Palm Kernel and Coconut Oils: Analytical Characteristics, Process Technology and Uses

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ABSTRACT

Palm kernel and coconut oils are the most used of the lauric acid group of oils. The characteristic of this group is their high content of saturated acids, lauric and myristic, and it is from this feature that their principal uses are derived. Due to their triglyceride composition, both oils have steep melting curves and melt below body temperature. Their low degree of unsaturation gives them high oxidative stability. As a result of these properties they are found widely used as hard butters and in vegetable fat ice-creams, coffee whiteners and similar products. Their use in margarine gives that product an attractive coolness in the mouth. Coconut oil is also used extensively as a raw material for soaps and detergents and as a body oil. The oils are susceptible to hydrolytic splitting and to trace metal catalyzed oxidation. They are particularly affected by contamination with other oils which produce either reduced oxidative stability or, when the contaminant is high melting, an unacceptable palate cling. Refining is normally done with caustic soda solutions and refining conditions are chosen to minimize neutral oil losses due to saponification. Physical refining is also practised and is particularly useful for treating palm kernel oils with high free fatty acid content. To improve their quality and applicability for several uses, both oils are hydrogenated, fractionated and interesterified in various combinations. Fractionation is done either by dry "pressing"or with the assistance of detergents or solvents, the highest quality products being obtained using solvents. The relatively high solubility of the fatty acids can result in effluent problems.

INTRODUCTION

Palm kernel and coconut oils are the two most commercially important oils in the lauric acid group. The oils of this group are derived from the seeds of species of palms, palm kernel oil being obtained from the African oil palm, *Elaeis guineensis*, and coconut oil from the coconut palm, *Cocos nucifera* (1-3).

Lauric acid oils are significantly different from other commercial oils and fats. In temperate climates they are solid at ambient temperatures. In the solid state they are hard and brittle but they melt sharply and completely below body temperature. They have low levels of unsaturation and are, in consequence, more stable to oxidation than other commercial oils.

The reason for thier distinction is their high content of relatively low molecular weight saturated fatty acids, in particular, lauric acid which is present at levels between 40 and 55%. The sharpness of their melting curves and their low melting points make them particularly useful as fats for synthetic creams, hard butters and similar products. The sodium soaps of the low molecular weight acids are hard and stable to oxidation and also soluble and free lathering.

The same high level of low molecular weight fatty acids is responsible for the main problem in the use of the oils for edible purposes. The triglycerides of these fatty acids are easily hydrolyzed, as a result of which an unpleasant soapy off-flavor is produced in the product. The solubility of these fatty acids in water can also be a problem in the effluent treatment of refineries processing lauric acid oils.

PRODUCTION

Production figures for palm kernel and coconut oils shown in Table I are compared with those for palm and soybean oils. From forecast figures for 1981-82, palm kernel and coconut oils together account for 9.7% of total vegetable oil production.

Being tree crops, these oils are known as semiflexible. In the past, coconut oil was the product of low yielding

TABLE I

World Fats and Oils Production – Selected Fats and Oils

Type of fats and oils	Production[a] (million ton)			Annual average increase[b] (%) (1970-79)
	1973	1977-78[c]	1981-82[d]	
Coconut oil	2.44	3.30	3.45	2.3
Palm kernel oil	0.43	0.56	0.72	3.5
Palm oil	2.23	3.71	5.37	9.8
Soybean oil	7.59	10.85	13.57	7.2
World total	42.93	52.30	59.24	3.4

[a] Source: Foreign Agriculture Circular (Jan.), commodity programs, Foreign Agricultural Service, US Department of Agriculture.

[b] Source: Food and Agriculture Organisation, 1980.

[c] Split year includes Northern hemisphere crops harvested in the late months of the first year shown combined with Southern hemisphere and certain Northern hemisphere crops harvested in the early months of the following year.

