

## Contents

---

<i>Foreword</i> .....	(v)
<i>Preface to Second Edition</i> .....	(vii)
<i>Preface to First Edition</i> .....	(ix)
<i>Introduction</i> .....	(xxvii)

### CHAPTER 1

#### Dairy Scenario

1.1 History of Dairy Industry .....	1
1.2 Dairy Industry in U.S.A. ....	3
1.3 Dairy Industry in U.K. ....	5
1.4 Dairy Industry in Australia .....	5
1.5 Dairy Industry in New Zealand .....	5
1.6 Dairy Farming in Canada .....	6
1.7 Global Dairy Scenario – Overview .....	6
1.8 Dairy Industry in India .....	19
1.9 Mile Stones in Dairy Development .....	19
1.10 Educational Institutions .....	21
1.11 Dairy Development .....	23
1.12 Evolution of Anand Model/Pattern .....	26
1.13 Role of NDDB in Dairy Development .....	28
1.14 Operation Flood (OF) 1970 - White Revolution OF - I .....	28
1.15 Present Dairy Scenario .....	30
1.16 National Dairy Plan - (NDP) .....	44
1.17 Present Status of Dairy Industry .....	47
1.17.1 Private Sector - Dairy Industries .....	53

**CHAPTER 2****Milk Processing Plant Layout and Management**

2.1	Location/Selection of Site .....	60
2.2	Classification of Dairy Plants .....	61
2.3	Topography .....	63
2.4	Nature of Ground .....	63
2.5	Planning and Principles of Dairy Layout .....	63
2.6	Soft Water .....	66
2.7	Hard Water .....	66

**CHAPTER 3****Milk and its Constituents**

3.1	Definitions of Milk .....	70
3.2	Composition of Milk .....	72
3.3	Constituents of Milk .....	79
3.4	Water .....	79
3.5	Lactose .....	80
3.6	Lactic Fermentation .....	81
3.7	Milk Fat .....	83
3.8	Milk Fat Constants/Properties .....	92
3.9	Substances Associated with Milk Fat .....	101
3.10	Milk Proteins .....	109
3.11	Mineral Matter of Milk .....	117
3.12	Vitamins of Milk .....	120
3.13	Gases Present in Milk .....	126
3.14	Enzymes in Milk .....	127
3.15	Colostrum Milk .....	128
3.16	Nutritive Value of Milk .....	131
3.17	Effect of Processing .....	140
3.18	Soft Curd Milk .....	141
3.19	Humanisation of Buffalo Milk .....	142
3.20	Vitamin-D Fortified Milk .....	142
3.21	Low Sodium Milk .....	142
3.22	Lactose Hydrolysed Milk .....	142
3.23	Cow Milk Vs. Buffalo Milk .....	143

**CHAPTER 4****Factors Affecting the Composition of Milk**

4.1	Variations in the Composition of Milk .....	147
4.1.1	Species .....	147
4.1.2	The Individuality of the Cow .....	148
4.1.3	Breed .....	148
4.1.4	Size of the Herd within Breed .....	150
4.1.5	Intervals between Milking .....	150
4.1.6	Variation from Day to Day .....	151
4.1.7	Efficiency of Milking .....	152
4.1.8	Different Quarters of the Udder .....	152
4.1.9	First and Last Milk Drawn .....	153
4.1.10	Stage of Lactation and Milk Yield .....	153
4.1.11	Season .....	156
4.1.12	Age of the Animal/Number of Lactations .....	159
4.1.13	Effect of Gestation .....	161
4.1.14	Level of Nutrition - Influence of Feeding .....	161
4.1.15	Excitement .....	163
4.1.16	Heat or Oestrus .....	163
4.1.17	Condition of Flesh at Calving .....	163
4.1.18	Relation between Daily and Yearly Production .....	164
4.1.19	Official Vs. Ordinary Milk Production Records .....	165
4.1.20	Hormonal Influence .....	166
4.1.21	Effect of Disease .....	167
4.1.22	Influence of Drugs .....	168
4.1.23	Miscellaneous Causes .....	168
4.2	Inter Relationship between the Milk Constituents .....	169

