

# Contents

<b>0</b>	<b>Water . . . . .</b>	<b>1</b>
0.1	Foreword . . . . .	1
0.2	Structure . . . . .	1
0.2.1	Water Molecule . . . . .	1
0.2.2	Liquid Water and Ice . . . . .	2
0.3	Effect on Storage Life . . . . .	3
0.3.1	Water Activity . . . . .	3
0.3.2	Water Activity as an Indicator . . . . .	5
0.3.3	Phase Transition of Foods Containing Water . . . . .	5
0.3.4	WLF Equation . . . . .	6
0.3.5	Conclusion . . . . .	7
0.4	References . . . . .	7
<b>1</b>	<b>Amino Acids, Peptides, Proteins . . . . .</b>	<b>8</b>
1.1	Foreword . . . . .	8
1.2	Amino Acids . . . . .	8
1.2.1	General Remarks . . . . .	8
1.2.2	Classification, Discovery and Occurrence . . . . .	9
1.2.2.1	Classification . . . . .	9
1.2.2.2	Discovery and Occurrence . . . . .	9
1.2.3	Physical Properties . . . . .	12
1.2.3.1	Dissociation . . . . .	12
1.2.3.2	Configuration and Optical Activity . . . . .	13
1.2.3.3	Solubility . . . . .	14
1.2.3.4	UV-Absorption . . . . .	15
1.2.4	Chemical Reactions . . . . .	16
1.2.4.1	Esterification of Carboxyl Groups . . . . .	16
1.2.4.2	Reactions of Amino Groups . . . . .	16
1.2.4.2.1	Acylation . . . . .	16
1.2.4.2.2	Alkylation and Arylation . . . . .	18
1.2.4.2.3	Carbamoyl and Thiocarbamoyl Derivatives . . . . .	20
1.2.4.2.4	Reactions with Carbonyl Compounds . . . . .	21
1.2.4.3	Reactions Involving Other Functional Groups . . . . .	22
1.2.4.3.1	Lysine . . . . .	23
1.2.4.3.2	Arginine . . . . .	23
1.2.4.3.3	Aspartic and Glutamic Acids . . . . .	23
1.2.4.3.4	Serine and Threonine . . . . .	24
1.2.4.3.5	Cysteine and Cystine . . . . .	24
1.2.4.3.6	Methionine . . . . .	24
1.2.4.3.7	Tyrosine . . . . .	24

1.2.4.4	Reactions of Amino Acids at Higher Temperatures .....	25
1.2.4.4.1	Acrylamide .....	25
1.2.4.4.2	Mutagenic Heterocyclic Compounds .....	26
1.2.5	Synthetic Amino Acids Utilized for Increasing the Biological Value of Food (Food Fortification) .....	29
1.2.5.1	Glutamic Acid .....	32
1.2.5.2	Aspartic Acid .....	32
1.2.5.3	Lysine .....	32
1.2.5.4	Methionine .....	33
1.2.5.5	Phenylalanine .....	33
1.2.5.6	Threonine .....	33
1.2.5.7	Tryptophan .....	33
1.2.6	Sensory Properties .....	34
1.3	Peptides .....	34
1.3.1	General Remarks, Nomenclature .....	34
1.3.2	Physical Properties .....	36
1.3.2.1	Dissociation .....	36
1.3.3	Sensory Properties .....	36
1.3.4	Individual Peptides .....	38
1.3.4.1	Glutathione .....	38
1.3.4.2	Carnosine, Anserine and Balenine .....	39
1.3.4.3	Nisin .....	39
1.3.4.4	Lysine Peptides .....	40
1.3.4.5	Other Peptides .....	40
1.4	Proteins .....	40
1.4.1	Amino Acid Sequence .....	41
1.4.1.1	Amino Acid Composition, Subunits .....	41
1.4.1.2	Terminal Groups .....	42
1.4.1.3	Partial Hydrolysis .....	43
1.4.1.4	Sequence Analysis .....	44
1.4.1.5	Derivation of Amino Acid Sequence from the Nucleotide Sequence of the Coding Gene .....	46
1.4.2	Conformation .....	48
1.4.2.1	Extended Peptide Chains .....	48
1.4.2.2	Secondary Structure (Regular Structural Elements) .....	49
1.4.2.2.1	$\beta$ -Sheet .....	50
1.4.2.2.2	Helical Structures .....	51
1.4.2.2.3	Reverse Turns .....	52
1.4.2.2.4	Super-Secondary Structures .....	52
1.4.2.3	Tertiary and Quaternary Structures .....	53
1.4.2.3.1	Fibrous Proteins .....	53
1.4.2.3.2	Globular Proteins .....	53
1.4.2.3.3	BSE .....	55
1.4.2.3.4	Quaternary Structures .....	56
1.4.2.4	Denaturation .....	56
1.4.3	Physical Properties .....	58
1.4.3.1	Dissociation .....	58
1.4.3.2	Optical Activity .....	60
1.4.3.3	Solubility, Hydration and Swelling Power .....	60
1.4.3.4	Foam Formation and Foam Stabilization .....	62
1.4.3.5	Gel Formation .....	62

1.4.3.6	Emulsifying Effect .....	63
1.4.4	Chemical Reactions .....	64
1.4.4.1	Lysine Residue .....	64
1.4.4.1.1	Reactions Which Retain the Positive Charge .....	64
1.4.4.1.2	Reactions Resulting in a Loss of Positive Charge .....	65
1.4.4.1.3	Reactions Resulting in a Negative Charge .....	65
1.4.4.1.4	Reversible Reactions .....	66
1.4.4.2	Arginine Residue .....	66
1.4.4.3	Glutamic and Aspartic Acid Residues .....	67
1.4.4.4	Cystine Residue (cf. also Section 1.2.4.3.5) .....	67
1.4.4.5	Cysteine Residue (cf. also Section 1.2.4.3.5) .....	68
1.4.4.6	Methionine Residue .....	69
1.4.4.7	Histidine Residue .....	69
1.4.4.8	Tryptophan Residue .....	70
1.4.4.9	Tyrosine Residue .....	70
1.4.4.10	Bifunctional Reagents .....	70
1.4.4.11	Reactions Involved in Food Processing .....	70
1.4.5	Enzyme-Catalyzed Reactions .....	74
1.4.5.1	Foreword .....	74
1.4.5.2	Proteolytic Enzymes .....	74
1.4.5.2.1	Serine Endopeptidases .....	74
1.4.5.2.2	Cysteine Endopeptidases .....	76
1.4.5.2.3	Metalo Peptidases .....	76
1.4.5.2.4	Aspartic Endopeptidases .....	76
1.4.6	Chemical and Enzymatic Reactions of Interest to Food Processing .....	79
1.4.6.1	Foreword .....	79
1.4.6.2	Chemical Modification .....	80
1.4.6.2.1	Acylation .....	80
1.4.6.2.2	Alkylation .....	82
1.4.6.2.3	Redox Reactions Involving Cysteine and Cystine .....	82
1.4.6.3	Enzymatic Modification .....	83
1.4.6.3.1	Dephosphorylation .....	83
1.4.6.3.2	Plastein Reaction .....	83
1.4.6.3.3	Cross-Linking .....	86
1.4.7	Texturized Proteins .....	87
1.4.7.1	Foreword .....	87
1.4.7.2	Starting Material .....	88
1.4.7.3	Texturization .....	88
1.4.7.3.1	Spin Process .....	88
1.4.7.3.2	Extrusion Process .....	89
1.5	References .....	89
2	<b>Enzymes</b> .....	93
2.1	Foreword .....	93
2.2	General Remarks, Isolation and Nomenclature .....	93
2.2.1	Catalysis .....	93
2.2.2	Specificity .....	94
2.2.2.1	Substrate Specificity .....	94
2.2.2.2	Reaction Specificity .....	95
2.2.3	Structure .....	95

2.2.4	Isolation and Purification . . . . .	96
2.2.5	Multiple Forms of Enzymes . . . . .	97
2.2.6	Nomenclature . . . . .	97
2.2.7	Activity Units . . . . .	98
2.3	Enzyme Cofactors . . . . .	98
2.3.1	Cosubstrates . . . . .	99
2.3.1.1	Nicotinamide Adenine Dinucleotide . . . . .	99
2.3.1.2	Adenosine Triphosphate . . . . .	102
2.3.2	Prosthetic Groups . . . . .	102
2.3.2.1	Flavins . . . . .	102
2.3.2.2	Hemin . . . . .	103
2.3.2.3	Pyridoxal Phosphate . . . . .	103
2.3.3	Metal Ions . . . . .	104
2.3.3.1	Magnesium, Calcium and Zinc . . . . .	104
2.3.3.2	Iron, Copper and Molybdenum . . . . .	105
2.4	Theory of Enzyme Catalysis . . . . .	106
2.4.1	Active Site . . . . .	106
2.4.1.1	Active Site Localization . . . . .	107
2.4.1.2	Substrate Binding . . . . .	108
2.4.1.2.1	Stereospecificity . . . . .	108
2.4.1.2.2	“Lock and Key” Hypothesis . . . . .	109
2.4.1.2.3	Induced-fit Model . . . . .	109
2.4.2	Reasons for Catalytic Activity . . . . .	110
2.4.2.1	Steric Effects – Orientation Effects . . . . .	111
2.4.2.2	Structural Complementarity to Transition State . . . . .	112
2.4.2.3	Entropy Effect . . . . .	112
2.4.2.4	General Acid–Base Catalysis . . . . .	113
2.4.2.5	Covalent Catalysis . . . . .	114
2.4.3	Closing Remarks . . . . .	117
2.5	Kinetics of Enzyme-Catalyzed Reactions . . . . .	117
2.5.1	Effect of Substrate Concentration . . . . .	117
2.5.1.1	Single-Substrate Reactions . . . . .	117
2.5.1.1.1	Michaelis–Menten Equation . . . . .	117
2.5.1.1.2	Determination of $K_m$ and $V$ . . . . .	120
2.5.1.2	Two-Substrate Reactions . . . . .	121
2.5.1.2.1	Order of Substrate Binding . . . . .	121
2.5.1.2.2	Rate Equations for a Two-Substrate Reaction . . . . .	122
2.5.1.3	Allosteric Enzymes . . . . .	123
2.5.2	Effect of Inhibitors . . . . .	125
2.5.2.1	Irreversible Inhibition . . . . .	126
2.5.2.2	Reversible Inhibition . . . . .	126
2.5.2.2.1	Competitive Inhibition . . . . .	126
2.5.2.2.2	Non-Competitive Inhibition . . . . .	127
2.5.2.2.3	Uncompetitive Inhibition . . . . .	128
2.5.3	Effect of pH on Enzyme Activity . . . . .	128
2.5.4	Influence of Temperature . . . . .	130
2.5.4.1	Time Dependence of Effects . . . . .	131
2.5.4.2	Temperature Dependence of Effects . . . . .	131
2.5.4.3	Temperature Optimum . . . . .	133
2.5.4.4	Thermal Stability . . . . .	134
2.5.5	Influence of Pressure . . . . .	136