[d] Forecast.

wild and native coconut palm trees which, because of their height, were easily damaged by tropical storms. As a result the coconut crop was uncertain. The development of high yielding dwarf varieties and cultivation in plantations have considerably increased crop yields and reliability. By contrast, breeding developments of the oil palm have resulted in smaller fruit kernels with a consequently lower yield of palm kernel oil from the fruit. However, the increase in oil palm planting has brought with it an increase in palm kernel oil production which appears certain to continue for the foreseeable future. Projections for Malaysian palm kernel oil production are: 1982 277,200 ton; 1985 352,800 ton; and 1990 568,000 ton.

The principal producing regions and countries for palm kernel oil in 1980 (4) were Africa (340,000 ton), of which Nigeria contributed 165,000 ton, and Asia and the Pacific with 330,000 ton, of which Malaysia produced 240,000 ton. The annual average increase of Malaysian production in the period 1970-79 was 21.7%. The largest producer of coconut oil is the Philippines, but substantial quantities of copra and coconut oil are produced throughout South East Asia and the Pacific Islands. The main producing countries are also the principal exporters.

The European Economic Community (EEC) in 1979 took 56% and the USA 21% of total world imports of palm kernel oil. The comparative figures for coconut oil in 1980 were 40% each for the EEC and USA.

CHARACTERISTICS

The similarity between the two oils can be seen in Table II, which is a comparison of the sections of the Codex Alimentarius Commission Standards dealing with identity and quality characteristics (5).

The higher saponification and Reichert-Meissl and Polenske values for coconut oil are due to the higher levels of low molecular weight fatty acids in the oil. The higher iodine value (IV) of palm kernel oil mirrors the larger amounts of oleic and linoleic acids which it contains. Iodine values are most commonly between 7 and 9 for coconut oil and 15-19 for palm kernel oil; higher values than these may indicate contamination. The fatty acid compositions shown in the Table have been included in the Standards as mandatory criteria. Specimen oils (3) contained 86.1% of saturated acids and 13.9% unsaturated acids in the case of palm kernel oil, and 91.7% and 8.3%, respectively, for coconut oil.

The color of the crude oils varies from a light yellow to brownish yellow. British Standard Specifications BS 628 and BS 652:1967 state that the maxima for coconut oil and palm kernel oil, respectively, shall be 1.2 red/5 yellow and 1.5 red/20 yellow in a Lovibond 1-in. cell.

The odor and taste of coconut oil is largely due to the presence of small quantities, perhaps less than 150 ppm, of δ- and γ-lactones. Similar compounds are responsible for the strong and very characteristic smell of crude palm kernel oil. In both cases the smell and taste are due to aldehydes and ketones resulting from oxidation. Normal refining techniques will produce deodorized oils having a very pale yellow color and a bland flavor.

No acid value is given in the CAC Standard for virgin palm kernel oil. It is understood that the omission in this and other similar cases is because the oil is not consumed in the virgin or crude state. BS 628 gives for crude coconut oil a maximum acid value of 14.1, equivalent to 5.0% by wt of free fatty acids (FFA) calculated as lauric acid. For crude palm kernel oil the figures given in BS 652 are maximum acid value 17.0, equivalent to 6.0% FFA as lauric acid. In practice, because of the susceptibility of the oil to enzymatic hydrolysis, the FFA varies with age and storage history.

TABLE II

Codex Alimentarius Commission: International Standards for Edible Coconut and Palm Kernel Oils

	Coconut oil	Palm kernel oil
Characteristics		
Relative density (40 C/water at 20 C)	0.908-0.921	0.899-0.914
Refractive index (n_D 40 C)	1.448-1.450	1.448-1.452
Saponification value (mg KOH/g oil)	248-265	230-254
Iodine value (WIJS)	6-11	13-23
Unsaponificable matter	15g/kg maximum	10g/kg maximum
Reichert value	6-8.5	4-7
Polenske value	13-18	8-12
Fatty acid composition (%) (by GLC)		
C6:0	<1.2	<0.5
C8:0	3.4-15	2.4-6.2
C10:0	3.2-15	2.6-7.0
C12:0	41-56	41-55
C14:0	13-23	14-20
C16:0	4.2-12	6.5-11
C18:0	1.0-4.7	1.3-3.5
C18:1	3.4-12	10-23
C18:2	0.9-3.7	0.7-5.4
Quality characteristics		
Color	Characteristic of the designated product	
Odor and taste	Characteristic of the designated product and free from foreign and rancid odor and taste	
Acid value (mg KOH/g)		
virgin oil	4 maximum	–
nonvirgin oil	0.6 maximum	0.6 maximum
Peroxide value (milliequivalents peroxide oxygen/kg oil)	10 maximum	10 maximum

Source: Reference 5.

