very turbid but became clear on passage through a mixture of filter cell and sodium sulfate. The absorption of this solution is shown in Figure 6.

Also shown in Figure 6 are the absorptions of samples of these wet gums dried at 80° and 100°. The results agree with those of Figure 5 in that little additional color is produced in the lecithin by drying up to at least 80°; however heating at 100° causes additional darkening. The low absorption at the minimum of 390 mμ in Curve 1 compared to that of the commercial wet gums shown in Figure 5, Curve 2, indicates that in the latter sample a large amount of brown color has already been formed before the gums are removed from the oil. This color is probably formed in the oil during the solvent stripping operation.

The brown color bodies of soybean lecithin have many of the characteristics of aldehyde-amine reaction products, such as are formed in a variety of food products. The absorption curve for the brown color is of the same shape as that found, for example, in egg lipides (1). As seen in Figure 2, a large part of the brown color is lost during saponification; however, if the curve for the aqueous solution is extended into the ultraviolet, a slight maximum at 270 mμ typical of an aldehyde-amine reaction product is found. The fluorescence of the lecithin under ultraviolet light, which increases with increasing brown color (11), is also typical of an aldehyde-amine reaction product.

The probable source of the amino group is the ethanolamine of the phosphatides. Sugars might be the source of the aldehyde group. However a sample of lecithin from which free sugars had been removed by Folch's (3) procedure darkened on heating in the same way as ordinary lecithin. Other sources of aldehyde may be the bound sugars remaining with the phosphatides, or possibly the acetal phosphatides recently reported by Lovern (6) to be present in soybean lecithin. It was also considered that the development of aldehyde amine brown color might be associated with the presence of unsaturated fatty acids in the lecithin with the oxidized acids furnishing aldehyde groups. A brown color might also be formed by a reaction similar to the yellowing of drying oils. However a sample of lecithin hydrogenated from an iodine value of 95 to 16 increased in color on heating even more rapidly than other samples.

Summary

The color of soybean lecithin is due to carotenoids, brown pigments, and occasionally porphyrins. In the water-washing of crude oil xanthophylls are preferentially removed with the gums, and carotene is practically absent in lecithin. Lutein is the principal carotenoid, comprising about three-quarters of the carotenoids in lecithin. Hydrogen peroxide bleaching destroys all the color to some extent, but by far the greater effect is on the carotenoids.

The brown color is very likely an aldehyde amine reaction product. It is largely formed by heating of the oil during the solvent-stripping operation. It is not increased by drying the gums under vacuum for 3 hours at 80°C. but it is increased on heating at 100° C. under the same conditions. The formation of the brown color is not prevented by removal of free sugars or by hydrogenation of the lecithin.

Acknowledgment

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The Application of Fatty Chemicals to Flotation

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THE fatty acids and their derivatives are versatile tools of modern industry. They present such a wide variety of applications that few industries do not utilize them directly or indirectly. One has only to mention the soap, paint, petroleum, and rubber industries to bring to mind a few of their well-known uses. However, in addition to such familiar applications of fatty acids, there are a number which are equally vital and important but which are less well known to those engaged in fatty acid production. Among these is the art of flotation.

The Flotation Process

Currently, the major industrial application (the one which we are describing) is in the concentration of the valuable minerals in ore deposits. Here, flotation refers specifically to the art and science of separating mineral particles from each other in a liquid pulp by means of air bubbles. This basic principle of the flotation process is simple, but its application involves numerous complexities.

How does one go about floating minerals that normally sink in water? This is done in a water medium by means of chemicals which preferentially coat in a monomolecular layer one type of mineral particle in a mixture of several types. These chemicals are called "collectors." They are divided into two classes—anionic and cationic. The anionic class, which includes fatty acids, is selective to those minerals which have a high concentration of positive surface charges; for example, the various calcium minerals such as calcite, phosphate rock, and fluorspar. The cationic class, which includes the amine derivatives of fatty acids, is selective to those minerals which have a high concentration of negative surface charges; for example, silica sand. The polar end of the collector attaches to the mineral surface either by chemical or physical adsorption; the nonpolar unreactive end is oriented away from the mineral surface. The result is a hydrophobic coating at the mineral surface which permits attachment to air bubbles. It is this surface condition which permits the floating of minerals which normally sink in water.

