

Contents

<i>Contributors</i>	xxiv
<i>Preface</i>	xxvii
1 Production Systems around the World	1
<i>Christian F. Gall</i>	
1.1 Ecological conditions	1
1.2 Systems	2
1.2.1 Small-scale milk production	2
1.2.2 Specialised milk production in large commercial dairies	3
1.2.3 Dairy ranching	3
1.2.4 Urban dairies	4
1.2.5 Pastoralists	4
1.3 Feed resources	6
1.4 Animal species used for milk production	6
1.4.1 Cattle	6
1.4.1.1 Milk yield	7
1.4.1.2 Milk composition	8
1.4.1.3 Milk production in the tropics	8
1.4.2 Sheep and goats	9
1.4.3 Buffalo	10
1.4.4 Camel	11
1.4.5 Mare	11
1.4.6 Yak	12
1.4.7 Reindeer	12
1.5 Breed improvement	12
1.5.1 Pure breeding	13
1.5.2 Artificial insemination	13
1.5.3 Embryo transfer	13
1.5.4 Genomic selection	13
1.5.5 Crossbreeding	13
1.6 Nutrition	14
1.7 Animal health	15
1.8 Reproduction	15
1.9 Rearing of youngstock	17
1.10 Housing	17
1.11 Milking	18
1.12 Milk marketing	18
1.12.1 Marketing by smallholders	19
1.12.2 Milk collection	19
1.12.3 Producer organisations	20

1.13	Economics of milk production	20
1.13.1	Productivity	21
1.13.2	Longevity and lifetime production	21
1.14	Criticism of milk production	22
1.14.1	Resource use	22
1.14.2	Impact on the environment	22
1.15	Dairy development	23
	References	24
2	Mammary Secretion and Lactation <i>Young W. Park, Pierre-Guy Marnet, Lucile Yart, and George F.W. Haenlein</i>	31
2.1	Introduction	31
2.2	Origin and anatomy of mammary glands	32
2.2.1	Types of mammalian species and mammary glands	32
2.2.2	Anatomy of mammary glands of domestic animals	32
2.3	Mammogenesis and mammary gland growth	33
2.4	Milk ejection (lactogenesis) and secretion	35
2.5	Maintenance of lactation (galactopoiesis)	36
2.6	Secretion of milk and its constituents	38
2.6.1	Types of milk secretion	38
2.6.2	Milk secretion process	39
2.6.3	Comparative composition of blood and milk nutrients	39
2.7	Involution of the mammary gland	40
2.8	Challenges and opportunities in mammary secretion today and tomorrow	41
	References	42
3	Milking Procedures and Facilities <i>Pierre-Guy Marnet</i>	46
3.1	Introduction	46
3.2	Machine milked animals throughout the world	46
3.3	Milking principles	48
3.4	Milking machine components and effects on milk harvesting and quality	49
3.4.1	Vacuum system	50
3.4.2	Pulsation system	51
3.4.3	Mechanical effect of machine milking on milk quality	51
3.4.3.1	Specific action of cluster and liners	52
3.4.3.2	Specific action at the milk pump level	53
3.4.4	Optional components	53
3.4.5	Milking parlors and milking stalls	54
3.4.6	Storing and cooling devices	57
3.4.7	Cleaning systems	58
3.4.8	New kinds of materials and sensing devices for better milk quality	59
3.5	Milking practices	59
3.6	Milking management of animals	60
3.6.1	Lowering milking frequency	60
3.6.2	Increasing milking frequency (three milkings and more per day)	61
3.7	Conclusions	61
	References	61

0	4	Milk Lipids	65
1		<i>Michael H. Gordon</i>	
2	4.1	Introduction	65
2	4.2	Fatty acids	65
2	4.3	Triacylglycerols	67
3	4.4	Polar lipids: phospholipids and cholesterol	68
4	4.5	Conjugated linoleic acids	68
1	4.6	Genetic influences on milk fat concentrations and fatty acid profiles	70
1	4.7	Influence of feeds, feeding regimes, pasture and stage of lactation on milk lipids and their levels	71
2	4.8	Digestion of milk fat	72
2	4.9	Nutritional effects of milk fatty acids	72
1	4.10	Evidence for effects of milk fat on CVD from prospective cohort studies	74
2	4.11	Evidence about the effects of dairy products on non-lipid risk factors	75
2	4.12	Conclusion	75
2		References	75
3	5	Milk Major and Minor Proteins, Polymorphisms and Non-protein Nitrogen	80
5		<i>Sándor Kukovics and Tímea Németh</i>	
3	5.1	Milk proteins	80
3	5.1.1	Factors affecting the protein content of the milk	81
3	5.2	The major milk proteins	81
3	5.2.1	Caseins	82
2	5.2.1.1	α_{s1} -Casein	84
2	5.2.1.2	α_{s2} -Casein	84
2	5.2.1.3	β -Casein	84
2	5.2.1.4	κ -Casein	84
1	5.2.1.5	The question of casein structure	84
1	5.2.1.6	The importance of casein structure	85
0	5.2.2	Whey (serum) proteins	86
0	5.2.2.1	α -Lactalbumin	86
0	5.2.2.2	β -Lactoglobulin	86
1	5.3	The polymorphisms of milk proteins	86
1	5.3.1	The presence of polymorphisms in cattle populations	87
1	5.3.2	Effects on milk production	93
1	5.3.3	Effects on milk composition	94
1	5.3.4	Interactions	95
1	5.3.5	Effects on cheesemaking properties	95
1	5.3.5.1	β -Lactoglobulin	96
1	5.3.5.2	κ -Casein	96
1	5.3.5.3	β -Casein	97
0	5.4	Milk protein variants and human nutrition: the human benefit	97
0	5.4.1	Hypoallergenic milk	97
0	5.4.2	Biopeptides	97
1	5.5	The minor proteins	99
1	5.5.1	Lactoferrin	99
1	5.5.2	Serum albumin (bovine serum albumin)	99
1	5.5.3	Immunoglobulins	99
1	5.5.4	Hormones	100
1	5.5.5	Growth factors	100