Good quality coconut oil has a FFA content of less than 1% and average quality as encountered in Europe between 2% and 3%. The FFA of palm kernel oil in Malaysia is of th order of 1.5% but is 3.5-6.0% in Europe.

The triglyceride compositions of the oils are similar. Coconut oil contains ca. 84% trisaturated, 12% disaturated-monounsaturated and 4% monosaturated-diunsaturated glycerides. The approximate figures for palm kernel oil are 63%, 26% and 11%, respectively. Figures 1 and 2 show the distribution of the triglycerides according to carbon number. The coconut oil triglycerides can be divided into 13 groups from carbon numbers 28-52. These groups contain 79 individual triglycerides (1). In the case of palm kernel oil, thirteen groups from C30 to C54 have been found to contain 87 triglycerides representing 99.9% of the total triglyceride content (3). The sharp melting characteristics of the oils are derived from the similarity of the melting points of the triglycerides. The somewhat softer consistency of palm kernel oil compared with coconut oil is due to the higher content of mono- and diunsaturated triglycerides.

Because the oils are low in unsaturated acids, their stability to oxidation is high. However, both oils, particularly palm kernel oil, contain small but significant quantities of linoleic acid. Therefore, considerable variations can be found in the stability of the deodorized oil, depending upon the crude oil quality. AOM tests on refined coconut oil samples have yielded results between 30 and 250 hr (1), and, on refined palm kernel oil, values between 15 and 100 hr have been obtained. The CAC Standards set a maximum peroxide value of 10 for both crude oils. In common usage the figures

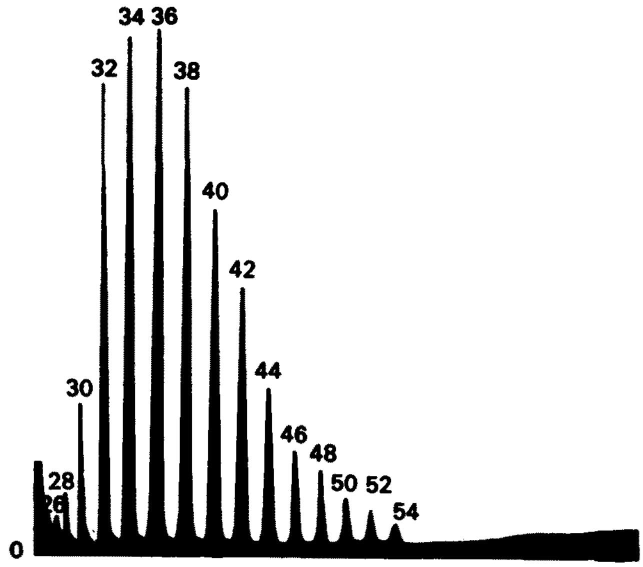

FIG. 1. Distribution of triglycerides by carbon number – coconut oil.

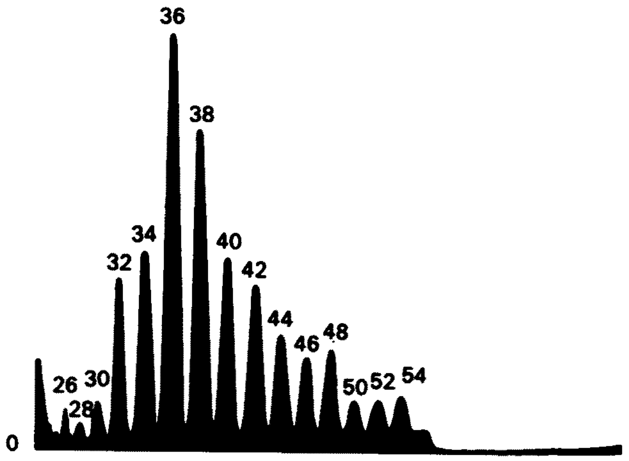

FIG. 2. Distribution of triglycerides by carbon number – palm kernel oil.

should be maxima of 7 for palm kernel oil and 2 for coconut oil. Although little information is available, suggested maxima for anisidine values of the crude oils are 3.0 for palm kernel oil and 2.5 for coconut oil. The combined tocopherol and tocotrienol content of the crude oils is low, ca. 40-100 ppm, but is nevertheless of importance for protection against oxidation.