In order to utilize these fatty acids and derivatives in flotation, several conditions must be fulfilled. The first requisite is that the valuable mineral is liberated from the valueless gangue in a size range suitable for the process. Mineral particles much larger than 300 microns—a little over a hundredth of an inch—are usually too coarse to be recovered by flotation. On the other hand, when particles are much smaller than 20 microns, selectivity between minerals is lost, and reagent consumption is increased to such an extent that the process is no longer economical. Since minerals seldom occur naturally under these sizing conditions, the ore preparation normally is accomplished by coarse crushing in a dry state, followed by grinding in a wet state to the desired size required for mineral liberation.

Following the grind, classification methods, usually wet, may be utilized to remove the too fine mineral particles. The ore is now ready for the flotation process.

The second requisite to flotation is the coating of the valuable mineral by the collector to provide the desired hydrophobic coating—a process already described.

The prepared ore in the form of a water pulp is processed in flotation cells. These are tanks in which, in the presence of reagents, the flotation feed is suspended in water by means of mechanical agitation or aeration. Fine air bubbles are dispersed in the pulp where attachment to the coated particles is effected. When the coated bubbles rise to the surface, they must remain stable a sufficient time for the froth to be removed. The stability and quality of the froth can be improved by the addition of reagents termed "frothers," which function by reducing the surface tension of the suspending liquid. Frothers are frequently not required with fatty acids which, in themselves, produce a frothing effect. Thus the coated mineral is lifted to the top of the flotation cell as froth which is raked off into a collecting trough. The non-coated portion, sinking, is withdrawn at the bottom.

The preceding description represents the simplest type of unit flotation operation. This unit operation may be repeated in a sequence of flotation cells as often as is necessary to secure the desired separation. The performance from cell to cell may be changed considerably so that, by the proper choice of reagents, the mineral that is depressed in one cell may be caused to float in a succeeding one. The action of the collector is usually repressed or enhanced by the addition of various modifying agents, such as secondary collectors, depressants, activators, pH regulators, coagulants, or dispersants. The most desirable and economical conditions for cell operation depend on so many variable factors that successful operation requires a large store of experience.

Collectors in Flotation

As mentioned earlier, the flotation reagent type with which we are concerned here is the collector, which acts to render minerals water-repellent. Since minerals wetted by water will not attach to air bubbles, the impossibility of flotation without this water-repellent coating becomes evident. The degree of success in the flotation operation is determined to a large extent by the characteristics of the collector used. Every collector should possess the following characteristics:

a) It must possess a greater affinity for the mineral that is being concentrated than for the other mineral constituents of the ore.
b) It must be relatively or completely soluble in water, or compatible with an ore-water pulp.
c) It should be quite stable chemically.
d) It should be non-corrosive.
e) It must be a potent collector which has the ability to promote speedy and rapid flotation of minerals with a minimum of contact time preceding flotation.

The chemicals used as collectors in flotation operations fall into several well-defined classes. These include:

a) the anionic metallic and metallic-sulfide collectors,
b) the anionic non-metallic and heavy-metal-oxide collectors, and
c) the cationic non-metallic collectors.

The anionic metallic and metallic-sulfide collectors include the xanthates and dithiophosphates; they concentrate most of the gold, copper, lead, zinc, and similar metals. Since this field currently uses no fatty acids or fatty-acid derivatives, it will not be discussed further. It is with the two other reagent classes that we are concerned in this article. These are:

a) the anionic non-metallic and heavy-metal-oxide collectors, which include fatty acids and petroleum sulfonates, and
b) the cationic non-metallic collectors, which are ammonium derivatives of the fatty acids.

Countless other sources of flotation chemicals have been investigated, but, so far, the list of highly efficient and inexpensive collectors remains quite small.

These two preceding collector types are of anything but academic interest to the fatty oil chemistry field; they represent a sizeable volume of business in the neighborhood of 10,000,000 lbs. of distilled products per year, not counting the huge, even greater amounts of crude fatty acids used each year in such fields as phosphate flotation. Of greater importance, this figure is not a static quantity but rather an ever-increasing one due to rapid advancement in the flotation field.

