

The
Chemical Physics of
FOOD

EDITED BY PETER BELTON



Blackwell
Publishing

Contents

<i>Preface</i>	<i>xi</i>
<i>Contributors</i>	<i>xiii</i>
<i>About the Editor</i>	<i>xiii</i>
1 Emulsions	1
<i>John N. Coupland</i>	
1.1 Introduction	1
1.2 Emulsion structure	2
1.2.1 Size	2
1.2.2 Concentration	3
1.2.3 Surface properties	4
1.2.3.1 Modified surfaces	5
1.2.3.2 Types of interfacial material	6
1.2.4 Interdroplet potentials	8
1.3 Emulsion dynamics	10
1.3.1 Creaming	11
1.3.2 Flocculation	12
1.3.3 Coalescence	13
1.4 Emulsion functionality	16
1.4.1 Rheology	16
1.4.2 Chemical reactivity	17
1.5 References	18
2 Physicochemical Behaviour of Starch in Food Applications	20
<i>Alain Buleon and Paul Colonna</i>	
2.1 Introduction	20
2.2 Starch composition and chemical structure	21
2.2.1 Granular structure	21
2.2.2 Molecular composition	24
2.2.2.1 Amylose	25
2.2.2.2 Amylopectin	26
2.2.2.3 Intermediate materials	30

2.2.2.4	Minor components	31
2.3	Modifications of starch by hydrothermal treatments and shearing	32
2.3.1	Gelatinization, pasting and melting	33
2.3.1.1	Structural changes	33
2.3.1.2	Mechanisms of gelatinization-melting	34
2.3.1.3	Functional properties	40
2.3.2	Gelation	40
2.3.2.1	Structural changes	40
2.3.2.2	Mechanisms	42
2.3.2.3	Functional properties	44
2.3.3	Glass transition and plasticization by water	45
2.3.4	Physical ageing	46
2.4	Interactions with other molecules	46
2.4.1	Hydrocolloids and proteins	47
2.4.2	Sugars	49
2.4.3	Amylose complexation with small molecules	50
2.4.3.1	Lipids	50
2.4.3.2	Alcohols, aroma and flavours	53
2.5	Starch as a nutrient	55
2.5.1	Classification	55
2.5.2	Resistant starch	56
2.6	Conclusions	57
2.7	References	59

3 Water Transport and Dynamics in Food **68**

Brian Hills

3.1	Introduction	68
3.2	Statistical thermodynamics and the microscopic water distribution	70
3.3	Experimental probes of the microscopic water distribution	74
3.4	The water self-diffusion propagator	77
3.5	Experimental probes of the water self-diffusion propagator	78
3.6	Water transport in nonequilibrium microheterogeneous systems	80
3.7	The state of water in nanopores	82
3.8	Experimental probes of water–biopolymer interactions	86
3.9	Molecular dynamics simulations of water–biopolymer interactions	94
3.10	The dependence of water dynamics on state variables	95
3.10.1	Low-water-content systems	95
3.10.2	Nonfreezing water	99
3.10.3	Diffusion studies of surface water	100
3.10.4	Water dynamics under high pressure	101
3.11	Conclusion	103
3.12	References	104

4 Glasses	108
<i>Roger Parker and Stephen G. Ring</i>	
4.1 Introduction	108
4.2 Glass transitions	109
4.2.1 Low molecular weight liquids and glasses	109
4.2.2 Biopolymer glasses and plasticization	111
4.2.3 Colloidal glasses	113
4.3 Glassy state dynamics	114
4.4 Structural relaxation in low molecular weight organic liquids and biopolymers	117
4.5 Mechanical stability – colloidal systems	119
4.6 Chemical stability	119
4.6.1 Chemical kinetics and the glassy state in single-phase systems	120
4.6.2 Chemical kinetics and the glassy state in multiphase systems	125
4.7 Glassy carbohydrates as encapsulation matrices and solvents	125
4.7.1 Flavour encapsulation in glassy carbohydrates	125
4.7.2 Solvent properties of amorphous carbohydrates	126
4.8 Concluding remarks	129
4.9 References	130
 5 Powders and Granular Materials	 135
<i>Gary C. Barker</i>	
5.1 Introduction	135
5.2 Packing	139
5.3 Segregation	142
5.4 Jamming	145
5.5 Discussion	148
5.6 References	148
 6 Gels	 151
<i>Victor J. Morris</i>	
6.1 Introduction	151
6.2 Polysaccharide gels	153
6.2.1 What are polysaccharides?	153
6.2.2 How do polysaccharides form networks?	158
6.2.2.1 Point cross-links	159
6.2.2.2 Block structures	160
6.2.2.3 Higher-order helical aggregates	163
6.2.3 What are fluid gels?	166
6.2.4 Polysaccharide mixtures	168
6.2.5 Phase-separated networks	169

6.2.5.1	Starch	169
6.2.5.2	Semi-refined carrageenans	172
6.2.6	Swollen networks	172
6.2.7	Interpenetrating networks	173
6.2.8	Coupled networks	173
6.2.8.1	Pectin-alginate gels	173
6.2.8.2	Xanthan-glucomannan gels	174
6.2.8.3	Xanthan-galactomannan gels	176
6.2.8.4	Algal polysaccharide glucomannan or galactomannan mixed gels	177
6.3	Protein gels	178
6.3.1	What are proteins?	178
6.3.2	How do proteins form networks?	179
6.3.2.1	Globular proteins	179
6.3.2.2	Fibrous proteins	181
6.3.2.3	Casein gels	183
6.3.3	Protein mixtures	184
6.3.4	Interfacial protein networks	184
6.3.4.1	Interfacial gelatin networks	185
6.3.4.2	Globular protein networks	185
6.3.5	Interfacial protein networks in foods	186
6.4	Polysaccharide-protein gels	189
6.5	Conclusions	191
6.6	References	191

7 Wheat-Flour Dough Rheology **199**

Robert S. Anderssen

7.1	Introduction	199
7.1.1	The two independent aspects of cereal science and technology: molecular biorheology and process biorheology	200
7.1.1.1	Genetics as the key to plant breeding: molecular biorheology	200
7.1.1.2	Process rheology as the key to efficiently maximizing end-product quality: process biorheology	201
7.1.2	The pervasive nature of wheat-flour dough rheology in cereal science and technology	201
7.1.3	The rheology perspective: the recovery of information from indirect measurements	211
7.2	Background, preliminaries and notation	212
7.3	The phenomenology of wheat-flour dough formation	212
7.4	Wheat-flour dough rheology modelling from an indirect measurement perspective: a plethora of models	216
7.5	The indirect measurement modalities that directly underpin the rheology of	

wheat-flour dough formation	219
7.5.1 The walk-in-refrigerator experiments	219
7.5.2 Temperature measurements	220
7.5.3 Mixograms	222
7.5.3.1 Qualitative and quantitative summaries of the global stress-strain dynamics in a mixogram	223
7.5.3.2 The hysteretic nature of the local structure in a mixogram	224
7.5.3.3 A hysteretic summary of the global structure in a mixogram	227
7.5.4 Uniaxial and biaxial extensions	227
7.5.5 The modalities that indirectly underpin the rheology	230
7.6 Modelling the viscoelasticity of wheat-flour dough formation	230
7.7 Some future challenges	233
Appendix 1: A brief literature summary	235
Appendix 2: Symbols and abbreviations	236
7.8 References	237
<i>Index</i>	241

The colour plate section appears after page 82