2.5.6	Influence of Water .....	137
2.6	Enzymatic Analysis .....	137
2.6.1	Substrate Determination .....	138
2.6.1.1	Principles .....	138
2.6.1.2	End-Point Method .....	138
2.6.1.3	Kinetic Method .....	140
2.6.2	Determination of Enzyme Activity .....	140
2.6.3	Enzyme Immunoassay .....	141
2.6.4	Polymerase Chain Reaction .....	142
2.6.4.1	Principle of PCR .....	143
2.6.4.2	Examples .....	144
2.6.4.2.1	Addition of Soybean .....	144
2.6.4.2.2	Genetically Modified Soybeans .....	144
2.6.4.2.3	Genetically Modified Tomatoes .....	144
2.6.4.2.4	Species Differentiation .....	144
2.7	Enzyme Utilization in the Food Industry .....	144
2.7.1	Technical Enzyme Preparations .....	145
2.7.1.1	Production .....	145
2.7.1.2	Immobilized Enzymes .....	145
2.7.1.2.1	Bound Enzymes .....	145
2.7.1.2.2	Enzyme Entrapment .....	145
2.7.1.2.3	Cross-Linked Enzymes .....	148
2.7.1.2.4	Properties .....	148
2.7.2	Individual Enzymes .....	149
2.7.2.1	Oxidoreductases .....	149
2.7.2.1.1	Glucose Oxidase .....	149
2.7.2.1.2	Catalase .....	149
2.7.2.1.3	Lipoxygenase .....	149
2.7.2.1.4	Aldehyde Dehydrogenase .....	149
2.7.2.1.5	Butanediol Dehydrogenase .....	149
2.7.2.2	Hydrolases .....	150
2.7.2.2.1	Peptidases .....	150
2.7.2.2.2	$\alpha$ - and $\beta$ -Amylases .....	150
2.7.2.2.3	Glucan-1,4- $\alpha$ -D-Glucosidase (Glucoamylase) .....	151
2.7.2.2.4	Pullulanase (Isoamylase) .....	152
2.7.2.2.5	Endo-1,3(4)- $\beta$ -D-Glucanase .....	152
2.7.2.2.6	$\alpha$ -D-Galactosidase .....	152
2.7.2.2.7	$\beta$ -D-Galactosidase (Lactase) .....	152
2.7.2.2.8	$\beta$ -D-Fructofuranosidase (Invertase) .....	152
2.7.2.2.9	$\alpha$ -L-Rhamnosidase .....	153
2.7.2.2.10	Cellulases and Hemicellulases .....	153
2.7.2.2.11	Lysozyme .....	153
2.7.2.2.12	Thioglucosidase .....	153
2.7.2.2.13	Pectolytic Enzymes .....	153
2.7.2.2.14	Lipases .....	154
2.7.2.2.15	Tannases .....	154
2.7.2.2.16	Glutaminase .....	154
2.7.2.3	Isomerases .....	154
2.7.2.4	Transferases .....	154
2.8	References .....	155

<b>3</b>	<b>Lipids</b>	158
3.1	Foreword	158
3.2	Fatty Acids	159
3.2.1	Nomenclature and Classification	159
3.2.1.1	Saturated Fatty Acids	159
3.2.1.2	Unsaturated Fatty Acids	162
3.2.1.3	Substituted Fatty Acids	164
3.2.2	Physical Properties	165
3.2.2.1	Carboxyl Group	165
3.2.2.2	Crystalline Structure, Melting Points	165
3.2.2.3	Urea Adducts	166
3.2.2.4	Solubility	167
3.2.2.5	UV-Absorption	167
3.2.3	Chemical Properties	167
3.2.3.1	Methylation of Carboxyl Groups	167
3.2.3.2	Reactions of Unsaturated Fatty Acids	168
3.2.3.2.1	Halogen Addition Reactions	168
3.2.3.2.2	Transformation of Isolene-Type Fatty Acids to Conjugated Fatty Acids	168
3.2.3.2.3	Formation of a $\pi$ -Complex with $\text{Ag}^+$ Ions	168
3.2.3.2.4	Hydrogenation	169
3.2.4	Biosynthesis of Unsaturated Fatty Acids	169
3.3	Acylglycerols	169
3.3.1	Triacylglycerols (TG)	170
3.3.1.1	Nomenclature, Classification, Calorific Value	170
3.3.1.2	Melting Properties	171
3.3.1.3	Chemical Properties	172
3.3.1.4	Structural Determination	173
3.3.1.5	Biosynthesis	177
3.3.2	Mono- and Diacylglycerols (MG, DG)	177
3.3.2.1	Occurrence, Production	177
3.3.2.2	Physical Properties	178
3.4	Phospho- and Glycolipids	178
3.4.1	Classes	178
3.4.1.1	Phosphatidyl Derivatives	178
3.4.1.2	Glyceroglycolipids	180
3.4.1.3	Sphingolipids	181
3.4.2	Analysis	182
3.4.2.1	Extraction, Removal of Nonlipids	182
3.4.2.2	Separation and Identification of Classes of Components	182
3.4.2.3	Analysis of Lipid Components	183
3.5	Lipoproteins, Membranes	183
3.5.1	Lipoproteins	183
3.5.1.1	Definition	183
3.5.1.2	Classification	184
3.5.2	Involvement of Lipids in the Formation of Biological Membranes	185
3.6	Diol Lipids, Higher Alcohols, Waxes and Cutin	186
3.6.1	Diol Lipids	186
3.6.2	Higher Alcohols and Derivatives	186
3.6.2.1	Waxes	186

3.6.2.2	Alkoxy Lipids . . . . .	187
3.6.3	Cutin . . . . .	187
3.7	Changes in Acyl Lipids of Food . . . . .	187
3.7.1	Enzymatic Hydrolysis . . . . .	187
3.7.1.1	Triacylglycerol Hydrolases (Lipases) . . . . .	188
3.7.1.2	Polar-Lipid Hydrolases . . . . .	190
3.7.1.2.1	Phospholipases . . . . .	190
3.7.1.2.2	Glycolipid Hydrolases . . . . .	190
3.7.2	Peroxidation of Unsaturated Acyl Lipids . . . . .	191
3.7.2.1	Autoxidation . . . . .	191
3.7.2.1.1	Fundamental Steps of Autoxidation . . . . .	192
3.7.2.1.2	Monohydroperoxides . . . . .	193
3.7.2.1.3	Hydroperoxide-Epidioxides . . . . .	195
3.7.2.1.4	Initiation of a Radical Chain Reaction . . . . .	196
3.7.2.1.5	Photooxidation . . . . .	196
3.7.2.1.6	Heavy Metal Ions . . . . .	198
3.7.2.1.7	Heme(in) Catalysis . . . . .	200
3.7.2.1.8	Activated Oxygen . . . . .	201
3.7.2.1.9	Secondary Products . . . . .	203
3.7.2.2	Lipoxygenase: Occurrence and Properties . . . . .	207
3.7.2.3	Enzymatic Degradation of Hydroperoxides . . . . .	209
3.7.2.4	Hydroperoxide-Protein Interactions . . . . .	211
3.7.2.4.1	Products Formed from Hydroperoxides . . . . .	211
3.7.2.4.2	Lipid-Protein Complexes . . . . .	212
3.7.2.4.3	Protein Changes . . . . .	213
3.7.2.4.4	Decomposition of Amino Acids . . . . .	214
3.7.3	Inhibition of Lipid Peroxidation . . . . .	214
3.7.3.1	Antioxidant Activity . . . . .	215
3.7.3.2	Antioxidants in Food . . . . .	215
3.7.3.2.1	Natural Antioxidants . . . . .	215
3.7.3.2.2	Synthetic Antioxidants . . . . .	218
3.7.3.2.3	Synergists . . . . .	219
3.7.3.2.4	Prooxidative Effect . . . . .	220
3.7.4	Fat or Oil Heating (Deep Frying) . . . . .	220
3.7.4.1	Autoxidation of Saturated Acyl Lipids . . . . .	221
3.7.4.2	Polymerization . . . . .	223
3.7.5	Radiolysis . . . . .	224
3.7.6	Microbial Degradation of Acyl Lipids to Methyl Ketones . . . . .	225
3.8	Unsaponifiable Constituents . . . . .	225
3.8.1	Hydrocarbons . . . . .	227
3.8.2	Steroids . . . . .	227
3.8.2.1	Structure, Nomenclature . . . . .	227
3.8.2.2	Steroids of Animal Food . . . . .	227
3.8.2.2.1	Cholesterol . . . . .	227
3.8.2.2.2	Vitamin D . . . . .	229
3.8.2.3	Plant Steroids (Phytosterols) . . . . .	229
3.8.2.3.1	Desmethylsterols . . . . .	229
3.8.2.3.2	Methyl- and Dimethylsterols . . . . .	231
3.8.2.4	Analysis . . . . .	232
3.8.3	Tocopherols and Tocotrienols . . . . .	233
3.8.3.1	Structure, Importance . . . . .	233

3.8.3.2	Analysis .....	234
3.8.4	Carotenoids .....	234
3.8.4.1	Chemical Structure, Occurrence .....	235
3.8.4.1.1	Carotenes .....	236
3.8.4.1.2	Xanthophylls .....	237
3.8.4.2	Physical Properties .....	240
3.8.4.3	Chemical Properties .....	241
3.8.4.4	Precursors of Aroma Compounds .....	241
3.8.4.5	Use of Carotenoids in Food Processing .....	244
3.8.4.5.1	Plant Extracts .....	244
3.8.4.5.2	Individual Compounds .....	244
3.8.4.6	Analysis .....	244
3.9	References .....	245
<b>4</b>	<b>Carbohydrates .....</b>	<b>248</b>
4.1	Foreword .....	248
4.2	Monosaccharides .....	248
4.2.1	Structure and Nomenclature .....	248
4.2.1.1	Nomenclature .....	248
4.2.1.2	Configuration .....	249
4.2.1.3	Conformation .....	254
4.2.2	Physical Properties .....	256
4.2.2.1	Hygroscopicity and Solubility .....	256
4.2.2.2	Optical Rotation, Mutarotation .....	257
4.2.3	Sensory Properties .....	258
4.2.4	Chemical Reactions and Derivatives .....	261
4.2.4.1	Reduction to Sugar Alcohols .....	261
4.2.4.2	Oxidation to Aldonic, Dicarboxylic and Uronic Acids .....	262
4.2.4.3	Reactions in the Presence of Acids and Alkalies .....	263
4.2.4.3.1	Reactions in Strongly Acidic Media .....	263
4.2.4.3.2	Reactions in Strongly Alkaline Solution .....	266
4.2.4.3.3	Caramelization .....	270
4.2.4.4	Reactions with Amino Compounds ( <i>Maillard Reaction</i> ) .....	270
4.2.4.4.1	Initial Phase of the Maillard Reaction .....	271
4.2.4.4.2	Formation of Deoxyosones .....	272
4.2.4.4.3	Secondary Products of 3-Deoxyosones .....	274
4.2.4.4.4	Secondary Products of 1-Deoxyosones .....	276
4.2.4.4.5	Secondary Products of 4-Deoxyosones .....	280
4.2.4.4.6	Redox Reactions .....	282
4.2.4.4.7	<i>Strecker Reaction</i> .....	282
4.2.4.4.8	Formation of Colored Compounds .....	284
4.2.4.4.9	Protein Modifications .....	285
4.2.4.4.10	Inhibition of the Maillard Reaction .....	289
4.2.4.5	Reactions with Hydroxy Compounds (O-Glycosides) .....	289
4.2.4.6	Esters .....	290
4.2.4.7	Ethers .....	291
4.2.4.8	Cleavage of Glycols .....	292
4.3	Oligosaccharides .....	292
4.3.1	Structure and Nomenclature .....	292
4.3.2	Properties and Reactions .....	294
4.4	Polysaccharides .....	296

4.4.1	Classification, Structure . . . . .	296
4.4.2	Conformation . . . . .	296
4.4.2.1	Extended or Stretched, Ribbon-Type Conformation . . . . .	296
4.4.2.2	Hollow Helix-Type Conformation . . . . .	297
4.4.2.3	Crumpled-Type Conformation . . . . .	298
4.4.2.4	Loosely-Jointed Conformation . . . . .	298
4.4.2.5	Conformations of Heteroglycans . . . . .	298
4.4.2.6	Interchain Interactions . . . . .	298
4.4.3	Properties . . . . .	300
4.4.3.1	General Remarks . . . . .	300
4.4.3.2	Perfectly Linear Polysaccharides . . . . .	300
4.4.3.3	Branched Polysaccharides . . . . .	300
4.4.3.4	Linearly Branched Polysaccharides . . . . .	301
4.4.3.5	Polysaccharides with Carboxyl Groups . . . . .	301
4.4.3.6	Polysaccharides with Strongly Acidic Groups . . . . .	302
4.4.3.7	Modified Polysaccharides . . . . .	302
4.4.3.7.1	Derivatization with Neutral Substituents . . . . .	302
4.4.3.7.2	Derivatization with Acidic Substituents . . . . .	302
4.4.4	Individual Polysaccharides . . . . .	302
4.4.4.1	Agar . . . . .	302
4.4.4.1.1	Occurrence, Isolation . . . . .	302
4.4.4.1.2	Structure, Properties . . . . .	302
4.4.4.1.3	Utilization . . . . .	303
4.4.4.2	Alginates . . . . .	303
4.4.4.2.1	Occurrence, Isolation . . . . .	303
4.4.4.2.2	Structure, Properties . . . . .	303
4.4.4.2.3	Derivatives . . . . .	304
4.4.4.2.4	Utilization . . . . .	304
4.4.4.3	Carageenans . . . . .	304
4.4.4.3.1	Occurrence, Isolation . . . . .	304
4.4.4.3.2	Structure, Properties . . . . .	305
4.4.4.3.3	Utilization . . . . .	306
4.4.4.4	Furcellaran . . . . .	306
4.4.4.4.1	Occurrence, Isolation . . . . .	306
4.4.4.4.2	Structure, Properties . . . . .	307
4.4.4.4.3	Utilization . . . . .	307
4.4.4.5	Gum Arabic . . . . .	307
4.4.4.5.1	Occurrence, Isolation . . . . .	307
4.4.4.5.2	Structure, Properties . . . . .	307
4.4.4.5.3	Utilization . . . . .	309
4.4.4.6	Gum Ghatti . . . . .	309
4.4.4.6.1	Occurrence . . . . .	309
4.4.4.6.2	Structure, Properties . . . . .	309
4.4.4.6.3	Utilization . . . . .	309
4.4.4.7	Gum Tragacanth . . . . .	310
4.4.4.7.1	Occurrence . . . . .	310
4.4.4.7.2	Structure, Properties . . . . .	310
4.4.4.7.3	Utilization . . . . .	310
4.4.4.8	Karaya Gum . . . . .	310
4.4.4.8.1	Occurrence . . . . .	310
4.4.4.8.2	Structure, Properties . . . . .	310