USES

About half of the production of palm kernel and coconut oils is used for technical purposes, of which the prinicpal is the manufacture of toilet soap. Both oils are also used as raw materials for the production of low molecular weight alcohols for detergents. The importance of the oils for this latter purpose is growing because of the increasing costs of production based on petroleum products.

In producer countries coconut oil has been, and to a lesser extent still is, used as a body and hair oil. It is also widely used for cooking and frying.

The edible uses for refined and otherwise processed lauric acid oils are discussed in the following sections. For most purposes in the list the oils are used in their refined natural and hydrogenated states. The solid fat indices of natural and fully hydrogenated coconut and palm kernel oils are shown in Table III. It can be seen that, because of the higher content of unsaturated acids, the effect of hydrogenation is greater on palm kernel oil. The hydrogenation can be stopped at any point between the figures shown. Except for special requirements, the hardening of palm kernel oil is stopped before an IV of 2.5, which corresponds to a "capillary rise" melting point of about 37 C, so that end-products do not have an unpleasant waxy palate-cling.

The oils in both the natural and hydrogenated states are susceptible to hydrolysis and therefore should not be used for products in which conditions and composition would favor the reaction. Prepared pastry doughs and cake mixes can be cited as examples of such products.

Margarines/Low-Calorie Spreads

For the production of margarines and low-calorie spreads, the two oils are mainly used in their natural state. In the early years of wrapped domestic margarines, it was common for both of the oils to be used in the fat blend at levels of 40% and higher. The relatively hard product was similar in this respect to butter and the sharp melting characteristic produced a pleasantly cool sensation in the mouth. Since then, the advent of soft margarines and the high price of lauric acid oils have greatly decreased their use. They are, however, still desirable for the effect they have on the meltdown of the product and therefore are included up to ca. 15% when prices permit.

TABLE III

Solid Fat Indices of Coconut and Palm Kernel Oils and Hydrogenated Coconut and Palm Kernel Oils

	Coconut oil		Palm kernel oil	
	Refined	Hydrogenated	Refined	Hydrogenated
SFI at 10 C	59	62	48	72
21.1	29	38	31	65
26.7	0	10	11	49
33.3	0	2.5	0	22
37.8	0	0	0	9.5
Wiley melting point (C)	24.4	36.7	28.3	44.4

In soft "refrigerator" margarines, the oils have two conflicting effects. In the first place, when used at over 15% of the blend, the texture of the product taken from the refrigerator is brittle. The second effect, which is more useful, is the formation of eutectic mixtures. Table IV demonstrates the marked softening effect at 10 C and 20 C, which is obtained in blends of palm oil and palm kernel oil. This effect makes possible the inclusion in a soft margarine blend of appreciably higher levels of palm oil than would otherwise be the case.

Refrigerator margarines which contain over 50% of polyunsaturated fatty acids require up to 80% liquid oil in the blend. It is difficult to incorporate sufficient solids into the remaining 20% to give the desired "body" to the product without giving it a waxy mouth sensation. Hydrogenated palm kernel or coconut oils may be used for this purpose either as a natural blend or interesterified with a second hard component (6,7).

Industrial cake and creaming margarines, which must have a smooth and plastic texture for ease of "creaming" and be capable of high air incorporation, are improved by the inclusion in the fat blend of 10-20% of lauric acid oils.

Cooking and Frying

The use of palm kernel and coconut oils for cooking and frying is a mixture of advantages and disadvantages. The advantages are that, due to the predominantly saturated fatty acid composition of the oils: the development of polymerized products or oxidized fatty acids is very low; the melting points of the oils are below body temperature and therefore the cooked food does not have a waxy taste; and the smell and flavor which develop during the cooking or frying life of the oil are not unpleasant, as is the case with some other oils and fats.