1.13	Economics of milk production	20	4	Mil
1.13.1	Productivity	21		Mic
1.13.2	Longevity and lifetime production	21		4.1
1.14	Criticism of milk production	22		4.2
1.14.1	Resource use	22		4.3
1.14.2	Impact on the environment	22		4.4
1.15	Dairy development	23		4.5
	References	24		4.6
				4.7
2	Mammary Secretion and Lactation	31		4.8
	<i>Young W. Park, Pierre-Guy Marnet, Lucile Yart, and George F.W. Haenlein</i>			4.9
2.1	Introduction	31		4.1
2.2	Origin and anatomy of mammary glands	32		4.1
2.2.1	Types of mammalian species and mammary glands	32		4.1
2.2.2	Anatomy of mammary glands of domestic animals	32		
2.3	Mammogenesis and mammary gland growth	33		
2.4	Milk ejection (lactogenesis) and secretion	35	5	Mil
2.5	Maintenance of lactation (galactopoiesis)	36		Sá
2.6	Secretion of milk and its constituents	38		5.1
2.6.1	Types of milk secretion	38		
2.6.2	Milk secretion process	39		5.2
2.6.3	Comparative composition of blood and milk nutrients	39		
2.7	Involution of the mammary gland	40		
2.8	Challenges and opportunities in mammary secretion today and tomorrow	41		
	References	42		
3	Milking Procedures and Facilities	46		
	<i>Pierre-Guy Marnet</i>			
3.1	Introduction	46		
3.2	Machine milked animals throughout the world	46		
3.3	Milking principles	48		
3.4	Milking machine components and effects on milk harvesting and quality	49		5.3
3.4.1	Vacuum system	50		
3.4.2	Pulsation system	51		
3.4.3	Mechanical effect of machine milking on milk quality	51		
3.4.3.1	Specific action of cluster and liners	52		
3.4.3.2	Specific action at the milk pump level	53		
3.4.4	Optional components	53		
3.4.5	Milking parlors and milking stalls	54		
3.4.6	Storing and cooling devices	57		5.4
3.4.7	Cleaning systems	58		
3.4.8	New kinds of materials and sensing devices for better milk quality	59		
3.5	Milking practices	59		
3.6	Milking management of animals	60		
3.6.1	Lowering milking frequency	60		
3.6.2	Increasing milking frequency (three milkings and more per day)	61		
3.7	Conclusions	61		
	References	61		

5.5.6	Milk enzymes	100
5.5.6.1	Lysozyme	100
5.5.6.2	Lactoperoxidase	100
5.5.7	Metal-binding proteins	100
5.5.8	Vitamin-binding proteins	100
5.5.9	Glycoproteins	101
5.5.10	Lactollin	101
5.5.11	β_2 -Microglobulin	101
5.5.12	Osteopontin	101
5.5.13	Proteose peptone 3	101
5.5.14	Milk fat globule membrane proteins	101
5.6	Non-protein nitrogen	101
5.6.1	Urea	102
	References	103
6	Milk Protein Allergy	111
	<i>Melanie L. Downs, Jamie L. Kabourek, Joseph L. Baumert, and Steve L. Taylor</i>	
6.1	Introduction	111
6.2	IgE-mediated food allergy	111
6.2.1	Mechanism	111
6.2.2	Commonly allergenic foods	112
6.2.3	Sensitization and its prevention	113
6.2.4	Diagnosis of food allergies	113
6.2.5	Prevention and treatment of food allergy	114
6.2.6	Cows' milk and avoidance diets	115
6.3	Delayed food allergies	116
6.4	Cows' milk allergy	116
6.4.1	Whey proteins	117
6.4.1.1	β -Lactoglobulin	117
6.4.1.2	α -Lactalbumin	117
6.4.1.3	Minor whey proteins	118
6.4.2	Caseins	118
6.5	Cross-reactivity with milk from other species	120
6.6	Effects of processing on allergenicity	121
6.7	Other mechanisms	123
	References	124
7	Milk Carbohydrates and Oligosaccharides	129
	<i>Alessandra Crisà</i>	
7.1	Introduction	129
7.2	Lactose and minor sugar	129
7.2.1	Composition and concentration of carbohydrate in milk and dairy products of different species	130
7.3	Oligosaccharides	134
7.3.1	Purification and characterization of oligosaccharides from milk	135
7.3.2	Methods for structural analysis	135
7.3.3	Composition and concentration of oligosaccharides in milk of different species	136
7.4	Carbohydrates as prebiotics in the gastrointestinal tract	138
7.5	Other oligosaccharide functions	139
7.6	Genetics of carbohydrate metabolism during lactation	140
	References	141

