

APPLIED DAIRY MICROBIOLOGY



Second Edition, Revised and Expanded

edited by
Elmer H. Marth
James L. Steele

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*University of Wisconsin-Madison
Madison, Wisconsin*



MARCEL DEKKER, INC.

NEW YORK • BASEL

ISBN: 0-8247-0536-X

This book is printed on acid-free paper.

Headquarters

Marcel Dekker, Inc.
270 Madison Avenue, New York, NY 10016
tel: 212-696-9000; fax: 212-685-4540

Eastern Hemisphere Distribution

Marcel Dekker AG
Hutgasse 4, Postfach 812, CH-4001 Basel, Switzerland
tel: 41-61-261-8482; fax: 41-61-261-8896

World Wide Web

<http://www.dekker.com>

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Current printing (last digit):

10 9 8 7 6 5 4 3 2 1

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Preface to the Second Edition

The dairy industry continues to consolidate, with mergers reducing the number of companies producing dairy products. The number of dairy farms is also decreasing, but the remaining farms are larger and the volume of milk they produce is increasing slowly. The amount and variety of dairy products are also increasing, and, in fact, new products are regularly introduced into the marketplace.

As the industry continues to evolve, so does dairy microbiology. This second edition of *Applied Dairy Microbiology* reflects that evolution and provides the reader with the latest available information. There are now 18 chapters, rather than the 14 found in the first edition. Nearly all chapters that appeared in both editions have been revised and updated.

Chapter 1, "Microbiology of the Dairy Animal," contains more information on *Escherichia coli* 0157:H7 and a discussion of bovine spongiform encephalopathy. Chapter 2, "Raw Milk and Fluid Milk Products," has been rewritten by new authors and contains much information not found in the first edition. New bacterial standards for dried milk products appear in Chapter 3, "Concentrated and Dry Milks and Wheys." Chapter 4, "Frozen Desserts," includes information on sherbet, sorbet, and ice cream novelties. Chapter 5, "Microbiology of Butter and Related Products," addresses current industrial practices and includes numerous figures. Chapter 6, "Starter Cultures and Their Use," discusses isolation and enumeration of lactic acid bacteria.

Chapter 7 of the first edition has evolved into two chapters with new authors: "Metabolism of Starter Cultures" and "Genetics of Lactic Acid Bacteria."

Both chapters deal with their subjects in far greater detail than in the first edition. Chapter 8 has also been split into two chapters, “Fermented Milks and Cream” (Chapter 9) and “Probiotics and Prebiotics” (Chapter 10).

“Cheese Products,” Chapter 11, discusses processed cheese products, and Chapter 12 covers “Fermented By-Products.” “Public Health Concerns,” Chapter 13, includes information on Creutzfeldt-Jakob disease.

Chapter 14, “Cleaning and Sanitizing in Milk Production and Processing,” is new to this edition of the book. This is followed by “Control of Microorganisms in Dairy Processing: Dairy Product Safety Systems” (Chapter 15). Another new addition to the book is Chapter 16, “Regulatory Control of Milk and Milk Products.” Chapter 17, “Testing Milk and Milk Products,” addresses rony milk (an old problem that has reappeared) and provides views of a modern dairy testing laboratory. The final chapter, “Treatment of Dairy Wastes” (Chapter 18) rounds out the topic.

As was true of the first edition, the present book is intended for use by advanced undergraduate and graduate students in food/dairy science and food/dairy microbiology. The book also will be useful to persons in the dairy industry—both those involved in manufacturing products and those doing research. Furthermore, it should be beneficial to students in veterinary medicine and to veterinarians whose practice includes dairy animals. Finally, the book will be helpful to many persons in local, state, and federal regulatory agencies.

Elmer H. Marth
James L. Steele

Preface to the First Edition

Two books on dairy microbiology were published in 1957: *Dairy Bacteriology, 4th Edition* (B. W. Hammer and F. J. Babel, John Wiley and Sons, New York) and *Dairy Microbiology* (E. M. Foster, F. E. Nelson, M. L. Speck, R. N. Doetsch, and J. C. Olson, Jr., Prentice-Hall, Englewood Cliffs, New Jersey). Since then, no book on this subject has been published in the United States (although a two-volume work on dairy microbiology appeared in Europe).

