Fifth Edition

BAILEY'S INDUSTRIAL OIL & FAT PRODUCTS

Volume 2

Edible Oil & Fat Products: Oils and Oil Seeds

Edited by

Y.H. Hui

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To assure accuracy of the information, each chapter in this five-volume text has been reviewed by experts in industry, government, and academia. Although most chapters have one or two reviewers, some have as many as five or six. A list of the reviewers is presented. However, in studying this list, please note:

1. The authors of the chapters have also served as reviewers for chapters other than their own. They are not included in this list.
2. This list is incomplete for a variety of reasons. The review was spread over three years and some names are misplaced, some reviewers wish to remain anonymous, and so on. A note of appreciation and/or apology is extended to those reviewers not included in the list.

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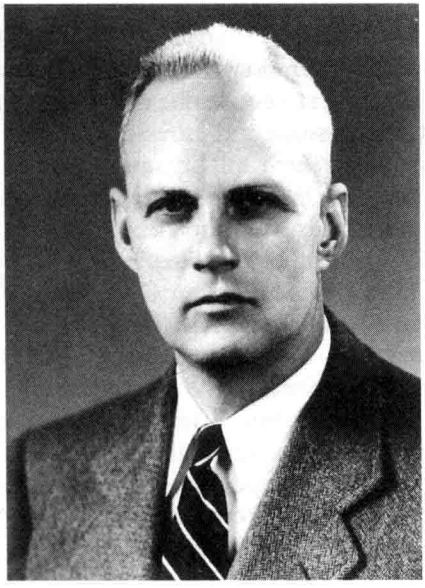
A Tribute to Alton E. Bailey



ALTON E. BAILEY

Alton Edward Bailey was born in Midland, Texas, in 1907 and died 46 years later in Memphis, Tennessee. During his relatively short professional career, A.E. Bailey made an imprint on the science and technology of fats and oils unequaled by any other person either before or since. Of his accomplishments, it is agreed that the most important was the legacy of his book, *Bailey's Industrial Oil and Fat Products*, first published in 1945. It immediately became

the Bible of the fats and oils industry and continues to be so regarded, even today. While updated and expanded several times since his death in order to include more recent scientific findings and engineering developments, the 1945 first edition can still be perused with the reader hardly being aware that A.E. Bailey wrote the words 50 years previously.

In our present age, when having a Ph.D. from a prestigious university is almost mandatory in order to be taken seriously as a research investigator or authoritative author, it is interesting to note that "Ed" Bailey's university education ended upon receiving a B.S. in Chemical Engineering from the University of New Mexico in 1927.

Following graduation, A.E. Bailey was employed in the laboratories of the Cudahy Packing Company, first in Omaha, Nebraska, and later in Memphis, Tennessee. He left Cudahy in 1941 to accept a position as head of the oil processing research section of the United States Department of Agriculture at their Southern Regional Research Laboratory in New Orleans. It was in the pilot plant there that Ed Bailey tested out and quantified many of his ideas. His published laboratory work relied heavily on the use of the then new tool of dilatometry to explain and understand the functional characteristics of fats.

Five years later, Alton Bailey resigned from the USDA to join the Votator Division of the Girdler Corporation in Louisville, Kentucky, as Chief Process Engineer of their Oil and Fat Section. In that position, he was instrumental in the development of the semicontinuous deodorizer which, in addition to producing products of very high quality, permitted rapid changeover from one product to another. In 1950, Mr. Bailey returned to Memphis as Vice President and Director of Research for The Humko Company, a position he occupied until his death.

Alton E. Bailey joined the American Oil Chemists' Society in 1935 and subsequently made many contributions to the technical publications, education programs, and organization management of AOCS. He was elected to the Governing Board in 1949 and served the Society as its president in 1951–1952.

According to his contemporaries, Ed Bailey possessed an exceptional intellect, intense curiosity, and extremely high motivation. Those attributes were coupled with an almost photographic memory, along with significant ability to organize material and put it into writing in a straightforward and understandable manner.

