The Recent Application Of Palm Stearin In Food Industry: A Review

Edy Subroto, Rizki Lutfiani Nurannisa

Abstract: Palm oil is divided into two main fractions, namely solid fraction called palm stearin (PS) and liquid fraction called palm olein (PO). The separation of this fraction aims to increase the potential application of palm oil, especially palm stearin, which has flexible melting characteristics for various food industries. This review presents various uses of palm stearin for the food industry. The use of stearin is not only for fat-based food but also as a substitute material that can affect the physical and chemical characteristics of other food products. The more advanced the technology, the more research is developing the potential of stearin with various treatments, especially through interesterification technology. The uses of palm stearin for the food industry include polysaccharide-based coating substitutes, margarine, shortening, cocoa butter replacers, lard replacers, and emulsion products. Palm stearin has a good effect on the physicochemical, functional, sensorial properties of various food products.

Index Terms: Palm stearin, food industry, margarine, shortening, emulsion

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1. INTRODUCTION

Oil palm plantations (Elaeis guineensis Jacq.) is a high productivity crop, which is the main potential to meet the world's vegetable oil needs. Commercially, there are two types of vegetable oil extracted from palm oil, namely crude palm oil (CPO) and palm kernel oil (PKO). Both have different types of fatty acids so that each has different benefits for various industries. CPO is more widely used in food industries such as cooking oil, margarine and shortening, while PKO is more suitable in non-food sectors such as cosmetics [1], [2]. In processing, CPO is divided into two fractions, namely palm stearin (30-35%) and palm olein (65-70%). Palm stearin (PS) is solid at room temperature because it has a high amount of saturated fatty acids [2], [3]. PS has a slip melting point (SMP) of about 44-56^{o}C [4]. It contains palmitic acid about 47-74%, oleic acid (16-37%), stearic acid (4-6%), linoleic acid (3-10%), and myristic acid (1-2%) [5]. The triglycerides composition of palm stearin was dominated by POP, PPP, and POO about 30.0%, 22.1%, and 16.3%, respectively [6]. The high melting point of palm stearin (44-56^{o}C) can cause problems in the manufacture of edible fats such as shortening and margarine, which results in the product having low plasticity [7]. However, palm stearin has great potential if its melting point can be lowered as desired for the manufacture of various food products. This can be conducted by mixing other oils which have a lower melting point in order to obtain a fat mixture with more suitable melting properties. Modification through the hydrogenation, interesterification, and fractionation has been widely used to improve the plasticity of fats [8]. The modification method through enzymatic interesterification between palm stearin and other oils is a suitable and growing method for modifying the physical and chemical properties of the lipid [9]. The purpose of the treatment is to improve the functionality of stearin. Fats with extensive plastic range properties such as palm stearin are used in the production of the bakery, shortening, and margarine [5], [8]. The use of stearin is not only for the manufacture of fat-based foods but as a substitute material that can affect the physical and chemical characteristics of food or supporting materials in the production of food produced.

- *Edy Subroto and Rizki Lutfiani Nurannisa: Department of Food Industrial Technology, Faculty of Agro-Industrial Technology, Universitas Padjadjaran, Jl.Raya Bandung-Sumedang Km. 21, Jatinangor, Sumedang 40600, Indonesia. E-mail: edy.subroto@unpad.ac.id; rizkilutfianin@gmail.com*

