The Present Status of Acetoglycerides[1,2]

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THE ACETOGLYCERIDES to which the present discussion will be confined almost entirely can be considered as being derived from fats and oils by replacing in the fat molecule two of the three long-chain fatty acid groups originally present with either two acetyl groups or one acetyl and one hydroxyl group. Acetoglycerides therefore are either triglycerides containing two acetyl groups per molecule or diglycerides containing one acetyl group. Monoacetotriglycerides are components of some of the mixtures which will be discussed, but these triglycerides do not possess the unique properties of the acetoglycerides as defined for this discussion.

The term acetostearin product will refer to products in which stearic acid is the major but not the only long-chain, saturated fatty acid combined in the glycerides; the term aceto-olein product will refer to products containing some glycerides of unsaturated acids other than oleic acid.

The first record of the preparation of an acetoglyceride product is found in a patent granted to Norman in 1920 (22). This patent, which is concerned with interesterification in general, contains a brief description of a product prepared by the reaction between triacetin and tristearin, followed by fractional crystallization from solvent. Practically no further work on acetoglycerides was reported in the literature until the last several years, when investigators at the laboratories of the Procter and Gamble Company and the Southern Regional Research Laboratory independently and almost simultaneously discovered that acetoglycerides normally solidify to a relatively stable, waxy crystalline form. Other potentially valuable properties were also discovered. As a consequence, more than a score of articles on acetoglycerides (also called acetin fats or acetylated monoglycerides) have appeared in the last five years.

The purpose of this paper is to review the preparation and properties of acetoglyceride products, discuss their potential uses in connection with foods, cosmetics, and pharmaceuticals, and present available information on their physiological behavior.

Information on the physiological effects of ingestion of acetoglycerides is presented because these compounds have attracted considerable interest for use with foodstuffs. They can be prepared from edible fats. They have physical properties unattained by natural fats, and these properties have the potential of extending the use of fatty substances in the fields of edible coatings, lubricants, and plasticizers. Normal metabolism of these materials is a prerequisite to their use in foodstuffs.

Methods of Preparation

While there are many methods of synthesizing acetoglycerides, only about three are suitable for large-scale use. They are: a) interesterification of triacetin and glycerides of the long-chain fatty acids, b) acetylation of monoglycerides of long-chain fatty acids with acetic anhydride, and c) direct esterification of acetic and fat-forming acids with glycerol.

By the first-mentioned method, fat and triacetin, preferably in a mole ratio of 1:6 or more, are interesterified in the presence of a suitable catalyst. Depending upon the type of end-product desired, free glycerol may also be added to this mixture. When sodium methoxide is used as a catalyst, a concentration of 0.2–0.4%, based on the weight of the reactants, is sufficient. The reaction, which is carried out under an inert gas, nitrogen, or hydrogen and at about 60°C., comes to equilibrium in less than 30 min. After the reaction has reached equilibrium, the catalyst is destroyed; and the uncombined triacetin and any mono- and diacetin are removed by vacuum distillation or stripping.

The preparation of acetoglyceride products from monoglycerides and acetic anhydride is quite simple. The monoglycerides, which may range down to 50% in actual content of monoesters, and the acetic anhydride are heated under a dry, inert atmosphere at 110°C. for from 1 to 4 hrs. Usually less than one mole of anhydride per hydroxyl equivalent is employed. The reaction is stopped by adding water to hydrolyze the uncombined anhydride. Acetic acid is removed by washing with water.

The preparation of acetoglyceride products by esterification of mixtures of acetic and long-chain fatty acids has not yet been reported in the literature, but it undoubtedly can be accomplished. Precautions must be taken, of course, to prevent loss of the relatively low-boiling acetic acid from the reacting mixture.

Like all oil and fat products intended for edible use, the acetoglyceride products must be purified to the point where they possess a light color and are bland in flavor and odor. This can be accomplished by bleaching with activated clay or carbon followed by steam deodorization. The latter process must be conducted under relatively mild conditions (approximately 1 hr. at 175°C. and a pressure of 1 mm. of mercury) to prevent the products from being degraded.

