at least one odd chain fatty acid (OCFA).
2. The composition of claim 1, wherein the at least one TAG is in an α or a β' crystal form.
3. The composition of claim 1 or 2, wherein the at least one TAG has a crystal structure that is predominantly, or substantially, in the β' crystal form; or wherein there is more of the β' crystal form of the at least one TAG present in the composition than any other crystal form of the at least one TAG.
4. The composition of claim 1 or 2, wherein the at least one TAG has a crystal structure that is predominantly, or substantially, in the α crystal form; or wherein there is more of the α crystal form of the at least one TAG present in the composition than any other crystal form of the at least one TAG.
5. The composition of any one of the preceding claims, wherein the at least one OCFA is a saturated OCFA.
6. The composition of any one of the preceding claims, wherein the at least one OCFA is selected from the group consisting of undecanoic acid (C11:0), tridecanoic acid (C13:0), pentadecanoic acid (C15:0), heptadecanoic acid (C17:0), nonadecanoic acid (C19:0), heneicosanoic acid (C21:0), tricosanoic acid (C23:0), and combinations thereof.
7. The composition of claim 6, wherein the at least one OCFA is selected from the group consisting of pentadecanoic acid (C15:0), heptadecanoic acid (C17:0), and combinations thereof.
8. The composition of any one of the preceding claims, wherein the at least one OCFA is present in an amount of at least 50 wt% of the total composition.
9. The composition of any one the preceding claims, wherein the at least one TAG is selected from the group consisting of triundecanoin, tritridecanoin, tripentadecanoin, triheptadecanoin, trinonadecanoin, triheneicosanoin, tritricosanoin, and combinations thereof.

10. The composition of claim 9, wherein the at least one TAG is selected from the group consisting of tripentadecanoin, triheptadecanoin, and combinations thereof.
11. A fat composition comprising the composition as defined in any one of claims 1 to 10, and a fat blend.
12. The fat composition of claim 11, wherein the total amount of the at least one TAG comprising at least one OCFA present in the fat composition is in an amount of between about 0.4 wt% to about 20 wt%, or in an amount of at least about 0.5 wt%, at least about 1 wt%, at least about 2 wt%, at least about 3 wt%, at least about 6 wt%, at least about 9 wt%, at least about 12 wt%, at least about 15 wt%, or at least about 18 wt% of the total fat composition.
13. The fat composition of claim 11 or 12, wherein the fat composition comprises a mixture of TAGs, wherein one of the TAGs is tripentadecanoin or triheptadecanoin.
14. The fat composition of any one of claims 11 to 13, wherein the fat blend comprises a vegetable oil and/or a fractionated product of vegetable oil.
15. The fat composition of claim 14, wherein the vegetable oil is selected from the group consisting of soybean oil, rapeseed oil, coconut oil, palm kernel oil, palm oil, peanut oil, shea nut oil, corn oil, cottonseed oil, rice bran oil, olive oil, canola oil, and combinations thereof.
16. The fat composition of claim 14, wherein the fractionated product of vegetable oil is selected from the group consisting of palm stearin, palm soft stearin, palm hard stearin, palm mid fraction, palm olein, palm super olein, palm kernel stearin, palm kernel olein, shea stearin, and shea olein.
17. The fat composition of any one of claims 14 to 16, where the vegetable oil is palm oil, and the fractionated product of vegetable oil is palm stearin.
18. The fat composition of any one of claims 11 to 17, wherein the fat composition has an x-ray diffraction (XRD) signature showing at least one β' crystal signal.
19. The fat composition of any one of the claims from 11 to 18, wherein the XRD signature of the fat composition shows predominantly β' crystal form; or wherein the XRD signature of the fat composition shows that there is more TAG of the β' crystal form present in the fat composition than TAGs of any other crystal form.

