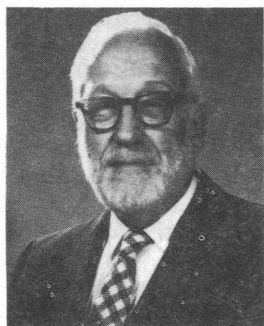


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History of the Development of Soy Oil for Edible Uses

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ABSTRACT

In the early 1940s, soybean oil was considered neither a good industrial paint oil nor a good edible oil. The history of soybean oil is a story of progress from a minor, little-known, problem oil to a major source of edible oil proudly labeled on premium products in the 1980s. It is also a story of cooperative government research and industrial implementation of research findings. After 3-1/2 decades, soybean oil, "the number one problem of the soybean industry," has become the source of choice for edible oil products

in the U.S., moreover, increasing outlets appear to be assured in the world markets of the future.

Soybeans were discovered by man before the building of Tenochtitlan by the Aztecs, before the advanced cultural development of the Mayas and the large-scale architecture of Teatihuacan by the Toltecs. Soybeans predate the pyramids, were grown before the building of the Tower of Babel, and came centuries before Solomon fashioned his

temple. As one of the oldest of crops cultivated by man, they were grown in China before records were kept (1). Not until 2838 BC were they noted, and then in a *materia medica*. Skipping over their immigration to other nations of Asia, Europe, and finally to much of the world, we find them being grown at the turn of the century in the U.S. first as forage crops, pastured and fresh-cut or preserved as silage or hay, used as a cover crop, or even plowed under as green manure. By 1924, one-third of the soybean acreage (1,567,000 acres) was harvested for beans; by 1943 (10,820,000 acres), two-thirds were harvested for beans. Now essentially all of the 70 million acres planted are for beans.

The first processing of soybeans to oil and meal in the U.S. appears to have been in 1911 on beans from Manchuria and with hydraulic pressing. After many unsuccessful attempts by various companies to press soybeans, an expeller plant was established in Chicago in 1922; A.E. Staley Manufacturing Company commenced operations in Decatur in that same year. Solvent extraction of soybean oil was undertaken from 1923 to 1925. By 1938, the production of soybean oil was 0.3 billion lb. Seven years later, in 1945, it had grown to 1.3 billion lb (8.7 billion lb in 1978). In that year, soybean oil for the first time exceeded cottonseed oil in production to become and remain the leading edible oil in the U.S.

This increased consumption was attained, despite the well known flavor and odor deficiencies of the oil. In part, it was occasioned by the exigencies of World War II shortages. As much as 30% of soybean oil was "forced" into certain margarine formulations and, at the same time, soybean oil was discounted 4-9 cents a pound over cottonseed oil for its flavor deficiency. Despite its expanding market, the flavor of soybean oil was singled out in 1945 as the "number one problem of the soybean industry"—a problem that would limit future soybean production. Soybean oil had been destined to become an industrial oil. However, as a paint oil, it dried slowly and developed "after tack." But then, as an edible oil, it tasted like paint.

It was in this critical state of affairs for the soybean industry that the Chairman of the Board of National Soybean Processors Association, Edward J. Dies, summoned the Soybean Research Council to the first of what was to become annual conferences on the Flavor Stability of Soybean Oil in Chicago 1946 (2). He welcomed 28 representatives of government, academic, and industrial research organizations and immediately charged them with, "I cannot too strongly emphasize the economic advantages of rapid solution of the problem of flavor stability in soybean oil and soybean oil products—let us solve it at the earliest possible moment. This meeting today was a deliberate move to bring together the best research minds in the nation who are engaged in work on this subject. The basic hope has been that we might be able to facilitate a free exchange of ideas and subsequently promote special collaboration among workers engaged in this field." The attendance list follows.

CONFERENCE ON FLAVOR STABILITY IN SOYBEAN OIL

Soybean Research Council
National Soybean Processors Association

April 22, 1946

Bismarck Hotel, Chicago, Illinois

Present

O.H. Alderks, The Procter and Gamble Company
H.C. Black, Swift and Company
R.A. Boyer, The Drackett Company
G.N. Bruce, Durkee Famous Foods

