Palm Oil and Palm Kernel Oil in Food Products

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ABSTRACT

Cocoa butter equivalent (CBE) formulation, especially the compatibility of palm oil based CBE with cocoa butter, is of special interest to chocolate manufacturers. Traditionally palm oil is fractionated to obtain high-melting stearin and olein with a clear point of around 25 C, the latter serving as cooking oil. Recently, palm oil has been fractionated to recover an intermediate fraction known as palm mid-fraction (PMF), which is suitable for CBE formulations.

Generally, production of PMF is based on a three-step procedure. However, a dry fractionation system, which includes selective crystallization and removal of liquid olein by means of a hydraulic press, has been developed. Iodine value, solid content (SFI) at different temperatures, cooling curves (Shukoff 0°) and triglyceride/fatty acid composition determination confirmed effectiveness of the procedure followed. A direct relationship between yield, quality of PMF and crystallization temperature during fractionation has been achieved. Yield of 60% for olein of IV 64-67 has been achieved. Yield of 30% for PMF of IV 36-38 and 10% for high melting stearin of IV of 20-22 are also being achieved.

High-melting stearin may be used in oleochemical applications, soaps, food emulsifiers and other industrial applications such as lubricating oil. Olein fraction, especially after flash hydrogenation thereby reducing the IV to 62/64, has excellent frying and cooking oil characteristics. Palm olein is also suitable as dietary fat and in infant formulation. Studies on interesterification of high-melting stearin with olein showed possibilities to formulate hardstocks for margarine and spread formulations, even without using hydrogenated fat components.

Palm kernel and coconut fats or fractions or derived products are used for confectionery products as partial CB replacers and as ice cream fats and coatings. Coconut oil also serves as a starting material for the production of medium-chain triglycerides.

INTRODUCTION

As a big chocolate manufacturer we are interested in problems linked to cocoa butter equivalent (CBE) formulations for a better understanding of phenomena concerning CBE interactions with cocoa butter (CB) in confectionery products. We are aware of the fact that these problems are among the most difficult in the application of fats in food products and that formulation of a suitable CBE is the highest art in fat technology (1,2).

We especially studied the compatibility of palm oil-based CBE's with CB, and in this respect studied the interaction of the palm mid-fraction with CBE fat components. This led us to study in more detail the fractionation process of palm oil and problems linked to it. As we can determine,

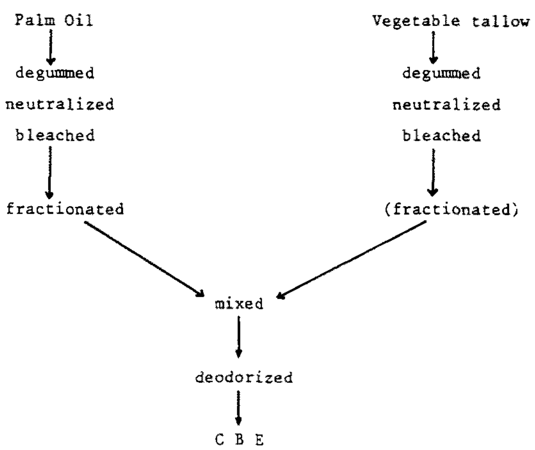

FIG. 1. Typical cocoa butter equivalent (CBE).

palm oil is fractionated to remove the high-melting stearin in order to get a cooking oil with a clear point of around 25 C and to produce the so-called palm mid-fraction (PMF).

In the first case, the higher-melting stearin can be removed by simply filtering off the crystallized stearin either batchwise or today by the continuous procedure developed by Tirtiaux. The stearin may be used for soap production such as palmolive soap. It may be further used as hardstock in margarine blends, where it imports an increased creaming power of the margarine blends, thus making it suitable for whipped toppings. The liquid olein fraction is suitable for cooking and table oils.

In the second case for the production of PMF for the use in CBE formulations, a much sharper separation for the recovery of the intermediate fraction is required. We therefore studied in detail the problems involved in the formulations of palm oil-based CBE's (Fig. 1).

