

DAIRY MICROBIOLOGY

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Dairy Microbiology

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PREFACE

Dairy Microbiology was prepared to serve as a useful source of information for the many persons interested in the microbiological quality of dairy products. It should make an excellent working reference for plant operators, fieldmen, laboratory personnel, sanitarians, and others. It also is intended for use by college students who have had an introductory course in general bacteriology.

As its title indicates, the book deals with the relation of microbiology to the dairy industry. It is an interpretative work, one that stresses the broad generalizations that can be drawn from information in the literature. Citations to original papers are used sparingly except for relatively recent information, the source of which might be of interest to the reader.

The first six chapters emphasize the application of well-known facts in the science of microbiology to the various pertinent phases of the dairy industry. The main dairy organisms are described, first according to the classical taxonomic arrangement and then according to physiological groupings in which the various organisms that produce the same changes in milk are placed together. Next, the authors deal with the factors affecting the growth of microorganisms, stressing the means of preventing growth where it is unwanted and of stimulating it where it is desired. They discuss in considerable detail the physical and chemical methods of killing microorganisms in milk and on dairy equipment. General directions for examining dairy products for microorganisms are given, with explanations of underlying principles. The limitations, advantages, and disadvantages of the methods used are discussed. Finally the sources of microorganisms in milk are considered, and emphasis is placed upon means of producing milk of the best possible bacteriological quality.

Chapters 7 to 14 deal with the microbiology of specific dairy products—market milk, fermented milks, cheese, butter, and evaporated, condensed, dried, or frozen products. Sufficient description of the method of manufacture employed for each product is given to permit the reader to understand how microorganisms are affected by the various processes involved. A separate chapter is devoted to a consideration of cultures or starters used for fermented products. The book's final chapter deals with the principles and problems of dairy plant waste disposal and with the utilization of dairy by-products by fermentation.

Dairy Microbiology is the result of the concerted efforts of five authors. Each chapter was prepared by the person best qualified to write it,

but was reviewed by all the others. The names of the authors are not associated with the individual chapters they have written, for the five authors prefer to consider each chapter, as well as the entire book, as a group project for which they are all equally responsible. The reader should know that the order of the names below, and on the title page, has no special significance.

The authors are indebted to many of their friends and colleagues for help. They are especially appreciative of the cooperation of Mrs. A. D. Orla-Jensen, who kindly placed at their disposal a number of photographs of microorganisms from the collection of the late Dr. S. Orla-Jensen. Sources of other illustrative materials are acknowledged throughout the book.

Special thanks go to the following persons who read sections of the manuscript and pointed out errors and areas for improvement: Dr. Wendell Arbuckle, University of Maryland; Dr. S. T. Coulter, University of Minnesota; Dr. W. C. Frazier, Dr. W. V. Price, and Dr. G. A. Rohlich, University of Wisconsin; Mr. Joe Greenspan, Consolidated Products Co.; Dr. W. L. Mallmann, Michigan State University; Mr. F. J. McKee, Kraft Foods Co.; Dr. J. W. Pette, Nederlands Instituut voor Zuivelonderzoek, Hoorn, Nederlands; Dr. F. R. Smith, Pet Milk Co.; Dr. R. P. Tittler and Dr. George Holm, United States Department of Agriculture; and Mr. Donald Williams, International Association of Ice Cream Manufacturers.

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CONTENTS

1	<i>An introduction to dairy microbiology</i>	1
	CLASSIFICATION OF MICROORGANISMS	3
	SOME BIOLOGICAL PROPERTIES OF MICROORGANISMS	4
2	<i>The microorganisms of milk and dairy products</i>	8
	Lactobacteriaceae	9
	STREPTOCOCCUS	10
	LEUCONOSTOC	16
	LACTOBACILLUS	17
	MICROBACTERIUM	20
	PROPIONIBACTERIUM	22
	Micrococcaceae	23
	MICROCOCCUS	23
	Enterobacteriaceae	25
	ESCHERICHIA-AEROBACTER	26
	PROTEUS	27
	SALMONELLA	27
	Pseudomonadaceae	27
	PSEUDOMONAS	28
	Bacillaceae	29
	BACILLUS	30
	CLOSTRIDIUM	31
	Miscellaneous Bacteria	32
	Bacterial Viruses and Rickettsiae	34
	Yeasts	36
	Molds	38
	Associative Action among Microorganisms	43
	Dairy Microorganisms as Physiological Groups	45