Physical and Chemical Properties

The unique property of acetoglycerides, one which makes them potentially useful in a number of applications, is their ability to exist as nongreasy, plastic solids (6, 10, 12, 16). All acetoglycerides exhibit this property though the aceto-oleins solidify at temperatures too low for most practical applications. In Figure 1 the plasticity of a film of acetostearin product is contrasted with the brittleness of tristearin.

Acetoglyceride products owe their plastic behavior not only to the softness of their crystals but probably also to the shape of the crystals, as shown in Figure 2. The acetostearins represented in the figure crystallized in a ribbon-like structure to form a felt-like matrix.

An indication of the degree of plasticity of some

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[2] Contribution from the Department of Biochemistry and Nutrition, School of Medicine, University of Southern California, Los Angeles, Calif.

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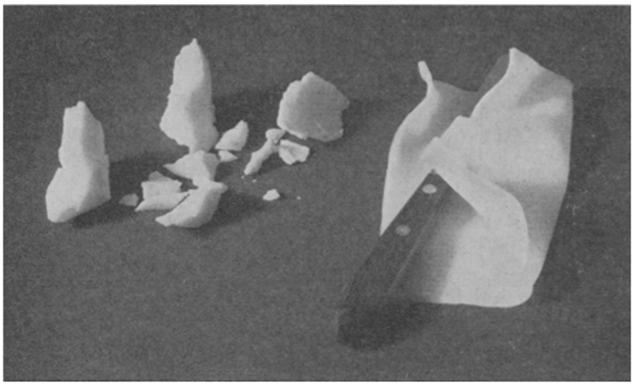

FIG. 1. A film of acetostearin product (right) and pieces of of tristearin (left).

acetostearin products is given in Table I: products 1–3 are essentially mixtures of 1,2-diaceto-3-stearin, 1-aceto-3-stearin, and 1-monostearin; products 4–6 contain the same compounds in addition to the corresponding palmitins.

Normal solidification of an acetoglyceride compound from the melt produces the waxy form which has been established by X-ray studies to be the *alpha* polymorphic form (16, 23), which is not thermodynamically stable. However the presence of small amounts of other glycerides stabilize the *alpha* form so that it will not transform when kept at room temperatures for several years.

The melting points of the waxy forms of the acetoglycerides, which are the subject of this discussion, range from —18.3°C. for 1,2-diaceto-3-olein (9) to 47.5°C. for 1-aceto-3-stearin (23); 1,2-diaceto-3-stearin melts at about 35°C. (16, 23). By the proper choice of components, mixtures can be prepared which have melting points between the extremes cited. One potentially useful mixture of this type consists of approximately equal proportions of diacetostearins and diacetopalmitins, which melts at about room temperature.

The density, viscosity, expansibility, solubility, and heat capacity of various acetoglyceride compounds and products have been determined and reported. In general, the properties mentioned resembled those of the glycerides found in ordinary fats and oils. What differences were found would be expected to occur on substituting acetic for a fat-forming acid in glycerides.

Because acetostearin products may be useful as coating materials, the permeability of such products to moisture and the atmospheric gases (carbon dioxide, oxygen, and nitrogen) has been determined (17, 18). While the products are not absolute barriers to water vapor, they are quite good in this property. The permeability is only slightly greater than that for nylon, ethylcellulose, and polystyrene. Permeability of the acetostearins to carbon dioxide was less than that for the ethylcellulose and approximately the same as for polystyrene and polyethylene. On the other hand, polystyrene and ethylcellulose were more permeable to oxygen and nitrogen than were the acetostearins.

