Jaocs news feature

Problems discouraging use of fish oil in American-manufactured shortening and margarine

MAURICE E. STANSBY, Pioneer Research Unit,
Northwest Fisheries Center,[1] Seattle, Washington 98112

Prior to 1950, California sardine oil was a component of many margarines and shortenings of American manufacture, with ca. 140 million pounds of fish oil used per annum in peak years. With the disappearance of commercial quantities of California sardines after 1950, fish oil dropped out of use for edible purposes in the U.S. In intervening years various circumstances, such as adoption of margarine standards of identity without provision for the use of fish oils, have discouraged use of other American fish oils, e.g., menhaden oil, in domestic production of edible fats. Of the various problems – uniformity of quality, legal requirements, public image and price considerations – the latter will be most difficult to overcome before fish oils can be in demand for such use. Satisfaction of legal and sanitation requirements can be met only by costly improvements in manufacturing facilities for preparation of fish oil, yet the main inducement for use of fish oil is its competitively low cost.

Twenty-five years ago more than 100 million pounds of fish oil—primarily pilchard, i.e., California sardine—were used in manufacturing American-produced margarine and shortening; today no American fish oil is used for that purpose. American fish oil prices often fluctuate widely, and the manufacturers feel that, with access to margarine and shortening as outlets for their product, these price fluctuations would be less severe. In all other countries, fish oil is used principally in the edible oil field. Yet there are a variety of problems to be overcome before such a market can be available to the American fish oil industry. This article traces the historical developments that have given rise to this situation and considers the problems to be solved in alleviating it.

Pre-1920

The chemistry of preparing hydrogenated fats from triglycerides containing unsaturated fatty acids was worked out and reported between 1897 and the first few years of the 20th century. By 1910, with the chemical basis of the process well documented, industrial research was underway toward perfecting methods for efficient manufacture of hydrogenated fat for use in edible products. Fish oils were among the first oils considered in this early work. Bedford and Williams (3) were pioneers in this field, filing on December 11, 1911, for a patent on methods for hydrogenating fish oils. The first U.S. patent on methods for hydrogenating fish oil was granted to Vilbushevitch in 1912 (11).

During 1910-20, applied research expanded the hydrogentation industry in European countries from a tiny endeavor to an almost full grown operation. The nucleus for the later gigantic Unilever Company began with research operations and a very small output at a modest concern started in 1911, at Joseph Cross Field near Warrington, England. By 1916 this concern, renamed Unilever, was already using fish oils (S. Lassen, personal communication, 1969).

Although by 1920 the use of hydrogenated fish oils in Europe was a fair-sized industry, operations had yet to begin in this country. Even the use of vegetable oils for hydrogenation lagged far behind that of most European countries. The delay in using fish oil in margarine was due, at least in part, to the fact that margarine was a less important food commodity in the U.S. than in Europe. Repressive legislation made margarine sales illegal in some states and, in others, subject to such restrictive practices that it could be sold only as a white, colorless product.

Although hydrogenated fish oil was not manufactured in the U.S. from 1910 to 1920, during World War I fish oil for edible use was included in fish cookery demonstrations conducted by the Bureau of Fisheries.

1920-51

Shortage of vegetable oils in the U.S. during World War I had focused attention upon the possibility of using fish oil in margarine or shortening. Considerable research and experimentation was carried out during the early 20's. Research by Richardson et al. (7) investigated the types of fatty acids produced during hydrogenation of American fish oil species, especially menhaden. Meanwhile, applied research on California sardine oil was in progress at two hydrogenation plants in the Los Angeles area. This oil seemed the most promising American fish oil for hydrogenation. California sardines had become a major source of fish during World War I. Markets for sardine oil had not been firmly established, and much was going into the low-priced outlet for use as soap. Furthermore California law prohibited sardine use except for food, so that only the waste from sardine canneries could be processed into oil if it was to be used for industrial purposes. If, however, a market for use of sardine oil in an edible product could be developed, it was argued that whole sardines could be rendered legally (1). These possibilities spurred research to find wider markets for sardine oil, especially in the field of an edible oil. By 1925, 120,000 lb of California sardine oil were hydrogenated and used in margarine. By 1928, the annual use of sardine oil in margarine had risen to 15 million pounds, and in 1936, a peak of 40 million pounds was reached.