100	8 Milk Bioactive Proteins and Peptides	148
100	<i>Hannu J. Korhonen and Pertti Marnila</i>	
100	8.1 Introduction	148
100	8.2 Caseins	149
101	8.3 Whey proteins	149
101	8.3.1 α -Lactalbumin	149
101	8.3.2 β -Lactoglobulin	149
101	8.3.3 Glycomacropeptide	150
101	8.3.4 Lactoferrin	150
101	8.3.4.1 Antimicrobial effects	151
101	8.3.4.2 Immunological effects and cancer prevention	152
102	8.3.4.3 Applications and safety aspects	152
103	8.3.5 Lactoperoxidase and lysozyme	153
111	8.3.5.1 Lactoperoxidase	153
111	8.3.5.2 Lysozyme	153
111	8.3.6 Growth factors and cytokines	154
111	8.3.7 Immunoglobulins	155
111	8.3.7.1 Functions of immunoglobulins	156
111	8.3.7.2 Immunoglobulins and immune milk preparations	156
111	8.4 Bioactive peptides	157
112	8.4.1 Production systems	158
113	8.4.2 Functionality	158
113	8.4.2.1 Antihypertensive	159
114	8.4.2.2 Antimicrobial	159
115	8.4.2.3 Immunomodulatory	159
116	8.4.2.4 Mineral binding	160
116	8.4.3 Occurrence in dairy products	161
117	8.4.4 Applications	161
117	8.5 Other minor proteins	161
117	8.6 Conclusions	163
118	References	163
120		164
121	9 Milk Minerals, Trace Elements, and Macroelements	172
123	<i>Frédéric Gaucheron</i>	
124	9.1 Introduction	172
129	9.2 Macroelements in milk and dairy products from the cow	172
129	9.2.1 Calcium (Ca)	172
129	9.2.1.1 Calcium in the human organism and biological roles	172
129	9.2.1.2 Contents and chemical forms of Ca in milk and dairy products	172
30	9.2.1.3 Dairy contribution to the total Ca intake and Ca absorption	178
34	9.2.1.4 Physiological roles of Ca from milk and dairy products	178
34	9.2.1.5 Calcium supplementation of dairy products	180
35	9.2.2 Phosphorus (P)	180
35	9.2.2.1 Phosphorus in the human organism and biological roles	180
36	9.2.2.2 Contents and chemical forms of P in milk and dairy products	180
38	9.2.2.3 Dairy contribution to the total P intake and P absorption	181
39	9.2.3 Magnesium (Mg)	181
40	9.2.3.1 Magnesium in the human organism and biological roles	181
41	9.2.3.2 Contents and chemical forms of Mg in milk and dairy products	181
41	9.2.3.3 Dairy contribution to the total Mg intake and Mg absorption	181

9.2.4	Sodium (Na), chloride (Cl), and potassium (K)	181
9.2.4.1	Sodium, chloride, and potassium in the human organism and biological roles	181
9.2.4.2	Contents and chemical forms of Na, Cl, and K in milk and dairy products	182
9.2.4.3	Dairy contribution to the total Na, Cl, and K intakes and Na, Cl, and K absorptions	182
9.3	Trace elements in milk and dairy products from the cow	182
9.3.1	Iron (Fe)	182
9.3.1.1	Iron in the human organism and biological roles	182
9.3.1.2	Contents and chemical forms of Fe in milk and dairy products	182
9.3.1.3	Dairy contribution to the total Fe intake and Fe absorption	183
9.3.1.4	Iron supplementation of dairy products	183
9.3.2	Copper (Cu)	183
9.3.2.1	Copper in the human organism and biological roles	183
9.3.2.2	Contents and chemical forms of Cu in milk and dairy products	183
9.3.2.3	Dairy contribution to the total Cu intake and Cu absorption	184
9.3.3	Zinc (Zn)	184
9.3.3.1	Zinc in the human organism and biological roles	184
9.3.3.2	Contents and chemical forms of Zn in milk and dairy products	184
9.3.3.3	Dairy contribution to the total Zn intake and Zn absorption	184
9.3.4	Selenium (Se)	185
9.3.4.1	Selenium in the human organism and biological roles	185
9.3.4.2	Contents and chemical forms of Se in milk and dairy products	185
9.3.4.3	Dairy contribution to the total Se intake	185
9.3.4.4	Selenium supplementation of dairy products	185
9.3.5	The other trace elements in milk and dairy products from the cow	185
9.3.5.1	Manganese (Mn)	185
9.3.5.2	Iodine (I)	186
9.3.5.3	Fluoride (F)	186
9.3.5.4	Chromium (Cr)	187
9.3.5.5	Lead (Pb) and cadmium (Cd)	187
9.3.5.6	Cobalt (Co)	187
9.3.5.7	Molybdenum (Mo)	187
9.3.5.8	Arsenic (As)	187
9.3.5.9	Nickel (Ni)	188
9.3.5.10	Silicon (Si)	188
9.3.5.11	Boron (B)	188
9.4	Minerals in milk and dairy products of other species	188
9.4.1	Sheep	188
9.4.2	Goat	188
9.4.3	Buffalo	190
9.4.4	Yak	190
9.4.5	Camel	190
9.4.6	Mare	191
9.5	Conclusion	191
	References	191
10	Vitamins in Milks <i>Benoît Graulet, Bruno Martin, Claire Agabriel and Christiane L. Girard</i>	200
10.1	Introduction	200
10.2	Availability of vitamins in milk in relation to human health	201

1	10.2.1	Fat-soluble vitamins	201
1	10.2.1.1	Vitamin A	201
2	10.2.1.2	Vitamin D	203
2	10.2.1.3	Vitamin E	204
2	10.2.1.4	Vitamin K	205
2	10.2.2	Water-soluble vitamins	206
2	10.2.2.1	B-complex vitamins	206
2	10.2.2.2	Vitamin C	211
2	10.2.3	Differences in milk vitamin content between bovine and other dairy species	211
3	10.3	Animal and nutritional factors modulating vitamin content in bovine milk	212
3	10.3.1	Effects of feeding practices on vitamin concentrations in milk	212
3	10.3.2	Non-dietary factors affecting milk concentrations of vitamins	214
3	10.4	Vitamin content in cheeses	214
3	10.5	Conclusions	215
4		References	215
4	11	Milk Minor Constituents, Enzymes, Hormones, Growth Factors, and Organic Acids	220
4		<i>Lígia R. Rodrigues</i>	
5	11.1	Introduction	220
5	11.2	Milk minor constituents	221
5	11.2.1	Salts and minerals	221
5	11.2.2	Vitamins	221
5	11.2.3	Immune components	224
5	11.2.4	Bioactive peptides	224
5	11.2.5	Polyamines	225
6	11.2.6	Nucleotides	225
6	11.2.7	Protease peptones	226
7	11.2.8	Branched-chain amino acids and other amino acids	226
7	11.2.9	Taurine	226
7	11.2.10	Glutathione	227
7	11.3	Milk enzymes	227
7	11.3.1	Lactoperoxidase	229
8	11.3.2	Catalase	229
8	11.3.3	Xanthine oxidoreductase	229
8	11.3.4	Proteinases	230
8	11.3.4.1	Plasmin	230
8	11.3.4.2	Cathepsin D	230
8	11.3.5	Lipases and esterases	230
0	11.3.6	Amylase	231
0	11.3.7	Alkaline phosphatase	231
0	11.3.8	Acid phosphatase	231
1	11.3.9	Ribonuclease	231
1	11.3.10	<i>N</i> -Acetyl- β -D-glucosaminidase	232
1	11.3.11	Lysozyme	232
0	11.3.12	γ -Glutamyl transferase	232
0	11.3.13	Superoxide dismutase	232
0	11.3.14	Sulphydryl oxidase	233
0	11.3.15	Aldolase	233
1	11.3.16	Glutathione peroxidase	233