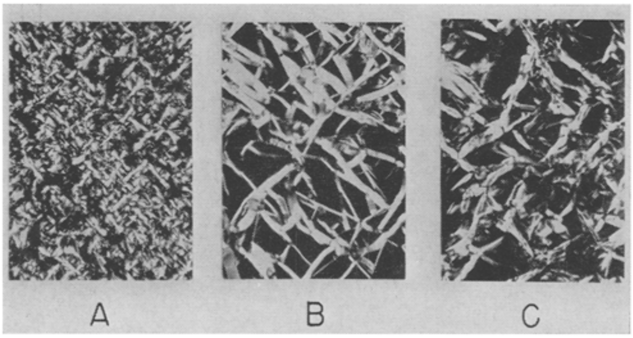

FIG. 2. Photomicrographs of (A) tristearin, 405 ×; (B) 1,2-diaceto-3-stearin, 150 ×; and (C) 1-aceto-3-stearin, 150 ×. Crystals formed by cooling to room temperature a drop of the melt on a slide.

TABLE I

Properties of Acetostearin Products Obtained by Acetylation of Monostearins (2)

Monostearin used	Product No.	Melting range, °C.	Hydroxyl value	Monoglyceride content, %	Elongation,[a] %	Maximum load,[b] lb.
1-Monostearin	1	45.0–48.0	153	17.8	>800	1.70
	2	39.5–42.0	78	2.7	>800	0.71
	3	38.0–39.0	36	0.3	>800	0.49
Commercial, molecularly distilled product, 91.5% monoester[c]	4	41.0–44.0	166	11.4	467	1.60
	5	32.0–35.5	78	2.8	513	0.43
	6	29.0–31.0	56	0.9	>800	0.32

[a] Elongation at break point of a strip measuring 3 x ¾ x ⅛ inches when stretched at a rate of 1.0 inch per minute at 22°C.

[b] Maximum load necessary to maintain stretching rate in elongation test. Values are an indication of strength.

[c] Contained about equal proportions of monostearin and monopalmitin.

In chemical properties the acetoglycerides resemble ordinary fats and oils of comparable degrees of unsaturation. Baur (5) has stated that shortenings and liquid base stocks for shortenings, both containing acetoglycerides, did not exhibit any evidence of acetic acid odor or flavor on being stored at 100°F.(38°C.) for one month. On heating acetostearins in air at 200°C., the changes occurring in color and viscosity are relatively small and about comparable to those experienced with completely hydrogenated vegetable oils (11). One acetostearin product made from completely hydrogenated cottonseed oil developed no peroxides and only a mild off-odor and flavor on aeration for 1,000 hrs. at 97.7°C.(11).

Contrary to what might be expected, the rate of hydrolysis of acetoglycerides on contact with water appears to proceed at a rate not greatly different from that obtained with a domestic vegetable oil like cottonseed oil (11).

Physiological Properties

Toxicity. The toxicity of acetostearins was studied by Ambrose and Robbins (1, 2), both by feeding massive, single doses of the material to animals and by giving smaller daily doses either in the diet or by injection. They found that a dose as large as 4 g. of acetoglycerides per kilogram of body weight given by stomach tube to rats yielded no evidence of toxicity. A daily dose of 80–100 mg. acetostearin/kg. of body weight, when given intravenously as a 10% emulsion to rabbits for 15 days, was found to be nontoxic. A questionable effect on clotting time was noticed, but the material was completely removed from the circulatory blood within 30 min. No pathology of visceral organs was noted on histological examination.

Guinea pigs when treated topically with 4 ml. of a 30% acetoglyceride emulsion for 45 days showed no local irritation, sensitization, or allergic reactions. Feeding experiments carried on for 14 weeks, during

TABLE II
Toxicity Studies on Acetoglycerides

Animal tested	Dose	Method of administration	Duration of experiment	Pathology
Rat	4 g./kg. body weight	Stomach tube	1 dose	No evidence of toxicity
Rabbit	80–100 mg./kg.	Intravenous injection	15 days	Possible slight effect on clotting time No pathology of visceral organs
Guinea pig	4 ml. of 30% emulsion	Daily inunction	45 days	No local irritation No sensitization No allergic response
Rat	5, 10, 20%	In diet	14 weeks	No deleterious effect on growth, food intake, or mortality

which acetostearin was incorporated in the diet at the 5, 10, and 20% level, resulted in no toxicity as judged by any deleterious effects on growth, food intake, and mortality.