History of Fatty Acids in Flotation

Crude fatty oils containing fatty acids as the glycerides were among the first flotation collectors. They were used initially about 40 years ago in floating metallic sulfides; they were replaced later by xanthates which were much more selective. However this record of previous use resulted in the testing and subsequent utilization of fatty oils as collectors when non-metallic flotation first was studied in the late 1920's. The fatty materials used then were often waste products which, because of spoilage, were offered to anyone who wanted them. The erratic mill results can easily be imagined since the operator had no information concerning the composition of any shipment and consequently did not know how the reagents would act from one shipment to the next. In time, the limits of flotation were proved to be a direct function of the amount of free fatty acids which occur in these crude fatty oils. The free acid was produced through enzyme rather than by chemical action. As soon as it was proved that the free fatty acids were responsible for flotation, the use of fatty oils was discontinued and the refined fatty acids found use as collectors. Red oil, a crude oleic acid, was first used. Later, because of their lower cost, fish oil fatty acids were substituted for red oil. They still continue to be used in large amounts outside the United States. Still later, tall oil became a cheap source of fatty acids. Tall oil fractions and red oil continue to be the major fatty acids used in the flotation field.

Factors Determining Flotation Uses of Fatty Acids

Several factors determine which fatty acids find use in flotation. The first consideration must be the length of the carbon chain. The chain length must be C8 or greater since the surface film produced by the lower acids on minerals is insufficiently hydrophobic to promote flotation. Also, the chain length of the fatty portion of saturated acids should be no greater than C18 or C20 because of the low solubility of the soaps, in which form these acids would have to be used. The distinguishing characteristic of these fatty acids or their soaps which permits mineral flotation is that of ionizing to produce the carboxylate anion ($RCOO^-$). These ions will coat all minerals which in water free an earth metal ion (for example, calcium) or onto the surface of which such an ion can be attached. The heavy, fatty portion of the molecule orients away from the mineral surface to provide a hydrophobic coating.

A second consideration which applies to fatty acids as flotation collectors is ease of use. This consideration drastically reduces the number of acids which find commercial utilization. Practically all of the fatty acids available are difficult to use because they are solids at room temperature. However in this series is an unique group of C18 acids—oleic, linoleic, anl linolenic—which are liquid at room temperature by virtue of the fact that they are unsaturated. Their liquid property results in their dispersing and emulsifying easily in a water medium with mechanical agitation; in this respect they are markedly superior to the solid, saturated acids.

A third and most important reason for using fatty acids in flotation is low cost and availability. Mixtures of all of the fatty acids in the C8 to C18 range of carbon chain lengths occur naturally as glycerides in substantial quantities. Their cost of refining is relatively low. The characteristics which result in the use of C18 unsaturated fatty acids in flotation in preference to the saturated are:

a) ease of use because of their liquid state and concurrently a more satisfactory mineral attachment,
b) a suitable carbon chain length to effect flotation,
c) low cost, and
d) adequate supply.

In addition to the above favorable characteristics, the unsaturated C18 fatty acids exhibit the following desirable properties which a collector should possess—they are stable compounds, are non-corrosive at normal temperatures, and foster a rapid type of float. An undesirable characteristic of all fatty acid flotation is the tendency to be non-selective. Modifying agents are used to control this action.

The group of fatty acids between C8 and C12 have possibilities for successful use in difficult separations of minerals of similar floatabilities. However these fatty acids are scarce in nature, and currently their prices are too high to be practical for most flotation separations.

It should be stressed that the fatty acids used in flotation are essentially mixtures in varying proportions of oleic and linoleic acids, with at the most a very small proportion of linolenic. Impurities include small amounts of saturated acids and rosin acids. These mixtures are satisfactory since testing has proved that the oleic and linoleic fractions, which combined represent by far the greater proportion of these commercial mixtures, are about equally very strong and selective collectors. Linolenic acid, concerning which considerably less is known, can be ignored because of the negligible amount usually present. Because of their higher proportion of linoleic acid, tall oil fractions are sometimes preferred when additional solubility and emulsification of the flotation reagent is desired. Even though saturates, such as palmitic and stearic acids, and rosin acids are strong flotation promoters when used as soaps, their presence is normally not desired in the fatty acid mixture for flotation because:

