Structured Lipids Based on Palm Oil

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Abstract Palm oil is usually used for the needs of food, chemical industry, and cosmetic industry. The basic processing of palm fruit can produce two types of oil namely crude palm oil (CPO) which is produced from the extraction process of the mesocarp part of the oil palm fruit and palm kernel oil (PKO) as an extract of the palm kernel part. Naturally, oils and fats have specific characteristics, and the development of food processing and technology causes these characteristics to not able to meet all the expected needs to obtain products with certain functional properties such as: lipids for sufferers of coronary heart disease, type 2 diabetes sufferers, patients in the post-operative recovery period, patients who suffer from allergies or digestive problems, and consumers who are controlling their weight low-calorie products. The dominant fatty acids in palm oil are palmitic, oleic acid, and linoleic acid. CPO also contains minor components such as squalene, sterols, and carotenoids. Structured lipids (SLs) are the result of modification or restructuring of triacylglycerols, which can be obtained by chemical or enzymatic interesterification of triacylglycerols containing short, medium, and/or long chain fatty acids. SLs are the result of modification or restructuring of triacylglycerols, which can be obtained by chemical or enzymatic interesterification of triacylglycerols. SLs can be sourced from animal or vegetable fats, or genetic engineering. SLs are synthesized for the purpose of obtaining functional lipids or nutraceuticals, which can improve or modify the physical, chemical, and rheological characteristics of oils and fats, and changing or enhancing nutrition properties of food, giving a certain health benefit. Palm oil has special fatty acids and other minor components, making it possible to be used as a raw material for the manufacture of SLs so that their bioavailability increases. Functional oil and fat production can be catalyzed by lipase. Fats/oils can improve physicochemical and nutritional properties using a lipase catalyst. Palm oil has special fatty acids and other minor components, making it possible to be used as a raw material for the manufacture of SLs so that their bioavailability increases. Functional oil and fat

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production can be catalyzed by lipase. Fats/oils can improve physicochemical and nutritional properties using a lipase catalyst.

Keywords Fatty acid · Interesterification · Palm oil · Structured lipids

1 Introduction

Palm oil is a vegetable oil that can be obtained from the mesocarp of the fruit of the oil palm tree, generally of the species Elaeis guineensis. Naturally, palm oil is red in color due to its high beta-carotene content. This oil is a common cooking ingredient in tropical countries including Africa, Southeast Asia, and parts of Brazil. The results of the palm oil industry are not only cooking oil but can also be used as a basic ingredient for other industries such as the food and cosmetics industries. Half of all fats and vegetable oils consumed come from palm oil (Murgianto et al. 2021).

Palm oil is usually used for the needs of food (popular components in baking, processed meals, snacks, frozen foods, and chocolate due to their neutral taste, texture, and practicality), chemical industry, and cosmetic industry. The largest demand for palm oil is used for food ingredients such as cooking oil, margarine, shortening, emulsifiers, cocoa butter substitutes, and other derivative products. The basic processing of palm fruit can produce two types of oil namely crude palm oil (CPO) which is produced from the extraction process of the mesocarp part of the oil palm fruit and palm kernel oil (PKO) as an extract of the palm kernel part (Ali et al. 2014). Commercial cooking oil is made from palm olein, whereas palm stearin is mostly used for shortening and margarine products. PKO has a sharp melting profile because high in lauric acid therefore it is suitable for confectioneries and other specialty fats. PKO is more widely used in a variety of non-edible products, such as cosmetics, detergents, surfactants, plastics, herbicides, and various other industrial and agricultural chemicals. The widespread use of palm oil makes this oil an important commodity that plays a role in food security in the world (Dian et al. 2017; Chew et al. 2021).

Naturally, oils and fats have specific characteristics. The development of food processing and technology causes these characteristics to be not able to meet all the expected needs. For example, lipids for sufferers of coronary heart disease, type 2 diabetes sufferers, patients in the post-operative recovery period, patients who suffer from allergies or digestive problems, and consumers who are controlling their weight low-calorie products and to obtain products with certain functional properties. Therefore, it is necessary to modify the fatty acids that make up the triacylglycerol (TAG) into structured lipids (SLs).