11.4	Milk hormones and growth factors	233	
11.4.1	Hormones	234	13.12
11.4.1.1	Gonadal hormones	234	
11.4.1.2	Adrenal gland hormones	234	
11.4.1.3	Pituitary hormones	234	
11.4.1.4	Hypothalamic hormones	235	
11.4.1.5	Other hormones	235	
11.4.2	Growth factors	235	
11.5	Milk organic acids	237	
11.6	Future perspectives and concerns	238	
	References	239	
12	Lactose Intolerance	246	
	<i>Salam A. Ibrahim and Rabin Gyawali</i>		
12.1	Introduction	246	
12.1.1	Lactose and lactase	246	
12.1.2	Types of lactose intolerance	248	
12.1.3	Symptoms of lactose intolerance	249	
12.1.4	Methods to quantify lactose maldigestion	249	
12.1.4.1	Direct measurements	249	
12.1.4.2	Indirect measurements	250	
12.1.5	Prevalence, age, gender, and genetics	250	
12.1.6	Non-probiotic dietary approach to alleviate lactose intolerance	251	
12.1.7	Intestinal microflora, fermentation, and fermented foods	252	
12.1.8	Use of probiotics to alleviate lactose intolerance	253	
12.2	Conclusions	256	
	References	256	14.3
13	Milk Quality Standards and Controls	261	
	<i>Young W. Park, Marzia Albenzio, Agostino Sevi, and George F.W. Haenlein</i>		
13.1	Introduction	261	
13.2	General principles for production of quality milk	262	14.4
13.3	Regulatory standards of quality milk and dairy products for different species	262	
13.4	Quality control principles for milk production on dairy farms	264	
13.5	HACCP plans and hazard components in the production of quality dairy products	265	
13.6	Recommended control systems for production of quality milk products	271	
13.7	Etiology of mastitis and milk hygiene	272	
13.8	Cell types and composition of milk in response to mammary gland inflammation	273	
13.9	Flow cytometric method for leukocyte differential count	275	
13.10	Factors affecting milk composition and yield in relation to milk quality	277	
13.10.1	Diet	277	14.5
13.10.2	Breed	277	
13.10.3	Stage of lactation	278	
13.10.4	Season	278	
13.10.5	Environmental temperature	278	15.1
13.10.6	Ventilation	279	
13.10.7	Milking machine	279	
13.10.8	Stocking density	280	15.2
13.10.9	Diseases	280	
13.10.10	Colostrum	281	15.3
13.10.11	Others	281	

13.11	Factors affecting quality of raw milk before and after milking	281
13.11.1	Factors affecting quality of raw milk before and during milking	281
13.11.2	Factors affecting quality of raw milk after milking	282
13.12	Pasteurization and post-pasteurization treatments for production of quality milk	282
13.12.1	Pasteurization	282
13.12.2	Vat pasteurization	282
13.12.3	Post-pasteurization contamination	283
	References	284
14	Sanitary Procedures, Heat Treatments and Packaging	288
	<i>Golfo Moatsou</i>	
14.1	Introduction	288
14.2	Sanitary aspects related to raw milk	288
14.2.1	Important microbiological aspects	288
14.2.2	Pathogenic microorganisms	290
14.2.3	Psychrotrophic microorganisms	291
14.2.4	Non-microbial contaminants in milk	291
14.2.5	Handling of raw milk: measures for controlling its keeping quality prior to processing	292
14.2.5.1	Biofilm control	292
14.2.5.2	Cooling and thermisation	292
14.2.5.3	Lactoperoxidase system	292
14.2.5.4	Carbon dioxide addition	292
14.2.5.5	Centrifugation, clarification and bactofugation	292
14.2.5.6	Microfiltration	293
14.3	Strategies for producing heat-treated milk for human consumption	293
14.3.1	Pasteurisation	293
14.3.2	UHT treatment	294
14.3.3	Extended shelf-life technology	295
14.3.4	Types of heat treatment	295
14.3.5	Packaging	297
14.4	Effects of heat treatments on milk	298
14.4.1	Effect on milk constituents	299
14.4.1.1	Proteins	299
14.4.1.2	Enzymes	300
14.4.1.3	Vitamins	302
14.4.2	Formation of new substances	303
14.4.2.1	Isomerisation of lactose to lactulose	303
14.4.2.2	Maillard reaction products	304
14.4.3	Others	305
14.5	Conclusions	305
	References	305
15	Sensory and Flavor Characteristics of Milk	310
	<i>Irma V. Wolf, Carina V. Bergamini, Maria C. Perotti, and Erica R. Hynes</i>	
15.1	Introduction	310
15.2	Significance of flavor and off-flavor on milk quality: sensory and instrumental methods	311
15.3	Milk from ruminant species	312
15.3.1	Volatile profile and sensory characteristics of fresh milk	312