Growth and Longevity. Pure acetostearin up to 4% or pure aceto-olein up to 1% included in the diet of rats for over 1 year did not interfere with growth or food utilization (1, 2). Commercially prepared acetostearins from hydrogenated lard or aceto-olein from cottonseed oil, or lard, when fed in concentrations of 5 to 10% of the diet for 86 weeks, showed no interference with growth or food utilization. Acetostearins fed at a level of 20% had a slight inhibitory effect on growth; at 20% aceto-oleins had no deleterious effect after 60 weeks.

TABLE III
Growth Studies Using Acetoglycerides Incorporated in the Diet of the Rat

Fat	Level in diet, %	Duration of experiment, weeks	Comment
I. a) Acetostearin, pure	4	57	No interference with growth or food utilization
b) Aceto-olein, pure	1	57	
II. Acetostearin from hydrogenated lard	5–10	86	No interference with growth or food utilization
III. Aceto-olein from cottonseed oil or lard	5–10	86	No interference with growth or food utilization
IV. Acetostearins	20	60	Slight inhibitory effect on growth
V. Aceto-oleins	20	60	No interference with growth

Other studies involving feeding experiments with acetoglycerides were reported by Mattson and coworkers (20, 21), who fed rather high levels of these fats to rats for short intervals. The nutritional value of these acetoglycerides was compared with that of the ordinary corresponding triglycerides from which they were prepared. Soybean oil at a 2% level was added to these diets to provide essential fatty acids where the fat used had an iodine value of 1. When the fats were added to the diet at the 50% level, ethylcellulose was added to prevent the fat from separating out.

It was concluded that the nutritional value of the acetoglycerides was essentially the same as that of the corresponding normal or conventional triglycerides from which they were prepared, as judged by gain in body weight, food consumption, and food efficiency of the animals on these diets.

TABLE IV
Experiments in Which the Fat Was Incorporated in the Diet at a Level of 25% and Fed for Eight Weeks [a]

Fat	Iodine value	Gain in body weight, g.	Food consumption, cal.	Food efficiency [b]
Hydrogenated mixture of soybean and cottonseed oils (75/25 mixture)	80	265	3490	7.6
Diaceto triglycerides	80	262	3460	7.6
Fully hydrogenated soybean oil	1	215	4740	4.5
Diaceto triglycerides	1	222	3360	6.6

[a] 2% soybean oil added to these diets.

[b] $\frac{\text{Gain in body weight}}{\text{Cal. eaten}} \times 100$.

Ambrose and Robbins (2) have reported that, in concentrations of 10% in the diet, two samples of aceto-olein had no ill effects over several generations while two of three samples of acetostearin had an apparent effect on progeny. Since the diets used in these studies contained approximately 5% additional fat (3% being cod liver oil) and since these workers (1) found some indications of vitamin E deficiency on this type of diet, it is likely that the apparent effect on reproduction of diets containing 10% acetostearin resulted from a deficiency of vitamin E.

Digestibility. Using the method of Augur, Rollman, and Deuel (4), Ambrose and Robbins (3) determined the digestibility coefficients of various acetoglycerides fed to both male and female adult rats at a level of 20% of the diet and compared these coefficients with that for a commercial shortening, Crisco.[4] Aceto-oleins were found to have the highest digestibility coefficients (99%). Acetostearins had much lower values (80–85%), and these did not correlate with the melting points of the acetostearins. A mixture of 15% acetostearin and 5% aceto-olein gave a small improvement in digestibility (85%) whereas, with a mixture of 10% of each of those acetylated fats, digestibility was considerably improved (94%) and compared favorably with the commercial shortening (96%). Either slight or no differences in digestibility were obtained

TABLE V
Experiments in Which the Fat Was Incorporated in the Diet at the 50% Level and Fed for Eight Weeks

Fat	Iodine value	Gain in body weight, g.	Food consumption, cal.	Food efficiency [a]
Hydrogenated mixture of soybean and cottonseed oils (75/25 mixture)	80	207	2800	7.4
Same as above plus ethylcellulose [b]	80	212	2870	7.4
Diaceto triglycerides plus ethylcellulose [b]	80	224	3130	7.2

[a] $\frac{\text{Gain in body weight}}{\text{Cal. eaten}} \times 100$.