Indirect use of fish oil in shortening accounted for a much larger annual consumption than reflected by published statistics for use of fish oil in edible products. This use involved the preparation of hydrogenated mono- and diglycerides from sardine oil by partial glycerolysis and hydrogenation. Mixtures of mono- and diglycerides have been added to shortening for many years (2,9) in the preparation of superglycerinated shortening. The

[1] National Marine Fisheries Service, NOAA, USDC.

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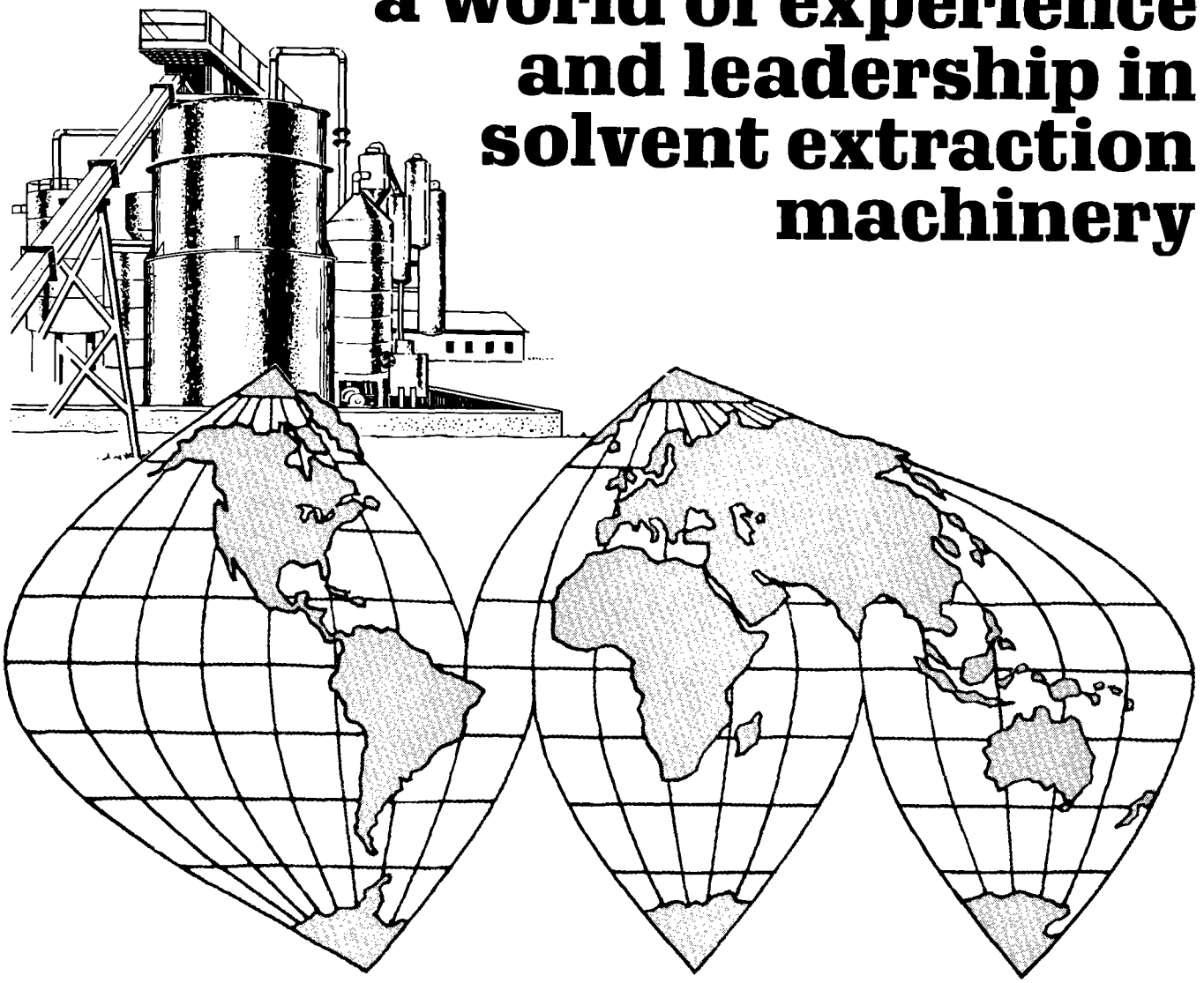