15.3.2	Variations in flavor of fresh milk from ruminant species	317
15.3.2.1	Variations in milk flavor associated with farm management	317
15.3.2.2	Variations in milk flavor associated with factory management	320
15.3.3	Volatile profile and sensory characteristics of heat-treated milk	322
15.3.3.1	Ultrapasteurized milk and ultra-high-temperature treated milk	322
15.3.3.2	Milk powder, sterilized, and concentrated milk	323
15.3.3.3	Infant formula	323
15.3.4	Variations in flavor of heat-treated milk	324
15.3.4.1	Ultrapasteurized milk and ultra-high-temperature treated milk	324
15.3.4.2	Milk powder, sterilized, and concentrated milk	325
15.3.4.3	Infant formula	326
15.3.5	Volatile profile and sensory characteristics of non-thermally treated milk	326
15.3.5.1	Microfiltration	326
15.3.5.2	Ultrasound	327
15.3.5.3	Pulsed electric field	327
15.3.5.4	Microwave	327
15.3.5.5	High hydrostatic pressure	327
15.3.5.6	Ultra-high-pressure homogenization	328
15.4	Milk from monogastric species	328
	References	329
16	Fermented Milk and Yogurt	338
	<i>Sae-Hun Kim and Sejong Oh</i>	
16.1	General aspects of fermented milk	338
16.1.1	Yogurts	338
16.1.1.1	Types of yogurt	338
16.1.1.2	Production and consumption	339
16.1.1.3	Recent new product trends	339
16.1.2	Other fermented bovine milk products	340
16.1.2.1	Cultured buttermilk	340
16.1.2.2	Cultured cream	341
16.1.2.3	Acidophilus milk	341
16.1.2.4	Kefir	341
16.1.2.5	Other fermented milk products	341
16.1.3	Fermented milk and yogurt products from other dairy species	341
16.1.3.1	Fermented goat milk products	341
16.1.3.2	Fermented sheep milk products	342
16.1.3.3	Fermented buffalo milk products	342
16.1.3.4	Fermented mare milk products	342
16.2	Standards and regulations	343
16.2.1	International Codex Standard	343
16.2.1.1	Description	343
16.2.1.2	Composition	343
16.2.2	USA, Australia and New Zealand, and Europe	343
16.2.2.1	Description	343
16.2.2.2	Composition	345
16.2.3	China	345
16.2.3.1	Description	345
16.2.3.2	Composition	345
16.2.4	Japan	345
16.2.4.1	Description	345
16.2.4.2	Composition	345

317	16.2.5	Korea	345
317	16.2.5.1	Description	345
320	16.2.5.2	Composition	345
322	16.3	Health benefits of fermented milk products	346
322	16.3.1	Nutritional benefits	346
323	16.3.2	Diarrhoeal disease	347
323	16.3.3	Immune regulation	347
324	16.3.4	Prevention of osteoporosis	347
324	16.3.5	Cholesterol reduction	348
325	16.3.6	Cancer prevention	349
326	16.4	Future aspects	353
326		References	353
327	17	Cheese Science and Technology	357
327		<i>Patrick F. Fox and Timothy P. Guinee</i>	
327	17.1	Introduction	357
328	17.2	Selection and treatment of milk	357
328	17.2.1	Milk of different species	359
328	17.2.2	Standardisation of milk composition	360
329	17.2.3	Heat treatment of milk	360
338	17.2.4	Cheese colour	361
338	17.3	Conversion of milk to cheese curd	361
338	17.3.1	Acidification and starter cultures	361
338	17.3.2	Secondary cultures	363
338	17.3.3	Coagulation	363
339	17.3.4	Rennet-coagulated cheeses	363
339	17.4	Post-coagulation operations	365
340	17.4.1	Cutting the gel	365
340	17.4.2	Cooking the curds	365
341	17.4.3	Syneresis	365
341	17.4.4	Draining the curd	367
341	17.4.5	Cheddaring of the curd	367
341	17.4.6	Curd washing	368
341	17.4.7	Moulding and pressing	369
341	17.4.8	Salting	369
342	17.4.8.1	Nutritional significance of salt in cheese	370
342	17.4.9	Packaging	370
342	17.5	Membrane processing in cheese technology	371
343	17.6	Ripening	372
343	17.6.1	Ripening agents	373
343	17.6.2	Ripening reactions	373
343	17.6.2.1	Glycolysis and related events	373
343	17.6.2.2	Lipolysis	374
343	17.6.2.3	Proteolysis	374
345	17.6.3	Accelerated ripening of cheese	375
345	17.7	Factors that affect the quality of cheese	375
345	17.8	Cheese flavour	377
345	17.9	Cheese texture	377
345	17.9.1	Measurement of cheese texture	377
345	17.9.2	Textural characteristics of different cheeses	377
345	17.9.3	Texture at the macrostructural level	378