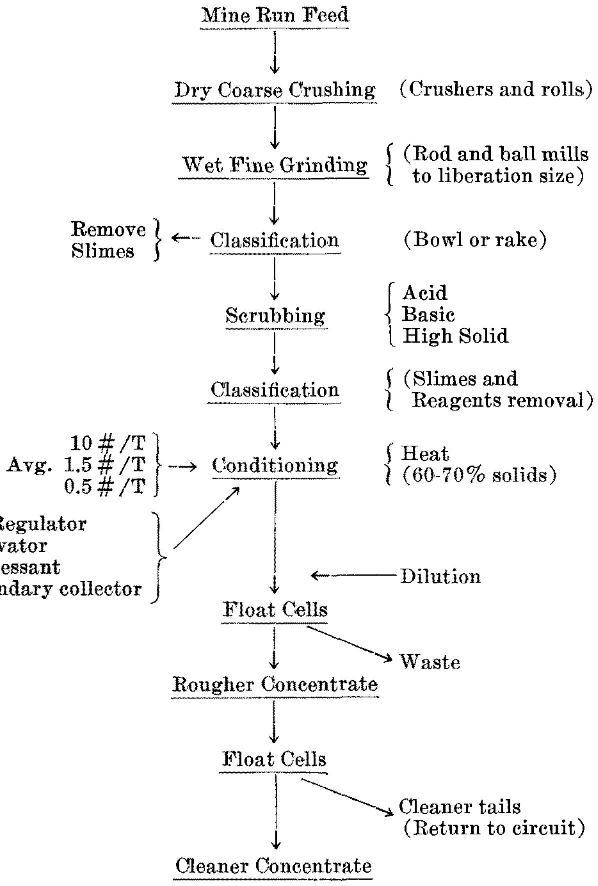
a) they raise the titer, and
b) they probably are inert in the float circuit, unless converted to soaps in order to make them sufficiently soluble to effect mineral attachment.

Flotation Applications of Fatty Acids

Specific applications of fatty acids in the mineral dressing field are varied. The more important mineral separations include phosphate (calcium phosphate) from silica; hematite (iron oxide) from silica; fluorspar (calcium fluoride) from calcite and silica; barite (barium sulfate) from silica; spodumene (source of lithium) from silica, mica, and feldspar; calcite (calcium carbonate) from mica and silica in cement rock; and ilmenite (source of titanium) from silica and magnetite.

A typical procedure to accomplish these mineral separations is presented in Figure 1. The ore is crushed dry in coarse crushing equipment and ground wet to liberation size of the valuable mineral in rod or ball mills. Softened water is often used in subsequent stages if an efficient separation of minerals is to result. A classification step for the removal of slimes usually follows grinding to increase selectivity and decrease reagent costs in the subsequent float. In many instances preliminary treatment of the mineral is required to alter surface characteristics. This consists of an acid, caustic, or high solids scrub. This scrub would be followed by a second classification stage to remove slimes and reagents. The next step is conditioning with reagents, which is carried out at a high solids pulp (60-70% solids) to obtain the best possible environment for attachment of the fatty acid to the mineral surface. An average reagent requirement would be about 1.5 lb. of fatty acid per ton of ore, with the extremes about 0.5 to 10 lb. per ton depending on the ore and its condition. Added under this same condition of high solids would be any activator, depressant, pH regulator, or secondary collector, such as a hydrocarbon, necessary to enhance or repress the fatty acid collector action. Reagent attachment can often be improved if the fatty acid is heated before addition to the pulp or if the entire conditioning operation is carried out at an elevated temperature. Crude fatty acids can be used if high recoveries are desired and sharp selectivity can be ignored. Distilled fatty acids must be used if both a sharp selectivity and a high recovery are desired. The conditioned pulp is then diluted to float solids (12-20%), and flotation is carried out in mechanical or air flotation cells. A relatively slow float at a low solids density is normally required in the interests of selectivity, and usually a series of cells will be used in any one operation. As the pulp proceeds through the successive cells, additional reagents can be added and the speed increased to obtain conditions which produce a higher recovery by floating coarser and unliberated mineral particles. The preceding operation is referred to as a rougher float. The rougher concentrate usually has to be refloated in the absence of reagents but at lower dilution and lower speed to secure the desired high grade of concentrate. The flotation concentrate is now ready for subsequent treatment. The reject from the flotation cells is discarded.