[b] Ethylcellulose added to prevent fat from separating out on standing.

TABLE VI
Experiments in Which the Fat Was Incorporated in the Diet at the 15% Level and Fed for 12 Weeks

Fat	Iodine value	Gain in body weight, g.	Food consumption, cal.	Food efficiency [a]
Hydrogenated mixture of soybean and cottonseed oils (75/25 mixture)	80	314	5230	6.0
Monoaceto triglycerides	80	290	4710	6.1

[a] $\frac{\text{Gain in body weight}}{\text{Cal. eaten}} \times 100$.

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[4] This product is named as part of the exact experimental conditions. It is not the policy of the Department to recommend or endorse the products of any particular manufacturer.

TABLE VII
Digestibility of Acetoglycerides and Crisco

Supplement fed in diet	Description of fat	Level added to diet, %	Total fat in diet, %	Coefficient of digestibility (combined sexes)
Control	Cod-liver oil and residual fat	....	5.9	......
AG 3 (aceto-olein from cottonseed oil)	Fully acetylated, I.V. 73.2	20	25.0	99.2
AG 21 (aceto-olein from lard)	Fully acetylated, I.V. 42	20	24.5	99.3
AG 194 (acetostearin from hydrogenated lard)	Fully acetylated, I.V. < 1	20	24.0	80.0
AG 194 (15%) +AG 3 (5%)	....	20	24.1	85.1
AG 194 (10%) +AG 3 (10%)	....	20	24.0	93.7
Crisco	....	20	24.4	95.9

when data for male and female rats were compared. Here again, the diet contained an additional 5% fat which, depending on the extent of unsaturation, might influence these results, particularly those for the digestibility of acetostearins.

Mattson and coworkers (20) have reported on their digestibility studies of mono- and diaceto triglycerides, prepared from partially and completely hydrogenated vagetable oils, and of the corresponding conventional triglycerides. Coefficient of utilization values, similar to digestibility coefficients but based on ingested long-chain fatty acids, were calculated. These workers concluded that the long-chain fatty acids of a diaceto triglyceride (iodine value 80) were absorbed as well as those of the corresponding triglyceride (87% *vs.* 87% at the 25% level; 91% *vs.* 96% at the 50% level). This conclusion applied also to the monoaceto triglyceride (iodine value 80) fed at a 15% level (92% *vs.* 90%). In contrast, the coefficient of utilization of stearic acid was increased markedly over that of tristearin by incorporating this fatty acid into a diacetin fat (9% *vs.* 83%).

In these studies it should be noted that the diaceto triglyceride of iodine value 80 and the hydrogenated oil used in its preparation are better digested at the 50% level than at the 25% level.

Herting and coworkers (15) presented data on fecal lipides expressed as excretion per day for rats fed normal and acetylated fats. Although fat intake is not reported and digestibility coefficients therefore cannot be calculated from their data, the data suggest that cottonseed oil, lard, and acetylated, unsaturated glycerides are absorbed to a much greater degree than hydrogenated lard and acetylated, saturated glycerides, in accord with the findings already reported.

TABLE VIII
Digestibility of Mono- and Diaceto Triglycerides and the *Corresponding Normal Triglycerides*

Type of fat	Iodine value	Concentration in diet, %	Coefficient of utilization (digestibility)
Triglyceride	80	15	90
Monoaceto-triglyceride	80	15	92
Triglyceride	80	25	87
Diaceto-triglyceride	80	25	87
Triglyceride	1	25	9
Diaceto-triglyceride	1	25	83
Triglyceride	80	50	97
Diaceto-triglyceride	80	50	91

Calloway and Kurtz (7) have reported on the digestibility of glycerides esterified with butyric acid. They report that the digestibility of fully hydrogenated lard fed at a level of 20% of the diet is enhanced by substituting one-third of the fatty acid radicals with butyryl groups. However, in simple mixtures, tributyrin did not enhance the absorption of lard triglycerides.