4.4.4.8.3	Utilization . . . . .	311
4.4.4.9	Guaran Gum . . . . .	311
4.4.4.9.1	Occurrence, Isolation . . . . .	311
4.4.4.9.2	Structure, Properties . . . . .	311
4.4.4.9.3	Utilization . . . . .	312
4.4.4.10	Locust Bean Gum . . . . .	312
4.4.4.10.1	Occurrence, Isolation . . . . .	312
4.4.4.10.2	Structure, Properties . . . . .	312
4.4.4.10.3	Utilization . . . . .	312
4.4.4.11	Tamarind Flour . . . . .	312
4.4.4.11.1	Occurrence, Isolation . . . . .	312
4.4.4.11.2	Structure, Properties . . . . .	312
4.4.4.11.3	Utilization . . . . .	313
4.4.4.12	Arabinogalactan from Larch . . . . .	313
4.4.4.12.1	Occurrence, Isolation . . . . .	313
4.4.4.12.2	Structure, Properties . . . . .	313
4.4.4.12.3	Utilization . . . . .	313
4.4.4.13	Pectin . . . . .	314
4.4.4.13.1	Occurrence, Isolation . . . . .	314
4.4.4.13.2	Structure, Properties . . . . .	314
4.4.4.13.3	Utilization . . . . .	315
4.4.4.14	Starch . . . . .	315
4.4.4.14.1	Occurrence, Isolation . . . . .	315
4.4.4.14.2	Structure and Properties of Starch Granules . . . . .	316
4.4.4.14.3	Structure and Properties of Amylose . . . . .	321
4.4.4.14.4	Structure and Properties of Amylopectin . . . . .	323
4.4.4.14.5	Utilization . . . . .	324
4.4.4.14.6	Resistant Starch . . . . .	325
4.4.4.15	Modified Starches . . . . .	325
4.4.4.15.1	Mechanically Damaged Starches . . . . .	325
4.4.4.15.2	Extruded Starches . . . . .	325
4.4.4.15.3	Dextrins . . . . .	326
4.4.4.15.4	Pregelatinized Starch . . . . .	326
4.4.4.15.5	Thin-Boiling Starch . . . . .	326
4.4.4.15.6	Starch Ethers . . . . .	326
4.4.4.15.7	Starch Esters . . . . .	326
4.4.4.15.8	Cross-Linked Starches . . . . .	327
4.4.4.15.9	Oxidized Starches . . . . .	327
4.4.4.16	Cellulose . . . . .	327
4.4.4.16.1	Occurrence, Isolation . . . . .	327
4.4.4.16.2	Structure, Properties . . . . .	328
4.4.4.16.3	Utilization . . . . .	328
4.4.4.17	Cellulose Derivatives . . . . .	328
4.4.4.17.1	Alkyl Cellulose, Hydroxyalkyl Cellulose . . . . .	329
4.4.4.17.2	Carboxymethyl Cellulose . . . . .	329
4.4.4.18	Hemicelluloses . . . . .	330
4.4.4.19	Xanthan Gum . . . . .	331
4.4.4.19.1	Occurrence, Isolation . . . . .	331
4.4.4.19.2	Structure, Properties . . . . .	331
4.4.4.19.3	Utilization . . . . .	331
4.4.4.20	Scleroglucan . . . . .	331

4.4.4.20.1	Occurrence, Isolation .....	331
4.4.4.20.2	Structure, Properties .....	331
4.4.4.20.3	Utilization .....	332
4.4.4.21	Dextran .....	332
4.4.4.21.1	Occurrence .....	332
4.4.4.21.2	Structure, Properties .....	332
4.4.4.21.3	Utilization .....	332
4.4.4.22	Inulin and Oligofructose .....	332
4.4.4.22.1	Occurrence .....	332
4.4.4.22.2	Structure .....	332
4.4.4.22.3	Utilization .....	332
4.4.4.23	Polyvinyl Pyrrolidone (PVP) .....	333
4.4.4.23.1	Structure, Properties .....	333
4.4.4.23.2	Utilization .....	333
4.4.5	Enzymatic Degradation of Polysaccharides .....	333
4.4.5.1	Amylases .....	333
4.4.5.1.1	$\alpha$ -Amylase .....	333
4.4.5.1.2	$\beta$ -Amylase .....	333
4.4.5.1.3	Glucan-1,4- $\alpha$ -D-glucosidase (Glucoamylase) .....	333
4.4.5.1.4	$\alpha$ -Dextrin Endo-1,6- $\alpha$ -glucosidase (Pullulanase) .....	334
4.4.5.2	Pectinolytic Enzymes .....	334
4.4.5.3	Cellulases .....	335
4.4.5.4	Endo-1,3(4)- $\beta$ -glucanase .....	335
4.4.5.5	Hemicellulases .....	335
4.4.6	Analysis of Polysaccharides .....	335
4.4.6.1	Thickening Agents .....	335
4.4.6.2	Dietary Fibers .....	336
4.5	References .....	337
<b>5</b>	<b>Aroma Compounds .....</b>	<b>340</b>
5.1	Foreword .....	340
5.1.1	Concept Delineation .....	340
5.1.2	Impact Compounds of Natural Aromas .....	340
5.1.3	Threshold Value .....	341
5.1.4	Aroma Value .....	342
5.1.5	Off-Flavors, Food Taints .....	343
5.2	Aroma Analysis .....	345
5.2.1	Aroma Isolation .....	345
5.2.1.1	Distillation, Extraction .....	346
5.2.1.2	Gas Extraction .....	348
5.2.1.3	Headspace Analysis .....	348
5.2.2	Sensory Relevance .....	349
5.2.2.1	Aroma Extract Dilution Analysis (AEDA) .....	350
5.2.2.2	Headspace GC Olfactometry .....	350
5.2.3	Enrichment .....	351
5.2.4	Chemical Structure .....	353
5.2.5	Enantioselective Analysis .....	353
5.2.6	Quantitative Analysis, Aroma Values .....	356
5.2.6.1	Isotopic Dilution Analysis (IDA) .....	356
5.2.6.2	Aroma Values (AV) .....	356
5.2.7	Aroma Model, Omission Experiments .....	357

5.3	Individual Aroma Compounds . . . . .	359
5.3.1	Nonenzymatic Reactions . . . . .	360
5.3.1.1	Carbonyl Compounds . . . . .	361
5.3.1.2	Pyranones . . . . .	361
5.3.1.3	Furanones . . . . .	361
5.3.1.4	Thiols, Thioethers, Di- and Trisulfides . . . . .	363
5.3.1.5	Thiazoles . . . . .	367
5.3.1.6	Pyrroles, Pyridines . . . . .	367
5.3.1.7	Pyrazines . . . . .	371
5.3.1.8	Amines . . . . .	373
5.3.1.9	Phenols . . . . .	374
5.3.2	Enzymatic Reactions . . . . .	374
5.3.2.1	Carbonyl Compounds, Alcohols . . . . .	376
5.3.2.2	Hydrocarbons, Esters . . . . .	379
5.3.2.3	Lactones . . . . .	380
5.3.2.4	Terpenes . . . . .	382
5.3.2.5	Volatile Sulfur Compounds . . . . .	387
5.3.2.6	Pyrazines . . . . .	388
5.3.2.7	Skatole, p-Cresol . . . . .	388
5.4	Interactions with Other Food Constituents . . . . .	389
5.4.1	Lipids . . . . .	390
5.4.2	Proteins, Polysaccharides . . . . .	391
5.5	Natural and Synthetic Flavorings . . . . .	393
5.5.1	Raw Materials for Essences . . . . .	393
5.5.1.1	Essential Oils . . . . .	394
5.5.1.2	Extracts, Absolues . . . . .	394
5.5.1.3	Distillates . . . . .	394
5.5.1.4	Microbial Aromas . . . . .	394
5.5.1.5	Synthetic Natural Aroma Compounds . . . . .	395
5.5.1.6	Synthetic Aroma Compounds . . . . .	395
5.5.2	Essences . . . . .	396
5.5.3	Aromas from Precursors . . . . .	397
5.5.4	Stability of Aromas . . . . .	397
5.5.5	Encapsulation of Aromas . . . . .	398
5.6	Relationships Between Structure and Odor . . . . .	398
5.6.1	General Aspects . . . . .	398
5.6.2	Carbonyl Compounds . . . . .	398
5.6.3	Alkyl Pyrazines . . . . .	399
5.7	References . . . . .	400
6	<b>Vitamins . . . . .</b>	403
6.1	Foreword . . . . .	403
6.2	Fat-Soluble Vitamins . . . . .	404
6.2.1	Retinol (Vitamin A) . . . . .	404
6.2.1.1	Biological Role . . . . .	404
6.2.1.2	Requirement, Occurrence . . . . .	404
6.2.1.3	Stability, Degradation . . . . .	406
6.2.2	Calciferol (Vitamin D) . . . . .	406
6.2.2.1	Biological Role . . . . .	406
6.2.2.2	Requirement, Occurrence . . . . .	406
6.2.2.3	Stability, Degradation . . . . .	407

6.2.3	$\alpha$ -Tocopherol (Vitamin E) . . . . .	407
6.2.3.1	Biological Role . . . . .	407
6.2.3.2	Requirement, Occurrence . . . . .	407
6.2.3.3	Stability, Degradation . . . . .	408
6.2.4	Phytomenadione (Vitamin K <sub>1</sub> Phylloquinone) . . . . .	408
6.2.4.1	Biological Role . . . . .	408
6.2.4.2	Requirement, Occurrence . . . . .	408
6.2.4.3	Stability, Degradation . . . . .	408
6.3	Water-Soluble Vitamins . . . . .	411
6.3.1	Thiamine (Vitamin B <sub>1</sub> ) . . . . .	411
6.3.1.1	Biological Role . . . . .	411
6.3.1.2	Requirement, Occurrence . . . . .	411
6.3.1.3	Stability, Degradation . . . . .	412
6.3.2	Riboflavin (Vitamin B <sub>2</sub> ) . . . . .	413
6.3.2.1	Biological Role . . . . .	413
6.3.2.2	Requirement, Occurrence . . . . .	413
6.3.2.3	Stability, Degradation . . . . .	413
6.3.3	Pyridoxine (Pyridoxal, Vitamin B <sub>6</sub> ) . . . . .	413
6.3.3.1	Biological Role . . . . .	413
6.3.3.2	Requirement, Occurrence . . . . .	414
6.3.3.3	Stability, Degradation . . . . .	414
6.3.4	Nicotinamide (Niacin) . . . . .	414
6.3.4.1	Biological Role . . . . .	414
6.3.4.2	Requirement, Occurrence . . . . .	414
6.3.4.3	Stability, Degradation . . . . .	415
6.3.5	Pantothenic Acid . . . . .	415
6.3.5.1	Biological Role . . . . .	415
6.3.5.2	Requirement, Occurrence . . . . .	415
6.3.5.3	Stability, Degradation . . . . .	415
6.3.6	Biotin . . . . .	415
6.3.6.1	Biological Role . . . . .	415
6.3.6.2	Requirement, Occurrence . . . . .	415
6.3.6.3	Stability, Degradation . . . . .	415
6.3.7	Folic Acid . . . . .	415
6.3.7.1	Biological Role . . . . .	415
6.3.7.2	Requirement, Occurrence . . . . .	416
6.3.7.3	Stability, Degradation . . . . .	416
6.3.8	Cyanocobalamin (Vitamin B <sub>12</sub> ) . . . . .	416
6.3.8.1	Biological Role . . . . .	416
6.3.8.2	Requirement, Occurrence . . . . .	417
6.3.8.3	Stability, Degradation . . . . .	417
6.3.9	L-Ascorbic Acid (Vitamin C) . . . . .	417
6.3.9.1	Biological Role . . . . .	417
6.3.9.2	Requirement, Occurrence . . . . .	417
6.3.9.3	Stability, Degradation . . . . .	418
6.4	References . . . . .	420
7	<b>Minerals</b> . . . . .	421
7.1	Foreword . . . . .	421
7.2	Main Elements . . . . .	421
7.2.1	Sodium . . . . .	421