2 APPLICATION OF PALM STEARIN IN FOOD INDUSTRY

2.1 Coating substitution material

The coating material is generally made from polysaccharides, but they have the disadvantage of being very hygroscopic. Hygroscopic properties can cause agglomeration/clumping caused by increased water content during storage [10]. Improvement of hygroscopicity properties of the coating material can be conducted by the addition of material with hydrophobic properties such as stearin and beeswax, so it is expected that the substituted coating does not easily absorb water [11]. Palm oil can be used as the material in the encapsulation process, especially to improve the ability of film-forming or to form the outer layer of encapsulation. Specifically, palm stearin plays a role in the process of film formation because its high melting point makes stearin have a crystalline structure [12]. To increase the ability to form films, it also requires the addition of materials that can improve film properties such as beeswax. The addition of beeswax can improve film on microcapsules. Mixing palm stearin and beeswax will form stronger hydrophobic properties that increase the efficiency of the moisture barrier in the coating [13]. One of the coating material in the form of polysaccharide includes xanthan gum. Ding et al. [11] reported that the addition of stearin and beeswax with a ratio of 7:3 to xanthan gum can increase the efficiency of encapsulation and improve the wall system on the coating. That is because there is a synergistic effect between stearin and beeswax. Long fatty acid in palm stearin and beeswax form a stable layer on the surface of core material that has a high degree of polarity. The decrease in the hygroscopic level of xanthan gum causes the coating not easy to absorb water vapor, and the coating is difficult to agglomerate. Therefore palm stearin and beeswax have the potential as suitable substitutes for coatings in the food industry [10]. Various solid lipids can also be used as coatings for the synthesis of nanostructured lipid carriers (NLCs) and solid lipid nanoparticles (SLNs) [14], [15]. Palm stearin and palm olein have been used for β-carotene-loaded nanostructured lipid carriers. Rohmah et al. [16] reported that palm stearin could be prospectively developed as β-carotene-loaded nanostructured lipid carriers that produce NLC with an encapsulation efficiency of 91.2

2.2 Margarine

The formation of trans fatty acids produced due to the hydrogenation process in making margarine can increase the risk of coronary heart disease and increase the amount of cholesterol in the blood plasma [17], [18]. Therefore, the development of margarine manufacturing processes is carried out, including through blending or interesterification. The process does not change the level of saturation of fatty acids and does not produce trans fats. In addition, interesterification can improve the slip melting point (SMP) and solid fat content (SFC) fat produced [19], [20]. Interesterfication changes the composition of triacylglycerol (TGA) through the redistribution of fatty acid positions, thereby improving the physicochemical properties of the resulting fat [17], [20]. Redistribution of fatty acid positions among the triacylglycerol (TAG) molecules also substantially improves lipid function. Sellami et al. [21] producing zero-trans margarine fat through enzymatic transesterification between palm stearin and palm olein obtained that transesterification results in redistribution to the triacylglycerol composition. The margarine obtained has good rheological behavior and is comparable to commercial margarine. Blending and interesterification processes in the production of trans fat-free margarine can also be carried out in a mixture of palm stearin, palm kernel oil, and soybean oil using sodium methoxide. The results showed that interesterification in the mixture was effective in modifying or improving physicochemical properties [22]. Some researchers use a mixture of milk fat to obtain margarine or fats that have good physicochemical and flavor properties [23], [24]. The addition of stearin is important in the process of making margarine because the components in stearin can increase the plasticity of fats and contribute to providing solid properties [17]. The addition of soybean oil to palm stearin can increase the amount of monounsaturated and polyunsaturated fatty acids so that the resulting margarine is healthier. Thus the mixture of soybean oil and stearin contains saturated fatty acids that are dominated by palmitic acid (59.4%) [17], [20]. The content of fatty acids in the products produced has an effect on physical properties such as the crystal structure of fats. The high amount of palmitic acid increases the stability of β′-crystals. Increased β′-crystals improve the even distribution of small crystals in the polymorph structure so as to stabilize the air cavity and increase mouthfeel [17], [25]. According to the research of Naeli et al. [20], the interesterification between palm stearin, palm kernel oil (PKO), and soybean oil caused a change in the composition of triacylglycerol (TAG). TAG composition decreased in PPP, LLL, OOO, POP, POO, LLO, LnLL, and PLLn as well as an increase in PPLn, PLP, POS, PLO, and PLL. In addition, there was a decrease in some trisaturated (S3) and tri-unsaturated (U3), as well as an increase in monosaturated-disaturated (SU2) and disaturated-monosaturated (S2U). The interesterification process also significantly reduces the amount of free fatty acids from the margarine produced. The advantage of interesterification is that it can reduce the amount of saturated fatty acids, but there is no loss during the interesterification process. Interesterification also increases product stability against oxidation. Interesterfication can reduce slip melting points due to decreased trisaturated (S3) TAGs and increased monosaturated-disaturated (SU2) TAGs. slip melting point margarine obtained from interesterification usually ranges from 23.6^{o}C to 36.3^{o}C, so that the resulting margarine melts completely at body temperature and can improve mouthfeel when consumed [20]. The microstructure of margarine shows a fine aqueous droplet that spreads between oil crystals/fats. The dispersion phase affects melting behavior, where an increase in the size of the droplet during storage causes a decrease in SFC below its critical point because solid fat is unable to withstand droplet unification, then the emulsion becomes unstable [25]. Ornla-ied et al. [18] reported the research on margarine from the interesterification of palm stearin and rice bran oil, it was found that the crystals formed had a smaller size (<10 mm). The ratio of rice bran oil to palm stearin of 40:60 shows needle-shaped crystals in small size and no aggregate crystals. The crystals in small sizes and compact are suitable for use in the bakery because the crystals can spread and stabilize the air conditions during the creaming stage so as to produce a smooth texture. Crystal structure formed between margarine from interesterification and commercial margarine does not differ significantly. Adding rice bran oil to palm stearin reduces the size of the crystals [25].