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name of this product refers to the preparation of mono- and diglycerides by heating the oil with glycerine. The resulting mixture of mono- and diglycerides is added at a level of 2.5-3% to make the superglycerinated shortening. Such shortening is much in demand in the baking industry, especially for use in cakes, since it permits a higher sugar-flour ratio without resulting in a detrimental texture. Superglycerinated shortenings are used widely in bakeries and for general household use. Their application to deep fat frying is not successful, due to lowering of smoke temperature.

A very large volume of mono- and diglycerides was made from California sardine oil at a hydrogenation plant at Tacoma, Washington, during the 1930's and 40's. This product was used not only in this country but also abroad, and at one time the volume of sardine oil used reached a peak of ca. 100 million pounds per year.

California sardine oil was last available in 1951, after which the fish disappeared almost completely. During the late 1940's when a shortage of sardine oil first occurred, the large glycerolysis operation supplemented its oil supply with herring oil from Alaska and British Columbia. The supply of this and other oils on the Pacific Coast was not sufficient to sustain this production after complete disappearance of the California sardine. Furthermore the increasing demand for hydrogen for the manufacture of ammonia in the Tacoma area left too little for other uses. As a result of these factors, this large scale glycerolysis-hydrogenation operation ceased in 1951, as did the use of fish oil as a triglyceride source for margarine and shortening manufacture in the U.S.

Post-1951

In the years immediately following 1951, no fish oil was made into shortening or margarine in this country. Principal reasons for this situation stem from changes in FDA regulations. The standards of identity promulgated for margarine did not permit the use of fish oil. While there was no such restriction on use of fish oil in shortening, new sanitary requirements for raw materials going into food products precluded use of ordinary commercial fish oil for this purpose. All existing plants for manufacture of fish oil were far from meeting the new sanitation requirements for manufacture of ingredients of food products. The only known case of fish oil's being included in an American-manufactured shortening since 1951 occurred during 1967. A large shortening manufacturer used fish oil briefly in a product marketed here. The oil used was herring oil, imported from Iceland and manufactured in a plant with adequate sanitation for processing food for human consumption. The inclusion of fish oil was discontinued because of apprehension that the required labeling statement indicating presence of a marine oil would reduce the product's volume of sale.

Since 1951, use of fish oil has continued to increase in volume in most countries other than the U.S. Most European countries are using considerable quantities in this way, especially northern European countries such as Great Britain and the Scandinavian countries. Japan also used much hydrogenated fish oil, and this practice is beginning in South America, especially in Peru and Chile. Canada, prior to 1950, had legal restrictions preventing such use of hydrogenated fish oil. Since that time, however, these restrictions have been lifted. Canada used much domestic herring oil and some imported menhaden oil in margarine and to a lesser extent in shortening.

Since 1951, the margarine and shortening industry has made the transition in principal production sources from cottonseed and coconut oils to soybean oil. This situation should be of interest to the fishing industry. Soybean oil resembles fish oil in that it contains considerable quantities of ω-3 fatty acids. These fatty acids cause a serious reversion problem. During storage there is a tendency for the original, somewhat unpleasant flavor, which had been removed by hydrogenation and other refining, to return. Nevertheless research has largely overcome this problem.