SLs can be carried out by interesterification, either chemically or enzymatically. The advantages of enzymatic interesterification are that the reaction is more specific, the reaction conditions (pH, temperature, pressure) are milder and the waste produced is minimal, thereby reducing environmental pollution. The composition of the TAG after enzymatic interesterification will depend on the reaction conditions such as the type of enzyme, reaction time and temperature, water activity of the enzyme, substrate ratio, and the type of substrate used. The interesterification process results in changes in the chemical, physical, and oxidative properties of the substrate of origin. With the superiority of fatty acids in palm oil, it is possible to serve as SLs which can be used as raw materials for functional food.

2 Palm Oil

2.1 General

Palm (*Elaeis guineensis*) is a plant originating from the West African region and classified as a tropical plant. Palm fruit has an oval shape and is attached to bunches and can weigh up to 10–40 kg. The palm fruit consists of 2 main parts, namely the pericarp and the seed. Oil palm fruit bunches are composed of fruit flesh (60%), bunch skin (29%), and fruit seeds/palm kernel (11%). The pericarp consists of the exocarp, mesocarp, and endocarp, while the seed portion consists of the endosperm (palm kernel/kernel), embryo, and seed coat (Ezechi and Muda 2019; Mahlia et al. 2019).

CPO obtained from extraction or from the pressing process of the flesh of the palm fruit and has not been refined. CPO refinery to make cooking oil always begins with heating, threshing, boiling, stirring, and pressing then proceed with filtering, purification, and phase separation (fractionation). Fractional crystallization, which can be classified into dry and solvent fractionation, is used to separate oils and fats into two or more components. The first stage of fractionation is crystallization, which is followed by the separation of solid and liquid fractions (Hasibuan et al. 2021). Palm oil is very useful for edible oil to make food products, such as frying or cooking oil including margarine, shortenings, red palm oil, and also specialty fats. Palm olein has no unpleasant odor, no trans-fatty acid, and has high resistance to oxidation. Therefore, it is suitable for frying and applications and it is commonly used for cooking, either with pan frying and deep frying and can be reused several times in restaurants, fast food restaurants, and also in the manufacture of snack foods and instant noodles (Purnama et al. 2020).

2.2 Palm Oil Processing

CPO still contains unwanted impurities. Components in the form of phospholipids, proteins, residues, and carbohydrates in the oil need to be removed through the degumming process. The principle of degumming is to separate the phosphatides into the aqueous phase so that they can be separated by precipitation, filtering, or centrifugation. Processing of oil palm bunches begins with heating, threshing, boiling, stirring, and pressing then followed by filtering, purifying, and separating phases (fractionation). Oil refining consists of several stages: gum separation, neutralization, bleaching, and deodorization. Bleaching process reduces the amount of carotene to get clear cooking oil (Andarwulan et al. 2018).

The liquid fraction of palm oil that has been refined at the deodorizing stage to remove free fatty acids and clarification to remove color and deodorize and fractionate is known as refined, bleached, and deodorized palm olein (RBDP Olein). CPO processing by modifying the refining process, without bleaching, to maintain the carotene content in palm oil can produce red palm oil or Red Palm Oil (RPO) (Sumarna et al. 2022). The content of carotene, especially α-carotene and β-carotene, is a precursor of vitamin A in the body. Before use, CPO extracted from fresh fruit bunches needs to be purified because CPO still contains unwanted impurities. Components in the form of phospholipids, proteins, residues, and carbohydrates in the oil need to be removed through the degumming process. The principle of degumming is to separate the phosphatides into the aqueous phase so that they can be separated by precipitation, filtering, or centrifugation.

Degumming process can be carried out in various ways. Wet degumming is able by adding phosphoric acid, and citric acid. Dry degumming uses the same steps as wet degumming but without adding water. Of the two methods performed, the wet degumming method produces better quality than the other method of dry degumming (Putri et al. 2019; Mayalibit et al. 2020). Neutralization process is carried out to separate the free fatty acids. Generally neutralization is done by reacting NaOH with acid free fat contained in the oil to form soap that can be separated (Musyaroh and Hidayat 2018). The process of deodorization of oil is carried out as one of the important steps that must be taken in order to reduce unwanted aromas or tastes. Both of these parameters are usually caused by damage to the oil component in the oil during processing, such as unsaturated hydrocarbons, terpenes, sterols, and tocopherols (Ramlah and Sampebarra 2018). Deodorization also affects the reduction of free fatty acid levels in oil, although not as much as degumming, neutralization, and bleaching processes (Riyadi et al. 2016).