2.3 Bakery shortening

Shortening is a fat-based food additive with a crystal structure. To increase the content of saturated fatty acids in shortening, some companies use the hydrogenation process so that it has the potential to produce trans fatty acids [2], [3]. Therefore, many companies are now starting to avoid the hydrogenation process. The alternative is to use sources of fat that are rich in saturated fatty acids such as palm stearin and the fraction of stearin from coconut oil or from palm kernel oil [26], [27]. Shortening for bakery products generally has solid fat content (SFC) between 15-25% at a temperature of 20^{o}C with a melting point >38^{o}C. Basically, palm oil has an SFC of around 22-25% at a temperature of 20^{o}C. It shows a consistency similar to plastic cake shortening, so that palm oil itself has the ability to be shortening. The addition of palm kernel oil (PKO) can also improve the ability of palm oil as a shortening [2]. According to Rudsari et al. [27], bakery shortening can be produced using palm stearin raw material. The functional characteristics of shortening can be improved by interesterification with ardeh oil (Sesamum indicum). The addition of ardeh oil improves the melting point in the resulting shortening. That is because ardeh oil increases the amount of unsaturated fatty acids. Interesterification reduces the slip melting point (SMP) due to changes in the formation of triacylglycerol (TAG) groups. The decrease in melting point during the interesterification process is due to an increase in di-unsaturated (SU2) TAGs and a decrease in trisaturated (S3) TAGs. Different ratios of palm stearin to ardeh oil produce shortening with different properties. The ratio of palm stearin to ardeh oil of 40:60 produces shortening that can be used on all bakery products because the shortening produced has a wide melting temperature range whereas the ratio of 50:50 produces shortening which is suitable for pie products because it can soften the dough while still providing a sense of flakiness [27].