The disadvantages are converned primarily with frying. Frying temperatures are lower than for higher molecular weight fatty acid oils and fats and consequently the food absorbs more oil. The triglycerides are more susceptible to hydrolysis and therefore there is a more rapid development of free fatty acids in the oils with a resultant, comparatively rapid lowering of the smoke point. Admixture of the oils with other frying oils, e.g., soybean oil or palm oil, produces foaming. In refineries processing a number of different oils, it is most important that the oils destined for use as frying oils should not be contaminated with lauric acid oils. As little as 3% contamination will have a significant effect on the performance of the product.

In tropical countries, the resistance of palm olein to cool temperatures can be improved by making use of the eutectic effect obtained by blending with coconut oil.

Synthetic Cream Fats

Dairy fat substitutes are used in such products as "whipped toppings" or synthetic creams, "filled milks" and "coffee whiteners" and nondairy ice-cream. The whipped toppings, filled milks and coffee whiteners are produced either as emulsions or as spray-dried powders.

The specification for the fat for such products is that the fat should be of vegetable origin for dietary reasons; it should be resistant to oxidation to prevent the development of off-flavors; should melt rapidly and as completely as possible at or below body temperature; it should have a significant solid fat content at storage temperatures to prevent breaking of the emulsion, and a high content of solid fat at the whipping temperature to assist stiffness.

Palm kernel and coconut oils – either in their natural or hydrogenated state – satisfy the specification and are widely used for these products. The hydrogenated fats are used for whipped toppings, coffee whiteners and some types of ice-cream. Slip melting points are about 35 C for the emulsions and 42 C for powdered products. The unhardened oil is used for liquid filled milks and other types of ice-cream.

Other hydrogenated vegetable oils do not possess the sharpness of melt-down of lauric acid oil products, and the desired solids content for storage and whipping can only be obtained at the expense of producing a waxy taste. It is customary, therefore, even when oil prices are against the use of palm kernel and coconut oils, to retain ca. 40% in the blend.

Confectionery Fats

Confectionery fats can be put to two uses, namely, for toffees and "chocolates." The fat for toffees should be clean melting at body temperature and consequently palm kernel and coconut oils are suitable. Because of their oxidative stability, they are used hydrogenated in preference to other hydrogenated oils when prices permit. A typical fat will consist of 50% hardened palm kernel oil, 35 C melting point, with 50% palm oil.

The second type of confectionery fat is the cocoa butter replacer or substitute. Cocoa butter substitutes, used as a generic term, can be subdivided into: equivalents, which are fats totally compatible with cocoa butter; partial replacers, which may be mixed with cocoa butter, but only in certain proportions; total replacers, which are not compatible with cocoa butter; and modifiers, which are fats added to cocoa butter in small amounts to alter the physical properties, e.g., to raise the melting point. The fats are also known as "hard butters."

Because of crystal modification on storage and the eutectic softening effect when the oils or their derivatives are blended with cocoa butter, palm kernel and coconut oils are limited in their application to the role of total replacers (8).

Palm kernel and coconut oils are used in their natural state for enrobing ice-cream. The hydrogenated oils are used for low-cost confectionery coatings and for "chocolates" for pets. Appreciably sharper melting characteristics

TABLE IV

Eutectic Mixtures

Blend (%)		Solid fat index (C)					Melting point (C)	Iodine value
Palm oil	Palm kernel oil	10	20	30	35	42		
0	100	51.2	37.4	1.3	1.0	0	27.5	17.6
20	80	44.2	26.0	1.2	0.8	0	26.8	–
40	60	40.2	18.0	3.1	2.1	0.4	28.8	–
60	40	36.3	12.2	4.6	3.9	1.6	32.0	–
80	20	33.9	14.5	6.3	3.8	0.6	33.0	–
100	0	42.4	21.6	8.4	5.2	0	33.5	52.0

are obtained by the random interesterification of hydrogenated palm kernel oil, as shown in Table V. Such products are used as pastel coatings (9). When the hydrogenated palm kernel oil is blended with hydrogenated palm or cottonseed oils and then interesterified, a product is obtained which is suitable for enrobing biscuits and various centers in enrobed bars.