The fractionation process in oil is carried out to separate the olein fraction (liquid phase) and the stearin fraction (solid phase) of the oil. The olein fraction is often used as cooking oil while the stearin fraction is often used as an ingredient raw margarine or shortening. Fractionation is accomplished by winterization, crystallization (hexane, acetone, or isopropyl alcohol), and detergent processes. Winterization can result in oil loss which is abundant whereas organic solvents are flammable and expensive in the process. The most commonly used is dry fractionation separated by cooling first so that the stearin freezes and the olein can be filtered.

Palm oil is naturally semi-solid at room temperature, meaning there is no need for it to be hydrogenated and therefore it contains no trans fats. Replacing trans fats with palm oil may reduce heart disease risk markers and improve blood lipids. In the hydrogenation process, unsaturated triglycerides are attacked more quickly than di-oleo-glycerides, and finally mono-oleo compounds. The concept of fatty acid selectivity indicates that the rate of hydrogenation of various unsaturated fatty acids depends on the concentration of hydrogen. Consequently the reaction rates of two different unsaturated fatty acids, for example, linoleic acid and oleic acid, are only a function of the concentrations of these acids and their rate constants, so that the concentrations of these acids can be determined experimentally, while the ratio of the hydrogenation rate constant can be calculated (Gunstone and Norris 2013). During the hydrogenation process, double bonds are not only saturated, but they may also shift their position along the fatty acid chain (positional isomerization) and/or undergo *cis-trans* isomerization. Because *trans* isomers strongly affect the physical properties of the triglycerides, the extent of the formation of these isomers has to be controlled. It is generally expressed as the "*trans* selectivity" or as the "isomerization index," which are defined as the increase in *trans* content (expressed as % elaidic) divided by the decrease in iodine value or by the decrease in double bond content, respectively, as observed in the early stages of the hydrogenation process. Elaidic acid, $C_{18}H_{34}O_2$, has an essentially linear alkyl chain. The double bond is twisted across the mean direction of the alkyl chain. In the crystal structure, the molecules form centrosymmetric O–HO hydrogen-bonded dimers.

2.3 Composition Palm Oil

The RBDPO fractionation will produce two unique fractions, namely the olein fraction which has a high iodine number and low melting point and the stearin fraction which has a lower iodine number and a high melting point (Tables 1 and 2).

CPO contains unsaturated fatty acids and saturated fatty acids. Saturated fatty acids have only single bonds between their carbon atoms, whereas unsaturated fatty acids have at least one double bond between their constituent atoms. Saturated fatty acids are more stable or less visible than unsaturated fatty acids. Double bonds in unsaturated fatty acids easily react with oxygen or are easily oxidized. Composition

Table 1 Comparison of fatty acid composition of palm oil

Fatty acids	CPO (%)	Oleic (%)	Stearic (%)
Lauric (C12)	0.10–0.40 (0.24)	0.20–0.40 (0.27)	0.10–0.30 (0.18)
Miristic (C14)	1.00–1.40 (1.11)	0.90–1.20 (1.09)	1.10–1.70 (1.27)
Palmitic (C16)	40.90–47.50 (44.14)	36.80–43.20 (40.93)	49.80–68.10 (56.79)
Stearic (C18)	3.80–4.80 (4.44)	3.70–4.80 (4.18)	3.90–5.60 (4.93)
Oleic (C18:1)	36.40–41.20 (39.04)	39.80–44.60 (41.51)	20.40–34.40 (29.00)
Linoleic (C18:2)	9.20–11.60 (10.57)	10.40–12.90 (11.64)	5.00–8.90 (7.23)
Linolenic (C18:3)	0.05–0.60 (0.37)	0.10–0.60 (0.40)	0.00–0.50 (0.09)
Arachidic (C20:0)	0.20–0.70 (0.38)	0.30–0.50 (0.37)	0.00–0.50 (0.24)

Gee (2007)

