Palm Oil in Margarines and Shortenings

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ABSTRACT

Palm oil has become used increasingly as a raw material in soaps, edible fat-based products and confectionary. This paper deals specifically with applications in margarines and shortenings. Properties of palm oil are described, indicating both the special characteristics that make it suitable for such applications and its limitations. Modification techniques which can minimize or eliminate the disadvantages and hence broaden the scope of application include hydrogenation, fractionation and interesterification. Various applications of palm oil, both modified and unmodified, in margarines and shortenings for use in both tropical and temperate climatic conditions are described.

PROPERTIES OF PALM OIL AND THEIR MODIFICATION

Palm oil has been used in its natural form for cooking purposes for hundreds of years. Both its red color from the carotenes present and its high acidity are recognized, and desirable characteristics in the preparation of "palm chop" a spicy chicken stew much favored in West Africa, the natural habitat of *Elaeis guineensis.*

As palm began to be cultivated in plantations, first in Africa and more recently in Southeast Asia, techniques for improving its value as an edible fat have rapidly evolved, overcoming many of the inherent disadvantages of the natural product.

Although a strong palm flavor is desirable in palm chop, this is not so in more conventional applications, and palm oil has traditionally been refined by treatment with caustic soda or soda ash to neutralize the free fatty acids present. Removal of carotenes to decolor the oil was traditionally done by adsorbtion on fullers earth, and by the use of steam distillation (deodorization) it is possible to eliminate short-chain fatty acids and other impurities, so that a relatively colorless, odorless and tasteless oil can be produced.

In recent years more effective techniques have evolved for refining the oil. These are based upon steam stripping of fatty acids and heat bleaching to decolor the oil. Such processes are normally combined with deodorization in either continuous or semi-continuous process plants, with much superior refining yields (loss of neutral oil in the byproduct being minimized) and thermal efficiency.

The physical properties of such oil are illustrated in Table I. It is interesting to note here the very wide range of properties, which depend largely upon the origin of the palm oil. The reason is, of course, the variation in fatty acid compositions in oil from different geographic areas, as shown in Table II. Obviously the varying proportions of oleic acid will influence I.V., and together with stearic and palmitic acids will affect the melting point and proportion of solids present at varying temperatures.

This mixture of solid and liquid components is undesirable in commercial cooking oils. A number of fractional crystallization techniques have been developed to segregate the liquid and solid phases. These are the subject of numerous patents, and include dry fractionation, Lanza (detergent) fractionation, and solvent fractionation. The most common technique is dry fractionation, normally at 28 C with a yield of 20 to 30% stearin and 70 to 80% olein.

TABLE I

Variations in Palm Oil Properties

Property	Range
I.V.	44-60
Melting point	35-39.5
Solids % (NMR)	
N10	42-54
N20	20-28
N30	6-10
N35	2-6

TABLE II

Variation in Fatty Acid Compositions of Palm Oils

Fatty acid	Zaire	Nigeria	Sumatra	Malaysia
C_{14}	0.5	1	1.5	1.5
C_{16}	42.0	40	45.0	46.0
C_{18}	5.5	5	3.5	4.5
$C_{18:1}$	40.0	41	39.0	37.0
$C_{18:2}$	11.0	12	10.0	10.0

TABLE III

Properties of Palm Oil Fractions

Solids % N-values (°C)	Dry olein	Wet olein	Dry stearin	Wet stearin
0	60-64	16		
10	33-44	0.5-4.0	68-76	94-97
20	4-11	0.0-0.1	45-54	93-97
30	0.2	–	31-36	74-90
40	–	–	17-16	51-74
50	–	–	5-7	31-55
Melting point (slip) (°C)	25-28	20-22	46-50	53-55
S_3[a]	2	1	19	61
S_2U[b]	52	33	45	35
SU_2	40	60	32	2
U_3	6	6	4	2

[a] S = saturated mainly palmitic and stearic acids. Ratio: oleins 6:1; stearins 12:1.

[b] Ratio SUS/SSU is between 5 and 8.

In the Lanza process the stearin crystals obtained by slow cooling are absorbed by the Lanza solvent which is essentially an aqueous solution containing a wetting agent. Because the separation is of water and oil phases it is much sharper, and superior olein yields are achieved. Fractionation with hexane or acetone as solvent is much more selective, and this is often used in three-stage fractionation to obtain mid-fractions, used as cocoabutter equivalents.

The different properties of oleins and stearins produced by dry and wet fractionation are illustrated in Table III. Although fractionation is mainly used to produce olein-based cooking oils that are liquid at ambient temperatures, both olein and stearin have application in certain margarine blends. For example, olein is a useful source of liquid oils which are required in certain soft margarine formulations.

Conversely, stearin is frequently used to stiffen palm-based tropical margarines which must not collapse at high ambient temperatures. Stearin is also a useful (and generally inexpensive, since it is considered to be a byproduct of the fractionation process) component of vegetable shortenings. Hence it is possible to produce margarines of varying characteristics by varying the composition of palm oil and the palm olein and stearin fractions, which makes palm oil a very versatile ingredient.

