Originally oleic acid was oxidized with chromic anhydride; more recently ozonolysis has been applied. The latter procedure is advantageous in that oxidative degradation of the cleavage products is less pronounced if it occurs at all. Along with the C_9 dibasic acid, azelaic, is produced the C_9 monobasic acid, pelargonic.

Cleavage of ricinoleic acid is accomplished through alkali fusion to yield the C_{10} dibasic acid, sebacic, together with "capryl alcohol." These dibasic acids are used in the production of polyesters and polyamides and, in the form of their esters, as plasticizers and high-temperature lubricants. Combined production of esters of azelaic and sebacic acids for 1956 was in excess of 21 million pounds, according to Department of Commerce figures.

Derivatives of fatty acids obtained by substitution or addition within the hydrocarbon chain are beginning to find commercial application. Two such products are the epoxide obtained from oleic acid or its ester and the sulfo acid produced by sulfonation of stearic acid. The epoxide, usually in the form of an ester or glyceride, is recommended as a halogen scavenger for polyvinyl resins. The sulfo acids have shown promise in detergent formulations and as flotation agents.

We have listed examples of the more important classes of fatty acid derivatives and have mentioned some of their applications. There are many other related compounds and types of compounds and many other important applications, each of which is probably deserving of extensive discussion. Here we have attempted to illustrate only in a very broad way the importance and usefulness of fatty chemicals.

In a discussion such as this, it is appropriate to speculate as to the future. As technology expands, we can expect our industry to expand. Opportunities for new uses for fatty chemicals will continue to arise, but it is the responsibility of the producers of these chemicals aggressively to seek these uses. As we have suggested earlier, a substantial proportion of the outlets for fatty acids is in applications of surface-active agents, and surface-active agents can be produced by other chemistry from other starting materials. The fatty acid industry has certain advantages through familiarity with this field. We must retain these advantages through continuing and expanding research, both basic and applied.

Supply of raw material is generally not a problem for fatty acid producers since much of the raw material is a by-product of other industries and is available in quantities which far exceed the demands of the fatty acid industry. As is true with any line of products, competition and obsolescence are constant threats to profitable operation. The only way to meet these threats is through new products which come only through research. Those who have been intimately concerned with the chemistry of fatty acids know that there are tremendous gaps in the existing knowledge of the field. It is to the best interest of the industry to increase the effort to fill these gaps since new facts are the basis for continued expansion.

Fifty Years of Progress in the Technology of Edible Fats and Oils

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A HALF CENTURY ago lard was the preferred shortening. It was solidified by dropping it on the exterior surface of a large chilled roll, then it was scraped off into a trough called a picker pan where it was beaten and conveyed to the filling station by a combination of blades and a screw conveyor.

By 1900 lard had a strong competitor in compound shortening. It is estimated that the domestic consumption of cottonseed oil was about 400 million pounds in 1900, and double that by 1905. Most of this oil went into compound shortenings, which at that time were largely blends of about 85 parts of cottonseed oil with 15 parts of oleostearine. The cottonseed oil was alkali-refined in open kettles, and the foots were separated by gravitation. The refined oils were decolorized by adsorption with fuller's earth in open tanks, filtered through presses, and deodorized with super-heated steam at oil temperatures from 275 to 340°F. at vacuums in the range of 28 to 29 in. Compound shortening was solidified on chill rolls, as was lard.

The fat ingredients of margarine were oleo oil, neutral lard, butter, and cottonseed oil. Only the cottonseed oil was refined and deodorized, and it was used only in the cheaper grades. The margarine ingredients were churned by hand or by steam power for about 30 min., run into ice water for about 10 min., thrown onto inclined tables with wooden shovels in a room at 70°F., and allowed to drain. Salt was put in the margarine while it was lying on the table. It was turned three to four times manually to facilitate draining, shoveled into a butter worker, and then packed by hand.

Can you imagine the cost of these processes and the acceptability of these products in today's market? We have indeed come a long way in 50 years. What have been the most important technological advances that have resulted in today's shortenings, margarines, and salad oils? The list is rather impressive.