The mode of digestion of acetylated glycerides has been studied in adult rats by Herting and coworkers (15) and it has been compared with that for cottonseed oil, lard, and hydrogenated lard. The fat content of the diets fed was varied from 22 to 33% so as to equate the content of fatty acid residues at about 21.5%. Cottonseed oil and lard exhibited little gastric lipolysis, but intestinal lipolysis was extensive with rapid absorption of the resulting products. Hydrogenated lard exhibited greater gastric lipolysis but poor absorption, as evidenced by high fecal fat values. The mode of digestion of acetylated monoglycerides from hydrogenated lard coincided with that of hydrogenated lard. The digestion of acetylated, mixed, saturated and unsaturated monoglycerides from lard was found to be intermediate between that of saturated and unsaturated triglycerides. This group (14) also reports no elevation in lipide-bound, steam-distillable acids in tissue fats of a dog fed a diet containing 25% acetylated monoglycerides. These acids were increased in the blood of rats fed acetylated monoglycerides at dietary levels up to 50% but not in carcass fat. Only small amounts of free acetic acid were found to be present in the gastric contents of rats fed acetylated monoglycerides.

Absorption. Ambrose and Robbins (3) studied the absorption of aceto-oleins and acetostearins of varying melting points in adult male rats during a 4-hr. period. The procedure used was essentially that of Deuel *et al.* (8) but differed in the fact that the fat was fed as part of the diet rather than given by stomach tube.

It was observed that the absorption of aceto-oleins was better than the absorption of acetostearins, which was of about the same order as for Crisco.[4] The acetostearins, although varying in melting point, demonstrated no significant differences in absorption.

TABLE IX
Absorption of Various Acetoglycerides and Crisco from the Gastrointestinal Tract of Fasting Rats[a, b]

Supplement fed	Iodine value	Melting point, °C.	Amount absorbed, %
Control	......	......	......
Fully acetylated aceto-olein from cottonseed oil (AG 3)	73.2	—2.0	76.1
Fully acetylated aceto-olein from lard (AG 21)	42.0	5.0	77.3
Partially acetylated acetostearin from hydrogenated lard (AG 31)	1.08	57.0	65.7
Fully acetylated acetostearin from hydrogenated lard (AG 26)	0.96	32.5	62.5
Fully acetylated acetostearin from hydrogenated lard (AG 194)	0.69	30.7	65.9
Crisco	......	......	67.6

[a] Fat consumed averaged 700 mg.
[b] Absorption time, 4 hrs.

Potential Uses

On the basis of the physiological behavior of the acetoglyceride products reported here, it may be possible that sufficient data will be forthcoming to qualify them for use with foods. They already are acceptable for use in cosmetics. Assuming that acetoglyceride products are proved to be without adverse physiological effect and considering their chemical and physical characteristics, a number of potential uses can be envisaged.

Obviously many different products can be prepared, and products can be tailored, within limits, for specific uses. However, for the purpose of describing possible uses, it is convenient to divide the acetoglycerides into three more or less arbitrary classes: aceto-oleins, low-melting acetostearins, and high-melting acetostearins.

Aceto-oleins. The melting point of mixed aceto-oleins can be as low as —20°C. Simultaneously the iodine value can be low; the iodine value of pure diaceto-olein is 57.6. Use of such mixtures is indicated where an oil of very low melting point and good resistance to oxidation is required.

Work on aceto-oleins at the Southern Regional Research Laboratory has been confined largely to the development of a special, margarine-like spread for the armed forces. A spread is required with an unusually long plastic range and good resistance to deterioration. The requirements seem to be fulfilled by mixtures consisting essentially of aceto-oleins, partially hydrogenated cottonseed oil, finely ground salt, traces of antioxidant, imitation butter flavor, and butter color.

The consistency curves shown in Figure 3 show the extremes of plastic range which can be attained with the mixtures mentioned.