17.10	Processed cheese products	378
17.10.1	Principles of manufacture	379
17.10.2	Uses and characteristics of PCPs	379
17.10.3	Cheese analogues	380
17.11	Cheese as a food ingredient	380
17.12	Cheese production and consumption	381
17.13	Classification of cheese	381
17.14	Cheese as a source of nutrients	383
17.14.1	Fat in cheese	383
17.14.2	Protein in cheese	383
17.14.3	Lactose	383
17.14.4	Inorganic elements	385
17.14.5	Vitamins	385
17.15	Conclusions	385
	References	386
18	Butter, Ghee, and Cream Products	390
	<i>Hae-Soo Kwak, Palanivel Ganesan, and Mohammad Al Mijan</i>	
18.1	Introduction	390
18.2	Manufacture of butter, ghee, and cream products	391
18.2.1	Butter	391
18.2.2	Ghee	392
18.2.3	Cream	392
18.2.3.1	Coffee cream	392
18.2.3.2	Cultured cream	392
18.2.3.3	Whipping cream	394
18.3	Nutritive values of butter, ghee, and cream	394
18.3.1	Butter	394
18.3.2	Ghee	395
18.3.3	Cream	395
18.4	Human health benefit components in butter, ghee, and cream	397
18.4.1	Milk fat globule membrane	397
18.4.2	Health benefits of MFGM polar lipids	397
18.4.3	Sphingolipids: anticholesterol effect and heart disease	398
18.4.4	Sphingolipids and cancer	398
18.4.5	Sphingolipids: bactericidal effect	398
18.4.6	Sphingolipids: effects on diabetes mellitus and Alzheimer disease	398
18.4.7	Sphingolipids and multiple sclerosis	398
18.4.8	Phospholipids	399
18.4.9	Protein fractions of MFGM	399
18.4.9.1	Anticancer effects	399
18.4.9.2	MFGM proteins, autism, and multiple sclerosis	399
18.4.9.3	Antibacterial and antiadhesive effects of MFGM proteins	399
18.5	Conjugated linoleic acid	400
18.5.1	Carcinogenesis	400
18.5.2	Colonic and colorectal cancer	400
18.5.3	Breast cancer	400
18.5.4	Gastrointestinal cancer	401
18.5.5	Diabetes	402
18.5.6	Obesity	402
18.5.7	Atherosclerosis	402

18.5.8	Immunity	402
18.5.9	Bone health	403
18.6	Short- and medium-chain fatty acids	404
18.7	New approach on cholesterol removal in butter, ghee, and cream	404
18.8	Conclusion	405
	References	405
19	Condensed and Powdered Milk <i>Pierre Schuck</i>	412
19.1	Introduction	412
19.2	World dairy powder situation	412
19.3	Overview of operations	413
19.3.1	Concentration by evaporation	413
19.3.1.1	Principle of vacuum evaporation	413
19.3.1.2	Energy	414
19.3.1.3	Production of concentrated whole and skimmed milk	417
19.3.1.4	Production of <i>dulce de leche</i>	417
19.3.2	Whey and lactose crystallisation	417
19.3.3	Drying	418
19.3.3.1	Spray drying	418
19.4	Properties of dehydrated products	425
19.4.1	Biochemical and physicochemical properties	425
19.4.1.1	Water content	425
19.4.1.2	Water availability	426
19.4.1.3	Protein modifications	428
19.4.2	Nutritional properties	429
19.4.3	Process properties of dairy powder	429
19.4.3.1	Particle size and powder structure	429
19.4.3.2	Flowability–floodability	430
19.4.3.3	Density	431
19.4.3.4	Rehydration properties	431
19.4.3.5	Hygroscopicity	432
19.4.3.6	Instant powders	432
	References	432
20	Frozen Dairy Foods <i>Arun Kilara and Ramesh C. Chandan</i>	435
20.1	Introduction	435
20.2	Technology essentials	435
20.2.1	Classification of and trends in the frozen desserts market	435
20.2.2	Formulation	436
20.2.2.1	Concentrated sources of milk fat	437
20.2.2.2	Concentrated sources of serum solids	439
20.2.2.3	Balancing ingredients	440
20.2.2.4	Sweeteners	440
20.2.2.5	Stabilizers	441
20.2.2.6	Emulsifiers	442
20.2.3	Processing	442
20.2.3.1	Blending	442
20.2.3.2	Pasteurization	444
20.2.3.3	Homogenization	444
20.2.3.4	Aging	444

20.2.3.5	Flavors	444	<u>22.3</u>
20.2.3.6	Freezing	446	<u>22.4</u>
20.2.3.7	Overrun	446	
20.2.3.8	Types of ice cream freezers	446	
20.2.3.9	Hardening	447	
20.2.4	Frozen yogurt	448	
20.2.5	Packaging	448	
20.3	Nutritional profile of ice cream	448	
20.3.1	Contribution of milk	448	
20.3.1.1	Milk proteins	449	
20.3.1.2	Milk fat	449	
20.3.1.3	Lactose	451	
20.3.1.4	Minerals	452	
20.3.1.5	Vitamins and some other minor constituents	452	
20.3.2	Nutrient profile of ice cream and frozen desserts	453	
20.3.3	Frozen dairy products from milk of species other than cow	455	
	References	456	
21	Nutritional Formulae for Infants and Young Children <i>Séamus McSweeney, Jonathan O'Regan and Dan O'Callaghan</i>	458	<u>22.5</u>
21.1	Introduction	458	
21.2	History of infant formula	458	
21.3	Classification and regulation of formulae for infants and young children	459	
21.4	Safety and quality	459	
21.5	Product range and formulation	459	
21.5.1	General formulation principles	459	
21.5.2	Milk protein-based first-age infant formulae	462	
21.5.2.1	Energy	462	
21.5.2.2	Protein	462	
21.5.2.3	Lipids	465	
21.5.2.4	Carbohydrate	466	
21.5.2.5	Minerals	467	
21.5.2.6	Vitamins	467	
21.5.2.7	Probiotics, prebiotics and synbiotics	468	
21.5.2.8	Other nutrients	468	
21.5.2.9	Processing aids and food additives	469	
21.5.3	Specialised first-age infant formulae	469	
21.5.4	Formulae for low-birthweight and premature infants	470	
21.5.5	Follow-on formulae	471	
21.5.6	Growing-up milks	471	
21.5.7	Formulae for pregnant and lactating women	471	
21.6	Processing and manufacture of formulae for infants and young children	471	
21.7	Packaging of formulae for infants and young children	473	
21.8	Future developments	473	
	References	473	
22	Whey and Whey Products <i>Sanjeev Anand, Som Nath Khanal, and Chenchaiah Marella</i>	477	<u>23.1</u>
22.1	Introduction	477	
22.2	Sources and types of whey	477	
22.2.1	Acid and sweet whey	477	
22.2.2	Whey from other species	478	