DISCUSSION OF RESULTS

Palm Oil-Based CBE

For the sake of completeness we present the whole procedure of CBE formulation. It is evident that the suitability of a CBE may be influenced by incomplete fractionation of the palm oil as well as of the vegetable tallow implicated in the formulation.

The known fractionation procedures are:

- solvent: acetone, hexane, or hexane/alcohol mixtures,
- detergent: Lanza, Lipofrac,
- dry: as described later.

Repartition of Palm Stearin PMF, Palm Olein

High-melting palm stearin represents approximately 10% of the palm oil. Its amount may vary according to the efficiency of olein removal. This yield is linked to an IV of approximately 20-22. The PMF represents approximately 30% of the original PO with an IV of 36-38. The low-melting olein which can be obtained at a yield of approximately 60% has an IV of 65.

PMF Recovery from PO

In many cases the production of PMF is based on a three-step procedure. The first step is mostly a dry fractionation procedure, involving continuous-working, florentine type filters or a drum filter. We were also able to show that a frame filter press, as it is used for bleaching earth removal, is suitable, provided that a specific filter cloth is used.

Our own investigations concerning the second and third step of the procedure are presented in Figure 2. The studied procedures concerning the yield of PMF and the quality of the secondary products are not satisfactory. We then studied in detail the dry fractionation procedure of the second and third step. The results of our investigations are shown in Figures 3 and 4, respectively.

We were able to reduce the three-step procedure to a two-step procedure in applying a carefully directed selective crystallization (4).

Therefore it follows that:

1. Crystallization of palm oil at 30 C is essential for the subsequent steps. Incomplete removal of olein from stearin is not important considering the ease of the following treatments, but this consequently reduces the yield of PMF. The first olein must have an IV of

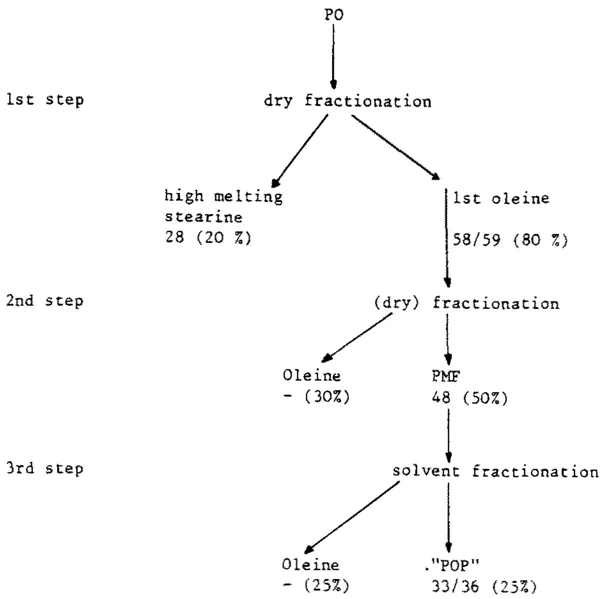

FIG. 2. Palm oil fractionation (commercially available procedures).

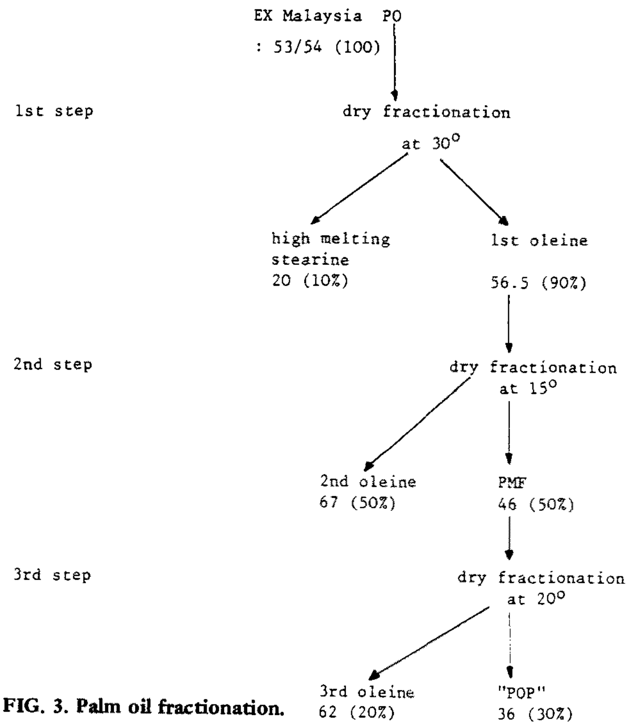

FIG. 3. Palm oil fractionation.