The stearin produced from the fractionation of palm kernel oil possesses an even steeper melting curve as shown in Table VI. The product depends upon the process and conditions used. The solid fat index of stearin 2 closely resembles that of cocoa butter (9,10).

As will readily be understood, the products from the processes mentioned, and the use of other oils in admixture with palm kernel and coconut oils, can be used for a wide variety of confectionery applications.

Biscuit Fats

Two types of fats may be used in biscuits, the dough fat and the filling-cream fat. Lauric acid oils may be used with advantage in both applications. The unhydrogenated oil is used in the dough fat at levels between 20% and 50% of the blend. The inclusion of palm kernel or coconut oil in this case improves the "shortness" of the biscuit and again helps to ensure that there is no waxy sensation on the palate when it is eaten.

Biscuit filling creams should snap when the biscuit is broken. They should also solidify rapidly to prevent problems on the production line and be highly resistant to oxidation because of the long life of the product. The lauric acid oils and hydrogenated fats fulfil these conditions and, therefore, are the most widely used for this purpose. The fat blend is typically 20% palm or hardened palm oil and 80% of a mixture of the natural and hardened palm kernel or coconut oil.

In whatever application, the lauric oils must be used under carefully controlled conditions. If any of the products in which they are used contain a trace of lipase, then the product will develop a soapy flavor. It is now common practice in a number of UK establishments handling such lauric-rich materials to monitor the other components of the product for the presence of lipase enzymes by the indoxyl acetate test.

PROCESSING

Refining

Palm kernel and coconut oils can be refined using either the chemical (caustic soda) or physical processes. Although the FFA content of palm kernel oil is normally less than 7%, some highly hydrolyzed oils can contain up to 15% FFA. Physical refining can be used for all qualities of lauric acid oils but, because of the low refining loss of the process, it is particularly advantageous for these high FFA oils.

TABLE VI

Solid Fat Indices of Palm Kernel Stearins Compared with Cocoa Butter

	Palm kernel stearin		
	1	2	Cocoa Butter
SFI at 10 C	68.9	76.1	76
21.1	61.2	71.0	73
26.7	47.6	59.9	62
33.3	0.6	1.9	10
37.8	0	0	0
Iodine value	6.8	5.0	—
Wiley melting point (C)	32.0	35.0	33.3

Apart from FFA and color, the most important impurities for removal during refining are the same as for other oils and fats, namely, phosphatides, trace metals and oxidation products. The phosphatide level of palm kernel and coconut oils is very low, but treatment with phosphoric acid at ca. 0.05% based on the oil weight does improve the final quality of the oil, possibly because of the attack of the acid on trace metal compounds. Coconut oil sometimes contains copra dust or "fines" which, without phosphoric acid treatment of the oil, can give severe problems with emulsion formation during caustic soda refining. In such cases the phosphoric acid addition should be increased to 0.2% or 0.3%.

The freshly deodorized flavor and the flavor stability of these oils is of utmost importance. Removal of trace metals, copper and iron, and of peroxides, aldehydes and ketones is crucial. The crude oils should not contain more than 2 ppm of iron and 0.2 ppm of copper. During refining these levels should be reduced to 0.10 ppm and 0.02 ppm, respectively. Activated bleaching earths remove trace metals and oxidation products as well as pigments and, in the case of lauric acid oils which are usually easily bleached, the quantity of earth used should be based on the removal of the former impurities rather than color.

The caustic soda refining process can be used in batch, semicontinuous or fully continuous centrifugal plant. To reduce losses due to saponification the lye used should be dilute. 12° Bé is used in batch and continuous processing and 5° Bé in the Zenith semicontinuous plant. "Acid oil factors," i.e., the percentage of acid oil produced divided by the percentage FFA in the crude oil, vary with oil quality but for good quality oils 1.6 for batch, 1.35 for continuous and 1.2 for semicontinuous plants can be achieved. Following caustic soda refining, bleaching earth dosage also depends upon crude oil quality but lies usually between 0.2% and 1.0% of activated earth.