Table 2 Physical characteristics and chemical composition

Characteristics	Typical	Range
Specific gravity, 30 °C	0.918	0.951–0.920
Index refraction, 25 °C	–	1.470–1.474
Iodin value	124.0	118.0–128.0
Saponification	–	187–193
Unsaponification	–	1.3–2.3
Melting point (°C)	–	−12 to −10
Solid point (°C)	–	1.0–20.0
Stability AOM (h)	19	16–19
α-Tocopherol (ppm)	152	116–172
β-Tocopherol (ppm)	12	0–22
γ-Tocopherol (ppm)	1276	119–1401
δ-Tocopherol (ppm)	61	59–65

O'Brien (2008)

of saturated and unsaturated fatty acids in palm oil is balanced. The dominant fatty acids consist of palmitic (44–45%), oleic acid (39–40%), and linoleic acid (10–11%). This allows it to be fractionated into two main fractions: liquid oil (65–70%), palm olein (mp 18–20 °C), and solid fraction (30–35%), stearin (mp 48–50 °C). CPO also contains minor components (1%) such as squalene (200–600 ppm), sterols (250–620 ppm), and carotenoids (500–700 ppm), pigments responsible for the reddish-orange color and the richest source of tocotrienols in the world (de Almeida et al. 2019).

Beta carotene is a minor component found in palm oil and is a secondary metabolite that belongs to the group of carotenoid compounds synthesized by plants, algae, and some microorganisms. This type of carotenoid is an organic compound that is a chromophore and has eleven conjugated double bonds in its structure. The beta carotene molecule has two beta-ionic rings which theoretically will experience chain termination at –C15 = C15′– so beta carotene will be converted into two retinol molecules (Bogacz-Radomska and Harasym 2018).

Beta carotene is a carotenoid compound that has high bioactivity. The bioactivity properties of beta carotene are useful as a source of provitamin A which can support the growth of embryo in pregnant women, the growth of children, and influence for eye health. Apart from that, beta carotene as well has high anticancer and antioxidant properties so it can ward off cancer, the bad influence of free radicals, increase body immunity, prevent aging in early childhood, and the risk of cardiovascular disease (Langi et al. 2018).

2.4 Deterioration of Palm Oil

The ratio of oil degradation mainly depends on fatty acid composition, type, and quality of the oil. The selection of oils should be based on the optimization of the process with regard to culinary aspects as well as nutritional, physiological, and technological requirements. The application of high temperatures to the oil results in a change in the composition of the fatty acids and produces monoglycerides, diglycerides, free fatty acids, primary and secondary oxidation products through processes such as oxidation, polymerization, and hydrolysis (Jadhav et al. 2022). Free fatty acid (FFA %) content is the most widely used criterion to determine the quality of palm oil. Codex Alimentarius standard for maximum concentration of FFA to 5.0% for CPO and up to 0.3% for RPO in oleic acid. Thus, according to this norm, all fresh oil (zero month storage) is within the established limits (de Almeida et al. 2019).

Lipid oxidation is an important quality criterion for the food industry. Oxidation is a reaction between unsaturated fats and oxygen which is accelerated by heat, light, and metals. Acid value gives an indicator of free fatty acids present in the sample of oil. Peroxide value is an indicator of primary oxidation products (hydroperoxides) formed due to oxidation of lipids in food which can be decomposed into aldehydes and ketones. Formation of secondary oxidation products like aldehyde and ketones by degradation of peroxide can be measured by p-Anisidine value. Lipid oxidation not only produces a rancid flavor but can also reduce nutritional quality and safety, namely the formation of oxidation products which cause toxic products in the presence of peroxide decomposition to produce secondary reaction products, and provide other physiological and pathological effects (Nurhasanah et al. 2019; Jadhav et al. 2022). Thermoxidative changes in heated oil with total polar components (TPC), anisidine (AV) values, formation of color components, and changes in the composition of fatty acids and tocopherols.