**CHAPTER 5****Physico-chemical Properties**

5.1	Physical State of Milk .....	171
5.1.1	Colour of Milk .....	172
5.1.2	Flavour and Taste .....	172
5.1.3	pH of Milk .....	173

---

5.1.4	Specific Gravity and Density .....	173
5.1.5	Acidity of Milk .....	175
5.1.6	Viscosity .....	176
5.1.7	Specific Heat .....	178
5.1.8	Surface Tension .....	179
5.1.9	Bound Water .....	179
5.1.10	Freezing Point .....	180
5.1.11	Boiling Point .....	181
5.1.12	Refractive Index (RI) .....	181
5.2	Butero-Refractometer Reading (B.R) .....	182
5.3	Oxidation-Reduction Potential .....	183
5.4	Electrical Conductivity .....	183
5.5	Buffering of Milk .....	184

**CHAPTER 6****Microbiology of Milk**

6.1	Importance of Study of Microbiology .....	187
6.2	Classification of Microorganisms of Milk .....	187
6.3	Types of Microorganisms in Milk .....	187
6.3.1	Bacteria .....	187
6.3.2	Yeast .....	188
6.3.3	Moulds .....	188
6.3.4	Viruses .....	189
6.3.5	Bacteriophages .....	189
6.3.6	Hetero Fermentative Organisms .....	189
6.4	Growth of Micro Organisms .....	193
6.4.1	Stages of Growth .....	193
6.5	Milk and Public Health .....	196
6.5.1	Source of Contamination .....	199
6.5.2	Producing Animal .....	199
6.5.3	Milking Area .....	200
6.5.4	Handling of Milk-Utensils and Equipment .....	200
6.5.5	Personnel Sources of Contamination .....	200
6.5.6	Water as a Source of Contamination .....	201

---

6.6	Types of Microorganisms in Milk .....	201
6.6.1	Bacteriophages .....	201
6.6.2	Spoilage of Milk .....	201
6.6.3	Gas Production .....	202
6.6.4	Proteolysis .....	202
6.6.5	Ropiness .....	202
6.6.6	Microbiological Flavour .....	203
6.7	Alkali Production .....	204
6.8	Microbial Examination of Milk .....	205
6.8.1	DMC Method .....	206
6.9	Destruction of Microorganisms .....	211
6.10	Bactofugation .....	211

**CHAPTER 7****Dairy Operations (Practices)**

7.1	Pricing of Milk .....	213
7.2	Cooling of Milk History .....	221
7.2.1	Refrigeration .....	222
7.2.2	Basic Principles of Refrigeration .....	223
7.3	Collection of Milk .....	226
7.3.1	Milk Collection Chilling Centres/Depots .....	226
7.4	Transportation .....	230
7.4.1	Methods of Transport .....	230
7.4.2	Types of Containers Used .....	232
7.5	Milk Processing .....	232
7.6	Receiving of Milk .....	234
7.7	Milk Reception Operations .....	235
7.8	Pre Heating .....	241
7.8.1	Filtration/Clarification .....	241
7.8.2	General Construction and Operation of Filters and Clarifiers ..	242
7.8.3	Location of Filters/Clarifier in the Processing Line .....	243
7.8.4	Relative Efficiency .....	243
7.8.5	Composition of Clarifier Slime .....	243
7.8.6	General Remarks .....	244

