1 Dairy Protein Powders 3

P. Schuck

1.1 Introduction 3

1.2 Extraction of Milk Proteins 5

1.2.1 Milk proteins 5

1.2.2 Separation of proteins 5

1.2.3 Pretreatment of milk 6

1.3 Drying Principles 10

1.3.1 Roller drying 10

1.3.2 Spray drying and fluid bed drying/cooling 11

1.4 Drying of Dairy Proteins 17

1.4.1 Heat treatment 17

1.4.2 Water transfer 18

1.4.3 Energy consumption 18

1.5 Powder Properties 20

1.5.1 Powder structure 20

1.5.2 Particle size distribution 20

1.5.3 Powder density 20

1.5.4 Flowability 21

1.5.5 Rehydration of dairy protein powders 22

1.6 Conclusion 25

2 Lactose: Chemistry, Processing, and Utilization 31


2.1 Introduction 31

2.2 Forms and Properties of Lactose 32

2.2.1 Types of lactose 33

2.2.2 Mutarotation 38
2.2.3 Solubility and supersaturation 38
2.2.4 Properties of lactose crystals 42
2.3 Manufacture of Lactose 43
2.3.1 Industrial processes for α-lactose monohydrate 44
2.3.2 Creation of amorphous lactose during the α-lactose monohydrate manufacturing process 47
2.3.3 Crystallization theory and research trends 48
2.3.4 Effect of impurities on lactose crystal growth 51
2.4 Effect of Moisture on Lactose in the Solid State 53
2.4.1 Moisture-induced crystallization of amorphous lactose 53
2.4.2 Effect of moisture on the crystalline forms of lactose 56
2.4.3 Effect of moisture and amorphous lactose content in lactose-rich dairy powders 57
2.5 Lactose Applications 58
2.6 Summary 60

3 Dairy Ingredients Containing Milk Fat Globule Membrane:
Description, Composition, and Industrial Potential 71
X. Elías-Argote, A. Laubscher, and R. Jiménez-Flores
3.1 Introduction 71
3.2 Origin and Function of the MFGM 73
3.3 Composition and Structure of the MFGM 75
3.3.1 Lipids of the milk fat globule membrane 76
3.3.2 Milk fat globule membrane proteins 79
3.4 Health Benefits of the Milk Fat Globule Membrane 83
3.4.1 Anticancer properties of MFGM 83
3.4.2 Antimicrobial and antiviral properties of the MFGM 84
3.4.3 MFGM and lactic acid bacteria binding 84
3.5 Technical Aspects and Foods Based on MFGM 85
3.5.1 Emulsifying and stabilizing properties of MFGM 85
3.5.2 Potential delivery systems derived from MFGM 86
3.5.3 MFGM components as part of food systems 86
3.5.4 Isolation of the MFGM 87
3.6 MFGM: A Novel Product from Dairy Products 88
3.7 Methodology to Monitor the Biological Activity of the MFGM
Before and After Processing 90
3.7.1 Atomic force microscopy 90
3.7.2 Confocal laser scanning microscopy 90
3.7.3 Laser tweezers and the MFGM 91
3.8 The Future of MFGM and Its Components 92
4 Biofunctional Dairy Protein Fractions 99
H. Roginski, L. Bennett, H. Korhonen, S.F. Gauthier, Y. Pouliot,
and B.W. Woonton
4.1 Introduction 99
4.2 Physiologically Active Peptides from Milk 99
4.2.1 Antihypertensive peptides 100
4.2.2 Biological role of antithrombotic peptides 101
4.2.3 Biological role of immunomodulatory peptides 102
4.2.4 Biological role of opioid receptor-binding peptides 103
4.2.5 Biological role of metal-binding peptides 104
4.2.6 Conclusions 105
4.3 Antimicrobial and Antiviral Effects of Milk Proteins and Peptides 105
4.3.1 Antimicrobial proteins 106
4.3.2 Antimicrobial peptides 110
4.3.3 Antiviral proteins and peptides from milk 114
4.3.4 Conclusions 116

4.4 Immunoglobulins 116

4.4.1 Structure 117

4.4.2 Recovery and purification 117

4.4.3 Biological effects 118

4.5 Milk Growth Factors 118

4.5.1 Composition and characteristics 119

4.5.2 Methods for extracting growth factors 119

4.5.3 Health benefits of milk growth factors 122

4.5.4 Future developments 123

4.6 Glycomacropeptide 123

4.6.1 Structure 123

4.6.2 Physiological effects in humans and animals 125

4.6.3 Future developments 126

5 Modern Chromatographic Separation Technologies for Isolation of Dairy Ingredients 137

B.W. Woonton, U. Kulozik, K. De Silva, and G.W. Smithers

5.1 Introduction 137

5.2 Isolation of Dairy Components Using Resin-Based Chromatography 138

5.2.1 Chromatographic hardware 138

5.2.2 Chromatographic adsorbents 141

5.2.3 Commercial applications of resin chromatography in the dairy industry 145

5.3 Membrane Adsorption Chromatography (MAC) 148

5.3.1 Principles of MAC technology and technical description 148

5.3.2 Separation of aCMP and gCMP by means of MAC 151
5.3.3 Separation of aCMP and gCMP in a direct capture mode 154

5.3.4 Processing scheme for the separation of CMP 156

5.4 Conclusions 156

6 Nonthermal Technologies in Dairy Processing 161

H.C. Deeth, N. Datta, and C. Versteeg

6.1 Introduction 161

6.2 High Pressure Processing 164

6.2.1 Principle 164

6.2.2 Equipment and operation 165

6.2.3 Effect on milk components 166

6.2.4 Applications 172

6.3 High Pressure Homogenization 177

6.3.1 Principle 177

6.3.2 Effect on milk components 178

6.3.3 Effect on products 183

6.3.4 Commercial developments 184

6.4 Ultrasonication 184

6.4.1 Principle 185

6.4.2 Setup 185

6.4.3 Effect on milk components 186

6.4.4 Applications 189

6.4.5 Commercial developments 192

6.5 Pulsed Electric Field Technology 192

6.5.1 Principle 193

6.5.2 Effect on milk components 194

6.5.3 Effects on products and processes 198

6.5.4 Commercial developments 199
10.8 Food Safety Programs and Food Safety Objectives 297
10.9 Emerging Processing Technologies 298
10.10 Validation and Verification 299
10.11 Conclusion 300

11 Market Acceptance of Dairy Ingredients: What Consumers Are Thinking and Demanding 303
B. Davis and B. Katz

11.1 Background: Recognition and Relevance Are Drivers of Consumer Acceptance 303
11.2 Shopper Interest in Select Functional Benefits 306
11.2.1 Cognitive performance 306
11.2.2 Weight management 307
11.2.3 Lifestyle concerns 309
11.2.4 Gastrointestinal health 310
11.3 Concluding Remarks 311

12 The Future of Dairy Ingredients: Critical Considerations That Will Underpin Future Success 313
P.S. Tong and G.W. Smithers

12.1 Introduction 313
12.2 Evolution of Dairy Ingredients 313
12.2.1 “First-generation” dairy ingredients 314
12.2.2 “Second-generation” dairy ingredients 315
12.2.3 “Third-generation” dairy ingredients 315
12.3 Next Generation of Dairy Ingredients 315
12.3.1 Verifiable dairy food quality and safety 316
12.3.2 Optimal nutritional and functional performance 316
12.3.3 Sustainability, environment, and animal welfare 316
12.4 Conclusions 316

Index 319