Another possible use for aceto-olein products might be as minor ingredients of enrobing fats. Tests have shown (13) that in concentrations of 2 to 8% the aceto-olein products should have a pronounced effect in reducing brittleness in hard fats when these are cooled to low temperatures.

Aceto-oleins, as well as acetostearins, have been tested in cosmetic preparations (19), and it is claimed that both could be used in a number of preparations, including lipsticks, shampoos, and alcoholic lotions. The acetoglycerides are relatively soluble in alcohol solutions.

Baur (5), in experimenting with compound shortenings containing large proportions of aceto-oleins, found them equivalent or better than regular commercial shortenings with regard to baking performance, workability, creaming volume, and gum and foam formation. Also they were more resistant to heat damage at high temperature. The regular shortenings were superior only in having a higher smoke-point.

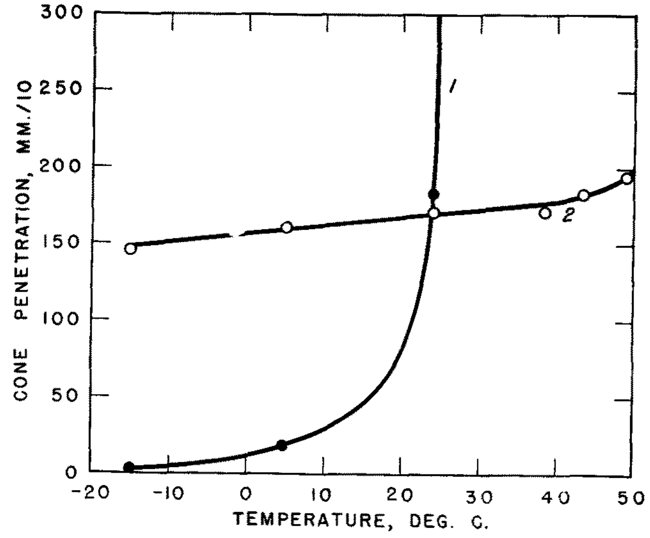

FIG. 3. Consistency *vs.* temperature curves: (1) margarine-like product containing essentially 79% aceto-olein product, 18.5% highly hydrogenated cottonseed oil, and 2.5% salt (7) and (2) a commercial margarine.

Low-Melting Acetostearins. The use of low-melting acetostearins is indicated where an oil melting at about room temperature and having an extraordinary resistance to oxidation, rancidity, and polymerization is required. One possible use would be as a slab dressing in the manufacture of candy. Another would be to impart gloss to hard gum-candies. A non-candy use might be as an anticlumping oil in packaging raisins.

A possible use for the low-melting acetostearins would be as a coating for processed meats in cold storage.

High-Melting Acetostearins. Potentially one of the most valuable uses for high-melting acetostearin products is as edible, protective coatings on foods. When applied by the dip method as thin, almost invisible films to processed meats like frankfurters, they retard loss of moisture, flavor and odor. The films might also serve as protective coatings on cheese, certain nuts, fruits, and baked goods. The films can serve as carriers for fat-soluble antioxidants.

Another use might be as ingredients of chocolate-type coatings for ice cream bars and candies for the purpose of reducing brittleness at low temperatures.

Summary

Acetoglycerides, which are defined as being either triglycerides containing two acetyl groups per molecule or diglycerides containing one acetyl group, can be prepared readily by several procedures, which are described.

The acetoglycerides exhibit unusual physical properties, the unique one of which is their ability to exist as nongreasy, plastic solids. Mixtures of saturated acetoglycerides can be prepared to melt in the temperature range of about 27 to 47°C. while mixtures of unsaturated acetoglycerides can melt as low as —20°C. In other physical properties and most chemical properties the acetoglycerides resemble those of ordinary fats.