3 *Methods of controlling growth of microorganisms* 55

MICROBIAL GROWTH	56
THE CONCEPT OF MICROENVIRONMENT	58
WATER RELATIONSHIPS	59
NUTRIENT REQUIREMENTS	61
pH	64
OXIDATION-REDUCTION POTENTIAL	68
OXYGEN RELATIONSHIPS	70
TEMPERATURE	72
ANTIBIOTICS	75
SULFONAMIDES	78
THE GERMICIDAL PROPERTY OF MILK	78
QUATERNARY AMMONIUM COMPOUNDS	79
SALT	81
FATTY ACIDS	81
MISCELLANEOUS AGENTS	82

4 *Destruction of microorganisms by physical and chemical agents* 85

Destruction of Microorganisms by Heat	86
THERMAL DEATH TIME	87
FACTORS WHICH INFLUENCE HEAT RESISTANCE	88
PASTEURIZATION	92
STERILIZATION	95
Destruction by Radiation	97
IONIZING RADIATION	97
DESTRUCTION OF BACTERIA IN MILK BY RADIATION	99
Effects of Sonic Energy, Electricity, and Pressure	99
SOUND	99
ELECTRICITY	101
PRESSURE	101
Effects of Surface Forces	102
Destruction by Chemicals	103
DEFINITIONS	103
ACIDS	104
ALKALIES	104
METALS AND THEIR SALTS	105
HYDROGEN PEROXIDE	106

HALOGENS	107
QUATERNARY AMMONIUM COMPOUNDS	109
Cleaning and sanitization	110
CLEANING	110
SANITIZATION	111
Miscellaneous Methods for Removal of Microorganisms	111
GRAVITY	111
CENTRIFUGAL FORCE	112
FILTRATION	112

5 *Microbiological methods of examining dairy products* 115

Bacterial Samples	117
-------------------	-----

Quantitative Methods for Total Bacteria	118
THE STANDARD PLATE COUNT	118
THE DIRECT MICROSCOPIC COUNT	123
THE METHYLENE BLUE REDUCTION TEST	128
THE RESAZURIN REDUCTION TEST	131

Quantitative Tests for Specific Types of Microorganisms 133

THERMODURIC BACTERIA	133
THERMOPHILIC BACTERIA	134
PSYCHROPHILIC MICROORGANISMS	136
COLIFORM BACTERIA	137
LIPOLYTIC BACTERIA	140
PROTEOLYTIC BACTERIA	141
ACID-PRODUCING BACTERIA	141
YEAST AND MOLD COUNTS	143
MOLD MYCELIA COUNT	144

Qualitative Tests for Certain Groups of Microorganisms 145

MASTITIS BACTERIA	145
BRUCELLA RING TEST	149
BACTERIOPHAGE	150

Qualitative Tests for Inhibitory Materials in Milk	152
--	-----

6 *Microbiology of milk on the producing farm* 156

- Contamination from the Cow 157
 - THE INTERIOR OF THE UDDER 157
 - BACTERIA IN ASEPTICALLY DRAWN MILK 158
 - THE COW AS A POSSIBLE SOURCE OF PATHOGENS 160
 - THE EXTERIOR OF THE UDDER 162
 - THE COAT OF THE COW 163
- The Role of Milking Utensils in Milk Sanitation 164
 - CLEANING METAL MILKING UTENSILS 165
 - SANITIZATION OF MILKING UTENSILS 166
 - DETERGENT-SANITIZER TREATMENT OF UTENSILS 170
 - CLEANING AND SANITIZATION OF MILKING MACHINES 171
 - PERMANENT PIPELINES 174
- Bacteria from Miscellaneous Sources 177
- Cooling of Milk 179