Problems

There are a variety of reasons given by different individuals in the American shortening industry for the failure of fish oil as a highly desirable raw material source. In this section these reasons will be examined and evaluated.

Reversion: Prior to 1952, users of fish oil in this country mentioned flavor reversion as a major problem, an even greater difficulty than that encountered earlier with vegetable oils. Before considering reversion problems, the nature of reversion will be discussed.

Two kinds of flavor reversion occur with hydrogenated oils. One results in return of the original oil flavor. Soybean oil has a "green" or "grassy" flavor, sometimes described as "beany." This flavor is generally disliked. Immediately after hydrogenation and other refining steps, this type of flavor is absent. It may return, however, after prolonged storage, especially when the product is shortening. Shortening is stored at room temperature for a year or longer, whereas margarine is held under refrigeration for at most only a few months. Furthermore margarine contains flavor components, e.g., diacetyl, that may mask small degrees of flavor reversion.

Similar reversion can occur with fish oil, but instead of a "grassy" or "beany" flavor the typical "fishy" flavor returns. A slight "fishy" flavor in a shortening would probably be considered a worse defect than a slight "grassy" or "beany" flavor.

An entirely different kind of flavor reversion can occur with any hydrogenated oil. Hydrogenation results in a flavor peculiar to the hydrogenation process itself. This flavor is variously described as "hardening," "tallowy," "candle-like" or "cardboard," and disappears as a result of refining steps following hydrogenation. It can, however, revert upon storage. These flavors and their reversion properties occur similarly with hydrogenated soybean oil, hydrogenated fish oil, or in fact with any hydrogenated oil.

Hannewijk (4) ascribes the return of this "hardening" flavor to be very slight increase in bound aldehyde content which occurs upon storage. Bound aldehydes form as a result of oxidation, so this form of flavor reversion is also one involving oxidation. Hannewijk also describes a very odd situation regarding this type of flavor reversion. The reverted flavor is sometimes not noticed when the product is tasted indoors, but when the taster inhales fresh air (even as late as 30 min after tasting), he experiences "an offensive taste in the throat." The hardening type of flavor in hardened soybean, linseed and marine oils, according to Hannewijk, is caused by the presence of 6-*trans*-nonenal, an aldehyde oxidation product with a taste threshold value of only 0.0003 ppm.

Since both types of flavor reversion result from oxidation, the degree of unsaturation of the fish oil (and changes that occur during hydrogenation) is important in determining stability against flavor reversion. This makes hydrogenated sardine oil more vulnerable to reversion than hydrogenated menhaden oil. Very likely, the severe flavor reversion in shortening made with California sardine oil could be much less acute in shortening made from hydrogenated menhaden oil.

Flavor reversion has been an equally difficult problem in soybean oil. The very extensive research carried out during the past 20 years on soybean oil reversion has overcome most of these problems. Because both soybean and fish oils have similar types of fatty acids, which are both highly polyunsaturated and of the ω-3 type, there is good reason to believe that the experience of American shortening manufac-

turers with soybean oil can be adapted to overcome similar problems with fish oils. This has certainly been the case with handlers of fish oil in margarine and shortening abroad, where there is actually a feeling that, from the standpoint of reversion, fish oils are easier to handle than soybean oil.

Miscellaneous technical problems: A number of miscellaneous problems are mentioned by potential users of fish oil. One is that the quality of fish oils is less uniform than that of most other oils. Quality generally refers to such factors as free fatty acid content, color, and sometimes composition, e.g., iodine value may vary from batch to batch.