7.2.2	Potassium . . . . .	423
7.2.3	Magnesium . . . . .	424
7.2.4	Calcium . . . . .	424
7.2.5	Chloride . . . . .	424
7.2.6	Phosphorus . . . . .	424
7.3	Trace Elements . . . . .	424
7.3.1	General Remarks . . . . .	424
7.3.2	Individual Trace Elements . . . . .	424
7.3.2.1	Iron . . . . .	424
7.3.2.2	Copper . . . . .	425
7.3.2.3	Zinc . . . . .	425
7.3.2.4	Manganese . . . . .	425
7.3.2.5	Cobalt . . . . .	426
7.3.2.6	Chromium . . . . .	426
7.3.2.7	Selenium . . . . .	426
7.3.2.8	Molybdenum . . . . .	426
7.3.2.9	Nickel . . . . .	426
7.3.2.10	Fluorine . . . . .	426
7.3.2.11	Iodine . . . . .	427
7.3.3	Ultra-trace Elements . . . . .	427
7.3.3.1	Tin . . . . .	427
7.3.3.2	Aluminum . . . . .	427
7.3.3.3	Boron . . . . .	427
7.3.3.4	Silicon . . . . .	428
7.3.3.5	Arsenic . . . . .	428
7.4	Minerals in Food Processing . . . . .	428
7.5	References . . . . .	428
<b>8</b>	<b>Food Additives . . . . .</b>	<b>429</b>
8.1	Foreword . . . . .	429
8.2	Vitamins . . . . .	430
8.3	Amino Acids . . . . .	430
8.4	Minerals . . . . .	430
8.5	Aroma Substances . . . . .	430
8.6	Flavor Enhancers . . . . .	430
8.6.1	Monosodium Glutamate (MSG) . . . . .	430
8.6.2	5'-Nucleotides . . . . .	431
8.6.3	Maltol . . . . .	431
8.6.4	Compounds with a Cooling Effect . . . . .	431
8.7	Sugar Substitutes . . . . .	432
8.8	Sweeteners . . . . .	432
8.8.1	Sweet Taste: Structural Requirements . . . . .	432
8.8.1.1	Structure-Activity Relationships in Sweet Compounds . . . . .	432
8.8.1.2	Synergism . . . . .	433
8.8.2	Saccharin . . . . .	433
8.8.3	Cyclamate . . . . .	434
8.8.4	Monellin . . . . .	436
8.8.5	Thaumatin . . . . .	437
8.8.6	Curculin and Miraculin . . . . .	438
8.8.7	<i>Gymnema silvestre</i> Extract . . . . .	438
8.8.8	Stevioside . . . . .	438

8.8.9	Phyllodulcin . . . . .	439
8.8.10	Glycyrrhizin . . . . .	439
8.8.11	Dihydrochalcones . . . . .	439
8.8.12	Ureas and Guanidines . . . . .	439
8.8.12.1	Suosan . . . . .	439
8.8.12.2	Guanidines . . . . .	440
8.8.13	Oximes . . . . .	440
8.8.14	Oxathiazinone Dioxides . . . . .	440
8.8.15	Dipeptide Esters and Amides . . . . .	441
8.8.15.1	Aspartame . . . . .	441
8.8.15.2	Superaspartame . . . . .	442
8.8.15.3	Alitame . . . . .	442
8.8.16	Hernandulcin . . . . .	442
8.9	Food Colors . . . . .	443
8.10	Acids . . . . .	443
8.10.1	Acetic Acid and Other Fatty Acids . . . . .	443
8.10.2	Succinic Acid . . . . .	443
8.10.3	Succinic Acid Anhydride . . . . .	447
8.10.4	Adipic Acid . . . . .	447
8.10.5	Fumaric Acid . . . . .	447
8.10.6	Lactic Acid . . . . .	448
8.10.7	Malic Acid . . . . .	448
8.10.8	Tartaric Acid . . . . .	448
8.10.9	Citric Acid . . . . .	448
8.10.10	Phosphoric Acid . . . . .	449
8.10.11	Hydrochloric and Sulfuric Acids . . . . .	449
8.10.12	Gluconic Acid and Glucono- $\delta$ -lactone . . . . .	449
8.11	Bases . . . . .	449
8.12	Antimicrobial Agents . . . . .	449
8.12.1	Benzoic Acid . . . . .	449
8.12.2	PHB-Esters . . . . .	450
8.12.3	Sorbic Acid . . . . .	451
8.12.4	Propionic Acid . . . . .	452
8.12.5	Acetic Acid . . . . .	452
8.12.6	SO <sub>2</sub> and Sulfite . . . . .	452
8.12.7	Diethyl (Dimethyl) Pyrocarbonate . . . . .	453
8.12.8	Ethylene Oxide, Propylene Oxide . . . . .	453
8.12.9	Nitrite, Nitrate . . . . .	454
8.12.10	Antibiotics . . . . .	454
8.12.11	Diphenyl . . . . .	454
8.12.12	o-Phenylphenol . . . . .	454
8.12.13	Thiabendazole, 2-(4-Thiazolyl)benzimidazole . . . . .	454
8.13	Antioxidants . . . . .	455
8.14	Chelating Agents (Sequestrants) . . . . .	455
8.15	Surface-Active Agents . . . . .	456
8.15.1	Emulsions . . . . .	456
8.15.2	Emulsifier Action . . . . .	457
8.15.2.1	Structure and Activity . . . . .	457
8.15.2.2	Critical Micelle Concentration (CMC), Lyotropic Mesomorphism . . . . .	458
8.15.2.3	HLB-Value . . . . .	459

8.15.3	Synthetic Emulsifiers .....	460
8.15.3.1	Mono-, Diacylglycerides and Derivatives .....	460
8.15.3.2	Sugar Esters .....	462
8.15.3.3	Sorbitan Fatty Acid Esters .....	462
8.15.3.4	Polyoxyethylene Sorbitan Esters .....	462
8.15.3.5	Polyglycerol – Polyricinoleate (PGPR) .....	462
8.15.3.6	Stearyl-2-Lactylate .....	463
8.16	Substitutes for Fat .....	463
8.16.1	Fat Mimetics .....	463
8.16.1.1	Microparticulated Proteins .....	463
8.16.1.2	Carbohydrates .....	463
8.16.2	Synthetic Fat Substitutes .....	463
8.16.2.1	Carbohydrate Polyester .....	464
8.16.2.2	Retrofats .....	464
8.17	Thickening Agents, Gel Builders, Stabilizers .....	464
8.18	Humectants .....	464
8.19	Anticaking Agents .....	464
8.20	Bleaching Agents .....	464
8.21	Clarifying Agents .....	464
8.22	Propellants, Protective Gases .....	465
8.23	References .....	465
<b>9</b>	<b>Food Contamination .....</b>	<b>467</b>
9.1	General Remarks .....	467
9.2	Toxic Trace Elements .....	468
9.2.1	Arsenic .....	468
9.2.2	Mercury .....	468
9.2.3	Lead .....	468
9.2.4	Cadmium .....	469
9.2.5	Radionuclides .....	470
9.3	Toxic Compounds of Microbial Origin .....	470
9.3.1	Food Poisoning by Bacterial Toxins .....	470
9.3.2	Mycotoxins .....	472
9.4	Plant-Protective Agents (PPA) .....	475
9.4.1	General Remarks .....	475
9.4.2	Active Agents .....	476
9.4.2.1	Insecticides .....	476
9.4.2.2	Fungicides .....	476
9.4.2.3	Herbicides .....	483
9.4.3	Analysis .....	483
9.4.4	PPA Residues, Risk Assessment .....	485
9.4.4.1	Exceeding the Maximum Permissible Quantity .....	485
9.4.4.2	Risk Assessment .....	485
9.4.4.3	Natural Pesticides .....	486
9.5	Veterinary Medicines and Feed Additives .....	486
9.5.1	Foreword .....	486
9.5.2	Antibiotics .....	487
9.5.3	Anthelmintics .....	487
9.5.4	Coccidiostats .....	487
9.5.5	Analysis .....	487
9.6	Polychlorinated Biphenyls (PCBs) .....	489

9.7	Harmful Substances from Thermal Processes .....	490
9.7.1	Polycyclic Aromatic Hydrocarbons (PAHs).....	490
9.7.2	Furan .....	490
9.7.3	Acrylamide .....	490
9.8	Nitrate, Nitrite, Nitrosamines.....	492
9.8.1	Nitrate, Nitrite .....	492
9.8.2	Nitrosamines, Nitrosamides .....	492
9.9	Cleansing Agents and Disinfectants .....	495
9.10	Polychlorinated Dibenzodioxins (PCDD) and Dibenzofurans (PCDF) .....	496
9.11	References .....	497
<b>10</b>	<b>Milk and Dairy Products .....</b>	<b>498</b>
10.1	Milk .....	498
10.1.1	Physical and Physico-Chemical.....	498
10.1.2	Composition .....	501
10.1.2.1	Proteins .....	501
10.1.2.1.1	Casein Fractions .....	502
10.1.2.1.2	Micelle Formation.....	508
10.1.2.1.3	Gel Formation .....	509
10.1.2.1.4	Whey Proteins .....	511
10.1.2.2	Carbohydrates .....	512
10.1.2.3	Lipids .....	513
10.1.2.4	Organic Acids .....	515
10.1.2.5	Minerals .....	515
10.1.2.6	Vitamins .....	515
10.1.2.7	Enzymes .....	516
10.1.2.7.1	Plasmin.....	516
10.1.2.7.2	Lactoperoxidase .....	517
10.1.3	Processing of Milk .....	517
10.1.3.1	Purification .....	518
10.1.3.2	Creaming .....	518
10.1.3.3	Heat Treatment .....	518
10.1.3.4	Homogenization .....	518
10.1.3.5	Reactions During Heating .....	519
10.1.4	Types of Milk .....	520
10.2	Dairy Products .....	521
10.2.1	Fermented Milk Products .....	521
10.2.1.1	Sour Milk .....	523
10.2.1.2	Yoghurt .....	523
10.2.1.3	Kefir and Kumiss .....	523
10.2.1.4	Taette Milk .....	524
10.2.2	Cream .....	524
10.2.3	Butter .....	524
10.2.3.1	Cream Separation and Treatment .....	525
10.2.3.2	Churning .....	525
10.2.3.3	Packaging .....	526
10.2.3.4	Products Derived from Butter .....	526
10.2.4	Condensed Milk .....	526
10.2.5	Dehydrated Milk Products .....	527
10.2.6	Coffee Whitener .....	528