John C. Cowan, Northern Regional Research Laboratory
B.F. Daubert, University of Pittsburgh
Edward J. Dies, National Soybean Processors Association
Maurice Durkee, A.E. Staley Mfg. Co.
Herbert J. Dutton, Northern Regional Research Laboratory
Egbert Freyer, Spencer Kellogg and Sons, Inc.
Calvin Golumbic, University of Pittsburgh
Warren Goss, Northern Regional Research Laboratory
Arne Gudheim, Lever Brothers
J.K. Gunther, Central Soya Co., Inc.
Fred Hafnor, Archer-Daniels-Midland Co.
R.G. Houghtlin, National Soybean Processors Association
H.T. Iveson, The Glidden Company
J. Jakobsen, General Mills, Inc.
N.F. Kruse, Central Soya Co., Inc.
Herbert W. Lemon, Ontario Research Foundation
Herbert E. Longenecker, University of Pittsburgh
Ralph H. Manley, General Mills, Inc.
Karl F. Mattil, Swift and Company
R.T. Milner, Northern Regional Research Laboratory
W.W. Moyer, A.E. Staley Mfg. Co.
F.W. Quackenbush, Purdue University
H.E. Robinson, Swift and Company
J.H. Sanders, The Procter and Gamble Company
L.A. Spielman, The Glidden Company

By test of history, the conferees drawn from government, academic and industrial research would seem to have lived up to Dies' expectations, and their names are well known to soybean oil research and among lipid chemists. Moreover, the cooperation of basic research groups and the industrial implementation of research findings account for the progress of a minor edible oil in the early 1940s to the major edible oil of the U.S. and the world, proudly labeled on premium products of the 1980s.

Trivial as it may seem now, the first significant research development was the establishment of objective methods to assess flavor and odor (3). Numerical values from a taste panel in one plant could then be easily reproduced by a panel in another institution. Equally important perhaps, research finally had a way to reliably assess the benefit of a given processing treatment rather than relying on the judgment of a single "expert."

With this new tool, trace metals were identified as having special significance in soybean oil compared to other edible fats and oils. While cottonseed oil can tolerate copper and iron in the parts per million (ppm) range, soybean oil is ruined by as little as 0.3 ppm of iron and 0.01 ppm of copper (4). Following this announcement of the deleterious effect of trace metals, especially in soybean oil, was the removal of brass valves in refineries and conversion from cold, rolled-steel deodorizers to stainless steel and even to nickel.

Strange as it may seem in retrospect, scientists had to establish that "soybean flavor reversion," as it was then called, was an oxidative process. When government scientists sharpened their analytical tools, the relationship of peroxidation to off-flavor became unmistakable. Industry's response was to blanket oils with inert gas at all critical, high-temperature steps, including final packaging.

The development reported at the 1946 conference has the aspects of a cloak-and-dagger story. At the close of World War II, Warren H. Goss, a chemical engineer at the Northern Regional Research Center (NRRC), was commissioned a major in the Army on special assignment to follow Patton's advancing tanks through Germany and to investigate the German oilseed industry. As the troops advanced, he kept hearing about a recipe to cure soybean reversion; but not until he reached Hamburg did he learn the exact details. It was a strange formula involving many water

washings and such steps as contacting oil with water glass; but strange or not, when tested at NRRC, it worked. It was not until after this 1946 conference that we found why it improved flavor stability. It worked not because of the unusual washing treatments, but because citric acid was added to the deodorizer and citric acid complexed trace prooxidant metals. Based on this discovery came the surge of metal deactivators, i.e., sorbitol, phosphoric acid, lecithin, polycarboxy acids and starch phosphates. The immediate response of industry was to adopt metal deactivators, and today there may not be a pound of soybean oil product not protected by citric acid or some similar metal scavenger.

These palliative steps, important as they were, still begged the question as to what caused off-flavor to develop, i.e., what was the unstable precursor of the odor? Phospholipids, isolinolenic acid, unsaponifiables and sterols were suspected. Circumstantial evidence pointed to the 7% content of linolenic acid, which draws its name from linseed oil, in which this fatty acid amounts to 50%.

In what is now a classic experiment, 9% linolenic acid was interesterified into the glyceride structure of a "non-reverting," nonlinolenic acid oil—namely, cottonseed oil. The taste panel identified cottonseed oil interesterified with linolenic acid as a soybean oil (5).

Armed with this new information, what could be done? Three alternatives were suggested with regard to linolenic acid removal: (a) breed it out (The American Soybean Association, through its Research Foundation, is currently supporting this research approach); (b) extract it out (during World War II, soybean oil was countercurrently extracted with furfural to yield a more flavor-stable raffinate for edible purposes and a high-iodine value extract fraction to substitute for the then-scarce linseed oil); or (c) react it out.

Of the three alternatives, reacting out linolenic acid appeared to be the most practical, short-term research approach. There began a long search for selective hydrogenation catalysts—those that would react with linolenic acid but not attack the desired, essential polyunsaturated fatty acid—linoleic.