When Fred Astaire died, Mikhail Baryshnikov commented, "Mr. Astaire was an *artiste*, the rest of us are dancers." We, who are authors of individual chapters of this fifth edition, feel the same relationship with Mr. Alton E. Bailey. We hope you will find our efforts worthy of being published in a book bearing his name.

ROBERT C. HASTERT

October 1995

BAILEY'S LEGACY IS DECADES OF FATS AND OILS RESEARCH

Following in the innovative footsteps of Alton E. Bailey, agricultural research scientists continue to have a significant impact on the fats and oils industry of today and tomorrow. Working in the scientific environment that cultured Bailey's creative genius, researchers at the regional research centers of the USDA's Agricultural Research Service (ARS) have contributed to decades of advancements in the processes and applications of fats and oils, both for food and industrial uses.

An extended program of research enabled scientists to help transform the soybean into the major source of high-protein feeds and food oil products of today. In the early 1940s the flavor of soybean oil was variously described by consumers as "grassy" or "beany" or "fishy," and it tasted even worse after it had been stored for awhile. In consultation with colleagues in the fats and oils industry, scientists decided that establishment of some uniformity of judgment about how various soybean oils tasted was an essential first step in the research. The technique of flavor evaluation, which they developed involving selected, trained taste panels and numerical rating of the flavors, was the first significant milestone in improving soybean oil

Guided by judgments of taste panels, researchers identified the source of many of the off-flavors in soybean oil as trace metals, particularly iron and copper. Even extremely small amounts of these contaminants sped oxidation of the oil, shortening its storage life and promoting undesirable flavors. Responding to these findings, industry removed brass valves in refineries and substituted stainless steel for the cold, rolled steel in equipment that came in contact with soybean oil. These actions alone improved the flavor of the oil. It was further discovered that the addition of citric acid to the deodorized oil would deactivate the trace metals in soybean oil. Today, practically all soybean oil is protected by adding citric acid during processing.

But many questions remained unanswered. Metal contaminants could speed the development of off-flavors, but chemists wondered what caused the flavors to develop in the first place. One of the principal causes turned out to be linolenic acid, a fatty acid that makes up from 7 to 9% of soybean oil. Of all the major edible vegetable oils on the market only soybean and rapeseed oils contained linolenic acid at these levels. It is this constituent of soybean oil that was a major contributor to deterioration on the shelf or when the oil was heated repeatedly in deep fryers. The industry turned to the nickel-catalyzed, partial hydrogenation process to lower the linolenic acid content of soybean oil to about 3.0%. In the 1960s, it was this lightly hydrogenated product that enabled soybean oil to displace cottonseed oil as the major edible oil in the world.

At the same time, the discovery that linolenic acid was a major reason soybean oil went bad spurred plant breeders in research to find soybean and

rapeseed lines with lower linolenic acid content, research that continues to this day.

Today, while hydrogenation of soybean oil is still required for use as a high temperature cooking oil, in shortenings and margarines, and for long-term storage, evaluations by taste panels have made it clear that the industry's implementation of improved processing techniques and protection of the oil during processing produces an oil that is stable at ambient temperatures and has good shelf-life stability.

Other researchers modified cottonseed oil, giving it properties similar to that of cocoa butter. The confectionery fats derived from cottonseed and soybean oil are now being used for many applications in the industry. Further, the fatty acids from vegetable oils were combined with sucrose or table sugar to form sucrose esters, used today as emulsifiers, stabilizers, and texturizers in baked goods, baking mixes, biscuit mixes, frozen dairy desserts, and whipped milk products.

Over the years, ARS has devoted much of its resources to discovering new industrial uses for fats and oils. A new market for fats and oils was created by the discovery of a process called epoxidation, in which hydrogen peroxide was used to insert an atom of oxygen into the hydrocarbon chain of fatty acids. Epoxidized oils, when used as plasticizers, blend well with commonly used resins. They also eliminate the need for poisonous salts of lead, barium, or cadmium in vinyl plastics, which turn the plastics cloudy or opaque. Seventy-five percent of the 50,000 tons of epoxidized oils now used are based on soybean oil. The discovery also helped to create a billion-dollar plastics industry. Today, about 75% of the plasticizers for flexible vinyl plastics are made from soybean oil.