2.4 Cocoa butter alternatives

Cocoa butter alternatives or cocoa butter replacers are made to replace the function of cocoa butter. Cocoa butter has a high price; therefore, the industry is replacing it with other vegetable fats that have lower prices, such as palm stearin. To improve the physical properties of the cocoa butter replacer produced, another vegetable fat was added to the oil palm stearin such as the addition of mango seed fat [28], addition of palm kernel oil [29], or the addition of Bambangan (Mangifera pajang) kernel fat by the interesterification process [30]. Interesterification reaction will produce semi-solid fat that does not contain trans fatty acid residues. Stearin naturally forms a stable β ′ crystal structure making it suitable for use as cocoa butter alternatives [31]. The resulting crystals are also small in size, shaped like a needle-shaped, and are numerous. Small crystals are more stable and have superior creaming properties [30]. The difference in the shape and size of the crystal is affected by temperature, the ability of polymorphism, and chemical composition. The best crystallization is shown at the storage of 20-23^{o}C. Triglycerides produce α-crystals (amorphous with small crystals), β′-crystals (bulky shape or spherulitic) and β-crystals (dominated by needle-shaped crystals). In palm stearin, crystals that form are stable in the β form, making it suitable for use in making chocolate and coatings [30]. Jahurul et al. [28] also succeeded in making Cocoa butter replacer by blending palm stearin with mango seed oil. Palm stearin is also used by Biswas et al. [29] by mixing palm kernel oil and palm mild fraction for confectionery filling.

2.5 Pig lard replacers

Lard from pigs is often used because of its sensory properties, mainly the taste and texture. Some countries, such as Japan, utilize lard from pigs to increase stickiness property in the meat consumed. The high saturated fatty acids in pork lard make the taste and texture of the final product preferred [32]. The addition of lard increases the content of triglyceride composition which is dominated by palmitic acid (25%) in food. However, excessive consumption of lard increases the risk caused by the accumulation of fat so that formulations that are similar in characteristics are needed but still safe for consumption. The lard formulation can be replaced with a mixture of some vegetable fats and conditioned to have similar characteristics. The mixture consists of palm oil, cocoa butter, avocado butter, and mee fat to replace liquid oil from pork oil; and a mixture of palm stearin, palm oil, soybean oil, cocoa butter, and mee fat to replace lard. All crystals form a β and β ′ structure that is dominated by a polymorph structure. This indicates that the fat produced is suitable as a lard substitution. Crystals with β structure will provide better products because they improve smooth mouthfeel and trap liquid oil because naturally, spherulitic crystals will form and allow as a lard replacer [32]. Palm stearin also could potentially be used to replace the portion of lard in frankfurter type beef sausages, where sausages containing palm stearin have the same physical and sensory qualities compared to controls using lard [33].

2.5 Emulsion and other products

Various emulsion products develop rapidly, along with the needs of the food industry to obtain a stable food system. Some researchers have used palm stearin for the synthesis of emulsion products. Arum et al. [34] synthesized emulsifiers from palm stearin through glycerolysis followed by cold-temperature fractionation. The results showed that emulsifiers from palm stearin contained about 91% monoacylglycerol and about 9% diacylglycerol. The emulsifier obtained has an emulsion capacity of 95.55% and has excellent stability. Subroto et al. [35] synthesized structured lipids containing mono- and diacylglycerol from a mixture of palm stearin and palm olein found that structured lipids produced by chemical glycerolysis-interesterification had an emulsion capacity of about 93.63% and had good stability. Whereas Wang et al. [36] studied the effect of adding palm stearin to glycerol monostearate-structured emulsions, it was found that palm stearin increased the stability of emulsions during storage at cold temperatures. Palm stearin can also be used for oleogel production. Ghosh et al. [37] produced oleogel from a mixture of palm stearin and cetyl caprylate, it was found that oleogel had a positive effect on in vivo testing. The research produced trans-free and quality oleogel because it provided good health effects. Whereas Das et al. [38] utilize palm stearin for mayonnaise production. A mixture of palm stearin and rice bran oil at a ratio of 3:7 produces a soft, creamy, and delicious mayonnaise.

3 Conclusion

Palm stearin is a material that has high plasticity, so it is suitable for use in various food industries such as the bakery, shortening and margarine industries. Palm stearin can also be used as a mixture in polysaccharide-based coatings. The addition of palm stearin to the coating material causes an increase in hydrophobic properties, which makes the coating material not easily undergo agglomeration during storage. In addition, palm stearin can be used as a raw material for the production of cocoa butter alternatives through a blending or interesterification. The interesterification process in palm stearin is also used in the production of trans fat-free margarine and shortening which has good physicochemical properties.

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