3 Structured Lipids

3.1 Definition

SLs are the result of modification or restructuring of triacylglycerols, which can be obtained by chemical or enzymatic interesterification of triacylglycerols containing short, medium, and/or long chain fatty acids. SLs can be sourced from animal or vegetable fats, or genetic engineering. SLs are synthesized for the purpose of obtaining functional lipids or nutraceuticals, which can improve or modify the physical, chemical, and rheological characteristics of oils and fats, and changing or enhancing nutrition properties of food, giving a certain health benefit. The properties of fatty acids based on physical, biological, and nutritional are largely determined by the position, number, and configuration of their double bonds. These determine the shape of the molecules, the way molecules can pack together in solid phases, monolayers, bilayers, and how individual molecules can interact with enzymes and receptors. Changes in the composition and position of the fatty acids in triacylglycerols are caused by the interesterification reaction causing changes in several properties such as solid fat content, crystallization behavior, physical properties, chemical properties, thermal properties, and consistency when compared to native lipids. The changes are verified through physical, chemical, and functional analysis due to the fact that SLs can present triacylglycerols. SLs can provide essential fatty acids such as linoleic (18:2n-6), oleic acid (18:1n-9), and linolenic acid (18:3n-3) as found in many vegetable oils, such as soybean oil, olive oil, palm oil, coconut oil. These fatty acids are essential for growth and development throughout the human life cycle, as well as the promotion of improvement in health, and plays an important role in reducing risk of metabolic syndrome (Moreira et al. 2017).

One form of lipid structure is specialty fats. Specialty fats are type of fat that has a special function, so that it has the potential for special applications such as to make confectionery fat, usually used to replace all or part of cocoa butter and dairy butter. Among specialty fats, cocoa butter alternatives represent perhaps the most diverse and widely developed specialty fats. Cocoa butter alternatives are designed to provide an alternative, both economically and functionally, to a high-value ingredient, cocoa butter. These fats are formulated or modified from palm oil, since the cocoa butter and dairy butter are expensive and their supply unreliable. The role of these fats is to provide specific texture and richness of taste. Furthermore, the confectionery fats should have a sharp melting behavior to melt easily in the month (Talbot 2015; Ramadan 2019).

SLs are beneficial for human nutrition because they can be tailor-made to target specific diseases and metabolic conditions, and reduce calories by specifically positioning certain fatty acids in the glycerol backbone. Such low-calorie fats are usually designed to take advantage of the limited absorption of long-chain saturated fatty acids or the lower caloric density of short-chain saturated fatty acids. SLs also lower cholesterol, LDL cholesterol, and triglycerides, given a normal diet as well as an atherogenic diet. In addition, lipid accumulation in the arteries was also significantly reduced. Thus low-calorie structured fat has the added benefit of reducing serum and liver lipids which are considered risk factors for cardiovascular disease (Kanjilal et al. 2016).

Lipase is more promising when certain positional modifications of triacylglycerols are addressed, in addition to resulting in less residue in SL production. In addition, enzymes can be reused many times, minor lipids, among other compounds with bioactive functions, are preserved due to milder reactions compared to chemical interesterification. After the interesterification reaction, the number of triacylglycerols is higher than diacylglycerol and monoacylglycerol content, hydrolysis followed by esterification leaving a small amount of diacylglycerol and monoacylglycerol, either by using lipase Lipozyme TL IM or by Rhizopus sp. (Moreira et al. 2017).

3.2 Structured Lipid Synthesis

3.2.1 Chemical

Chemically catalyzed is the most common interesterification process which is described as a "reshuffling". Accidental and limited interesterification can occur when the oil is heated to above 200 °C, as illustrated by the characteristic change in crystallization of confectionery fat after deodorization (Gunstone and Norris 2013). In general, the chemical interesterification process takes place with three kinds of reactions at once, namely: (1) Alcoholysis, (2) Acidolysis, and (3) Transesterification. For the interesterification reaction, use under low pressure in a water bath at 80–85 °C for 30 min. After drying, 1% (m/m) sodium methoxide powder (Oliveira et al. 2017).

The advantages of chemical interesterification are relatively faster methods, one of which is for the synthesis of tripalmitin. Palmitic acid is not easily oxidized even at relatively high temperatures. The final product contained is 97.60% PPP, 1.46% dipalmitin, 0.08 and 0.26% monopalmitin. The disadvantage of this method is that the alkaline catalyst in liquid form mixes perfectly with the product so that purification of the product from the catalyst is relatively difficult. In addition, the use of alkaline catalysts results in side reactions that are very disturbing, namely the occurrence of saponification reactions to form unwanted by-products thereby reducing yields (Wei et al. 2015).