When the two aforementioned books were published, there were numerous small dairy farms and dairy factories, and they produced a limited number of products. As time went on, dairy farms evolved into fewer but larger units with cows that produced more milk than in earlier years. Factories, too, decreased in number and increased in size and complexity. Furthermore, these factories began producing a far greater array of products than in the 1950s. All these changes have had an impact on dairy microbiology as it is currently understood and practiced.

Much of the information in the dairy microbiology books of the 1950s resulted from research done in dairy industry or closely related departments of most land grant universities. These departments also trained many of the workers in the dairy industry. As time went on, when problems occurred in other segments of the food industry, faculty in dairy industry departments were often consulted. In some instances, existing faculty responded to the new challenges; in others, faculty were added to work in various non-dairy segments of the food industry. Eventually, most dairy industry departments evolved into food science departments. This led to publication of several books on food microbiology—these

books usually contain a chapter or two on dairy microbiology but offer no thorough discussion of the subject.

Although food service departments have replaced most dairy industry departments in land grant universities, research on dairy microbiology has not stopped. In the 1980s, six centers for dairy research were established at various U.S. universities—the availability of funds through these centers and through national and several state promotional organizations served to stimulate research on dairy foods in general and on dairy microbiology in particular. Industrial research in this field has also expanded, but often the resulting information is proprietary.

This book updates and extends information available in earlier texts on dairy microbiology. In a manner unique to this book, it begins with a discussion of the microbiology of the milk-producing animal and how this relates to biosynthesis and quality of raw milk. This is followed by a series of chapters dealing with the microbiology of unfermented (except in a few instances) dairy foods: raw milk, fluid milk products, dried and concentrated milks and whey, frozen dairy desserts, and butter and related products. The book then considers fermented dairy foods by devoting two chapters to microorganisms used to manufacture these foods. The first of these describes starter cultures and how they are used. The second deals with genetics and metabolism of starter bacteria. Fermented dairy foods are discussed in the succeeding two chapters: cultured milks and creams in one, cheese products in the other. Another unique feature of this book is the discussion of probiotics in the chapter on cultured milks and creams. Probiotics refers to the purposeful ingestion of certain bacteria, usually dairy-related lactic acid bacteria, to improve the health and well-being of humans. Use of various microorganisms to produce valuable products through fermentation of whey, the principal by-product of the dairy industry, concludes this part of the book.

During the last four decades of the twentieth century there have been major and minor outbreaks of foodborne illness associated with dairy foods. Some of the outbreaks have been salmonellosis (nonfat dried milk, pasteurized milk, cheese, ice cream), staphylococcal food poisoning (butter, cheese, chocolate milk), and listeriosis (pasteurized milk, cheese, chocolate milk). In addition, pathogens responsible for these and other diseases have occasionally been found in dairy foods that did not cause illness. These developments have prompted concerns about public health in the food industry in general and the dairy industry in particular. Consequently, the largest chapter in this book deals with this important subject. The next chapter discusses control of pathogenic and spoilage microorganisms in processing dairy foods in which the concept of Hazard Analysis and Critical Control Points (HACCP) is emphasized.

Various microbiological tests are done to ensure the quality and safety of dairy foods. Sampling and testing are discussed in the penultimate chapter of the

book. Another unique feature of this book is the last chapter which provides information on treatment of dairy wastes, processes that are microbiological in nature.

There is some overlap among chapters in this book. For example, *Listeria monocytogenes*, *Salmonella*, psychrotrophic bacteria, lactic acid bacteria, milk composition, and bacterial standards for milk and some products are mentioned in more than one chapter. We could have exercised our prerogative as editors and eliminated the duplication, but we elected not to do so because: (a) many persons who use this book will not read it from cover to cover but instead will read one or two chapters of immediate interest and so the information in each chapter should be as complete as possible, (b) removing repetitive material, in most instances, would be detrimental to the flow of thought within a chapter and hence its readability, and (c) repetition enhances the educational value of the book—it's been said that the "three Rs" of learning are repetition, repetition, and repetition.

This book is intended for use by advanced undergraduate and graduate students in food/dairy science and food/dairy microbiology. It will also be useful to persons in the dairy industry—both those producing products and those doing research. In addition, it should be beneficial to students in veterinary medicine and to veterinarians whose practice includes dairy animals. Finally, the book will be helpful to many persons in local, state, and federal regulatory agencies.

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