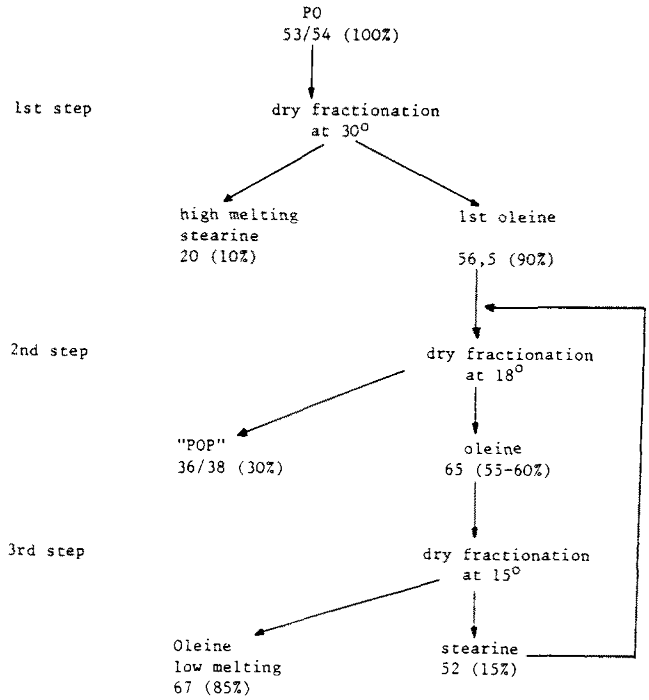

FIG. 4. Palm oil fractionation.

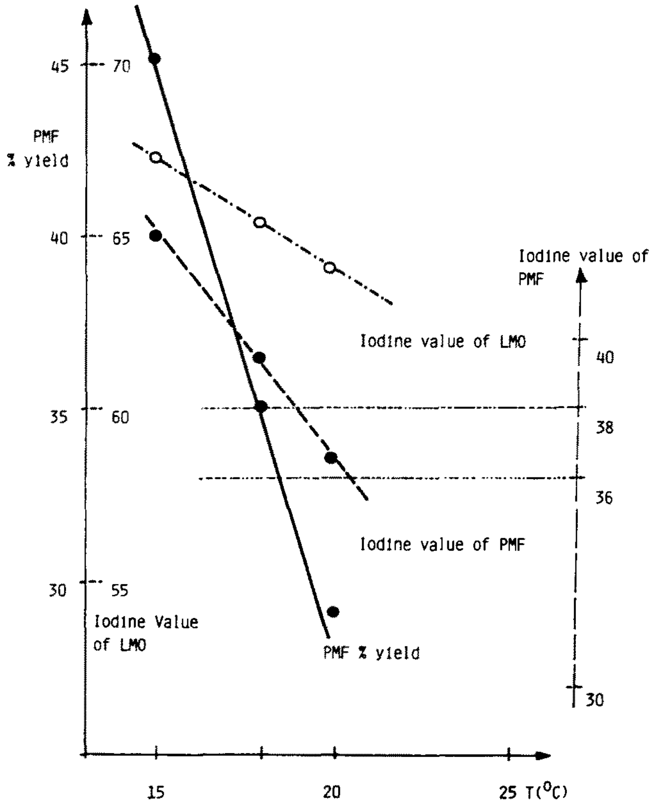

FIG. 5. Relationship between IV of LMO, PMF and fractionation temperature.

(56-57) and should not even contain traces of crystallized high-melting stearin (see Fig. 3).

2. Figure 5 shows the relationship between IV of the olein, yield of PMF and IV of the PMF as a function of the crystallization temperature.

Adding a further crystallization step to the second olein increases the overall yield of PMF and consequently increases the IV of the low-melting olein obtained.