20. A bakery specialty fat comprising the fat composition of any one of claims 11 to 19.
21. The bakery specialty fat of claim 20, wherein the bakery specialty fat is selected from the group consisting of puff pastry margarine, puff pastry shortening, general purpose shortening, general purpose margarine, spread margarine, low fat spread, butter oil substitute, and liquid shortening.
22. An animal-based product comprising the fat composition of any one of claims 11 to 19.
23. An edible product comprising the fat composition of any one of claims 11 to 19.
24. A cosmetic product comprising the fat composition of any one of claims 11 to 19.
25. A prophylactic product comprising the fat composition of any one of claims 11 to 19.
26. A method of producing a composition comprising at least 80% TAG containing at least one OCFA, the method comprises the following steps:
- (a) adding at least one OCFA to glycerol in a reaction vessel;
 - (b) adding between about 0.1% to about 0.3% activated carbon by total reaction mass;
 - (c) flushing the atmosphere with nitrogen gas, thereby obtaining a nitrogen blanket;
 - (d) increasing temperature of the reaction vessel consistently to between about 205°C to about 210°C;
 - (e) incubating for about 7 to 8 hours at between about 205 to about 210°C;
 - (f) allowing the reaction vessel to cool to about 80°C and subsequently filtering the reaction vessel content,
- thereby producing a composition comprising at least 80% TAG containing at least one OCFA.
27. The method of claim 26, wherein the ratio of OCFA to glycerol is between about 2.9:1 to about 3.2:1.
28. The method of claim 26 or 27, wherein the activated carbon is added in an amount of about 0.2% by total reaction mass.
29. The method of any one of claims 26 to 28, wherein the method further comprises:
- (g) adding at least about 0.1% tetrabutyl titanate (TBT; functions as an esterification catalyst) by total reaction mass to the reaction vessel after step (e) (but before step (f));

- (h) incubating the reaction vessel for about 4 to about 5 hours under negative pressure at between about 205°C to about 210°C after step (g) (but before step (f));
- (i) (after step (f)) alkali washing, dehydrating and decolorising the filtered reaction vessel content from step (f), to obtain the composition.
30. The method of claim 29, where the composition comprises at least about 95% TAG with at least one OCFA.
31. The method of any one of claims 26 to 30, wherein the at least one OCFA is selected from the group consisting of undecanoic acid (C11:0), tridecanoic acid (C13:0), pentadecanoic acid (C15:0), heptadecanoic acid (C17:0), nonadecanoic acid (C19:0), heneicosanoic acid (C21:0), tricosanoic acid (C23:0), and combinations thereof.
32. The method of claim 31, wherein the at least one OCFA is selected from the group consisting of pentadecanoic acid (C15:0), heptadecanoic acid (C17:0), and combinations thereof.
33. The method of any one of claims 26 to 32, wherein the TAG is selected from the group consisting of triundecanoin, tritridecanoin, tripentadecanoin, triheptadecanoin, trionadecanoin, triheneicosanoin, tritricosanoin, and combinations thereof.
34. The method of claim 33, wherein the TAG is selected from the group consisting of tripentadecanoin, triheptadecanoin, and combinations thereof.
35. A method for obtaining a fat composition as defined in any one of claims 11 to 19, the method comprising:
- (i) melting at least one TAG comprising at least one OCFA and melting a fat blend;
 - (ii) mixing the melted at least one TAG and the melted fat blend from step (i) to obtain a mixture; and
 - (iii) solidifying the mixture from step (ii) to obtain the fat composition.
36. The method of claim 35, wherein step (iii) is carried out at a temperature between 15°C to 20°C.
37. The method of claim 35 or 36, wherein the at least one TAG comprising the at least one OCFA is added in an amount of between about 0.4 wt% to about 20 wt%, or in an amount of at least about 0.5%, at least about 1%, at least about 2%, at least about 3%, at least about

6%, at least about 9%, at least about 12%, at least about 15%, or at least about 18% of the total fat composition.

38. The method of any one of claims 35 to 37, wherein step (ii) further comprises fractionating after mixing.

39. The method of any one of claims 35 to 38, wherein the method further comprises step (iv) texturizing the solidified mixture.

40. The method of claim 39, wherein texturizing the solidified mixture comprises melting at about 70°C, and cooling at less than about 10°C.

41. The method of claim 40, wherein texturizing the solidified mixture comprises traditional margarine or shortening processing, including chilling and working.