7 *Microbiology of market milk and related products* 188

- Government Control of Milk Supplies 188
 - PRINCIPLES OF EFFECTIVE CONTROL 189
 - FEDERAL MILK CONTROL AGENCIES 190
 - STATE MILK CONTROL AGENCIES 191
 - MUNICIPAL MILK CONTROL 191
 - ORDINANCES 191
 - GRADE A MILK PRODUCTS 192
- Industry Quality Control Programs 195
- The Procurement of Milk 196
- Processing Market Milk and Cream 196
 - CREAM 201
 - CHOCOLATE MILK 202
 - CLEANING AND SANITIZATION OF EQUIPMENT 203
 - CLEANED-IN-PLACE PIPELINES 203
- Bacteriological Problems of Market Milk Products 205
 - EXCESSIVE BACTERIAL COUNTS IN RAW MILK 205
 - THE PROBLEM OF THERMODURIC BACTERIA 208
 - THE PROBLEM OF THERMOPHILIC BACTERIA 213
 - THE PROBLEM OF COLIFORM BACTERIA 217
 - THE PROBLEM OF PSYCHROPHILIC BACTERIA 221
- The Spread of Disease Through Milk 227

8 *Microbiology of condensed, concentrated, and evaporated milk* 232

Bulk Condensed Milk 232

THE MILK SUPPLY 233

PROCESSING 233

KEEPING QUALITY 234

Concentrated Milks 235

Evaporated Milk 237

RAW MILK SUPPLY 237

INFLUENCE OF MANUFACTURING PROCESSES
UPON MICROORGANISMS 239

SPOILAGE 242

Concentrated Sour Milk and Whey 244

9 *Microbiology of sweetened condensed and dry milk products* 247

Sweetened Condensed Milks 247

INSPECTION OF THE RAW MILK SUPPLY 248

PROCESSING 248

INSPECTION OF THE FINISHED PRODUCTS 252

DEFECTS CAUSED BY MICROORGANISMS 253

Dry Milks 254

INSPECTION OF THE RAW MILK SUPPLY 255

PROCESSING 256

INSPECTION OF THE FINISHED PRODUCTS 260

RECONSTITUTED DRY MILK 262

BACTERIAL STANDARDS 263

10 *Microbiology of ice cream and related frozen products* 266

MICROBIOLOGY OF ICE CREAM INGREDIENTS 267

PROCESSING ICE CREAM MIX 270

INSPECTION OF THE FINISHED PRODUCT 279

RECONTAMINATION BY DISPENSING 282

DISEASE TRANSMISSION BY ICE CREAM 282

11 *Microbiology of lactic cultures* 287

- LACTIC ACID PRODUCTION 288
- CITRATE FERMENTATION 289
- SYMBIOTIC RELATIONSHIPS 291
- CARRYING OF CULTURES 293
- Judging Culture Quality 299
- Culture Defects 302
 - INSUFFICIENT DEVELOPMENT OF ACIDITY 302
 - INSUFFICIENT FLAVOR DEVELOPMENT 308
 - HARD AND LUMPY CURD 309
 - HIGH ACIDITY 309
 - WHEYING OFF 310
 - ROPINESS 310
 - GASSINESS 311
 - BITTERNESS 312
 - MALTINESS 312
 - METALLIC OR PUCKERY FLAVOR 312
 - GREEN OR GREEN-APPLE FLAVOR 312
- Intermediate Cultures 313
- Sources and Types of Commercial Cultures 314

12 *Microbiology of fermented milks* 318

- Cultured Buttermilk 319
 - ORGANISMS IN THE CULTURE 321
 - THE MILK AND ITS HEAT TREATMENT 321
 - STAGE OF ACTIVITY OF BULK STARTER 321
 - INCUBATION TEMPERATURE 322
 - THE CORRECT STAGE
 - OF ACID DEVELOPMENT IN THE BUTTERMILK 322
 - CARE IN CHILLING AND BOTTLING 323
 - DEFECTS 323
- Cultured Sour Cream 324
- Bulgarian Buttermilk 324
- Acidophilus Milk 325
 - PREPARATION OF ACIDOPHILUS MILK 326
- Yogurt 327
 - MANUFACTURE OF YOGURT 327
 - ORGANISMS IN YOGURT 328

CARRYING THE MOTHER CULTURE	329
DEFECTS OF YOGURT	330
Kefir	331
Kumiss	331
Taette	332
Skyr	332
Fermented Milks as Carriers of Pathogenic Microorganisms	332