Utilization of the PO Fractions

High-melting stearin (HMS). HMS is suitable as crystallization starter in the confectionery industry. It may be used as starting material (palmitic acid and stearic acid) for oleochemicals. As we are discussing food uses of PO fractions, HMS is suitable for food emulsifier preparations after glycerolysis to give mono- and monodiglycerides. Many applications of HMS are open after interesterification with the low-melting olein (LMO) in plastic shortenings, in food preparations or as a hardstock in margarine formulations.

Low-melting olein (LMO). The low-melting olein is a very suitable frying medium (5) and can be used as such. A slight hydrogenation reducing the IV by one or two units considerably increases its stability and its frying performance. Comparative experiments could show that this LMO

TABLE I

Specifications for PMF

Solid content at	20 C	65-75%
	25 C	55-65%
	30 C	above 30%
	35 C	0-5%
	40 C	0
Slip melting point	°C	33-35
Cooling curve	T_{min}	above 17 C
(Shukoff, 0 C)	T_{max}	above 20 C
Iodine value		36-38

is one of the best frying media. Especially for starch-based products it has better flavor-preserving properties compared to other frying media based on soybean or cottonseed oil. The question remains open whether in industrial applications there is a correlation between foaming behavior and polymers formed during frying. The LMO of IV 67 remains liquid at 18 C and is an excellent table and cooking oil (6).

Baby food formulations. Due to the fact that the LMO contains between 10 and 15% palmitic acid in the 2-position of the glycerol chain and moreover, due to its overall stability, LMO is an ideal fat which, mixed in suitable amounts with other fats or oils (corn, butter, etc.), gives a suitable fat mix for baby food formulations. This amount of palmitic acid in the 2-position is relatively high for a vegetable oil but is still very far below maximum values in some animal fats which may be as high as 70%. Digestibility of the product is also influenced by this fact.

Shortenings and margarines. As outlined earlier LMO may be interesterified with the HMS to give products suitable for use as shortenings and in margarine blends without being necessary to use hardened fats; this is especially important in Europe and USA for the so-called health margarine blends (7).

Palm mid-fraction (PMF). The palm mid-fractions obtained by the dry fractionation procedure are suitable to CBE formulations. This is surprising, as so far unique dry fractionation was considered to be unsuitable for palm oil. We characterized PMF by the analytical criteria shown in Table I.

The cooling curve according to Shukoff at 0 C is an important criterion characterizing the crystallization behavior of PMF and that of other fats. It is sensitive to impurities and admixture of foreign triglycerides, due to improper crystallization.

An easy to obtain and still important analytical parameter is the iodine value (IV) which is related strongly to the solid content at 30 C and 35 C (8). If a PMF fits the presented quality criteria then it is suitable for CBE formulations.

Optimum utilization of PMF. For an optimum use of PMF in CBE we have to consider several facts.

- PMF shows strong interactions with CBE components as shea stearin, sal stearin, etc. Maximum depression of the solid contents at 30 C are found in most cases at 30% addition of foreign fats.
- PMF which is soft with SFI's at 30 C lower than 30%, gives CBE's which are softer than CB at 20 C with SFI's lower than 70% despite the fact that at 30 C and 35 C the SFI's may even be higher than those of CB.
- Formulations of CBE's may be guided by triglyceride composition preferably evaluated by capillary gas chromatography (9) giving blends more easily compatible with CB but not necessarily similar to CB with respect to physical properties.
- CBE's can be formulated according to the desired