444	22.3	Whey production and utilization	480
446	22.4	Major commercialized whey products	480
446	22.4.1	Whey powder	480
446	22.4.2	Whey protein concentrates	481
447	22.4.3	Whey protein isolate	481
448	22.4.4	Whey protein fractions	483
448	22.4.4.1	α -Lactalbumin	483
448	22.4.4.2	β -Lactoglobulin	484
448	22.4.4.3	Glycomacropeptide	484
449	22.4.4.4	Bovine serum albumin	484
449	22.4.4.5	Lactoferrin	484
451	22.4.4.6	Lactoperoxidase	485
452	22.4.4.7	Immunoglobulins	485
452	22.4.5	Non-protein whey products	485
453	22.4.5.1	Lactose	485
455	22.4.5.2	Milk minerals	485
456	22.4.6	Products from non-bovine whey	486
458	22.4.6.1	Whey cheeses	486
458	22.4.6.2	Other whey products	486
458	22.5	Nutritional value of whey components	487
458	22.5.1	Protein and bioactive peptides	487
458	22.5.1.1	Whey protein quality	487
459	22.5.1.2	Whey protein digestion and absorption	488
459	22.5.1.3	Biological functions of whey proteins	488
459	22.5.1.4	Antimicrobial activity of whey proteins	488
459	22.5.1.5	Therapeutic values of whey proteins	489
459	22.5.1.6	Whey proteins in specialized nutrition	489
462	22.5.2	Lactose	491
462	22.5.2.1	Whey products for lactose intolerance	491
465	22.5.3	Vitamins and minerals in whey	492
466	22.6	Future prospects for dietary applications of whey	492
467		References	492
468	23	Goat Milk	498
468		<i>George Zervas and Eleni Tsipakou</i>	
469	23.1	Introduction	498
469	23.2	Composition of goat milk	499
470	23.2.1	Fat	499
471	23.2.2	Fatty acids	500
471	23.2.3	Proteins	500
471	23.2.4	Whey proteins	501
473	23.2.5	Amino acids	501
473	23.2.6	Non-protein nitrogen	502
473	23.2.7	Minor proteins	502
473	23.2.8	Carbohydrates	502
477	23.2.9	Minerals and vitamins	502
477	23.3	Effects of feeding and management on goat milk composition	502
477	23.4	The contribution of goat milk to human nutrition and health	504
477	23.4.1	The effects of milk fat	504
477	23.4.2	The effects of milk proteins	506
477	23.4.3	The effects of milk bioactive peptides	508
478	23.4.3.1	Angiotensin I-converting enzyme	508

23.4.3.2	Nucleotides	508	
23.4.3.3	Polyamines	509	
23.4.3.4	Sialic acid	509	
23.4.3.5	Taurine	509	
†	23.4.3.6 Growth factors	509	
23.4.4	The effects of milk oligosaccharides	509	
23.4.5	The effects of milk minerals and vitamins	509	
23.4.6	Goat milk products	509	24.4
23.4.6.1	Fermented milk, yogurt	510	
23.4.6.2	Cheeses	510	
23.4.6.3	Powder and condensed milk	511	
23.4.6.4	Butter	511	
23.4.6.5	Other goat milk products	511	
23.5	Conclusions	512	25.1
	References	512	25.2
24	Buffalo Milk	519	
	<i>Sarfraz Ahmad</i>		
24.1	Introduction	519	
24.1.1	Buffalo populations and breeds	519	
24.1.2	Buffalo milk production and consumption	519	
24.1.3	Socioeconomic importance of buffaloes	521	25.3
24.1.4	Buffalo milk commercial products	521	
24.2	Major milk constituents and their nutritional importance	522	
24.2.1	Fat	522	
24.2.1.1	Fat globules	525	25.4
24.2.1.2	Triglycerides	526	25.5
24.2.1.3	Fatty acids	526	25.6
24.2.1.4	Conjugated linoleic acid	526	25.7
24.2.1.5	Minor fat constituents (cholesterol, phospholipids, gangliosides)	526	
24.2.2	Proteins	527	
24.2.2.1	Caseins	527	26.1
24.2.2.2	Whey proteins	530	26.2
24.2.2.3	Minor proteins	530	
24.2.3	Carbohydrates	534	
24.2.3.1	Oligosaccharides	534	
24.2.3.2	Minor sugar fractions	534	
24.2.4	Minerals	535	
24.2.4.1	Major minerals	535	
24.2.4.2	Trace elements	535	
24.2.5	Enzymes	536	26.3
24.2.5.1	Lysozyme	536	
24.2.5.2	Lactoperoxidase	537	
24.2.5.3	Xanthine oxidase	537	
24.2.6	Vitamins	537	
24.2.6.1	Fat-soluble vitamins	538	
24.2.6.2	Water-soluble vitamins	538	
24.3	Nutritional and health benefits of buffalo milk and its products	538	26.4
24.3.1	Buffalo health	539	26.5
24.3.2	Effect of buffalo milk on particular diseases	540	
24.3.2.1	Osteoporosis	540	
24.3.2.2	Allergy	540	