It is perhaps fitting that hydrogenation should be mentioned first, inasmuch as the first hydrogenated shortening will soon celebrate its own 50th anniversary. Hydrogenation of food fats was introduced in this country in 1911 and grew at a rapid pace. The importance of hydrogenation to the growth of the shortening and margarine industries, also to the soybean industry, can scarcely be exaggerated. Just try to visualize the kinds of frying fats, biscuit and cracker shortenings, and margarines we would be making today if we did not have hydrogenation facilities, considering the fact that our major raw material is now soybean oil. It may simply be coincidence, but after a very slow growth in its first 50 years margarine increased four-fold in *per capita* consumption in the 25 years after the first hydrogenated vegetable oil product was introduced. Certainly hydrogenation has helped make it possible to tailor the available raw materials to the exacting demands of the consumer. While on the subject of hydrogenation, we should not overlook the value of modern catalysts. Today we have available from several sources catalysts of predictable and reproducible activity and selectivity.

Continuous centrifugal refining has been a major technological advance of considerable economic importance. Contrast the old, cumbersome kettle-refining methods with today's efficient processes. Not only do the centrifuges increase our recovery of neutral oil, but also the shortened contact time between alkali and the oils generally results in an over-all improvement in finished oil quality.

THE USE of stabilizers, both as antioxidants and as metal scavengers, has had a profound influence on our industry. The use of antioxidants has become so universal that it is hard to realize that the first approval for the addition of an antioxidant to a meat fat was obtained as recently as 1940. And that antioxidant, gum guaiac, is already all but forgotten, so rapid has been our progress in this field. Again one can scarcely exaggerate the importance of antioxidants in helping meat fats remain competitive with the hydrogenated vegetable oils. The use of the acidic metal scavengers is one of the areas where the origin is hidden in the cloak of trade secrets. To the best of our knowledge, citric and phosphoric acids were first used in this country in deodorized vegetable oil products about 25 years ago. It is only within about the past 15 years that their utility has been discussed in print. We now universally recognize the importance of metal scavengers in deodorized products, whether of vegetable or of animal origin. They are another of the things that we wonder how we ever got along without.

The past 50 years have seen deodorization go from a secret art to a product of science and engineering of which the industry can be reasonably proud. True, there is still plenty of room for improvement, but now at least we have considerable knowledge of the fundamental principles of deodorization and have some highly efficient equipment that economically produces oils almost completely devoid of flavor with a minimum of detriment to nutritional qualities and flavor stability. This development has been especially important in the preparation of oils and fats for frozen desserts, icings, margarine, and other types of products where off-flavors are so rudely apparent.

The development of vacuum bleaching techniques and more recently of continuous processes has been important economically, also in helping further to improve our standards of flavor quality. We think it is especially important that the use of vacuum bleaching techniques avoid the peroxide build-up that is encountered in atmospheric processes.

Many of us can still remember the installation of our first internal chilling machines. You have to be a relative newcomer in the business not to have seen a lard chilling roll in operation. The modern internal chilling devices not only provide us with better quality control but also with much better sanitation.

These internal chilling machines are now also an integral part of modern margarine manufacture. Here again, our progress in engineering technology has provided us with efficient churns from which the margarine emulsion flows through the chilling unit into completely mechanized filling and packaging machines. One has only to watch the operations of one of these intricate filling and packaging lines to marvel at the ingenuity of our mechanical engineers.

The mechanical removal of oil from oil-bearing seeds has also been improved by a major conversion from hydraulic to screw presses. But, of course, the big advance in this area has been in the conversion to solvent extraction. Today between a third and a half of our cottonseed and practically all of our soybeans are solvent-extracted. The less rigorous treatment involved in these processes has resulted in improved oils and, in our opinion, has contributed greatly to the successful use of soybean oil in shortenings and margarine.

RECENTLY, too, we have seen the development of greatly improved processes of continuous rendering. Until the development of these continuous centrifugal processes our progress in the past 50 years has been marked by rather minor improvements. The continuous centrifugal processes constitute a major break-through in our meat fat technology, representing not only substantial economic advantages but also resulting in considerably improved products. We anticipate that the next decade will see a substantial conversion to centrifugal rendering operations.

Development of emulsifiers and their application to specific problems has added glamor to our industry. Where previously our products were scarcely one step above the commodity level, the advent of emulsifiers, particularly the mono- and diglycerides, opened up the era of truly tailor-made products. At the same time we might add that it closed the door on the idea of an all-purpose shortening. Now our scientists create a new product for every use. As you will recall, the initial shortening with emulsifier added helped create the high-ratio cake. In the past 15 years we have seen a veritable flood of new shortening products specifically designed for one or more special uses, such as bread, sweet doughs, icings, layer cakes, pound cakes, cake mixes, cream fillers, whipped toppings, etc. The most recent addition to the field of emulsifiers, the lactylated mono- and diglycerides, is finding considerable application in the cake mix field. It is also reported that propylene glycol monostearate is useful in this type of product.