FIG. 1
Typical Fatty Acid Flotation Circuit



Tonnage production statistics of the more important minerals floated with fatty acids, shown in Table I, give a good indication of the size and importance of this field from the mining viewpoint.

TABLE I
Tonnage Production Statistics
(Fatty Acids)

Mineral	Approx. 1952 Prod. in Tons of Concentrates	Uses
1. Phosphate Rock	10,000,000	1. Fertilizers 2. Phosphoric Acid
2. Fluorspar	235,000	1. Flux in steel production 2. HF Manufacture 3. Glass and enamel
3. Barite	600,000	1. Well drilling muds 2. Pigments 3. Chemicals
4. Hematite	400,000 (Projected in 1954)	1. Steel

This summary of production includes only the more important mineral separations accomplished with fatty acids. Some of the minerals not mentioned are produced in smaller tonnages, but they are equally important to the economic life of the Country. These include minerals of titanium, lithium, uranium, tungsten, and others.

The Fatty Amines in Flotation

The fatty acids are utilized in flotation not only as such but also in the form of organic derivatives, the amines, which are the cationic-type of flotation reagent. Amine flotation is in itself equally as important as the fatty acid field. The principles involved are similar; this subject therefore will be given a more limited discussion.

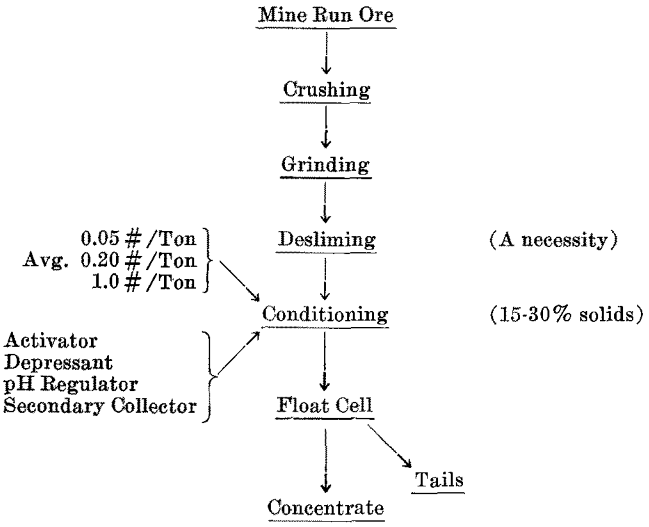
The amines are the most versatile of all known reagents for non-metallic mineral separations. The development of these cationic reagents during the past 15-20 years has been the major factor in the advance of the field of non-metallic mineral separations. The two cationics most widely used in flotation are coco amine derived from coconut oil fatty acids and tallow amine derived from tallow fatty acids. Coco amine is a mixture of straight chain amines, largely C12 but with smaller amounts of the C8 through C18 group. Tallow amine is a mixture of C16 saturated and of the C18 saturated and unsaturated straight chain amines. Both coco and tallow amines can be neutralized with acids, such as acetic or hydrochloric, to provide the neutral salts which are water-soluble and easily dispersible in flotation pulps. In water the amine acetates (RNH_3Ac) ionize to give the cation (RNH_3^+) and the anion (Ac^-). In contrast with the fatty acid mode of ionization in which the large fatty portion of the molecule carries a negative charge, here the ionized group containing the large fatty amine portion carries a positive charge. For this reason the amines are specific collectors for the acidic minerals which possess a high concentration of negative surface charges, minerals such as silica, and silicates including mica, feldspar, spodumenae, and similar non-metallics.

Flotation Applications of Fatty Amines

Some of the possible applications of the amines in flotation include the following separations: silica from phosphate; sylvite (KCl) from halite (NaCl); mica and silica from cement rock; silica from barite; calcite and silica from fluorspar; spodumene from mica, feldspar, and silica; mica from feldspar and silica; feldspar from silica; silica from iron-bearing minerals; and silica from ilmenite.