From the standpoint of hydrogenation costs, the content of sulfur compounds in fish oil is sometimes excessive. High sulfur content poisons the hydrogenation catalyst, requiring more to be used. This problem is currently of concern to hydrogenators, and was the topic of several papers at the ISF XIth World Congress. Mørk (6) described extensive research on the mechanism of the action of sulfur in fish oils as it affected catalyst poisoning, and Urdahl et al. (10) showed that fish oils prepared from very freshly caught fish contained considerably less sulfur than those from spoiled fish. Recent legislation in Denmark requires all fish, including those to be used for fish oil production, to be iced with at least 20% their weight of ice, and research is underway to develop mechanical icing equipment for use aboard vessels, which would make it economically feasible to ice fish destined for fish meal and oil production (P. Hansen, personal communication, 1972).

Most problems of uniformity can be overcome by more careful quality control or by blending different batches of oil.

Public image of fish oil: The public image of fish oil varies from one region of the world to another. In many countries a statement on the label of margarine or shortening that the product contains oil of marine origin causes little or no difficulty. There is a strong belief that such a statement on an American product would cause considerable buyer resistance. This situation may stem partly from the idea that vegetable oils in a shortening are far superior to animal fat. Of course this situation developed years ago when newly introduced hydrogenated vegetable oil shortenings provided resistance to oxidation and resulting rancidity superior to that of lard. Even today many shortenings stress the wording "100% vegetable oils."

When sardine oil was added to shortening in the U.S., prior to 1952, it was common to use it only in a second-grade product under an alternate label of a given manufacturer. There is considerable belief in the American shortening industry that such a practice would be necessary today, should fish oil be used. Use of fish oil in only second-grade shortenings would have an adverse effect on the price that could be paid for the fish oil.

There is one possible way to avoid this problem. In past years when a mono- and diglyceride product was added to a shortening, the additive was classified as a chemical, and there was no requirement to indicate the source of components of added chemicals. If this is still the case, it should be possible to add hydrogenated mono- and diglycerides prepared from fish. While only 2.5-3% of a superglycerinated shortening can be this mono- and diglyceride mixture, the volume of such shortening is so great that a very large proportion, if not all, of the American menhaden oil production would be required to saturate the market.

Price: The principal reason that the American shortening industry might be interested in using hydrogenated fish oil is its low cost. However the reason that the fish oil industry wants to develop a market in shortening is to stabilize, and eventually increase, the price of fish oil.

The steps necessary to improve American-produced fish oil for use in shortening—increasing the sanitation of the manufacturing plants and the uniformity of the oil—will raise production costs and, in turn, the selling price of the oil. We must ask: Is there room, between the price the shortening industry pays for raw material and this increased manufacturing cost of fish oil, to add a further increase for improving the fish oil industry's profit margin and retain a price attractice to the shortening industry? The answer to this question may be one of the most critical factors in determining whether fish oil will again be used by the American shortening industry.

Legal restrictions: When use of American fish oil as a component of shortening and margarine began during the 1920's there were no legal restrictions concerning its use, and this situation continued for many years. Today, since use of fish oils for edible purposes in the U.S. has all but disappeared, new requirements established by the FDA have been adopted relating to the sanitation conditions of the plant in which the food component is prepared. Unfortunately few, if any, fish oil plants in this country meet these requirements. If fish oil is to be used in food in this country, it is universally agreed that most plants will have to be modified to meet required standards.

Since the early days when American margarine manufacturers used fish oil in their product, standards of identity for margarine have been set up by the FDA. Because fish oil was not included in these standards, it cannot be used in margarine. While it is possible to change standards of identity, such changes require extensive hearings with new evidence submitted and are very time consuming.

There is some fear on the part of the fishing industry that the FDA might take administrative action toward barring the use of fish oil in shortening on some other grounds. These might relate to the question of whether hydrogenated fish oils are safe or desirable components of shortening, or whether a product made from whole fish is aesthetically desirable. Fish oils were used in this country extensively for many years up to 1952, in both shortening and margarine. Today hydrogenated fish oils are used more than ever before in northern European countries, Canada, Japan and some South American countries. In no place has either of the two above-mentioned reasons ever been used to bar use of hydrogenated fish oils in shortening.