---

7.9	Cooling and Storage of Raw Milk-Cooling (In the Dairy Plant) .....	244
	7.9.1 Methods .....	245
	7.9.2 Storage .....	246
	7.9.3 Types of Storage Tanks .....	246
	7.9.4 Location of the Storage Tank .....	247
	7.9.5 Parts of the Storage Tank .....	247
7.10	Standardisation .....	248
7.11	Homogenization .....	252
	7.11.1 Process of Homogenization .....	253
	7.11.2 Homogenizer .....	254
	7.11.3 Factors Influencing Homogenization .....	255
	7.11.4 Method of Manufacture .....	256
7.12	History .....	256
	7.12.1 Definition .....	258
	7.12.2 Pasteurization Process .....	261
	7.12.3 Methods of Pasteurization .....	262
7.13	Bottling/Bottle Filling .....	278
	7.13.1 Gravity Fillers .....	278
	7.13.2 Vacuum Fillers .....	279
	7.13.3 Caps and Capping .....	280
	7.13.4 Inspection of Filled Bottles .....	281
	7.13.5 Decrating or Recrating of the Bottles .....	281
	7.13.6 Crate Stacker .....	281
7.14	Packaging .....	281
	7.14.1 Glass Bottle Vs Paper/Film Package .....	282
7.15	Storage .....	283
7.16	Distribution .....	285
	7.16.1 Organisation of Routes .....	286
7.17	Judging and Grading of Milk .....	289
	7.17.1 High Grade Market Milk - its Requirements .....	290
	7.17.2 Manufacture of Different Grades of Milk .....	291
	7.17.3 Flavour Defects-Causes and Prevention .....	291

**CHAPTER 8****Dried Milk or Milk Powder**

8.1	Whole Milk Powder-PFA or Legal Standard .....	296
8.2	Skim Milk Powder (SMP) .....	296
8.3	Drying of Milk Freezing .....	300
8.4	Cooling of Milk causes Several Changes, the most Important Ones being .....	301
8.5	Freezing .....	301
8.6	Drying of Milk-Heat Application .....	302
	8.6.1 Vacuum Roller Drying .....	302
	8.6.2 Band Film Drying .....	303
	8.6.3 Foam Drying .....	303
	8.6.4 Freeze Drying .....	303
	8.6.5 Spray Drying .....	304
8.7	Configuration of the Drier .....	309
	8.7.1 Heating of the Air .....	309
	8.7.2 Automization and Air Inlet .....	309
8.8	Instantization .....	311
8.9	Keeping Quality .....	312
	8.9.1 Changes during Storage .....	312
	8.9.2 Lactose Protein Changes .....	313
8.10	Dehydration-Concentrated Milk .....	313
8.11	Sweetened Condensed Milk .....	315
8.12	Un-sweetened Condensed Skim Milk .....	315
8.13	Composition .....	315
	8.13.1 Physico-chemical Properties .....	316
	8.13.2 Colour and Flavour .....	317
	8.13.3 Viscosity : which is again influenced by .....	317
8.14	Method of Manufacture-(Sweetened Condensed Milk) .....	317
	8.14.1 Heating .....	318
	8.14.2 Homogenisation .....	319
	8.14.3 Sugar .....	319
	8.14.4 Concentration .....	319
	8.14.5 Cooling and Seeding .....	319
	8.14.6 Packaging .....	319

8.15	Keeping Quality .....	320
8.16	Evaporated Milk or Un-sweetened Condensed Milk .....	321
	8.16.1 Composition .....	322
8.17	Food Value .....	323
8.18	Method of Manufacture .....	323
8.19	Preheating/Fore Warming .....	324
	8.19.1 Concentrating .....	325
	8.19.2 Packaging .....	325
8.20	UHT Process of Sterilization .....	326
	8.20.1 Recombination .....	326
	8.20.2 Properties of the Product .....	326
	8.20.3 Heat Stability .....	327
	8.20.4 Defects in Evaporated Milk .....	328