3.2.2 Enzymatic

In addition to chemically catalyzed randomization, there are also directed interesterification processes in which the equilibrium associated with complete randomization is disturbed either by distillation of the most volatile components, such as FAME (fatty acid methyl esters) (Gunstone and Norris 2013).

Enzymes are well-known as one of the biocatalysts of a wide variety of processes that are highly effective and efficient catalysts characterized by high activity and selectivity to accelerate biochemical reactions. The conversion of substrate catalyzed by lipase into products is carried out by reducing the energy of the activation reaction, carried out under mild conditions (pH and temperature), very good selectivity, and substrate activity. Many commercially essential processes, especially in various food, cosmetic, and pharmaceutical industries use lipases as a natural catalyst. Lipases are a powerful tool for biotransformation on a broad substrate range (Robinson 2015; Liu and Dong 2020; Pandey et al. 2020). Catalysts are widely used in the chemical industry sector: in basic chemistry, in polymerization chemistry, and in refining such as refining including coconut oil-based products, as well as in liquid reactions industrial processes (pharmacy, food, cosmetic, etc.) (Bedade et al. 2019).

The enzymes that can be used for the above purposes are Lipozyme TL IM and Novozyme 435. Lipozyme TL IM is a type of commercial lipase enzyme immobilized using silica gel from *Thermomyces lanuginosus* and is widely used for various esterification reactions. This enzyme has positional specificity of the TAG molecule, namely at the primary position (sn-1,3) with a mild optimal temperature (25–60 °C). Meanwhile, Novozyme 435 is a type of non-specific immobilized commercial lipase enzyme using macroporous acrylic resin beads with an optimum temperature of 40–60 °C (Ortiz et al. 2019).

Modification of the simple mixture by these two lipases causes a change in thermal profile, which causes a delayed crystallization process, as well as the decrease in enthalpy, indicating that it is interesterified the sample releases less energy during crystallization. Energy measured in this process refers to the rearrangement of the liquid phase molecules, which release energy and reformulate in the solid state. In addition, the crystallization curve also reveals that the higher degree of unsaturation fatty acids in the TAGs lowers the end temperature and enthalpy of crystallization. This phenomenon can be explained by the fact that enthalpies are calculated by the area of each peak and according to the number of crystals formed during cooling indicated crystallization curve of the SLs mixture difference performances presented by lipases, synthesized SLs with Rhizopus sp. lipase showed three crystallization peaks, due to incomplete restructuring of the tri- and saturated TAG formed presenting a higher enthalpy value for each peak compared to samples catalyzed by Lipozyme TL IM (Moreira et al. 2017).

Bioavailability of fatty acids is not only determined by composition, but also determined by the position of each type of fatty acid on the glycerol backbone. Unsaturated long chain fatty acids in position sn-2 can improve bioavailability, because pancreatic lipase confers less activity on these fatty acids when esterified to the sn-1 and sn-3 positions. The absorption of long chain fatty acids and MCFA will be higher if they are present in the sn-2 position of the TAG. The TAG will be converted into 2 monoglycerides which are more water soluble by pancreatic lipase in the body. At position sn-1,3 can support low lipid absorption, without compromising the fatty acids located in sn-2. Based on this perspective, this type of SL synthesis requires modification at certain positions on the glycerol backbone, which can be obtained by enzymatic interesterification (Moreira et al. 2017).

Lipases can be produced by plants, animals, and microorganisms, and microbial lipases are receiving more attention from the industry because of their ability to remain active at extreme temperatures, organic solvents, pH, exhibit high selectivity, wide substrate specificity, and do not require cofactors. The advantages of lipases can reduce the number of hazardous solvents needed; the total reaction steps make the process cheaper and more environmentally friendly. Other benefits of using lipases are mild reaction conditions, low energy consumption, biodegradability, and yields of a pure product. The lipase from *Thermomyces lanuginosus* expressed in *Aspergillus oryzae* is the first commercialized recombinant lipase. Lipase is an enzyme that can work reversibly, catalyzes the hydrolysis of triacylglycerol to glycerol and free fatty acids and, or partial hydrolysis to diacylglycerols (DAGs) and monoacylglycerols (MAGs) (Subroto et al. 2019).