10.2.7	Ice Cream . . . . .	528
10.2.8	Cheese . . . . .	529
10.2.8.1	Curd Formation . . . . .	529
10.2.8.2	Unripened Cheese . . . . .	530
10.2.8.3	Ripening . . . . .	532
10.2.8.4	Processed Cheese . . . . .	536
10.2.8.5	Imitation Cheese . . . . .	536
10.2.9	Casein, Caseinates, Coprecipitate . . . . .	536
10.2.10	Whey Products . . . . .	537
10.2.10.1	Whey Powder . . . . .	537
10.2.10.2	Demineralized Whey Powder . . . . .	538
10.2.10.3	Partially Desugared Whey Protein Concentrates . . . . .	538
10.2.10.4	Hydrolyzed Whey Syrups . . . . .	539
10.2.11	Lactose . . . . .	539
10.2.12	Cholesterol-Reduced Milk and Milk Products . . . . .	539
10.3	Aroma of Milk and Dairy Products . . . . .	539
10.3.1	Milk, Cream . . . . .	539
10.3.2	Condensed Milk, Dried Milk Products . . . . .	539
10.3.3	Sour Milk Products, Yoghurt . . . . .	540
10.3.4	Butter . . . . .	540
10.3.5	Cheese . . . . .	541
10.3.6	Aroma Defects . . . . .	543
10.4	References . . . . .	544
<b>11</b>	<b>Eggs . . . . .</b>	<b>546</b>
11.1	Foreword . . . . .	546
11.2	Structure, Physical Properties and Composition . . . . .	546
11.2.1	General Outline . . . . .	546
11.2.2	Shell . . . . .	547
11.2.3	Albumen (Egg White) . . . . .	548
11.2.3.1	Proteins . . . . .	548
11.2.3.1.1	Ovalbumin . . . . .	548
11.2.3.1.2	Conalbumin (Ovotransferrin) . . . . .	550
11.2.3.1.3	Ovomucoid . . . . .	550
11.2.3.1.4	Lysozyme (Ovoglobulin G1) . . . . .	550
11.2.3.1.5	Ovoglobulins G2 and G3 . . . . .	551
11.2.3.1.6	Ovomucin . . . . .	551
11.2.3.1.7	Flavoprotein . . . . .	551
11.2.3.1.8	Ovoinhibitor . . . . .	551
11.2.3.1.9	Avidin . . . . .	551
11.2.3.1.10	Cystatin (Ficin Inhibitor) . . . . .	551
11.2.3.2	Other Constituents . . . . .	551
11.2.3.2.1	Lipids . . . . .	551
11.2.3.2.2	Carbohydrates . . . . .	552
11.2.3.2.3	Minerals . . . . .	552
11.2.3.2.4	Vitamins . . . . .	552
11.2.4	Egg Yolk . . . . .	553
11.2.4.1	Proteins of Granules . . . . .	554
11.2.4.1.1	Lipovitellins . . . . .	554
11.2.4.1.2	Phosvitin . . . . .	554
11.2.4.2	Plasma Proteins . . . . .	555

11.2.4.2.1	Lipovitellenin .....	555
11.2.4.2.2	Livetin .....	555
11.2.4.3	Lipids .....	555
11.2.4.4	Other Constituents .....	556
11.2.4.4.1	Carbohydrates .....	556
11.2.4.4.2	Minerals .....	556
11.2.4.4.3	Vitamins .....	556
11.2.4.4.4	Aroma Substances .....	557
11.2.4.4.5	Colorants .....	557
11.3	Storage of Eggs .....	557
11.4	Egg Products .....	557
11.4.1	General Outline .....	557
11.4.2	Technically-Important Properties .....	558
11.4.2.1	Thermal Coagulation .....	558
11.4.2.2	Foaming Ability .....	558
11.4.2.2.1	Egg White .....	558
11.4.2.2.2	Egg Yolk .....	559
11.4.2.3	Emulsifying Effect .....	559
11.4.3	Dried Products .....	559
11.4.4	Frozen Egg Products .....	560
11.4.5	Liquid Egg Products .....	561
11.5	References .....	561
<b>12</b>	<b>Meat .....</b>	<b>563</b>
12.1	Foreword .....	563
12.2	Structure of Muscle Tissue .....	564
12.2.1	Skeletal Muscle .....	564
12.2.2	Heart Muscle .....	567
12.2.3	Smooth Muscle .....	567
12.3	Muscle Tissue: Composition and Function .....	568
12.3.1	Overview .....	568
12.3.2	Proteins .....	568
12.3.2.1	Proteins of the Contractile Apparatus and Their Functions .....	568
12.3.2.1.1	Myosin .....	568
12.3.2.1.2	Titin .....	569
12.3.2.1.3	Actin .....	570
12.3.2.1.4	Tropomyosin and Troponin .....	571
12.3.2.1.5	Other Myofibrillar Proteins .....	571
12.3.2.1.6	Contraction and Relaxation .....	572
12.3.2.1.7	Actomyosin .....	573
12.3.2.2	Soluble Proteins .....	573
12.3.2.2.1	Enzymes .....	573
12.3.2.2.2	Myoglobin .....	573
12.3.2.2.3	Color of Meat .....	575
12.3.2.2.4	Curing, Reddening .....	576
12.3.2.3	Insoluble Proteins .....	577
12.3.2.3.1	Collagen .....	577
12.3.2.3.2	Elastin .....	584
12.3.3	Free Amino Acids .....	584
12.3.4	Peptides .....	584
12.3.5	Amines .....	584

12.3.6	Guanidine Compounds .....	585
12.3.7	Quaternary Ammonium Compounds .....	585
12.3.8	Purines and Pyrimidines .....	586
12.3.9	Organic Acids .....	586
12.3.10	Carbohydrates .....	586
12.3.11	Vitamins .....	586
12.3.12	Minerals .....	587
12.4	Post Mortem Changes in Muscle .....	587
12.4.1	Rigor Mortis .....	587
12.4.2	Defects (PSE and DFD Meat) .....	588
12.4.3	Aging of Meat .....	589
12.5	Water Holding Capacity of Meat .....	590
12.6	Kinds of Meat, Storage, Processing .....	592
12.6.1	Kinds of Meat, By-Products .....	592
12.6.1.1	Beef .....	592
12.6.1.2	Veal .....	592
12.6.1.3	Mutton and Lamb .....	593
12.6.1.4	Goat Meat .....	593
12.6.1.5	Pork .....	593
12.6.1.6	Horse Meat .....	593
12.6.1.7	Poultry .....	593
12.6.1.8	Game .....	593
12.6.1.9	Variety Meats .....	593
12.6.1.10	Blood .....	594
12.6.1.11	Glandular Products .....	595
12.6.2	Storage and Preservation Processes .....	595
12.6.2.1	Cooling .....	595
12.6.2.2	Freezing .....	595
12.6.2.3	Drying .....	597
12.6.2.4	Salt and Pickle Curing .....	597
12.6.2.5	Smoking .....	597
12.6.2.6	Heating .....	597
12.6.2.7	Tenderizing .....	598
12.7	Meat Products .....	598
12.7.1	Canned Meat .....	598
12.7.2	Ham, Sausages, Pastes .....	598
12.7.2.1	Ham, Bacon .....	598
12.7.2.1.1	Raw Smoked Hams .....	598
12.7.2.1.2	Cooked Ham .....	598
12.7.2.1.3	Bacon .....	599
12.7.2.2	Sausages .....	599
12.7.2.2.1	Raw Sausages .....	600
12.7.2.2.2	Cooked Sausages .....	600
12.7.2.2.3	Boiling Sausages .....	601
12.7.2.3	Meat Paste (Pâté) .....	601
12.7.2.3.1	Pastes .....	601
12.7.2.3.2	Pains .....	601
12.7.3	Meat Extracts and Related Products .....	601
12.7.3.1	Beef Extract .....	601
12.7.3.2	Whale Meat Extract .....	602
12.7.3.3	Poultry Meat Extract .....	602

12.7.3.4	Yeast Extract . . . . .	602
12.7.3.5	Hydrolyzed Vegetable Proteins . . . . .	602
12.8	Dry Soups and Dry Sauces . . . . .	603
12.8.1	Main Components . . . . .	603
12.8.2	Production . . . . .	604
12.9	Meat Aroma . . . . .	605
12.9.1	Taste compounds . . . . .	605
12.9.2	Odorants . . . . .	605
12.9.3	Process Flavors . . . . .	607
12.9.4	Aroma Defects . . . . .	608
12.10	Meat Analysis . . . . .	608
12.10.1	Meat . . . . .	608
12.10.1.1	Animal Origin . . . . .	608
12.10.1.1.1	Electrophoresis . . . . .	608
12.10.1.1.2	Sexual Origin of Beef . . . . .	610
12.10.1.2	Differentiation of Fresh and Frozen Meat . . . . .	610
12.10.1.3	Pigments . . . . .	611
12.10.1.4	Treatment with Proteinase Preparations . . . . .	611
12.10.1.5	Anabolic Steroids . . . . .	612
12.10.1.6	Antibiotics . . . . .	612
12.10.2	Processed Meats . . . . .	612
12.10.2.1	Main Ingredients . . . . .	613
12.10.2.2	Added Water . . . . .	613
12.10.2.3	Lean Meat Free of Connective Tissue . . . . .	613
12.10.2.3.1	Connective Tissue Protein . . . . .	613
12.10.2.3.2	Added Protein . . . . .	613
12.10.2.4	Nitrosamines . . . . .	614
12.11	References . . . . .	614
<b>13</b>	<b>Fish, Whales, Crustaceans, Mollusks . . . . .</b>	<b>617</b>
13.1	Fish . . . . .	617
13.1.1	Foreword . . . . .	617
13.1.2	Food Fish . . . . .	618
13.1.2.1	Sea Fish . . . . .	618
13.1.2.1.1	Sharks . . . . .	618
13.1.2.1.2	Herring . . . . .	618
13.1.2.1.3	Cod Fish . . . . .	621
13.1.2.1.4	Scorpaenidae . . . . .	622
13.1.2.1.5	Perch-like Fish . . . . .	622
13.1.2.1.6	Flat Fish . . . . .	622
13.1.2.2	Freshwater Fish . . . . .	623
13.1.2.2.1	Eels . . . . .	623
13.1.2.2.2	Salmon . . . . .	623
13.1.3	Skin and Muscle Tissue Structure . . . . .	623
13.1.4	Composition . . . . .	624
13.1.4.1	Overview . . . . .	624
13.1.4.2	Proteins . . . . .	624
13.1.4.2.1	Sarcoplasma Proteins . . . . .	625
13.1.4.2.2	Contractile Proteins . . . . .	625
13.1.4.2.3	Connective Tissue Protein . . . . .	625
13.1.4.2.4	Serum Proteins . . . . .	626

13.1.4.3	Other N-Compounds .....	626
13.1.4.3.1	Free Amino Acids, Peptides .....	626
13.1.4.3.2	Amines, Amine Oxides .....	626
13.1.4.3.3	Guanidine Compounds .....	626
13.1.4.3.4	Quaternary Ammonium Compounds .....	626
13.1.4.3.5	Purines .....	627
13.1.4.3.6	Urea .....	627
13.1.4.4	Carbohydrates .....	627
13.1.4.5	Lipids .....	627
13.1.4.6	Vitamins .....	628
13.1.4.7	Minerals .....	628
13.1.4.8	Aroma Substances .....	628
13.1.4.9	Other Constituents .....	629
13.1.5	Post mortem Changes .....	629
13.1.6	Storage and Processing of Fish and Fish Products .....	630
13.1.6.1	General Remarks .....	630
13.1.6.2	Cooling and Freezing .....	631
13.1.6.3	Drying .....	632
13.1.6.4	Salting .....	633
13.1.6.5	Smoking .....	633
13.1.6.6	Marinated, Fried and Cooked Fish Products .....	634
13.1.6.7	Saithe .....	635
13.1.6.8	Anchosen .....	635
13.1.6.9	Pasteurized Fish Products .....	635
13.1.6.10	Fish Products with an Extended Shelf Life .....	635
13.1.6.11	Surimi, Kamboko .....	635
13.1.6.12	Fish Eggs and Sperm .....	635
13.1.6.12.1	Caviar .....	635
13.1.6.12.2	Caviar Substitutes .....	636
13.1.6.12.3	Fish Sperm .....	636
13.1.6.13	Some Other Fish Products .....	636
13.2	Whales .....	636
13.3	Crustaceans .....	636
13.3.1	Shrimps .....	636
13.3.2	Crabs .....	637
13.3.3	Lobsters .....	637
13.3.4	Crayfish, Crawfish .....	637
13.4	Mollusks ( <i>Mollusca</i> ) .....	638
13.4.1	Mollusks ( <i>Bivalvia</i> ) .....	638
13.4.2	Snails .....	638
13.4.3	Octopus, Sepia, Squid .....	639
13.5	Turtles .....	639
13.6	Frogdrums .....	639
13.7	References .....	639
<b>14</b>	<b>Edible Fats and Oils .....</b>	<b>640</b>
14.1	Foreword .....	640
14.2	Data on Production and Consumption .....	640
14.3	Origin of Individual Fats and Oils .....	640
14.3.1	Animal Fats .....	640
14.3.1.1	Land Animal Fats .....	640