## CHAPTER 9

### Dairy Products

9.1	Cream .....	329
	9.1.1 Separation Methods .....	331
	9.1.2 Physico-chemical Properties of Cream .....	337
	9.1.3 Factors Affecting the Fat Loss in Skim Milk during Separation .....	339
	9.1.4 Yield of Cream .....	342
	9.1.5 Quality of Cream .....	343
	9.1.6 Defects in Cream .....	343
	9.1.7 Uses of Cream .....	344
9.2	Ice Cream .....	344
	9.2.1 Composition .....	348
	9.2.2 Milk Solids Not Fat (MSNF) .....	350
	9.2.3 Home Production .....	353
	9.2.4 Large Scale or Factory Production of Ice-cream .....	355
	9.2.5 Figuring the Mix/Composition of the Mix .....	357
	9.2.6 Properties of the Mix .....	358



---

9.2.7	Preparation of the Mix .....	360
9.2.8	Pasteurizing the Mix .....	361
9.2.9	Freezing Process-changes taking Place .....	363
9.2.10	Defects in Ice-cream .....	367
9.3	Butter .....	368
9.3.1	Composition .....	370
9.3.2	Cooling and Ageing of Cream .....	372
9.3.3	Ripening of Cream .....	373
9.3.4	Churning .....	373
9.3.5	Theories of Churning .....	374
9.3.6	Churning Operation/Procedure .....	375
9.3.7	Difficulties/Problems of Churning .....	377
9.3.8	Method of Working/Kneading .....	379
9.3.9	Defects or Faults in Butter .....	380
9.4	Cheese .....	381
9.4.1	Types/Classification of Cheese .....	384
9.4.2	Composition of Cheese .....	385
9.4.3	Food and Nutritive Value .....	387
9.4.4	Ripening or Adding Starter to the Milk .....	390
9.4.5	Cottage Cheese .....	396
9.4.6	Processed Cheese .....	397
9.4.7	Packaging .....	399
9.4.8	Storage .....	399
9.4.9	Defects/Abnormalities in Cheese .....	399
9.5	Butter Oil .....	399
9.5.1	Direct Evaporation Method .....	400
9.5.2	Directly from Cream by De-emulsification .....	401
9.5.3	Packaging .....	402
9.6	Ghee .....	403
9.6.1	Physico-chemical Constants of Ghee .....	405
9.6.2	Manufacturing Methods .....	406
9.6.3	Keeping Quality .....	408
9.6.4	Grading .....	408
9.6.5	Defects .....	409

---

9.7	Khoa .....	410
9.7.1	Standards of Khoa .....	411
9.7.2	Physico-chemical Changes during Khoa Making .....	413
9.7.3	Methods of Preparation .....	414
9.7.4	Factors affecting the Quality and Yield of Khoa .....	416
9.7.5	Packaging and Shelf Life of Khoa .....	418
9.8	Paneer .....	419
9.8.1	Principle .....	419
9.8.2	Conditions of Manufacture .....	420
9.8.3	Manufacture of Paneer .....	421
9.8.4	Varieties of Paneer .....	423
9.8.5	In Package Paneer Process .....	424
9.8.6	Preservation of Paneer .....	425
9.9	Chhena .....	426
9.9.1	Chemical Composition .....	427
9.9.2	Traditional Chhena Making Process .....	429
9.9.3	Mechanisation Process for Chhana Making .....	430
9.9.4	Innovation Process in Chhana Making .....	432
9.9.5	Dry Chhena Powder .....	432
9.9.6	Active Packaging for Chhena .....	432
9.9.7	Chhena based Sweet Products .....	432
9.10	Dahi/Curd .....	437
9.10.1	Production Methods .....	439
9.10.2	Quality Control of Dahi .....	440
9.11	Srikhand .....	443

**CHAPTER 10****Dairy by-products**

10.1	Skim Milk - its Utilization .....	451
10.2	Casein-Industrial .....	452
10.2.1	Manufacture of Casein-Industrial .....	453
10.2.2	Grain-Curd Casein .....	456
10.2.3	Rennet Casein-Manufacture .....	457
10.2.4	Manufacture of Casein from Butter Milk .....	457
10.2.5	Casein - Defects, Causes and Prevention .....	458