13 *Microbiology of cheese* 334

The Essential Steps in Cheese Making	336
PREPARING AND INOCULATING THE MILK WITH LACTIC ACID BACTERIA	336
CURDLING THE MILK	338
SHRINKING THE CURD AND PRESSING IT INTO FORMS	340
SALTING	342
RIPENING	342
Preservation of Cheese	349
Spoilage of Cheese	350
MOLD	350
GAS FORMATION	352
RIND ROT	354
MISCELLANEOUS FLAVOR DEFECTS	354
COLOR DEFECTS	354
Examples of the Important Groups of Cheese	354
Unripened Natural Cheeses	355
Cottage Cheese	355
MANUFACTURE	355
DEFECTS	357
Cream and Neufchâtel Cheeses	360
Hard Grating Cheeses	361
Hard Cheeses	362
Cheddar Cheese	362
MANUFACTURE	362
CHANGES DURING MANUFACTURE	366
CHANGES DURING RIPENING	367
DEFECTS	371
Provolone and Caciocavallo Siciliano	372

Swiss Cheese	372
MANUFACTURE	373
CHANGES DURING MANUFACTURE	375
CHANGES IN THE PRESS	378
CHANGES DURING RIPENING	379
Edam and Gouda	385
Semi-Soft Cheeses	385
Blue Cheese	386
MANUFACTURE	387
CHANGES DURING MANUFACTURE	389
CHANGES DURING RIPENING	389
DEFECTS	392
CHEESE MADE WITH WHITE MUTANTS OF <i>PENICILLIUM ROQUEFORTI</i>	393
Gammelost	393
Brick Cheese	394
MANUFACTURE	395
CHANGES DURING MANUFACTURE	395
CHANGES DURING RIPENING	396
DEFECTS	397
Limburger Cheese	398
MANUFACTURE	398
CHANGES DURING MANUFACTURE	398
CHANGES DURING RIPENING	399
DEFECTS	400
Soft Ripened Cheeses	400
Camembert	400
MANUFACTURE	400
CHANGES DURING MANUFACTURE	402
CHANGES DURING RIPENING	402
DEFECTS	404
Process Cheese and Related Products	406
COLD-PACK CHEESE	408
Transmission of Diseases Through Cheese	408

14 *Microbiology of cream and butter* 414

TYPES OF BUTTER MADE	417
Procurement of Cream and Milk	418

Grading Milk and Cream	418
ROUTINE METHODS OF GRADING	419
SPECIAL METHODS APPLIED TO CREAM	420
Factors Influencing the Quality of Cream for Butter Making and Their Control	422
FACILITIES FOR CARE OF CREAM ON THE FARM	425
CARE OF EQUIPMENT	425
COOLING	426
OTHER FACTORS	426
Effect of Processing and Subsequent Handling on the Microflora of Butter	427
NEUTRALIZATION	427
PASTEURIZATION	427
EFFECT OF EQUIPMENT	430
USE OF BUTTER CULTURES	431
EFFECT OF CHURNING	435
EFFECT OF WORKING AND PRINTING	436
TEMPERATURE OF STORAGE	441
MISCELLANEOUS FACTORS	442
Butter Defects	442
SURFACE TAIN, PUTRID, CHEESY	443
RANCIDITY AND FRUITINESS	445
MALTY DEFECT	446
SKUNK-LIKE ODOR	447
BACTERIAL DISCOLORATION OF BUTTER	447
SURFACE DISCOLORATION OF BUTTER DUE TO MOLDS AND YEASTS	448
Analysis of Butter for Special Purposes	450
MOLD AND YEAST COUNTS	451
KEEPING QUALITY TESTS	451
THE COLIFORM TEST APPLIED TO BUTTER	452
PROTEOLYTIC AND LIPOLYTIC COUNTS	453
Spread of Disease Through Butter	454

15

*Dairy plant waste disposal
and utilization of by-products* 459

Dairy Plant Waste Disposal	459
EFFECT OF ADDING DAIRY WASTES TO A BODY OF WATER	461
PREVENTING WASTE AT THE DAIRY PLANT	463
TREATMENT OF DAIRY WASTES	467