Enzymatic interesterification process system can be done with the feedbatch system and system continuous. (Wei et al. 2015) observed *Thermomyces lanuginosus* lipase activity during batch interesterification process. Activity enzymes decreased rapidly after 6 times (equal to 24 h) reaction on batch system.

4 Structured Lipids Based on Palm Oil

Palm oil has special fatty acids and other minor components, making it possible to be used as a raw material for the manufacture of SLs so that their bioavailability increases. Functional oil and fat production can be catalyzed by lipase. Fats/oils can improve physicochemical and nutritional properties using a lipase catalyst. Unsaturated fatty acids in triglycerides are mostly in the sn-2 position. The lipase specificity of sn-1,3 can be used to catalyze the transesterification reaction while maintaining sn-2 fatty acids. Strategies for Human Milk Fat Subtitute (HMFS) have been developed to mimic the fat composition and distribution of human milk. HMFS is used in infant formula to mimic the fat of breast milk. Breast milk is the main choice for newborns, infant formula that most closely resembles breast milk is a good substitute for baby nutrition when breastfeeding is insufficient or cannot be done. Fatty acid components in human milk fat are oleic acid, palmitic acid, linoleic acid, followed by stearic acid, myristic acid, and lauric acid. The distribution position of breast milk fatty acids is 70% palmitic acid is in the sn-2 position and UFA (oleic acid, linoleic acid linolenic acid, etc.) is in the sn-1.3 position. This characteristic makes breast milk fat different from most vegetable oils in that most of the UFA is in the sn-2 position and the SFA especially palmitic acid is in the sn-1,3 position (Qin et al. 2014; Hasibuan et al. 2021).

Cocoa butter (CB) is a very important ingredient that contributes to the textural and sensory properties of confectionery products, particularly chocolate products (up to 32% CB in chocolate formulations). CB is hard and brittle under room temperature, but when eaten, it melts perfectly in the mouth with a soft creamy texture and a cold sensation. The CB polymorphism has a major influence on the physical properties of chocolate products, such as gloss, snap, contraction, heat resistance, fast and sharp melting in the mouth, and bloom resistance. The special nature of CB is not followed by supply, price, use in hot climates, and consistency of quality between regions (Zhang et al. 2020). SL plays a role in the development of bakery products. Based on the SL1 melting profile, it is suitable for the manufacture of biscuits and cakes in terms of sensory and organoleptic properties. The organoleptic characteristics and quality of biscuits and cakes made with SL1 were indistinguishable from those prepared with traditional bread tallow. This suggests that bakery fats can be fully replaced by SLs studied to prepare trans-free low-calorie cakes and biscuits. Thus the use of low-calorie fat can be applied to bakery products, cakes and biscuits are not only trans-free but also have added value for health such as low calories and hypocholesterolemic properties (Kanjilal et al. 2016). Binary mixture of PKO and interesterified fats was dominant in β′ crystal. The chocolate showed consistent texture before and after tempering process (Zhang et al. 2020).

PKO with other vegetable oils can be used as raw material for SL. PKO contains a wide variety of fatty acids (C6−C20) and has more β′ polymorphs than β. Margarine made with SL from a mixture of PKO, canola oil, and stearin fractions has a hardness, stickiness, or compactness similar to commercial margarine. Therefore, the SL is suitable for the formulation of trans-free margarines with low atherogenicity and desirable textural properties (Kim 2008).

5 Conclusion

Palm oil is produced from the extraction process of the mesocarp part of the palm fruit (CPO) and palm kernel oil (PKO). Naturally, oils and fats have specific characteristics, developments in food processing and technology have made these characteristics unable to meet all the expected requirements for obtaining products with certain functional properties by making SLs by modifying or restructuring triacylglycerols, which can be obtained by chemical or enzymatic interesterification of triacylglycerols. SLs can be sourced from animal or vegetable fats, or genetic engineering. SL is synthesized with the aim of obtaining functional lipids or nutraceuticals, which can improve or modify the characteristics of oils and fats, and change or enhance the nutritional properties of foods, providing certain health benefits. Palm oil has special fatty acids and other minor components, making it possible to use it as a raw material for SL so that its bioavailability increases.

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