---

10.3	Butter Milk-Condensed Butter Milk .....	461
10.4	Whey .....	461
10.4.1	Utilization of Whey .....	462
10.4.2	Small Scale Utilization of Whey .....	464
10.4.3	Large Scale Utilization of Whey .....	464
10.4.4	Concentration of Whey .....	464
10.4.5	Uses of Condensed Whey .....	465
10.4.6	Storage of Whey Powder .....	466
10.4.7	Whey Protein Concentrate .....	467
10.4.8	Manufacture of Whey Protein Concentrate (WPC) .....	467
10.5	Lactose .....	468
10.5.1	Grades of Lactose .....	469
10.5.2	Method of Manufacture .....	470
10.5.3	Yeild .....	473
10.5.4	Uses .....	473
10.6	Lassi .....	474
10.7	Ghee Residue .....	475

**CHAPTER 11****Milk - Different Varieties/Forms**

11.1	Sterilized Milk .....	479
11.1.1	Definition .....	479
11.1.2	Manufacturing Details .....	481
11.1.3	UHT Method of Sterilization .....	483
11.2	Homogenized Milk .....	483
11.3	Soft Curd Milk .....	484
11.4	Flavoured Milks .....	485
11.4.1	Fruit Flavoured Milks/Drinks .....	487
11.4.2	Sterilized Flavoured Milks/Drinks .....	488
11.4.3	Vitaminized/Irradiated Milk .....	489
11.4.4	Frozen Concentrated Milk .....	489
11.5	Fermented Milk .....	490
11.5.1	The Merits of the Fermented Milk .....	490

---

11.6	Natural Butter Milk .....	490
	11.6.1 Cultured Butter Milk .....	490
	11.6.2 Manufacturing Procedure/Preparation .....	492
	11.6.3 Creaming .....	492
11.7	Acidophilus Milk .....	492
	11.7.1 Procedure .....	494
11.8	Bulgarian Butter Milk .....	494
11.9	Kumiss .....	494
11.10	Kefir .....	494
11.11	Yoghurt .....	494
	11.11.1 Procedure .....	496
11.12	Flavoured Yoghurt Preparation .....	496
11.13	Standardised Milk .....	497
11.14	Reconstituted/Rehydrated Milk .....	497
	11.14.1 Procedure .....	498
11.15	Recombined Milk .....	498
	11.15.1 Procedure .....	499
11.16	Toned Milk .....	500
	11.16.1 Procedure .....	501
	11.16.2 Double Toned Milk .....	501
	11.16.3 Humanized Milk .....	501
11.17	Miscellaneous Milks .....	502
	11.17.1 Filled Milk .....	502
	11.17.2 Vegetable Toned Milk .....	502
	11.17.3 Artificial Milk .....	502
11.18	Synthetic Milk .....	503
	11.18.1 Procedure .....	503
	11.18.2 Harmful Effects and its Prevention .....	504
	11.18.3 Effect of Synthetic Milk .....	505
	11.18.4 Yeast Milk .....	511