24.3.2.3	Dental caries	541
24.3.2.4	Cancer	541
24.3.3	Role of constituents of buffalo milk and products in human nutrition and health	542
24.3.3.1	Fatty acids and glycerides	542
24.3.3.2	Conjugated linoleic acid	543
24.3.3.3	Minerals	543
24.3.3.4	Bioactive peptides from caseins and whey proteins	545
24.4	Conclusions	546
	References	554
25	Sheep Milk <i>Miguel Angel de la Fuente, Mercedes Ramos, Isidra Recio and Manuela Juárez</i>	554
25.1	Introduction	555
25.2	Lipids	555
25.2.1	Triacylglycerides	556
25.2.2	Fatty acid composition	556
25.2.2.1	Saturated fatty acids	557
25.2.2.2	Unsaturated fatty acids	558
25.2.2.3	<i>Trans</i> fatty acids	558
25.2.2.4	Conjugated linoleic acid	560
25.2.3	Other minor lipid compounds	561
25.3	Proteins and their biological functions	563
25.3.1	Bioactive peptides derived from sheep milk proteins	563
25.3.1.1	Antihypertensive peptides	565
25.3.1.2	Antimicrobial peptides	567
25.3.1.3	Other biological activities of peptides from ovine proteins	567
25.4	Carbohydrates	568
25.5	Minerals	569
25.6	Vitamins	569
25.7	Sheep milk products	570
	References	578
26	Camel Milk <i>Kenji Fukuda</i>	578
26.1	Introduction	579
26.2	Camel milk production and utilization worldwide	579
26.2.1	Camel milk production	579
26.2.2	Utilization of Bactrian camel milk	580
26.2.3	Utilization of dromedary camel milk	580
26.2.4	Utilization of camel milk in Australia	582
26.3	Camel milk components and their nutritional aspects	582
26.3.1	Mineral salts and vitamins	582
26.3.2	Lipids	583
26.3.3	Carbohydrates	585
26.3.4	Proteins	585
26.3.4.1	Caseins	585
26.3.4.2	Whey proteins	586
26.4	Milk allergy	587
26.5	Health-beneficial microorganisms in camel milk and its products	587
26.5.1	Lactic acid bacteria	587
26.5.2	Yeasts	589
	References	

27	Horse and Donkey Milk <i>Elisabetta Salimei and Francesco Fantuz</i>	594
27.1	Introduction	594
27.2	Worldwide horse and donkey distribution and milk production	594
27.2.1	Horse and donkey milk production for human consumption	595
27.3	Gross composition and physical properties of horse and donkey milk	596
27.4	Nitrogen fraction of horse and donkey milk	598
27.4.1	Caseins	599
27.4.2	Whey proteins	600
27.4.3	Non-protein nitrogen	601
27.5	Fat and lipid fractions in horse and donkey milk	601
27.6	Lactose and other carbohydrates in horse and donkey milk	602
27.7	Minerals and vitamins in horse and donkey milk	603
27.8	Bioactive compounds	603
27.9	Horse and donkey milk in the human diet and well-being	605
27.9.1	Equid milk sanitation and quality standards and controls	605
27.9.2	Horse and donkey milk as hypoallergenic and functional food	606
27.9.3	Equid milk dairy products	607
27.10	Conclusions	608
	References	609
28	Sow Milk <i>Sung Woo Kim</i>	614
28.1	Introduction	614
28.2	Porcine mammary gland	614
28.2.1	Structure and anatomy	614
28.2.2	Mammary gland growth	615
28.2.3	Maternal nutrition and mammary gland growth	617
28.2.4	Litter size and mammary gland growth	619
28.3	Porcine colostrum and milk	621
28.4	Dietary manipulations that affect milk production and composition	622
28.5	Sow milk in human nutrition research	623
28.6	Summary	623
	References	623
29	Yak Milk <i>Ying Ma, Shenghua He, and Haimei Li</i>	627
29.1	Introduction	627
29.2	Basic composition	627
29.3	Physical characteristics	629
29.4	Proteins	630
29.4.1	Nitrogen distribution	630
29.4.2	Protein composition	632
29.4.3	Minor proteins	633
29.4.4	Milk fat globule membrane proteins	635
29.4.5	Amino acids	636
29.4.6	Bioactive peptides derived from yak milk proteins	637
29.5	Lipids	638
29.6	Minerals	640
29.7	Vitamins	640
	References	641

30	Other Minor Species Milk (Reindeer, Caribou, Musk Ox, Llama, Alpaca, Moose, Elk, and Others) <i>Young W. Park and George F.W. Haenlein</i>	644
30.1	Introduction	644
30.2	General aspects of milk of minor species	644
30.3	Production, composition, and utilization of milk from minor dairy species	645
30.3.1	Reindeer	645
30.3.1.1	Production of reindeer milk	646
30.3.1.2	Nutritional composition of reindeer milk	646
30.3.1.3	Contribution of reindeer milk to human foods	647
30.3.2	Caribou	647
30.3.3	Musk ox	648
30.3.4	Llama milk	649
30.3.4.1	Milk yield	650
30.3.4.2	Milk composition	650
30.3.5	Alpaca	651
30.3.6	Moose	652
30.3.7	Elk	653
30.3.8	Mithun	653
30.3.9	Other minor species	654
30.3.9.1	Pinniped	654
30.3.9.2	Polar bear	655
30.3.9.3	Elephant	655
	References	656
31	Human Milk <i>Duarte P.M. Torres and Young W. Park</i>	659
31.1	Introduction	659
31.2	Human milk feeding and its practice	660
31.3	Production of human milk	661
31.4	Composition of human milk	661
31.4.1	General composition	661
31.4.2	Milk protein	662
31.4.3	Milk carbohydrates	664
31.4.3.1	Major carbohydrates	664
31.4.3.2	Human milk oligosaccharides and infant microbiota	664
31.4.4	Milk fat	667
31.4.4.1	Milk fat composition	667
31.4.4.2	Fatty acids of human milk in the health and cognitive development of children	668
31.4.5	Milk micronutrients	669
31.4.5.1	Iron and minerals	669
31.4.5.2	Vitamins	670
31.5	Infant formulae and alternative feeding	672
	References	673
	<i>Index</i> A color plate section falls between pages 52 and 53	679