TABLE V

Solid Fat Indices of Hydrogenated and Hydrogenated Interesterified Coconut and Palm Kernel Oils

	Coconut oil		Palm kernel oil	
	Hydrogenated	Hydrogenated interesterified	Hydrogenated	Hydrogenated interesterified
SFI at 10 C	62	54	72	68
21.1	38	37	65	57
26.7	10	17	49	42
33.3	2.5	0	22	12
37.8	0	0	9.5	0
Wiley melting point (C)	36.7	31.7	44.4	35.0

Before the distillation/deodorization step in physical refining, the oils are given a "dry" pretreatment. This consists of 0.05-0.1% of 80% phosphoric acid followed by 1.0-1.5% of activated bleaching earth and filtration. Some coconut oils produced from "smoke dried" copra can be very difficult to bleach. For these cases additional use of activated carbon at 10% of the weight of bleaching earth used can be of assistance.

Deodorization temperatures are usually 180-190 C for batch equipment and 220 C for continuous or semicontinuous plant. The distillation and deodorization in physical refining are carried out at 240 C.

The hydrolytic splitting of these oils is autocatalytic and therefore the free fatty acid of the deodorized oils should be less than 0.03% so as to achieve good flavor stability.

Hydrogenation

Probably the most important characteristic of hydrogenated palm kernel and coconut oils is the fast and clean melting sensation. It is therefore of prime importance that the refined feed oil should not be contaminated, particularly prior to and during the hydrogenation process. 2% contamination with a liquid oil such as soybean or rapeseed is sufficient to produce a noticeable waxy palate response. Ideally the catalyst carrier oil should be palm kernel oil but, if this is not obtainable, palm oil is preferable to soybean. For the same reason the oils should be hydrogenated using active, fresh catalyst rather than a "used" catalyst from the hydrogenation of another type of oil. Because of the low content of unsaturated acids and the very low final IV, the question of selectivity is not important.

Iodine value is used to control the reaction because the refractive index change is small and quick melting point determinations are unreliable with these oils. The iodine value is also ususally an important item in the product specification.

Interesterification

The interesterification reaction poses no real problems with the lauric acid oils. Because of their susceptibility to hydrolysis and the reaction which takes place between free fatty acids and the interesterification catalysts, it is more than usually necessary to ensure that the oils are neutral and dry before adding the catalyst.

Fractionation

Natural coconut oil is seldom fractionated due to the low yield, ca. 10-15%, of the stearin. A process has, however, been patented for the fractionation of the product from the directed interesterification of coconut oil. The yield of stearin was 46% (11).

Palm kernel oil can be fractionated by the "dry," detergent (12) and solvent (13) processes. In Table VI, stearin 1 is typical of the products obtainable by the "dry" and detergent processes and stearin 2 by the solvent process. The solvent process is the more versatile and produces sharper fractions. Solvents used are acetone, hexane and 2-nitropropane.

The characteristics and yield of the stearin product depend upon the nature of the parent material and on the process conditions. Stearin 1 is obtained from palm kernel oil in 30% yield by the detergent method, and for stearin 2 using solvent fractionation the yield is ca. 40%.

Palm kernel olein may either be hydrogenated to produce other types of hard butters or used in margarines. It may be used as the fat component in calf milk replacers or added to palm kernel meal to satisfy the requirements of animal feed manufacturers. It may also be blended off in palm kernel oil.

EFFLUENT

The solubility in water of the principal component fatty acids of palm kernel and coconut oils are: caprylic acid 1100 parts per million (ppm); capric acid 100 ppm; lauric acid 12 ppm; and myristic acid 6 ppm (1). These solubilities limit the effectiveness of the various physical methods of oil separation from process effluent according to the quantity of these oils being processed.

In addition to this problem, the volatility of the low molecular weight fatty acids results in reduced efficiency of vapor scrubbers installed to remove fatty material from deodorizer vapor outlets. Figures which illustrate this point are the total fat contents of single-pass barometric water leaving the vacuum equipment of such an installation, e.g.: rapeseed or soybean oils 10 ppm; palm oil 25 ppm; palm kernel and coconut oils 50 ppm.

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