TABLE IV

Glyceride Composition of Some Palm Oils (mol %)

	Malaysia	Zaire	Sumatra
S_3	7.9	6.6	10.5
SUS	42.8	45.4	40.0
SSU	6.6	4.7	8.6
SUU USU	35.7	37.8	34.0
U_3	6.8	5.5	6.6

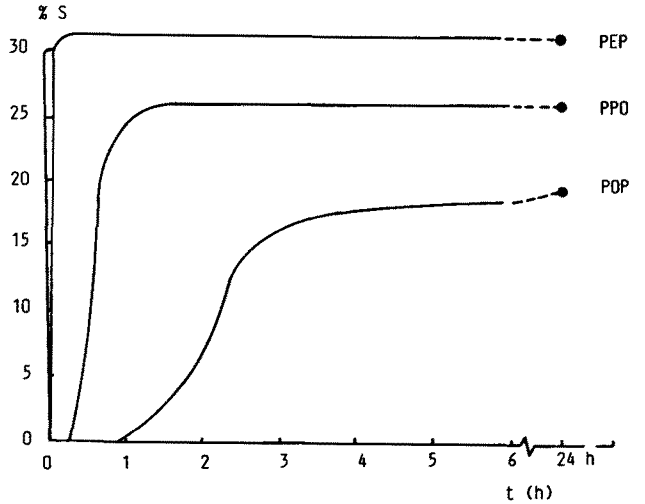

FIG. 1. Crystallization behavior of mixtures of pure triglycerides in trioleate (10 C).

TABLE V

Properties of Palm Oil Before and After Interesterification

Triglycerides	Noninteresterified	Interesterified
S_3	7.9	12.4
SUS	42.8	12.2
SSU	6.6	24.2
SU_2	35.7	35.8
U_3	6.8	0.5
Ratio SUS/SSU	6.5	0.5
Solids (%)		
10°	50	50
20°	22	35
30°	7	18
35°	4	13
40°	0.5	9

However, there are drawbacks to the use of palm oil because of its slow crystallization behavior, which can lead to coarse crystals, causing product graininess. Slow crystallization also leads to processing difficulties. The reasons for this slow crystallization are attributed to the presence of mono- and diglycerides and of other minor ingredients, and also to the presence of a high percentage of the symmetrical mono-unsaturated triacyl group (generally described as SUS). Table IV shows typical glyceride compositions of the more commonly available palm oils. In each case the SUS content ranges from 40 to 45%, with the palmitic-oleic-palmitic (POP) triglyceride predominating.

Crystallization characteristics have been investigated by NMR techniques where the percentage of solids present in a blend of 30% of specific triglyceride in triolein cooled from 60 C to 10 C can be determined. Figure 1 illustrates the relative speed of crystallization of POP and other triglycerides such as PPO and PEP (palmitic-elaedic-palmitic).

It has been found that with the molecular rearrangement that takes place in the interesterification process (which is the subject of many patents) the proportion of POP can be reduced, and that of the faster crystallizing PPO increased. There is, unfortunately, an offsetting disadvantage in that interesterified palm oil also contains a higher proportion of tripalmitate, which is very high melting and hence has undesirable organoleptic properties. These changes in properties are illustrated in Table V. Hence application of interesterification techniques, although useful, is restricted.

Another modification technique is hardening, whereby unsaturated triglycerides are converted to their saturated equivalents, by the catalytic hydrogenation of palm oil. This is generally used to increase the melting point by production of trisaturated products such as tripalmitate, which are used to improve the stability of tropical margarines. By this route some POP is also converted to its isomer PEP, and hence crystallization characteristics are improved, although again at the expense of a higher proportion of high melting products. Hence, the judicious use of hydrogenation and interesterification techniques can assist in producing margarine blends with improved crystallization behavior and better physical characteristics.

Mono- and diglycerides can also play an important part in crystallization behavior. Although monoglycerides at levels below 0.5% do not have any major effect, diglycerides, which are widely present in palm oil, will retard crystallization. Special separation techniques have been developed for removing diacyl glycerides and oxidized glycerols.

Minor components with a polar structure will also retard crystallization. Slightly polar components include epoxy glycerols, hydroperoxides, diacylglycerols and monohydroxyglycerol, medium polar products include monoglycerols, dihydroxyglycerols and sterol esters. These components can be reduced by conventional alkali refining or by special (and expensive) solvent stripping.

Another disadvantage of the use of palm oil in margarine is known as posthardening, where the consistency (hardness) of the product increases for up to two weeks after manufacture. This is clearly undesirable in refrigerated margarines, which should be soft and easily spreadable. It had been thought that posthardening was caused by the crystallization characteristics of palm oil, but it is now known that this is not the case. Experiments have shown that, whereas hardness can double over a period of one week, the corresponding increase in solids content is only 1%. The posthardening effect has now been shown to relate to the type of triglyceride present, with once again the symmetrical triglycerides being the worst offenders. Modification techniques which reduce their presence will therefore help to minimize the posthardening effect.