**CHAPTER 12****Quality Control of Milk and Milk Products**

12.1	Quality of Milk .....	519
12.1.1	Raw Milk and its Quality Control .....	520
12.1.2	Processing/Production - its Quality Control .....	520
12.2	Finished Product - Quality Control .....	521
12.2.1	Quality Control Laboratory .....	521
12.2.2	Sampling - Quality Control .....	522
12.2.3	Quality Control of Foods and Legislative Criteria .....	523
12.2.4	International Food Safety Laws and Standard .....	524
12.3	Food and Agriculture Organisation (FAO).....	524
12.3.1	The Codex Alimentarius Commission and the FAO/WHO Food Standards Programme .....	524
12.4	Hazard Analysis and Critical Control Point (HACCP) .....	525
12.4.1	Analyse Hazards .....	527
12.4.2	Identification of Critical Control Points .....	527
12.4.3	Advantages of HACCP .....	528
12.5	ISO 9000 Series and Other Standards .....	528
12.5.1	ISO 9001 .....	529
12.5.2	ISO 9002 .....	529
12.5.3	ISO 9003 .....	529
12.5.4	ISO 9004 .....	529
12.5.5	Differences between ISO 9001, 9002, and 9003 .....	530
12.6	Indian Food Laws and Standards .....	530
12.6.1	Prevention of Food Adulteration (PFA) Act .....	530
12.6.2	Food Safety and Standards Authority of India (FSSAI) .....	531
12.6.3	Export Inspection Council .....	533
12.7	Bureau of Indian Standards (BIS) .....	533
12.8	Clean Milk Production .....	534

**CHAPTER 13****Milk Residues**

13.1	Pesticide Residue in Milk and Milk Products .....	537
13.1.1	Foreign Substances .....	537
13.2	Oxytocin Residual Effect .....	545

**CHAPTER 14****Packaging**

14.1	Importance of Packaging .....	549
14.1.1	The Main Objectives of the Packaging are .....	551
14.2	Selection of Packaging Materials .....	552
14.2.1	Product Range .....	552
14.2.2	Consumer Needs .....	553
14.2.3	The shift in the Consumer Perception of Packaging is Noticeable from .....	553
14.2.4	There are several Attributes that Appeal to the Consumer such as .....	553
14.3	Packaging Materials .....	554
14.3.1	Packaging Materials - Range .....	556
14.3.2	Packaging Techniques .....	559
14.4	New Concepts of Packaging .....	562
14.4.1	MAP Technology .....	562
14.4.2	Advantages and Disadvantages of MAP .....	562
14.4.3	Gases for MAP .....	563
14.4.4	Methods of MAP .....	563
14.4.5	Packaging Material for MAP .....	564
14.4.6	Typical MAP Machines .....	564
14.5	Packaging Machines .....	565
14.6	Disposal of Packages .....	567

**CHAPTER 15****Cleaning and Disinfection**

15.1	Cleaning and Disinfection Processes .....	571
15.1.1	Check on Cleaning Efficiency .....	571
15.2	Water for Dairy Industry .....	574
15.2.1	Coagulation .....	574
15.2.2	Chlorination .....	574
15.3	Hardness of Water .....	575
15.3.1	Temporary Hardness .....	576
15.3.2	Permanent Hardness .....	576

---

15.3.3	Estimation of Hardness .....	576
15.3.4	Treatment of Hard Water .....	577
15.4	Removing Temporary Hardness .....	577
15.4.1	Lime Soda Process .....	577
15.4.2	Treatment with Ion Exchange Resins .....	577
15.5	Milk Stone .....	578
15.6	Methods of Cleaning .....	579
15.7	Classification of Detergents .....	579
15.7.1	Sequestering/Chelating Agents .....	580
15.7.2	Surface Active/Wetting Agents .....	581
15.8	Properties of Detergent .....	582
15.8.1	Sanitizers .....	583
15.8.2	Heat .....	583
15.8.3	Hot Water .....	584
15.8.4	Hot Air .....	584
15.8.5	Irradiation .....	584
15.8.6	Chemical Sanitisation .....	584
15.8.7	Chlorine Compounds .....	584
15.8.8	Iodine Compounds .....	585
15.9	Quaternary Ammonium Compounds (QAC) .....	586
15.10	Procedure of Cleaning and Sanitizing .....	586
15.11	Methods .....	589
15.11.1	Hand Washing .....	589
15.11.2	Mechanical Washing .....	590
15.11.3	Cleaning in Place (CIP) .....	591
	<b>Practical Manual .....</b>	<b>595</b>
	<b>Index .....</b>	<b>723</b>