REGULATORY AGENCIES IN POLLUTION CONTROL 468

The Use of Whey in Industrial Fermentations 470

LACTIC ACID PRODUCTION FROM WHEY 471

ALCOHOLIC FERMENTATION OF WHEY

AND YEAST DELACTOSED WHEY 473

SYNTHESIS OF VITAMINS 475

INDEX 479

An introduction to dairy microbiology

The dairy industry provides an excellent example of an area in which bacteria, yeasts, molds, viruses, and occasionally rickettsiae are very important in determining the quality of the final products. In this industry the control and destruction of undesirable microorganisms as well as their purposeful introduction and utilization are problems which demand much attention. The nutritional qualities of milk and milk products make them desirable foods for humans and young animals. The same nutritional values also permit growth of many microorganisms, some of which cause undesirable changes. Milk is a secretory product of animal origin, and its sanitary qualities are influenced by many factors in the course of its production, processing, and delivery to the consumer. This chapter is a brief review of principles upon which the application of microbiology to the dairy industry is based.

An example of a segment of the dairy industry that is dependent to a large extent on desirable enzymatic changes caused by microorganisms is cheese manufacturing. The flavors and the physical characteristics of cheese are largely ascribed to the alteration of milk constituents by various species acting simultaneously or sequentially. Only a few bacterial and mold species are added deliberately to cheese milk or to the curd during the manufacturing process. Doubtless others would be used if it were known how and when to use them in order to initiate desirable reactions. Probably much of the microbial activity that takes place during cheese ripening is due to species that enter the milk by chance at various points in the manufacturing process. Much remains to be learned about the biological and physico-chemical factors that govern the growth of the mixed populations found in cheese. Ultimately, new techniques will be developed to secure accurate data on these points.

The taste and aroma of good butter are pleasing to most consumers. At present, flavor is the greatest competitive asset of butter. Starter cultures, which are mixed bacterial cultures selected for acid- and flavor-producing

ability, are important in the manufacture of some fine flavored butter. The conditions under which optimum flavor develops and the relationships between species are fairly well known, and there is no doubt that the changes brought about by butter starter cultures are desirable.

Yogurt, sour cream, and buttermilk are examples of fermented milks made by the addition of various microorganisms to concentrated milk, cream, and skimmilk, respectively. Each product has a characteristic flora that is responsible, in part, for its distinctive flavor and physical appearance. It is now possible to manufacture these fermented milks with uniform properties from day to day by using starter cultures specially selected for their desirable flavor and acid-producing ability.

The conversion by microorganisms of certain of the constituents of milk into economically valuable products like vitamins, solvents, and food adjuncts can now be done on an industrial scale. There is essentially no limit, except the ingenuity of the experimenter, to the variety of substances which may be obtained in this way. On the other hand, milk constituents which have no economic value, or which are inadvertently wasted, must be changed to stably oxidized and non-obnoxious substances before being discharged into streams or lakes. Here again microbial activity is in large measure responsible for the desired changes in the organic constituents of dairy wastes in the process of sewage treatment.

Microorganisms are undesirable in milk and its products if they are capable of causing deterioration in flavor or physical appearance, if they are able to produce disease, or if they indicate careless or unsanitary handling of the product. Off-flavors produced by microorganisms are not only undesirable per se, but indicate that there has been opportunity for growth. It is important that the dairy microbiologist understand the factors which influence the deterioration of dairy products and the methods by which this deterioration can be prevented. Souring of milk or cream is undesirable under most circumstances, but souring (production of lactic acid) is essential for the manufacture of cheese or cultured milk. Discolorations, sliminess, ropiness, putrefaction, rancidity, gassiness, and many other defects are caused by various microorganisms growing in dairy products.

Milk and some milk products occasionally have been found to be carriers of microorganisms that cause disease. Fortunately these agents of disease can be controlled, and at present only a few outbreaks are reported each year, these usually being due to the consumption of unpasteurized or grossly contaminated products. As new processes and products are developed by the dairy technologist, they must be carefully checked to insure that they are safe from the public health point of view.

Many of the ordinances and other regulations under which milk and milk products are produced and handled specify quantitative, and in some instances qualitative, microbiological standards. These standards are the