14.3.1.1.1	Edible Beef Fat . . . . .	642
14.3.1.1.2	Sheep Tallow . . . . .	643
14.3.1.1.3	Hog Fat (Lard) . . . . .	643
14.3.1.1.4	Goose Fat . . . . .	644
14.3.1.2	Marine Oils . . . . .	644
14.3.1.2.1	Whale Oil . . . . .	644
14.3.1.2.2	Seal Oil . . . . .	644
14.3.1.2.3	Herring Oil . . . . .	644
14.3.2	Oils of Plant Origin . . . . .	644
14.3.2.1	Fruit Pulp Oils . . . . .	645
14.3.2.1.1	Olive Oil . . . . .	645
14.3.2.1.2	Palm Oil . . . . .	646
14.3.2.2	Seed Oils . . . . .	647
14.3.2.2.1	Production . . . . .	647
14.3.2.2.2	Oils Rich in Lauric and Myristic Acids . . . . .	647
14.3.2.2.3	Oils Rich in Palmitic and Stearic Acids . . . . .	648
14.3.2.2.4	Oils Rich in Palmitic Acid . . . . .	649
14.3.2.2.5	Oils Low in Palmitic Acid and Rich in Oleic and Linoleic Acids . . . . .	650
14.4	Processing of Fats and Oils . . . . .	653
14.4.1	Refining . . . . .	653
14.4.1.1	Removal of Lecithin . . . . .	654
14.4.1.2	Degumming . . . . .	654
14.4.1.3	Removal of Free Fatty Acids (Deacidification) . . . . .	654
14.4.1.4	Bleaching . . . . .	655
14.4.1.5	Deodorization . . . . .	655
14.4.1.6	Product Quality Control . . . . .	656
14.4.2	Hydrogenation . . . . .	656
14.4.2.1	General Remarks . . . . .	656
14.4.2.2	Catalysts . . . . .	657
14.4.2.3	The Process . . . . .	658
14.4.3	Interestesterification . . . . .	658
14.4.4	Fractionation . . . . .	659
14.4.5	Margarine – Manufacturing and Properties . . . . .	660
14.4.5.1	Composition . . . . .	660
14.4.5.2	Manufacturing . . . . .	661
14.4.5.3	Varieties of Margarine . . . . .	661
14.4.6	Mayonnaise . . . . .	661
14.4.7	Fat Powder . . . . .	661
14.4.8	Deep-Frying Fats . . . . .	661
14.5	Analysis . . . . .	662
14.5.0	Scope . . . . .	662
14.5.1	Determination of Fat in Food . . . . .	662
14.5.2	Identification of Fat . . . . .	663
14.5.2.1	Characteristic Values . . . . .	663
14.5.2.2	Color Reactions . . . . .	664
14.5.2.3	Composition of Fatty Acids and Triacylglycerides . . . . .	664
14.5.2.4	Minor Constituents . . . . .	665
14.5.2.5	Melting Points . . . . .	666
14.5.2.6	Chemometry . . . . .	666
14.5.3	Detection of Changes During Processing and Storage . . . . .	667

14.5.3.1	Lipolysis .....	667
14.5.3.2	Oxidative Deterioration .....	667
14.5.3.2.1	Oxidation State .....	667
14.5.3.2.2	Shelf Life Prediction Test .....	668
14.5.3.3	Heat Stability .....	668
14.5.3.4	Refining .....	669
14.6	References .....	669
<b>15</b>	<b>Cereals and Cereal Products .....</b>	<b>670</b>
15.1	Foreword .....	670
15.1.1	Introduction .....	670
15.1.2	Origin .....	670
15.1.3	Production .....	671
15.1.4	Anatomy – Chemical Composition, a Review .....	671
15.1.5	Special Role of Wheat–Gluten Formation .....	673
15.1.6	Celiac Disease .....	674
15.2	Individual Constituents .....	674
15.2.1	Proteins .....	674
15.2.1.1	Differences in Amino Acid Composition .....	674
15.2.1.2	A Review of the Osborne Fractions of Cereals .....	675
15.2.1.3	Protein Components of Wheat Gluten .....	680
15.2.1.3.1	High-Molecular Group (HMW Subunits of Glutenin) .....	681
15.2.1.3.2	Intermediate Molecular Weight Group ( $\omega_5$ -Gliadins, $\alpha_1,2$ -Gliadins) .....	684
15.2.1.3.3	Low-Molecular Group ( $\alpha$ -Gliadins, $\gamma$ -Gliadins, LMW Subunits of Glutenin) .....	685
15.2.1.4	Structure of Wheat Gluten .....	691
15.2.1.4.1	Disulfide Bonds .....	691
15.2.1.4.2	Contribution of Gluten Proteins to the Baking Quality .....	692
15.2.1.5	Puroindolins .....	695
15.2.2	Enzymes .....	695
15.2.2.1	Amylases .....	695
15.2.2.2	Proteinases .....	696
15.2.2.3	Lipases .....	696
15.2.2.4	Phytase .....	696
15.2.2.5	Lipoxygenases .....	697
15.2.2.6	Peroxidase, Catalase .....	698
15.2.2.7	Glutathione Dehydrogenase .....	698
15.2.2.8	Polyphenoloxidases .....	698
15.2.2.9	Ascorbic Acid Oxidase .....	698
15.2.2.10	Arabinoxylan Hydrolases .....	698
15.2.3	Other Nitrogen Compounds .....	699
15.2.4	Carbohydrates .....	701
15.2.4.1	Starch .....	701
15.2.4.2	Polysaccharides Other than Starch .....	702
15.2.4.2.1	Pentosans .....	702
15.2.4.2.2	$\beta$ -Glucan .....	703
15.2.4.2.3	Glucofructans .....	703
15.2.4.2.4	Cellulose .....	703
15.2.4.3	Sugars .....	703
15.2.5	Lipids .....	703

15.3	Cereals – Milling . . . . .	706
15.3.1	Wheat and Rye . . . . .	706
15.3.1.1	Storage . . . . .	707
15.3.1.2	Milling . . . . .	707
15.3.1.3	Milling Products . . . . .	708
15.3.2	Other Cereals . . . . .	710
15.3.2.1	Corn . . . . .	710
15.3.2.2	Hull Cereals . . . . .	710
15.3.2.2.1	Rice . . . . .	710
15.3.2.2.2	Oats . . . . .	710
15.3.2.2.3	Barley . . . . .	711
15.4	Baked Products . . . . .	711
15.4.1	Raw Materials . . . . .	711
15.4.1.1	Wheat Flour . . . . .	711
15.4.1.1.1	Chemical Assays . . . . .	711
15.4.1.1.2	Physical Assays . . . . .	713
15.4.1.1.3	Baking Tests . . . . .	714
15.4.1.2	Rye Flour . . . . .	715
15.4.1.3	Storage . . . . .	716
15.4.1.4	Influence of Additives/Minor Ingredients on Baking Properties of Wheat Flour . . . . .	716
15.4.1.4.1	Ascorbic Acid . . . . .	716
15.4.1.4.2	Bromate, Azodicarbonamide . . . . .	719
15.4.1.4.3	Lipoxygenase . . . . .	719
15.4.1.4.4	Cysteine . . . . .	719
15.4.1.4.5	Proteinases (Peptidases) . . . . .	720
15.4.1.4.6	Salt . . . . .	721
15.4.1.4.7	Emulsifiers, Shortenings . . . . .	721
15.4.1.4.8	$\alpha$ -Amylase . . . . .	721
15.4.1.4.9	Milk and Soy Products . . . . .	722
15.4.1.5	Influence of Additives on Baking Properties of Rye Flour . . . . .	722
15.4.1.5.1	Pregelatinized Flour . . . . .	722
15.4.1.5.2	Acids . . . . .	722
15.4.1.6	Dough Leavening Agents . . . . .	722
15.4.1.6.1	Yeast . . . . .	723
15.4.1.6.2	Chemical Leavening Agents . . . . .	723
15.4.2	Dough Preparation . . . . .	723
15.4.2.1	Addition of Yeast to Wheat Dough . . . . .	723
15.4.2.1.1	Direct Addition . . . . .	723
15.4.2.1.2	Indirect Addition . . . . .	723
15.4.2.2	Sour Dough Making . . . . .	724
15.4.2.3	Kneading . . . . .	725
15.4.2.4	Fermentation . . . . .	726
15.4.2.5	Events Involved in Dough Making and Dough Strengthening . . . . .	726
15.4.2.5.1	Dough Making . . . . .	726
15.4.2.5.2	Dough Strengthening . . . . .	730
15.4.3	Baking Process . . . . .	731
15.4.3.1	Conditions . . . . .	731
15.4.3.2	Chemical and Physical Changes – Formation of Crumb . . . . .	731
15.4.3.3	Aroma . . . . .	734
15.4.3.3.1	White Bread Crust . . . . .	734

15.4.3.3.2	White Bread Crumb .....	736
15.4.3.3.3	Rye Bread Crust .....	737
15.4.4	Changes During Storage .....	739
15.4.5	Bread Types .....	740
15.4.6	Fine Bakery Products .....	741
15.5	Pasta Products .....	741
15.5.1	Raw Materials .....	741
15.5.2	Additives .....	742
15.5.3	Production .....	742
15.6	References .....	742
<b>16</b>	<b>Legumes .....</b>	<b>746</b>
16.1	Foreword .....	746
16.2	Individual Constituents .....	746
16.2.1	Proteins .....	746
16.2.1.1	Glubulines .....	746
16.2.1.2	Allergens .....	751
16.2.2	Enzymes .....	753
16.2.3	Proteinase and Amylase Inhibitors .....	754
16.2.3.1	Occurrence and Properties .....	754
16.2.3.2	Structure .....	755
16.2.3.3	Physiological Function .....	756
16.2.3.4	Action on Human Enzymes .....	757
16.2.3.5	Inactivation .....	757
16.2.3.6	Amylase Inhibitors .....	757
16.2.3.7	Conclusions .....	758
16.2.4	Lectins .....	759
16.2.5	Carbohydrates .....	759
16.2.6	Cyanogenic Glycosides .....	760
16.2.7	Lipids .....	761
16.2.8	Vitamins and Minerals .....	762
16.2.9	Phytoestrogens .....	762
16.2.10	Saponins .....	763
16.2.11	Other Constituents .....	764
16.3	Processing .....	764
16.3.1	Soybeans and Peanuts .....	764
16.3.1.1	Aroma Defects .....	764
16.3.1.2	Individual Products .....	765
16.3.1.2.1	Soy Proteins .....	765
16.3.1.2.2	Soy Milk .....	766
16.3.1.2.3	Tofu .....	766
16.3.1.2.4	Soy Sauce (Shoyu) .....	766
16.3.1.2.5	Miso .....	767
16.3.1.2.6	Natto .....	767
16.3.1.2.7	Sufu .....	767
16.3.2	Peas and Beans .....	768
16.4	References .....	768
<b>17</b>	<b>Vegetables and Vegetable Products .....</b>	<b>770</b>
17.1	Vegetables .....	770
17.1.1	Foreword .....	770

17.1.2	Composition .....	770
17.1.2.1	Nitrogen Compounds .....	770
17.1.2.1.1	Proteins .....	770
17.1.2.1.2	Free Amino Acids .....	770
17.1.2.1.3	Amines .....	786
17.1.2.2	Carbohydrates .....	786
17.1.2.2.1	Mono- and Oligosaccharides, Sugar Alcohols .....	786
17.1.2.2.2	Polysaccharides .....	786
17.1.2.3	Lipids .....	787
17.1.2.4	Organic Acids .....	787
17.1.2.5	Phenolic Compounds .....	788
17.1.2.6	Aroma Substances .....	788
17.1.2.6.1	Mushrooms .....	788
17.1.2.6.2	Potatoes .....	788
17.1.2.6.3	Celery Tubers .....	788
17.1.2.6.4	Radishes .....	789
17.1.2.6.5	Red Beets (28) .....	790
17.1.2.6.6	Garlic and Onions .....	790
17.1.2.6.7	Watercress .....	791
17.1.2.6.8	White Cabbage, Red Cabbage and Brussels Sprouts .....	792
17.1.2.6.9	Spinach .....	792
17.1.2.6.10	Artichoke .....	792
17.1.2.6.11	Cauliflower, Broccoli .....	792
17.1.2.6.12	Green Peas .....	793
17.1.2.6.13	Cucumbers .....	793
17.1.2.6.14	Tomatoes .....	793
17.1.2.7	Vitamins .....	793
17.1.2.8	Minerals .....	793
17.1.2.9	Other Constituents .....	793
17.1.2.9.1	Chlorophyll .....	793
17.1.2.9.2	Betalains .....	796
17.1.2.9.3	Goitrogenic Substances .....	798
17.1.2.9.4	Steroid Alkaloids .....	798
17.1.3	Storage .....	799
17.2	Vegetable Products .....	799
17.2.1	Dehydrated Vegetables .....	799
17.2.2	Canned Vegetables .....	800
17.2.3	Frozen Vegetables .....	801
17.2.4	Pickled Vegetables .....	802
17.2.4.1	Pickled Cucumbers (Salt and Dill Pickles) .....	802
17.2.4.2	Other Vegetables .....	802
17.2.4.3	Sauerkraut .....	802
17.2.4.4	Eating Olives .....	803
17.2.4.5	Faulty Processing of Pickles .....	804
17.2.5	Vinegar-Pickled Vegetables .....	804
17.2.6	Stock Brining of Vegetables .....	804
17.2.7	Vegetable Juices .....	805
17.2.8	Vegetable Paste .....	805
17.2.9	Vegetable Powders .....	805
17.3	References .....	805