APPLICATION IN MARGARINES AND SHORTENINGS

Certainly considerations of price, availability, storage and transportation facilities and so on will influence formulation decisions, but the following discussion gives indications of possible applications when these economic factors are favorable.

Nonrefrigerated Margarines

These have wide application, especially in tropical climates where refrigeration facilities tend to be limited. For such margarines the principal requirements are for good stability, with no collapse, oil exudation or phase separation at ambient storage temperatures, which can be as high as 35 C. Obviously, this is only possible at the expense of oral melt properties, since by definition, solids must still be present to a certain extent at ambient temperature.

Palm oil stiffened with either hardened palm oil or palm stearin can produce margarines of adequate emulsion stability, and although not essential, the incorporation of lauric oils can help to improve oral properties. Spreadability at ambient temperatures is not a problem, and posthardening effects are not a drawback in such circumstances.

Refrigerated Margarines

Requirements for refrigerated margarines are quite distinct, with a relatively low hardness at 10 C being necessary in order to achieve spreadability immediately upon removal from the refrigerator. Conversely, the product should remain stable and not too soft at ambient temperature (this is of course more of a problem in tropical countries). This is difficult to achieve with palm oil because of the posthardening effect, and although the use of interesterification can help, the corresponding increase in high-melting triglycerides leads to an undesirable tailing effect with high N_{35} values and correspondingly poor oral melt properties.

In practice this means that only limited use of interesterified palm oil, generally less than 15%, is customary, although in addition it is possible to incorporate palm olein as an alternative to other soft oils in the blend. It is also advantageous to interesterify palm oil with liquid or lauric oils, since this will reduce the trisaturated glycerides while a high asymmetrical triglyceride content is retained.

Another approach is to reduce the posthardening effect by injecting air to soften the blend. Although this may permit the use of higher percentages of palm oil, organoleptic properties become less than optimal, particularly when palm stearin is incorporated to initiate crystallization. In any case crystallization is very slow, which means that generally this technique is more appropriate for tub than for wrapped margarine.

High EFA Margarines

Palm oil has a low EFA content of only 10%. With a minimum EFA of 35% generally considered necessary to support health claims, the use of palm products is restricted. The most common application is incorporation of palm olein together with a highly polyunsaturated oil such as sunflowerseed oil.

Shortenings

Broadly similar considerations will apply to the use of palm oil in shortenings although in the absence of water the posthardening effect is substantially reduced. Hence, in tropical climates with high ambient temperatures, the use of palm/palm stearin and palm/hardened palm blends are acceptable, with softer blends being preferred in more temperate regions.

The difficult processing conditions related to the slow crystallization behavior of palm oil are again a major consideration, and much deeper cooling (a 30% increase in cooling surface per ton throughput) and increased residence time is required to minimize post crystallization.

Palm Oil Products in Cooking Fats

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ABSTRACT

Palm oil and its products are used widely, either on their own or in combination with other oils and fats, to make products for cooking and other applications such as baking, icing, filling and topping. Palm oil and its products are not only cheaper to process but also impart into the product the functional properties demanded by some of these applications. Legislation governing production and marketing of these products in some of the important countries is reviewed. The physico-chemical characteristics of products marketed in different countries are also presented. Formulations based on palm oil and its products are suggested to make low or no *trans* acid fats and high PUFA fats.

INTRODUCTION

Traditionally ghee, clarified and crystallized butter fat from buffalo and cow milks, and animal fats, especially tallow, were the main fats used in Southeast Asia for cooking foods. Because of high prices, especially of ghee, and declining production of tallow, cheaper hydrogenated vegetable oils were introduced as an alternative to ghee and tallow. These hydrogenated products were readily accepted by the consumers, especially in countries where animal fat was used as an all-purpose cooking medium.

In the beginning the fats based on only one hydrogenated oil, such as groundnut oil or cottonseed oil, were produced. As the industry became more sophisticated and due to the increased availability of a number of vegetable oils in the international market at competitive prices, the products based on blends of hydrogenated vegetable oils or animal fats were produced. It has now become normal practice to make these fats from blends of oils/fats rather than from a single oil/fat.

These products are used mainly for shallow and deep frying of foods. In some countries, however, these are formulated for such general-purpose applications as baking, filling, icing and toppings. The use of palm oil and its products in the formulation of these fats has some distinct economic and technological advantages. As such, in countries using a semi-solid product as a main source of edible fat, the export of palm oil has increased many fold during the last few years as shown in Table I.

Cooking fats based on 100% palm oil products are now being marketed in a number of countries. In some countries, however, the level of use of palm oil products is restricted due to some technological and consumer constraints.

TABLE I

Import of Palm Oil by Selected Countries

	Year (tons)	
Country	1980	1983
India	88,589	282,920
Iraq	40,729	60,450
Jordan	–	44,517
Kuwait	–	29,997
Pakistan	100,235	326,523