Modification of vegetable oil fatty acids has been a significant alternative to petrochemicals for chemical feedstocks. Oleic acid is converted to emulsifiers, cosmetic ingredients, and other specialty chemicals and is used in textile mills in lubricants and antistatic agents. Acetoglycerides, derived from fatty acids, can be formed into thin, stretchable films for a variety of uses in the food and cosmetics industries. Another development was a group of multipurpose chemicals called isopropenyl esters from fatty acids. These can be used to make paper and cotton repel water, to coat glass to reduce breakage in bottling lines, and in other applications where they have proven superiority to chemicals now in use.

A significant market for soybean oil was created in 1988 when scientists formulated a 100% soybean-oil-based printing ink that not only has a lower cost than petroleum-based inks, but also gives superior penetration of pigment into newsprint. These inks are adjustable to a wide range of viscosity and tackiness for news offset printing and have rub-off characteristics equal to those formulated and marketed as low-rub inks.

In 1959, the North Central Section, American Oil Chemists' Society, established the Alton E. Bailey award to annually recognize research and/or service

in the field of oils, fats, and related disciplines. The list of 35 scientist recipients from academia, industry, and government is testament to the lasting impact of Bailey's legacy of research in the fats and oils field.

TIMOTHY L. MOUNTS

October 1995

Preface

This fifth edition of *Bailey's Industrial Oil and Fat Products* differs from the fourth edition in many ways:

1. There are five volumes instead of three.
2. All five volumes are published at one time instead of over several years.
3. In the fourth edition, chapters on edible and nonedible products were distributed over the three volumes. However, the fifth edition is clearly divided into the two groups: edible (Volumes 1–4) and nonedible (Volume 5).
4. Volume 1 serves as an introduction covering several subjects, some of which are basic to the discipline while others, because of their unique themes, cannot be placed in other volumes. As a result, Volume 1 covers such topics as chemistry, nutrition, toxicology, vegetable oil, animal fats, flavors, analysis, and sensory evaluations. Each of Volumes 2 to 4 covers one specific topic on edible oils or fats. Volume 2 covers individual oil seeds; Volume 3 discusses the application of oils and fats; and Volume 4 concentrates on the technology and engineering of processing vegetable oils.
5. Volume 5 covers the application of oils and fats in nonedible products including consumer goods such as soap, paints, leather, textiles, pharmaceuticals, and cosmetics. Other topics include rendering, fatty acids, and glycerine.

As observed, this new edition does not exactly update the fourth edition. Rather, it is more comprehensive and covers more applied information. Many professionals have expressed to me the following:

1. Much of the information in the older editions will always be useful.
2. Each new edition does not always update information in the last edition.

3. Each new edition always covers more information than the last edition.
4. Each new edition provides more applied information than the last edition.

Volume 2 discusses 12 vegetable oils (canola, cottonseed, olive, palm, peanut, rice bran, safflower, sesame, soybean, and sunflower). The first half of each Chapter covers the basic sciences and applications such as biology, chemistry, analyses, health, and economics; the second half concentrates on production technology and engineering including quality assurance, packaging, and waste management. It must be emphasized that the unique background of the author or the discussion of a unique vegetable oilseed determines the emphasis of each section in each Chapter. To the best of my knowledge, no recent book covers similar topics in such depth and breadth. There are vegetable seeds and oils other than those mentioned in this Volume. Their exclusion is mainly related to space, and I apologize for this circumstance.

In any book with multiple authors, the editor faces the same difficulties: length, content, format, delay, and updates. In spite of the difficulties encountered in an undertaking of this magnitude, I feel that through the excellent work of the authors I have achieved the major goal of this edition. This five-volume text will provide professionals in the oil and fat industry an excellent reference source on the subject matter with a special emphasis on edible products. Most of the authors are from industry, with a limited number from academia and government. They have worked hard to make this edition a success and I will forever be grateful for their participation. But, of course, you are the final judge of the usefulness of this work.

Y. H. HUI