A typical procedure to accomplish these mineral separations is presented in Figure 2. The crushing and grinding of the ore would be as previously described. A step for the removal of slimes follows grinding if the quantity of reagents used in the separation is to be economical. The ore is usually ready for flotation at this point in contrast with fatty acid flotation where further surface treatment is normally required. Conditioning with reagents is at a very low solids density (about 15-30%), which also contrasts with the higher density in the typical fatty acid procedure. The average reagent requirement, much less than with fatty acids, is about 0.2 lb. of amines per ton of ore with the extreme 0.05 to 1.0 lb./ton. Added under these same conditions at low solids would be any activators, depressants, pH regulators, and secondary collectors. Reagent attachment can sometimes be improved if the entire conditioning and float operation is carried out at an elevated temperature. The conditioning and float times are held at a minimum to prevent slimes formation, which can upset the normal amine float circuit much more than does the formation of slimes in the fatty acid circuit.

FIG. 2
Typical Fatty Amine Flotation Circuit



The amine float is a very rapid one; this is an advantage which necessitates less float cell capacity to process a given tonnage of ore than would be required for a similar fatty acid float. Very seldom is a repeated series of cleaning operations necessary to obtain a satisfactory grade of product because the amines are a more selective collector type than are fatty acids.

An industrial example which in a striking way takes advantage of these differences in flotation properties of amines and fatty acids is found in the phosphate rock industry. Here, a bulk rougher float of the phosphate minerals from the ore is made with fatty acids to secure high recovery, but at the sacrifice of the desired selectivity. The fatty acid concentrate is then subjected to an amine float which upgrades the fatty acid concentrate by floating from it the silica which it contains.

Tonnage production statistics of the more important minerals floated with fatty amines, shown in Table 2, give some indication of the size and importance of this field.

There are other applications of the fatty amines to flotation, but they are less important tonnage-wise.

TABLE II
Tonnage Production Statistics
(Fatty Amines)

Mineral	Approx. 1952 Prod. in Tons of Concentrates	Uses
1. Potash	1,600,000 (As K_2O)	1. Fertilizers
2. Phosphate Rock	10,000,000	1. Fertilizers 2. Phosphoric acid
3. Feldspar	400,000	1. Glass 2. Pottery 3. Enamel

Future of Fatty Chemicals in Flotation

The preceding discussion of the flotation field pinpointing the specific sections related to fatty acids and fatty amines gives a partial picture of the current status only as it relates to mineral separations. The flotation principle is constantly finding greater application in many non-mineral fields. Of many instances cited in current literature, the few specific examples listed will give an indication of the variety of these non-mineral applications:

a) peeling coarse hulls from grains of wheat,
b) de-inking used paper,
c) recovering fossil resin from coal, and
d) reclaiming of silver salts from photographic developing chemicals.

These ever-expanding industrial uses of the flotation principle are accompanied by ever-expanding mineral uses, which are the result of the three following conditions:

a) The constant necessity to utilize lower grade sources for minerals as the high grade reserves are depleted. This condition is especially true in our country, which possesses such a huge industrial potential for all types of minerals. Examples of such lower-grade minerals would be ores of sulfur, coal, iron, and copper.
b) The steady rate of improvement in flotation reagents and in beneficiation equipment makes it possible to separate complex ores which a few years ago were waste rock deposits of potential value only, due to the inability selectively to separate the various constituents. The classic examples of these are the pegmatites, complex mixtures consisting mostly of mica, quartz, and feldspar but with small quantities of rare and valuable minerals of lithium, tin, beryllium, titanium, and others.
c) The current industrial stress on metals and minerals formerly unutilized or used to a much lesser extent has resulted in the necessity for developing and continuing to develop new procedures for concentrating ores of such metals as uranium, vanadium, tungsten, lithium, beryllium, thorium, zirconium, titanium, and others.

The fatty acids and fatty amines are finding use in practically all of the above listed mineral separations. The versatility of these reagents thus becomes apparent. With such tools the modern ore dressing specialist has relatively unlimited ways of accomplishing results on complex non-metallic ores. He is capable of floating almost any mineral he wishes under conditions which can be definitely controlled. The fatty chemicals today are functioning in the mineral flotation field to provide modern industry and modern agriculture with the tools necessary not only for optimum current production but also for future expansion and future innovations.