Another problem in using marine oils, particularly menhaden oil, for edible products has recently arisen as a result of *Codex Alimentarius* standards (recommended but not yet adopted) for international trading purposes, which limit amounts of iron and arsenic to 0.1 ppm. In menhaden oil each of these trace elements is often present at levels above those limits Research on the trace element sulfur as previously mentioned, has shown that use of the freshest possible fish will diminish the amount of this element. The same may be true for iron and especially for arsenic, and restriction of menhaden oil production to use of only fresh raw material might overcome this problem. This might mean that the fish would need to be iced at sea, as is being done in Denmark for herring and certain other species; this would increase production costs considerably.

Since recent reports of the adverse dietary effects of certain components of peanut oil (such as eruicic acid, e.g., Kritchevsky et al. [5]) upon fatty infiltration of the myocardium with subsequent fibrotic changes in experimental animals, the question of whether hydrogenated herring or other fish oil might pose similar problems has concerned manufacturers of edible products containing such fish oil. Currently a large cooperative investigation on this matter is under way between governmental laboratories in Canada

(Continued on page 225A)

Noted chemist visits University of Minnesota

Walter O. Lundberg, active AOCS member and editor of *Lipids,* has reported that George O. Burr and his wife paid a visit to the University of Minnesota campus on April 12-13. Burr is well known for his pioneering work in the chemistry of vitamin E, as well as the chemistry and biochemistry of essential fatty acids. Burr served as head of the University of Minnesota Department of Physiological Chemistry until the 1940's, when he left to become director of the research laboratories owned by the Hawaiian Sugar Producers' Association in Honolulu. He retired from this position about 8 years ago after having made several significant discoveries relating to sugar production and metabolism. Following his retirement, he spent 6 years in Taiwan to aid in the development of a national sugar laboratory.

In 1966, at a meeting of the Society, Burr was presented a Special Award for the amount of $1500, with which he created a special fund for assisting students in Taiwan. This project is still in operation and to date has enabled 11 graduate students to complete their degrees.

While in Minnesota, Burr was honored at the dedication of the new Biological Sciences Building on the St. Paul campus. ■

• Problems in use of fish oil. . .

(Continued from page 224A)

and Norway (E. Heen, personal communication, 1972). Until results of this or similar investigations have been concluded, we cannot assess whether such factors may be a further deterrent to wider use of fish oils in edible food products. Other nutritional aspects of fish oils have been reviewed by Stansby (8).

Of the five areas of difficulty discussed above—reversion, miscellaneous technical problems, public image, price, and legal restrictions—legal restrictions are of lease concern to individuals outside the fish industry who are worried about the use of hydrogenated fish oils in shortening. This is based on the assumption that, in any case, fish oil would have to be processed in plants with adequate sanitation. Price seems the most critical factor in determining the possibility of using hydrogenated fish oils in edible fats of American manufacture.

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Papers on simulation needed for publication

Papers are wanted for publication in the 1974 Simulation Councils Proceedings, titled *Simulation Systems in Manufacturing Industries,* edited by Marvin Johnson and Said Ashour. Papers must deal with case studies describing computer simulation applications in manufacturing industries such as petroleum, chemical, primary metals and nonmetals, food and feed, textile, clothing, transportation equipment, instruments, electronic and electrical equipment, ordinance and machinery industries. Those describing original, unconventional, imaginative, and unusual applications are most desirable.

Abstracts permitting assessment of the paper's merit are due by September 17, 1973; manuscript deadline is December 17, 1973. Contact: Marvin M. Johnson, professor, Industrial and Management Systems, Engineering Dept., University of Nebraska, Lincoln, Neb. 68508; or Said Ashour, executive director, ADAR Corp., 917 Drexel Lane, Bryn Mawr, Pa. 19010. ■

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