An extremely important area of our newer technology, which could well be a subject for an entire symposium, is analytical methodology. As our formulations and processes have become more complex, our analytical chemists have managed to come up with new methods needed to cope with new problems. In many instances this has necessitated the application of highly complicated equipment. In other cases it has required chemical ingenuity. Among the new methods that have contributed markedly to our advancing technology are the active oxygen method, spectrophotometric determination of polyunsaturated acids, infrared determination of *trans* isomers, periodate determination of monoglycerides, dilatometric estimation of soild fats, spectrometric determination of color, chromatographic determination of total neutral oil, analysis for refining loss by centrifugal methods, detection of crystal structure by x-ray techniques, and the most recent and perhaps one of the most significant developments, the analysis for fatty acid composition by vapor phase chromatography. Certainly one must not overlook the development of the "Official Methods of the American Oil Chemists' Society" which have contributed so greatly to the improvement and standardization of all of our methods of analysis.

IMPORTANT PROGRESS in our technology of both shortenings and margarines has resulted from fundamental information developed from the x-ray techniques. We have learned to classify our various products according to their inherent crystal type and have been able to associate this fundamental information with specific desirable or undesirable functional properties. Two important applications of this knowledge come immediately to mind. The first of these is the formulation of margarine to prevent the development of graininess during storage. After it was recognized that this graininess is associated with the formation of the *beta* type of crystals, formulation control was relatively simple. The other example is the development of lard having a modified crystal structure. As we all know, lard in its natural state tends to result in waxy or grainy crystals. This has been associated with the *beta*-forming tendencies of the solid glycerides of lard. However, when lard is properly treated with an interesterification catalyst, the proportion of these *beta*-forming crystals apparently is sufficiently reduced so that the modified lard becomes stable in the *beta*-prime crystal structure. The first successful shortenings based on crystal-modified lard were marketed in early 1950 and made lard for the first time fully competitive with the hydrogenated vegetable shortenings for cake baking.

You can see from the above summary of our technological advances that we have arrived at 1959 with better engineered, more economical processes for making a wide variety of products with improved functional properties. Our shortenings and margarines are better than ever from the point of view of odor, flavor, appearance, and performance in baking, frying, creaming, etc. But how are they as food? We must never lose sight of the fact that the end-objective in all of this processing is to produce a food product. So the question is properly asked, are the edible fats we are manufacturing today more or less nutritious than those of 50 years ago?

In our opinion, the trend has been in the direction of improved quality as a food. First, of course, palatability is an extremely important factor in a food product, and the modern shortening and margarines not only are better in odor, flavor, texture, and getaway when freshly prepared but retain these qualities longer than ever before. There have been great strides made in the area of sanitation, with much less exposure of the products of today to the atmosphere and to human handling. Our technology has made it possible for us to maintain an adequate supply of food fats. For example, how could we possibly produce sufficient margarine and shortening of suitable quality if we had not learned how to use soybean oil successfully? The increased consumption of vegetable oils in our food fat supply has increased our consumption of vitamin E. They have also helped us increase our total consumption of linoleic acid.

In summation, then, our technology has made it possible to provide our nation with an adequate supply of palatable, nutritious, high-quality shortenings and margarines at by far the lowest cost per calorie of any food on the market today.

Fifty Years of Progress in the Utilization of Inedible Fats and Oils

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IN SPITE OF all that we hear or read, vegetable oils are extremely important to the paint industry and will continue to be. If, as seems probable, the types of vehicles used by the paint industry change even more in the next few years, we can be sure that vegetable oils, in one form or another, will continue to appear in most protective and decorative coatings.

Looking back 50 years, we see that 1909 was an important period for inedible vegetable oils since it may be regarded as either the end of the old era or the first stage of the new. In the utilization of oils we were just breaking the ground for the most tremendous changes, not only in uses as such but in the thinking which motivated the industry. It is not mere coincidence that the American Oil Chemists' Society was founded then. Much of the change in the past fifty years has been brought about by the members of this Society, acting either as individuals or as a group.

Since our very useful Journal was not in existence in 1909, we must look at two of the publications in which technical articles on the chemical industry appeared. These are Industrial and Engineering Chemistry, which started with Volume I in that year and, like our Society, is celebrating its Fiftieth Anniversary. The other is the Annual Proceedings of the American Society for Testing Materials. In 1909 the Proceedings of the Twelfth Annual Meeting were published, in a volume of some 698 pages.

In the former we find an article by Charles H.