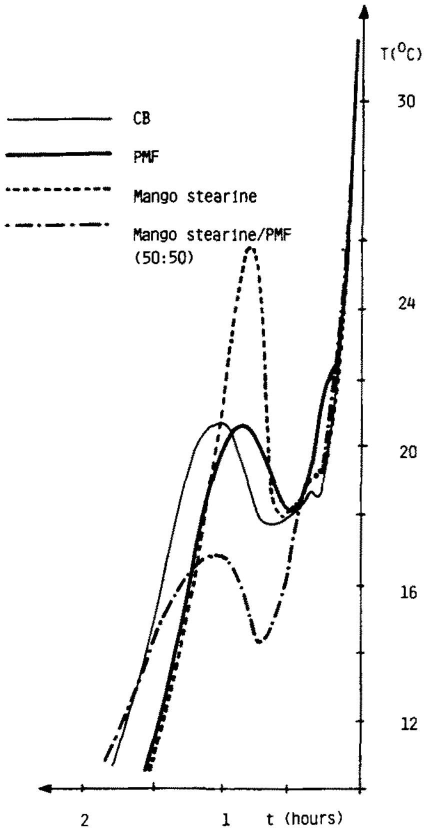

FIG. 6. Cooling curves Shukoff (0 C) of CB and CBE components.

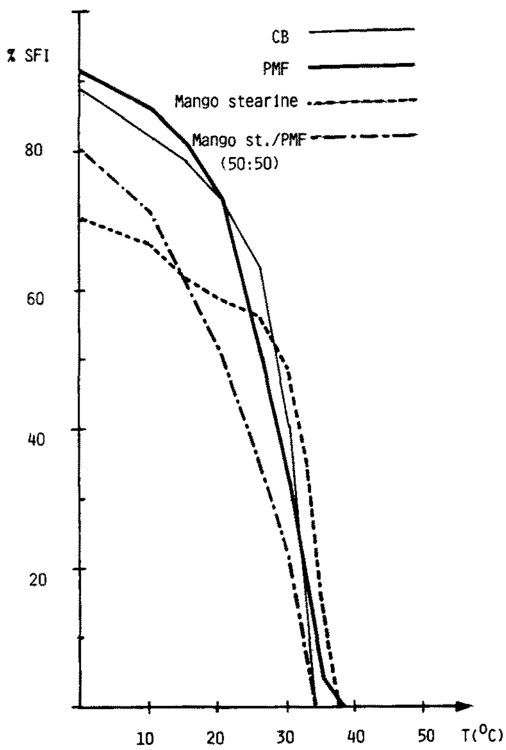

FIG. 7. SFI's of CB and CBE components.

physical properties, obtaining by this way CBE blends not necessarily fully compatible with CB. As a general overview Figures 6 and 7 represent the physical properties of CB together with the present PMF, mango stearin and a blend of 50% PMF with mango stearin.

TABLE II

Main Physical and Chemical Characteristics of Coconut and Palm Kernel Oil

	Coconut oil	Palm kernel oil
Slip melting point (°C)	24-26	27-29[a]
IV	7-11	14-21[a]
% solids (p-NMR) 20 C	35-42	42-50[a]
30 C	1	1[a]
35 C	0	0[a]
Fatty acid composition (%)		
C_{10} and /0	10-15	7-12[b]
C_{12}	44-51	44-52[b]
C_{14}	13-19	14-19[b]
C_{16}	7-11	7-11[b]
C_{18}	1-4	1-4[b]
$C_{18'}$	5-8	11-19[b]
$C_{18''}$	1-3	1-3[b]

[a]W. McDonald, The Alternative Approach.

[b]Codex alimentation normes. Codex standard 124 - 1981 CN, 126 - 1981 PK.

Optimum formulation of CBE will contain 30-50% of PMF together with vegetable tallow or tallow stearins. Finally it has to be mentioned that the described fractionation strongly depends on the quality of the starting material, i.e., either of PO or the vegetable tallows (see Fig. 1). In cases where the starting material, prior to neutralization and fractionation, underwent a hydrolytic splitting resulting in FFA values of the PO higher than 3.5%, then the mono- and diglycerides formed may accumulate in the PMF. During crystallization they may act as surface active compounds and may influence crystallization, thus requiring an adaptation of the procedure. The same is true for dry fractionation of vegetable tallows. This procedure is unsuitable in all cases where relatively high amounts of unsaponifiable matters are present as is the case for mowrah and shea oil.

Further physical refining of palm oil for dry fractionation has to be avoided since the inevitable isomerization of processed oil prevents the selective crystallization necessary for recovery of the PMF. The same is true also for CBE's which may undergo isomerization during this treatment.

LAURIC FATS

The most important lauric fats are coconut and palm kernel oils. Table II lists the main characteristics (10,11).