<b>18</b>	<b>Fruits and Fruit Products . . . . .</b>	807
18.1	Fruits . . . . .	807
18.1.1	Foreword . . . . .	807
18.1.2	Composition . . . . .	807
18.1.2.1	N-Containing Compounds . . . . .	807
18.1.2.1.1	Proteins, Enzymes . . . . .	807
18.1.2.1.2	Free Amino Acids . . . . .	809
18.1.2.1.3	Amines . . . . .	812
18.1.2.2	Carbohydrates . . . . .	817
18.1.2.2.1	Monosaccharides . . . . .	817
18.1.2.2.2	Oligosaccharides . . . . .	817
18.1.2.2.3	Sugar Alcohols . . . . .	817
18.1.2.2.4	Polysaccharides . . . . .	818
18.1.2.3	Lipids . . . . .	818
18.1.2.3.1	Fruit Flesh Lipids (Other than Carotenoids and Triterpenoids) . . . . .	818
18.1.2.3.2	Carotenoids . . . . .	818
18.1.2.3.3	Triterpenoids . . . . .	819
18.1.2.3.4	Fruit Waxes . . . . .	820
18.1.2.4	Organic Acids . . . . .	820
18.1.2.5	Phenolic Compounds . . . . .	822
18.1.2.5.1	Hydroxycinnamic Acids, Hydroxycoumarins and Hydroxybenzoic Acids . . . . .	823
18.1.2.5.2	Flavan-3-ols (Catechins), Flavan-3,4-diols, and Proanthocyanidins (Condensed Tanning Agents) . . . . .	827
18.1.2.5.3	Anthocyanidins . . . . .	829
18.1.2.5.4	Flavanones . . . . .	832
18.1.2.5.5	Flavones, Flavonols . . . . .	834
18.1.2.5.6	Lignans . . . . .	835
18.1.2.5.7	Flavonoid Biosynthesis . . . . .	835
18.1.2.5.8	Technological Importance of Phenolic Compounds . . . . .	835
18.1.2.6	Aroma Compounds . . . . .	837
18.1.2.6.1	Bananas . . . . .	837
18.1.2.6.2	Grapes . . . . .	837
18.1.2.6.3	Citrus Fruits . . . . .	837
18.1.2.6.4	Apples, Pears . . . . .	839
18.1.2.6.5	Raspberries . . . . .	839
18.1.2.6.6	Apricots . . . . .	839
18.1.2.6.7	Peaches . . . . .	840
18.1.2.6.8	Passion Fruit . . . . .	840
18.1.2.6.9	Strawberries . . . . .	841
18.1.2.6.10	Pineapples . . . . .	841
18.1.2.6.11	Cherries, Plums . . . . .	841
18.1.2.6.12	Litchi . . . . .	842
18.1.2.7	Vitamins . . . . .	842
18.1.2.8	Minerals . . . . .	843
18.1.3	Chemical Changes During Ripening of Fruit . . . . .	843
18.1.3.1	Changes in Respiration Rate . . . . .	843
18.1.3.2	Changes in Metabolic Pathways . . . . .	844
18.1.3.3	Changes in Individual Constituents . . . . .	845
18.1.3.3.1	Carbohydrates . . . . .	845
18.1.3.3.2	Proteins, Enzymes . . . . .	846

18.1.3.3.3	Lipids .....	846
18.1.3.3.4	Acids .....	846
18.1.3.3.5	Pigments .....	846
18.1.3.3.6	Aroma Compounds .....	846
18.1.4	Ripening as Influenced by Chemical Agents .....	847
18.1.4.1	Ethylene .....	847
18.1.4.2	Anti-Senescence Agents .....	848
18.1.4.2.1	Polyamines .....	848
18.1.4.2.2	1-Methylcyclopropene (MCP) .....	848
18.1.5	Storage of Fruits .....	848
18.1.5.1	Cold Storage .....	848
18.1.5.2	Storage in a Controlled (Modified) Atmosphere .....	848
18.2	Fruit Products .....	849
18.2.1	Dried Fruits .....	849
18.2.2	Canned Fruits .....	850
18.2.3	Deep-Frozen Fruits .....	850
18.2.4	Rum Fruits, Fruits in Sugar Syrup, etc. ....	851
18.2.5	Fruit Pulps and Slurries .....	851
18.2.6	Marmalades, Jams and Jellies .....	851
18.2.6.1	Marmalades .....	851
18.2.6.2	Jams .....	852
18.2.6.3	Jellies .....	852
18.2.7	Plum Sauce (Damson Cheese) .....	852
18.2.8	Fruit Juices .....	852
18.2.8.1	Preparation of the Fruit .....	853
18.2.8.2	Juice Extraction .....	853
18.2.8.3	Juice Treatment .....	853
18.2.8.4	Preservation .....	854
18.2.8.5	Side Products .....	854
18.2.9	Fruit Nectars .....	854
18.2.10	Fruit Juice Concentrates .....	854
18.2.10.1	Evaporation .....	855
18.2.10.2	Freeze Concentration .....	855
18.2.10.3	Membrane Filtration .....	855
18.2.11	Fruit Syrups .....	855
18.2.12	Fruit Powders .....	856
18.3	Alcohol-Free Beverages .....	856
18.3.1	Fruit Juice Beverages .....	856
18.3.2	Lemonades, Cold and Hot Beverages .....	856
18.3.3	Caffeine-Containing Beverages .....	856
18.3.4	Other Pop Beverages .....	856
18.4	Analysis .....	856
18.4.1	Various Constituents .....	857
18.4.2	Species-Specific Constituents .....	858
18.4.3	Abundance Ratios of Isotopes .....	858
18.5	References .....	859
<b>19</b>	<b>Sugars, Sugar Alcohols and Honey .....</b>	<b>862</b>
19.1	Sugars, Sugar Alcohols and Sugar Products .....	862
19.1.1	Foreword .....	862
19.1.2	Processing Properties .....	862

19.1.3	Nutritional/Physiological Properties .....	866
19.1.3.1	Metabolism .....	866
19.1.3.2	Glycemic Index .....	867
19.1.3.3	Functional Food .....	867
19.1.4	Individual Sugars and Sugar Alcohols .....	867
19.1.4.1	Sucrose (Beet Sugar, Cane Sugar).....	867
19.1.4.1.1	General Outline .....	867
19.1.4.1.2	Production of Beet Sugar .....	869
19.1.4.1.3	Production of Cane Sugar .....	872
19.1.4.1.4	Other Sources for Sucrose Production .....	873
19.1.4.1.5	Packaging and Storage .....	873
19.1.4.1.6	Types of Sugar.....	873
19.1.4.1.7	Composition of some Sugar Types .....	873
19.1.4.1.8	Molasses .....	874
19.1.4.2	Sugars Produced from Sucrose .....	874
19.1.4.3	Starch Degradation Products .....	875
19.1.4.3.1	General Outline .....	875
19.1.4.3.2	Starch Syrup (Glucose or Maltose Syrup) .....	875
19.1.4.3.3	Dried Starch Syrup (Dried Glucose Syrup) .....	876
19.1.4.3.4	Glucose (Dextrose) .....	876
19.1.4.3.5	Glucose-Fructose Syrup (High Fructose Corn Syrup, HFCS) ...	877
19.1.4.3.6	Starch Syrup Derivatives .....	877
19.1.4.3.7	Polydextrose .....	877
19.1.4.4	Milk Sugar (Lactose) and Derived Products .....	877
19.1.4.4.1	Milk Sugar .....	877
19.1.4.4.2	Products from Lactose .....	877
19.1.4.5	Fruit Sugar (Fructose).....	878
19.1.4.6	L-Sorbose and Other L-Sugars .....	878
19.1.4.7	Sugar Alcohols (Polyalcohols) .....	878
19.1.4.7.1	Isomaltol (Palatinit) .....	878
19.1.4.7.2	Sorbitol.....	879
19.1.4.7.3	Xylitol .....	879
19.1.4.7.4	Mannitol .....	879
19.1.5	Candies .....	879
19.1.5.1	General Outline .....	879
19.1.5.2	Hard Caramel (Bonbons) .....	879
19.1.5.3	Soft Caramel (Toffees) .....	880
19.1.5.4	Fondant .....	880
19.1.5.5	Foamy Candies .....	880
19.1.5.6	Jellies, Gum and Gelatine Candies .....	881
19.1.5.7	Tablets .....	881
19.1.5.8	Dragées .....	881
19.1.5.9	Marzipan .....	881
19.1.5.10	Persipan .....	881
19.1.5.11	Other Raw Candy Fillers .....	881
19.1.5.12	Nougat Fillers .....	881
19.1.5.13	Croquant .....	882
19.1.5.14	Licorice and its Products .....	882
19.1.5.15	Chewing Gum .....	882
19.1.5.16	Effervescent Lemonade Powders.....	882
19.2	Honey and Artificial Honey .....	883

19.2.1	Honey . . . . .	883
19.2.1.1	Foreword . . . . .	883
19.2.1.2	Production and Types . . . . .	884
19.2.1.3	Processing . . . . .	884
19.2.1.4	Physical Properties . . . . .	885
19.2.1.5	Composition . . . . .	885
19.2.1.5.1	Water . . . . .	885
19.2.1.5.2	Carbohydrates . . . . .	885
19.2.1.5.3	Enzymes . . . . .	886
19.2.1.5.4	Proteins . . . . .	888
19.2.1.5.5	Amino Acids . . . . .	888
19.2.1.5.6	Acids . . . . .	888
19.2.1.5.7	Aroma Substances . . . . .	889
19.2.1.5.8	Pigments . . . . .	889
19.2.1.5.9	Toxic Constituents . . . . .	889
19.2.1.6	Storage . . . . .	889
19.2.1.7	Utilization . . . . .	890
19.2.2	Artificial Honey . . . . .	890
19.2.2.1	Foreword . . . . .	890
19.2.2.2	Production . . . . .	890
19.2.2.3	Composition . . . . .	890
19.2.2.4	Utilization . . . . .	890
19.3	References . . . . .	891
<b>20</b>	<b>Alcoholic Beverages . . . . .</b>	<b>892</b>
20.1	Beer . . . . .	892
20.1.1	Foreword . . . . .	892
20.1.2	Raw Materials . . . . .	892
20.1.2.1	Barley . . . . .	892
20.1.2.2	Other Starch- and Sugar-Containing Raw Materials . . . . .	892
20.1.2.2.1	Wheat Malt . . . . .	892
20.1.2.2.2	Adjuncts . . . . .	892
20.1.2.2.3	Syrups, Extract Powders . . . . .	894
20.1.2.2.4	Malt Extracts, Wort Concentrates . . . . .	894
20.1.2.2.5	Brewing Sugars . . . . .	894
20.1.2.3	Hops . . . . .	894
20.1.2.3.1	General Outline . . . . .	894
20.1.2.3.2	Composition . . . . .	895
20.1.2.3.3	Processing . . . . .	896
20.1.2.4	Brewing Water . . . . .	897
20.1.2.5	Brewing Yeasts . . . . .	897
20.1.3	Malt Preparation . . . . .	898
20.1.3.1	Steeping . . . . .	898
20.1.3.2	Germination . . . . .	898
20.1.3.3	Kilning . . . . .	898
20.1.3.4	Continuous Processes . . . . .	898
20.1.3.5	Special Malts . . . . .	899
20.1.4	Wort Preparation . . . . .	899
20.1.4.1	Ground Malt . . . . .	899
20.1.4.2	Mashing . . . . .	899
20.1.4.3	Lautering . . . . .	900