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Glyceride Composition of Fats and Oils Determined by Oxidation and Crystallization Methods[1]

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THE first application of oxidation methods to the study of glyceride composition was made by Hilditch and Lea (3). They described a method for determining trisaturated (GS_3) glycerides by oxidation of the fat in acetone solution with powdered permanganate, followed by aqueous potassium carbonate washes, which remove the acidic products from the unchanged GS_3. Attempts by several investigators (1, 4, 7) to extend the oxidation method for the determination of disaturated (GS_2U), monounsaturated (GSU_2), and triunsaturated (GU_3) glycerides by means of fractionation of the azelaoglycerides produced were unsuccessful, owing partly to hydrolysis of these products during the oxidation.

Kartha (7, 8, 9) however showed that hydrolysis can be prevented by maintaining an excess of acetic acid during the oxidation of the fat in acetone solution with permanganate. He described a procedure for separating the azelaoglycerides into two fractions, analyses of which provided a basis for calculation of the amounts of GS_2U, GSU_2, and GU_3 in the fat. He proposed an interesting hypothesis concerning the pattern of distribution of glycerides elaborated by plants and animals. The pattern is a restricted random distribution. The synthesis or elaboration of the fat by the plant or animal is thought to be of random character, but according to the nature of the plant or animal some cannot tolerate the amount of GS_3 produced. The amount of GS_3 not desired is transformed by interchange of saturated acids with unsaturated acids available from GSU_2 and GU_3. The extent to which any GS_3 enters into this rearrangement depends on the difference between the amount of this glyceride found experimentally and the amount calculated according to random theory. The effect of this rearranged "excess GS_3" superimposed on an otherwise random distribution can be calculated. Kartha found that the glyceride distribution by his oxidation method was in good agreement with that calculated according to his hypothesis for 27 fats and oils investigated. He also reported that the glyceride distribution of fats determined by either oxidation or crystallization methods does not agree in general with that calculated according to Hilditch's rule of even distribution (5).

Systematic fractional crystallization of fats from acetone at several low temperatures and analyses of fractions produced have been employed by some (6, 12, 13) as a basis for estimating the distribution of the principal classes of glycerides. Crystallizations in a much simpler way have been used to determine only the trisaturated glycerides (10).

Kartha (7) did not make any direct comparisons between results by his experimental method and those by crystallization methods on identical samples of different fats. Therefore it was considered of value to make such direct comparison on a number of dissimilar fats and oils. The results form the basis of the present report; calculations of composition according to random pattern and according to Kartha's hypothesis are included.

Experimental

Lard, palm oil, chicken fat, and cottonseed oil comprised the dissimilar fats and oils selected for investigation of glyceride composition. The lard was of high quality and composed of 25% "killing" and 75% "cutting" fat. The palm oil was from Sumatra and was alkali-refined in the laboratory. The chicken fat was rendered in the laboratory from fresh adipose tissue removed from around the gizzard and from body cavity fat depots. The cottonseed oil was of good quality and was alkali-refined.

In the oxidation method for determining glyceride composition, the procedures used for oxidizing the fat, separating the azelaoglycerides, and calculating the glyceride composition were the same as those originally described by Kartha (7, 8, 9). Briefly, the azelaoglycerides formed in the oxidation were separated as their Mg salts into soluble and insoluble fractions from an aqueous medium. The weight of the azelaoglycerides in the insoluble fraction was obtained, and the saturated acid content of each fraction was then found by the Bertram procedure. From these data the amounts of GS_2U and GSU_2 were calculated. The GS_3 was determined independently by the crystallization method described in this paper, and the GU_3 was obtained by difference.

In the crystallization method a series of fractional crystallizations from acetone at different temperatures was employed to separate the fat into relatively simple fractions, each of which contained substantially not more than 2 of the 4 classes of glycerides. The sequence of crystallization steps as outlined in Chart 1 was somewhat different from that reported in previous work (13), but, in general, the treatment and method of calculation of glyceride composition

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