Fairly extensive investigations of the physiological behavior of acetoglycerides have been made. It is concluded, from the work reported to date, that acetoglycerides have no deleterious effect on growth or on reproduction and that the mode of digestion of aceto-oleins and acetostearins does not differ appreciably from that of the corresponding natural fats. The acetyl group appears to be hydrolyzed and absorbed quickly and completely; no acetate has been demonstrated in the feces of acetoglyceride-fed rats. The rate of absorption of aceto-oleins exceeds that of acetostearins, but that for the latter is not unlike that of a commercial shortening. As to over-all digestibility, that of aceto-oleins, fed at levels up to 50% of the diet, appears to be equal to that of the corresponding normal triglycerides whereas the digestibility of acetostearins, at levels up to 25% of the diet, when measured in animals pre-fed or simultaneously fed sufficient unsaturated fat to preclude essential fatty acid deficiency, is markedly better than the absorption of the normal saturated glycer-

ides. When fed as a mixture, aceto-olein appears to enhance the digestibility of acetostearin.

A number of potential uses of acetoglyceride products as components of foods and cosmetic preparations are mentioned. One possible use of acetostearins appears to be as a protective coating for food products.

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Interaction of Sucrose Monolaurate with Other Surface-Active Agents[1]

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A PROCESS for the manufacture of sucrose monoesters of fatty acids has reached a stage of development where commercial quantities will soon be made available. These sucrose esters differ fundamentally from ethylene-oxide derived, nonionic surface-active agents in that water solubility is imparted by a multiplicity of hydroxyl groups rather than ether linkages. Data concerning some of the surface-active properties of these sucrose esters have recently appeared (6). Unlike polyoxyethylene derivatives containing an equal number of oxygen atoms, the sucrose esters do not exhibit a cloud point below 100°C.

The present study is concerned with interaction between sucrose monolaurate and other water-soluble, surface-active agents. The problem of interaction between surface-active materials is of considerable importance and has received a great deal of attention. The effect of lauryl alcohol in enhancing the foam stability of sodium lauryl sulfate is well known (1). Interaction between cholesterol and other biologically-active materials and water-soluble, surface-active agents has been investigated (5). Inactivation of phenolic germicides by polyoxyethylene-derived nonionics has also been discussed (2). In general, these studies have been concerned with combinations of water-soluble, surface-active agents and relatively water-insoluble organic compounds.

It appeared possible that the large number of hydroxyl groups present in the sugar esters would contribute sufficient hydrogen-bonding energy for substantial interaction with the polar and ionic groups of other water-soluble, surface-active agents.

Materials and Methods

Sucrose monolaurate and sucrose monostearate were prepared according to a procedure previously described (6). They were purified by several recrystallizations from ethanol. Sodium lauryl sulfate was prepared from fractionated C. P. dodecanol and recrystallized from ethanol. Absence of a minimum in the surface tension-concentration curve for sodium lauryl sulfate indicated that the material was pure. Polyethylene glycol 400 monolaurate (Kessler Chemical Company) and Ninol AA62 Extra (Ninol Laboratories Inc.) are commercial materials. They were used without purification. The former is an ester of lauric acid and an ethylene oxide polymer of average molecular weight 400. Ninol AA62 Extra is a lauroyl diethanolamide with an amide content of 92%.

Surface-tension values were determined by the Du Nouy ring method at 27.1 ± 0.1°C. Measurements were made at intervals of a few minutes until the values agreed within 0.2 dynes/cm.

Foam test measurements were made, using the method of Ross and Miles (7). The solutions were maintained at 27.1 ± 0.1°C. Duplicate determinations resulted in foam height values, which checked within 5 mm.

A surface viscosimeter was constructed in accordance with details provided elsewhere (1). The deflection of the bob could be read accurately to 0.2 degree. Measurements were made at 27.0 ± 0.1°C.

Results

Surface Tension. Surface-tension values for sucrose monolaurate and sucrose monostearate in distilled water are plotted against the logarithm of the concentration in Figure 1. The concentration at which the two linear portions of each curve intersect is considered to represent the CMC value. The uncertainty in determining these CMC values graphically is about 15%. These estimated CMC values are 34×10^{-5} molar for sucrose monolaurate and 64×10^{-7} molar for sucrose monostearate. The accepted value for the lowering of the CMC accompanying an increase in the length of an unbranched alkyl chain is 2^n, where n is the increase in the number of carbon

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