20.1.4.4	Wort Boiling and Hopping .....	900
20.1.4.5	Continuous Processes .....	900
20.1.5	Fermentation .....	900
20.1.5.1	Bottom Fermentation .....	900
20.1.5.2	Top Fermentation .....	901
20.1.5.3	Continuous Processes, Rapid Methods .....	901
20.1.6	Bottling .....	901
20.1.7	Composition .....	901
20.1.7.1	Ethanol .....	901
20.1.7.2	Extract .....	901
20.1.7.3	Acids .....	902
20.1.7.4	Nitrogen Compounds .....	902
20.1.7.5	Carbohydrates .....	902
20.1.7.6	Minerals .....	902
20.1.7.7	Vitamins .....	902
20.1.7.8	Aroma Substances .....	902
20.1.7.9	Foam Builders .....	902
20.1.8	Kinds of Beer .....	903
20.1.8.1	Top Fermented Beers .....	903
20.1.8.2	Bottom Fermented Beers .....	904
20.1.8.3	Diet Beers .....	904
20.1.8.4	Alcohol-Free Beers .....	904
20.1.8.5	Export Beers .....	904
20.1.9	Beer Flavor and Beer Defects .....	904
20.2	Wine .....	906
20.2.1	Foreword .....	906
20.2.2	Grape Cultivars .....	907
20.2.3	Grape Must .....	911
20.2.3.1	Growth and Harvest .....	911
20.2.3.2	Must Production and Treatment .....	913
20.2.3.3	Must Composition .....	914
20.2.3.3.1	Carbohydrates .....	915
20.2.3.3.2	Acids .....	915
20.2.3.3.3	Nitrogen Compounds .....	915
20.2.3.3.4	Lipids .....	915
20.2.3.3.5	Phenolic Compounds .....	915
20.2.3.3.6	Minerals .....	916
20.2.3.3.7	Aroma Substances .....	916
20.2.4	Fermentation .....	916
20.2.5	Cellar Operations After Fermentation; Storage .....	917
20.2.5.1	Racking, Storing and Aging .....	917
20.2.5.2	Sulfur Treatment .....	917
20.2.5.3	Clarification and Stabilization .....	918
20.2.5.4	Amelioration .....	918
20.2.6	Composition .....	919
20.2.6.1	Extract .....	919
20.2.6.2	Carbohydrates .....	919
20.2.6.3	Ethanol .....	919
20.2.6.4	Other Alcohols .....	920
20.2.6.5	Acids .....	920
20.2.6.6	Phenolic Compounds .....	920

20.2.6.7	Nitrogen Compounds . . . . .	921
20.2.6.8	Minerals . . . . .	921
20.2.6.9	Aroma Substances . . . . .	921
20.2.7	Spoilage . . . . .	924
20.2.8	Liqueur Wines . . . . .	926
20.2.9	Sparkling Wine . . . . .	926
20.2.9.1	Bottle Fermentation ("Méthode Champenoise") . . . . .	927
20.2.9.2	Tank Fermentation Process ("Produit en Cuve Close") . . . . .	927
20.2.9.3	Carbonation Process . . . . .	928
20.2.9.4	Various Types of Sparkling Wines . . . . .	928
20.2.10	Wine-Like Beverages . . . . .	928
20.2.10.1	Fruit Wines . . . . .	928
20.2.10.2	Malt Wine; Mead . . . . .	929
20.2.10.3	Other Products . . . . .	929
20.2.11	Wine-Containing Beverages . . . . .	929
20.2.11.1	Vermouth . . . . .	929
20.2.11.2	Aromatic Wines . . . . .	929
20.3	Spirits . . . . .	929
20.3.1	Foreword . . . . .	929
20.3.2	Liquor . . . . .	929
20.3.2.1	Production . . . . .	929
20.3.2.2	Alcohol Production . . . . .	930
20.3.2.3	Liquor from Wine, Fruit, Cereals and Sugar Cane . . . . .	931
20.3.2.3.1	Wine Liquor (Brandy) . . . . .	931
20.3.2.3.2	Fruit Liquor (Fruit Brandy) . . . . .	931
20.3.2.3.3	Gentian Liquor ("Enzian") . . . . .	932
20.3.2.3.4	Juniper Liquor (Brandy) and Gin . . . . .	932
20.3.2.3.5	Rum . . . . .	932
20.3.2.3.6	Arrack . . . . .	933
20.3.2.3.7	Liquors from Cereals . . . . .	933
20.3.2.4	Miscellaneous Alcoholic Beverages . . . . .	935
20.3.3	Liqueurs (Cordials) . . . . .	935
20.3.3.1	Fruit Sap Liqueurs . . . . .	935
20.3.3.2	Fruit Aroma Liqueurs . . . . .	935
20.3.3.3	Other Liqueurs . . . . .	935
20.3.4	Punch Extracts . . . . .	936
20.3.5	Mixed Drinks . . . . .	936
20.4	References . . . . .	936
<b>21</b>	<b>Coffee, Tea, Cocoa . . . . .</b>	<b>938</b>
21.1	Coffee and Coffee Substitutes . . . . .	938
21.1.1	Foreword . . . . .	938
21.1.2	Green Coffee . . . . .	939
21.1.2.1	Harvesting and Processing . . . . .	939
21.1.2.2	Green Coffee Varieties . . . . .	939
21.1.2.3	Composition of Green Coffee . . . . .	940
21.1.3	Roasted Coffee . . . . .	940
21.1.3.1	Roasting . . . . .	940
21.1.3.2	Storing and Packaging . . . . .	941
21.1.3.3	Composition of Roasted Coffee . . . . .	942
21.1.3.3.1	Proteins . . . . .	942

21.1.3.3.2	Carbohydrates . . . . .	942
21.1.3.3.3	Lipids . . . . .	942
21.1.3.3.4	Acids . . . . .	943
21.1.3.3.5	Caffeine . . . . .	943
21.1.3.3.6	Trigonelline, Nicotinic Acid . . . . .	944
21.1.3.3.7	Aroma Substances . . . . .	944
21.1.3.3.8	Minerals . . . . .	946
21.1.3.3.9	Other Constituents . . . . .	946
21.1.3.4	Coffee Beverages . . . . .	946
21.1.4	Coffee Products . . . . .	948
21.1.4.1	Instant Coffee . . . . .	948
21.1.4.2	Decaffeinated Coffee . . . . .	949
21.1.4.3	Treated Coffee . . . . .	949
21.1.5	Coffee Substitutes and Adjuncts . . . . .	949
21.1.5.1	Introduction . . . . .	949
21.1.5.2	Processing of Raw Materials . . . . .	949
21.1.5.3	Individual Products . . . . .	950
21.1.5.3.1	Barley Coffee . . . . .	950
21.1.5.3.2	Malt Coffee . . . . .	950
21.1.5.3.3	Chicory Coffee . . . . .	950
21.1.5.3.4	Fig Coffee . . . . .	950
21.1.5.3.5	Acorn Coffee . . . . .	950
21.1.5.3.6	Other Products . . . . .	950
21.2	Tea and Tea-Like Products . . . . .	951
21.2.1	Foreword . . . . .	951
21.2.2	Black Tea . . . . .	951
21.2.3	Green Tea . . . . .	952
21.2.4	Grades of Tea . . . . .	952
21.2.5	Composition . . . . .	952
21.2.5.1	Phenolic Compounds . . . . .	953
21.2.5.2	Enzymes . . . . .	953
21.2.5.3	Amino Acids . . . . .	954
21.2.5.4	Caffeine . . . . .	954
21.2.5.5	Carbohydrates . . . . .	954
21.2.5.6	Lipids . . . . .	955
21.2.5.7	Pigments (Chlorophyll and Carotenoids) . . . . .	955
21.2.5.8	Aroma Substances . . . . .	955
21.2.5.9	Minerals . . . . .	956
21.2.6	Reactions Involved in the Processing of Tea . . . . .	956
21.2.7	Packaging, Storage, Brewing . . . . .	958
21.2.8	Maté (Paraguayan Tea) . . . . .	958
21.2.9	Products from Cola Nut . . . . .	958
21.3	Cocoa and Chocolate . . . . .	959
21.3.1	Introduction . . . . .	959
21.3.2	Cacao . . . . .	959
21.3.2.1	General Information . . . . .	959
21.3.2.2	Harvesting and Processing . . . . .	960
21.3.2.3	Composition . . . . .	961
21.3.2.3.1	Proteins and Amino Acids . . . . .	961
21.3.2.3.2	Theobromine and Caffeine . . . . .	962
21.3.2.3.3	Lipids . . . . .	962

21.3.2.3.4	Carbohydrates . . . . .	962
21.3.2.3.5	Phenolic Compounds . . . . .	962
21.3.2.3.6	Organic Acids . . . . .	963
21.3.2.3.7	Volatile Compounds and Flavor Substances . . . . .	964
21.3.2.4	Reactions During Fermentation and Drying . . . . .	964
21.3.2.5	Production of Cocoa Liquor . . . . .	965
21.3.2.6	Production of Cocoa Liquor with Improved Dispersability . . . . .	965
21.3.2.7	Production of Cocoa Powder by Cocoa Mass Pressing . . . . .	966
21.3.3	Chocolate . . . . .	966
21.3.3.1	Introduction . . . . .	966
21.3.3.2	Chocolate Production . . . . .	966
21.3.3.2.1	Mixing . . . . .	966
21.3.3.2.2	Refining . . . . .	966
21.3.3.2.3	Conching . . . . .	966
21.3.3.2.4	Tempering and Molding . . . . .	967
21.3.3.3	Kinds of Chocolate . . . . .	967
21.3.4	Storage of Cocoa Products . . . . .	969
21.4	References . . . . .	969
<b>22</b>	<b>Spices, Salt and Vinegar . . . . .</b>	<b>971</b>
22.1	Spices . . . . .	971
22.1.1	Composition . . . . .	971
22.1.1.1	Components of Essential Oils . . . . .	971
22.1.1.2	Aroma Substances . . . . .	974
22.1.1.2.1	Pepper . . . . .	975
22.1.1.2.2	Vanilla . . . . .	976
22.1.1.2.3	Dill . . . . .	976
22.1.1.2.4	Fenugreek . . . . .	976
22.1.1.2.5	Saffron . . . . .	977
22.1.1.2.6	Mustard, Horseradish . . . . .	977
22.1.1.2.7	Ginger . . . . .	977
22.1.1.2.8	Basil . . . . .	977
22.1.1.2.9	Parsley . . . . .	978
22.1.1.3	Substances with Pungent Taste . . . . .	979
22.1.1.4	Pigments . . . . .	981
22.1.1.5	Antioxidants . . . . .	981
22.1.2	Products . . . . .	981
22.1.2.1	Spice Powders . . . . .	981
22.1.2.2	Spice Extracts or Concentrates (Oleoresins) . . . . .	982
22.1.2.3	Blended Spices . . . . .	982
22.1.2.4	Spice Preparations . . . . .	982
22.1.2.4.1	Curry Powder . . . . .	982
22.1.2.4.2	Mustard Paste . . . . .	982
22.1.2.4.3	Sambal . . . . .	982
22.2	Salt (Cooking Salt) . . . . .	982
22.2.1	Composition . . . . .	982
22.2.2	Occurrence . . . . .	983
22.2.3	Production . . . . .	983
22.2.4	Special Salt . . . . .	983
22.2.5	Salt Substitutes . . . . .	983
22.3	Vinegar . . . . .	983

22.3.1	Production .....	984
22.3.1.1	Microbiological Production .....	984
22.3.1.2	Chemical Synthesis .....	984
22.3.2	Composition .....	984
22.4	References .....	985
<b>23</b>	<b>Drinking Water, Mineral and Table Water .....</b>	<b>986</b>
23.1	Drinking Water .....	986
23.1.1	Treatment .....	986
23.1.2	Hardness .....	986
23.1.3	Analysis .....	987
23.2	Mineral Water .....	988
23.3	Table Water .....	988
23.4	References .....	988
<b>Index</b>	.....	<b>989</b>