The physical and chemical properties of these two fats are quite similar. Palm kernel oil has a melting point slightly higher than coconut oil (29 C compared to 26 C of coconut oil). The fatty acid composition is quite similar. The amount of the main fatty acid present (lauric acid C_{12}) is almost equal. Palm kernel fat has a lower content of short chain fatty acids and a slightly higher amount of oleic acid. This gives a higher IV than that for coconut oil.

Lauric fats are among the most stable oils and fats. Because of their low content of unsaturated fatty acids coconut oil is more stable and more appreciated due to the pleasant coconut flavor which often appears also as a non-disturbing off-flavor during prolonged storage. Palm kernel oil, on the other hand, may show an off-flavor characterized as astringent and coarse. This is mainly true when palm kernel oils are recovered from badly stored or already damaged kernels. The use of lauric fats requires some precaution as they contain short-chain fatty acids. These may give rise to a very unpleasant soapy taste if, by some lipolytic activity of certain food ingredients, triglycerides are split into free fatty acids. Our palate is very sensitive even to traces of free caproic and caprylic acid. Formation of a soapy taste may become a serious problem when lauric fats are used for foods with a very long shelf life.

Lauric Fats as Cocoa Butter Substitute (12)

In Europe, lauric fats are often fractionated in order to get sharp-melting lauric stearins. As these lauric stearins shows a pronounced cooling effect in the mouth, they are very well appreciated as filling fats in confectionery. Moreover, they are also used in toffees and coatings (13). Coconut stearin obtained by fractionation of coconut oil has a melting point of 36 C. These stearins, due to their low content of unsaturated fatty acids, have IVs of 4-8 and are very stable, coconut stearin being even more stable than palm kernel stearin. By hydrogenation of palm kernel stearin of IV 6-10 to a IV of 0-2 a sharp-melting hard butter can be obtained. However, this fat has a very long shelf life and a pronounced cooling effect which is linked to a sharp melting, similar to that of cocoa butter. The lauric olein can be hydrogenated to give melting points similar to or slightly higher than the starting oil to which their physical properties will again become similar.

They are appreciated as cooking fats for shallow and deep frying where they ensure a homogenous browning of starch-based foods like doughnuts. However, due to their strong foaming and hydrolytic instability in long-time deep frying, they are not suitable for industrial application. Hardened oleins are ideal ice cream coating fats because the coatings formed are hard but still elastic and not brittle and break less than with lauric fats as such or stearins.

Lauric oleins and stearins are also used in coffee whiteners and whipped creams (powders). There they impart an easy air incorporation during whipping resulting in a well appreciated overrun. Today utilization of palm kernel-based confectionery fats is increasing at the expense of coconut oil-based specialties. Yet, some years ago, palm kernel fat was considered to be inferior to coconut oil. This increase is mainly due to the following facts:

- Modern fat technology allows production of palm kernel fats similar to those based on coconut. This allows the user to swtich from one fat to the other as soon as the price relation between these two fats changes.
- The exportations of coconut producing countries show a decreasing tendency whereas the production of palm kernel fat is increasing (14).
- Palm kernel fat-producing countries take much effort to increase the quality of their product. Hence, palm kernel fat is now a premium oil commodity.

Lauric Fats as Coatings

It is evident that utilization of lauric fat in confectionery application together with cocoa butter results in problems in terms of incompatibility of the different fats. A typical example is the system of a coated chocolate bar which after some months of storage gives rise to fat bloom.

In analyzing the different fat phases, i.e., cooling and fat bloom region separately, it can be shown that there is a strong tendency for the more liquid part of the fat to migrate to the surface. By applying a high-resolution gas chromatographic separation to the various samples the contribution of each single fat to the bloom phase can be determined. It could be shown that the coating contained a mixture of partially hydrogenated coconut oil and cocoa butter. In the region of carbon number C_{54}, one can distinguish 4 peaks, each differing by one double bond (see Fig. 8).