Fortunately, at this time, basic researches on catalyst selectivity bore fruit. NRRC scientists found that among many metals tested, copper behaved with almost enzymatic specificity, hydrogenating linolenic acid some 15 to 20 times more rapidly than linoleic acid (6). It meant that not 3-5% linolenic salad oils, but "zero" percent linolenic oils could be produced, with little attack on the essential linoleic acid and with, concomitantly, the advantage of low winterization losses. Room-odor studies, conducted by NRRC's taste-odor panel, could hardly detect the fishy odors characteristic of unhydrogenated soybean oil or of soybean oil partially hydrogenated by conventional nickel catalysts.

At this point in history, then, one might well ask, "What today is the status of the flavor stability problem of soybean oil?"

For application in margarines and shortenings, it is generally conceded there is essentially no problem in the use of hydrogenated soybean oil; because of its large, stable supply and its ease of refining and odor removal, it is an oil of choice. For low-temperature salad oil applications, soybean oil "specially processed" (hydrogenated-winterized) has wide acceptance. The remaining unsolved flavor problem of soybean oil is in its high-temperature, deep-fat frying applications. This is primarily of concern in the export market. Fishiness and retention of odor in the

kitchen after frying are the complaints, particularly from those consumers accustomed to the peculiar but traditional odors of heated peanut and olive oils.

Paradoxically (and ironically as it seems to non-Asians), in a recent visit by the representatives of the People's Republic of China to NRRC, we were to learn that soybean oil still poses no flavor problem in China. If one wishes sesame flavor, he cooks in crude sesame seed oil, if rape flavor, in crude rapeseed oil, and if soya flavor, in crude soybean oil. The best solution to the world's ethnic and cultural preferences would seem to be to provide a soybean oil that remains bland and stable on heating (7). This stability and blandness have been characteristic of copper-hydrogenated oils produced and evaluated both at NRRC and commercially in France and the U.S. They do not, we emphasize, taste or smell like heated peanut oil, heated olive oil, or other traditionally preferred oils, but can be blended with them.

This, then, effectively brings the history of soybean oil (8,9) to bear on the future. For, if there be any merit to the study of history, it is to help us understand the present (be consoled, it has happened before) and to project the future (be advised, it will happen again). For goals of future research, I see (10): (I) novel ways of extracting, refining, and processing soybean oil such as: (a) super critical gaseous extraction and simultaneous fractionation of soybean oil; (b) continuous high-pressure hydrogenation with selective copper catalysts and appropriate analytical transducers for computer control and specification of flavor-stable hardened products; (c) physical refining with its concomitant lowering of energy cost; (II) soybean oil of higher stability and lower iodine value by selective breeding, mutation, and other techniques of genetics, thereby affording reduced hydrogenation cost; (III) a bland, stable, liquid soybean oil for deep-fat cooking used either by itself or in blends with traditional oils; (IV) more complete knowledge of the relationship of lipid metabolism to atherosclerosis, of the incorporation of isomeric fatty acids in human tissues and of other nutritional and health-related problems of fats in diets; (V) reevaluation of oil-producing soybeans as a photosynthetic trap for solar energy and for its on-farm use as a diesel fuel.

While there may be "no new thing under the sun," there may well be new ways of producing and processing soybeans and soybean oil, including helping the soybean plant to become a more efficient converter of solar energy to food, feed, fiber, fuel and fertilizer nitrogen.

REFERENCES

1. Markley, K.S., and W.H. Goss, in "Soybean Chemistry and Technology," Chemical Publishing Company, Inc., Brooklyn, New York, 1944.
2. Proceedings of the Conference on Flavor Stability in Soybean Oil, Soybean Research Council, National Soybean Processors Association, Chicago, Illinois, 1946.
3. Moser, H.A., C.M. Jaeger, J.C. Cowan and H.J. Dutton, *JAOCs* 24:291 (1947).
4. Dutton, H.J., A.W. Schwab, H.A. Moser and J.C. Cowan, *Ibid.* 25:384 (1948).
5. Dutton, H.J., C.R. Lancaster, C.D. Evans and J.C. Cowan, *Ibid.* 28:115 (1951).
6. Koritala, S., and H.J. Dutton, *Ibid.* 43:86 (1966).
7. Cowan, J.C., C.D. Evans, H.A. Moser, G.R. List, S. Koritala, K.J. Moulton and H.J. Dutton, *Ibid.* 47:470 (1970).
8. Cowan, J.C., and C.D. Evans, in "Autoxidation and Antioxidants," Vol. II, Chap. 14, edited by W.D. Lundberg, New York, NY, 1962, pp. 593-628.
9. Dutton, H.J., *ACS Symp. Ser.* 75:81-93 (1978).
10. Dutton, H.J., *JAOCs* 57:20A (1980).