The tristearate (SSS) originates from hydrogenated

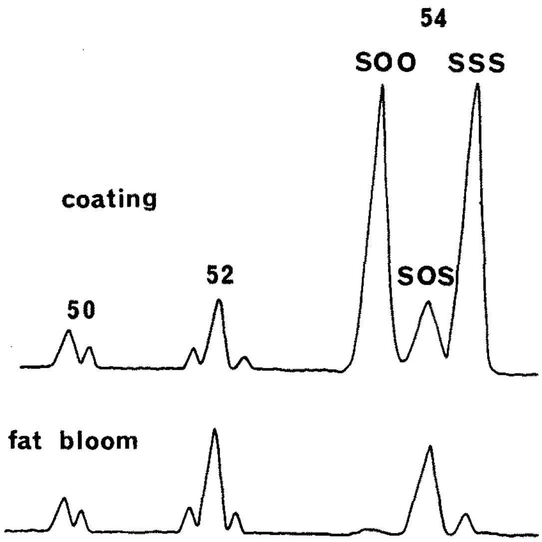

FIG. 8. Capillary gas chromatograms of fat bloom and coating.

coconut oil whereas the SOS comes almost exclusively from cocoa butter. The small amount of diunsaturated compound is present in both cocoa butter and coconut oil, whereas the triunsaturated (000) is a component of cocoa butter. The ratio of SOS to SSS is approximately 1:1. In the fat bloom sample one can observe a rather changed ratio of SOS to SSS which is now close to 8:1, indicating a preferred migration of this fraction of cocoa butter to the surface area (15).

Lauric Fats for Medium-Chain Triglycerides

Lauric fats, in particular coconut oil, are an important starting material for the production of medium-chain triglycerides (MCTs). The MCTs have an important position in the formulation of dietetic foods mainly for enteral and parenteral administration due to the fact that they are rapidly metabolized, thus being an excellent source of rapid energy. In cases of malabsorption of fats MCTs are the only fats which can be absorbed readily, which is most important for premature babies. MCTs are thus a valuable nutrient in infant feeding (16).

In view of the growing importance of MCTs for the food industry it may be interesting to look for palm kernel oil varieties containing higher amounts of caprylic and capric acids. These would be equally important as precursor of medium-chain triglycerides.

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Confectionery Fats from Palm Oil

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ABSTRACT

The influence of diglycerides (DG's) and trisaturated glycerides (P-P-P) on tempering and the hardness of confectionery products are described. Palm oil and its processed products in confectionery fats have been reported (1,2). Palm oil contains a symmetric triglyceride (P-O-P) as a main component which has polymorphic changes similar to those of cocoa butter, so a mixture of these is able to use a tempering process similar to that used for cocoa butter.

Details for fat crystals and polymorphism have been reported (3,4). Okada (5) used a mixture of tristearin and tripalmitin and studied the behavior of polymorphism using X-ray diffraction. The effects of DG's on polymorphic change in palm oil also have been reported (6,7), and Okiy (8) suggested that DG's have an inferior effect on the quality of palm oil when used in the solidified phase. However, there have not been many papers regarding how the above influence works in the production process or how it affects confectionery products.

Palm oil contains about 10% trisaturated glycerides together with a few percent of mono- and diglycerides as minor components, which have been produced during the maturation of palm fruits and processing of fats. It is very difficult to eliminate these completely during the refining process.

This paper reports a study of the influence of these minor components on tempering and hardness of products by using a simulated tempering machine. We have found that DG's lower the temperature of tempering and soften the hardness of products and that P-P-P increased the viscosity of products during tempering process but increased the hardness of products very little.

INTRODUCTION

Cocoa butter is an important and expensive raw material used in the chocolate and related confectionery industries. Chocolate needs more cocoa butter than is present in cocoa beans. Today there are a number of fats suitable for total or partial replacement of cocoa butter components in confectionery products. When we consider the use of alternative fats, we have to study the properties and composition of cocoa butter.

Physico-chemical properties of cocoa butter have been reported. Kattenberg (9) pointed out that, according to their origin, cocoa butters have different properties that might have been caused by the content of symmetric glyceride (S-O-S), as shown on Table I and Figure 1. On the contrary, DG's and trisaturated glyceride contents of cocoa