

Sweeteners and Sugar Alternatives in Food Technology

Edited by Helen Mitchell



Blackwell
Publishing

Contents

<i>Preface</i>	xv
<i>Contributors</i>	xvii
PART ONE: NUTRITION AND HEALTH CONSIDERATIONS 1	
1 Glycaemic Responses and Toleration 3	
Geoffrey Livesey	
1.1 Introduction	3
1.2 Glycaemic response in ancient times	4
1.3 Glycaemic response approaching the millennium	5
1.4 The glycaemic response now and in future nutrition	6
1.5 Measurement and expression of the glycaemic response	6
1.6 The acute glycaemic response to sugars and sweeteners	10
1.7 Long-term glycaemic control with sweeteners and bulking agents	11
1.8 Gastrointestinal tolerance in relation to the glycaemic response	13
1.9 Finally	15
2 Dental Health 19	
Anne Maguire	
2.1 Introduction	19
2.2 Dental caries	19
2.2.1 The problem	19
2.2.2 Aetiology	20
2.2.3 Control and prevention	21
2.2.4 Determining cariogenicity	21
2.3 Reduced calorie bulk sweeteners	23
2.3.1 Erythritol	23
2.3.2 Isomalt	24
2.3.3 Lactitol	25
2.3.4 Maltitol	25
2.3.5 Sorbitol	27
2.3.6 Mannitol	28
2.3.7 D-tagatose	28
2.3.8 Xylitol	28
2.3.9 Key points from the dental evidence for reduced calorie sweeteners and their use	30

2.4	High-potency (high-intensity) sweeteners	31
2.4.1	Acesulfame K	31
2.4.2	Aspartame and neotame	31
2.4.3	Cyclamate and saccharin	32
2.4.4	Sucratose	33
2.4.5	Other sweeteners	33
2.4.6	Key points from the dental evidence for high-potency (high-intensity) sweeteners and their use	34
2.5	Bulking agents	34
2.5.1	Polydextrose	34
2.5.2	Fructose and glucose polymers	34
2.5.3	Key points from the dental evidence for bulking agents	35
2.6	Summary	35
3	Digestive Health	44
	Arthur C. Ouwehand, Henna Mäkeläinen, Kirsti Tiihonen and Nina Rautonen	
3.1	Introduction	44
3.1.1	Prebiotics, sweeteners and digestive health	44
3.1.2	Intestinal microbiota	44
3.1.3	Gut health	44
3.2	Prebiotics versus fibre	45
3.2.1	Endogenous prebiotics	45
3.2.2	Milk oligosaccharides	45
3.2.3	Secreted substrates in the gut	46
3.3	Prebiotics	46
3.3.1	Current prebiotics	47
3.4	Health benefits	48
3.5	Synbiotics	49
3.6	Safety considerations	50
3.7	Conclusion	51
4	Calorie Control and Weight Management	54
	Julian Stowell	
4.1	Caloric contribution of sugars in our diet	54
4.2	Calorie control and its importance in weight management	55
4.3	Satiety: role of intense and bulk sweeteners	55
4.4	Legislation relevant to reduced-calorie foods	59
4.5	Conclusions	60
PART TWO: HIGH-POTENCY (HIGH-INTENSITY) SWEETENERS		63
5	Acesulfame K	65
	Bernd Haber, Gert-Wolfhard von Rymon Lipinski and Susanne Rathjen	
5.1	Introduction and history	65
5.2	Organoleptic properties	66
5.2.1	Acesulfame K as the single sweetener	66

5.2.2	Blends of acesulfame K with other sweetening agents	66
5.2.3	Compatibility with flavours	69
5.3	Physical and chemical properties	69
5.3.1	Appearance	69
5.3.2	Solubility	70
5.3.3	Stability	70
5.4	Physiological properties	71
5.5	Applications	72
5.5.1	Beverages	72
5.5.2	Dairy products and edible ices	75
5.5.3	Bakery products and cereals	75
5.5.4	Sweets and chewing gum	77
5.5.5	Jams, marmalades, preserves and tinned fruit	78
5.5.6	Delicatessen products	78
5.5.7	Table-top sweeteners	79
5.5.8	Pharmaceuticals	80
5.5.9	Cosmetics	80
5.5.10	Tobacco products	81
5.5.11	Technical applications	81
5.6	Safety and analytical methods	81
5.6.1	Pharmacology	81
5.6.2	Toxicology	81
5.6.3	Safety assessments and acceptable daily intake	82
5.6.4	Analytical methods	82
5.7	Regulatory status	82
5.7.1	Approvals	82
5.7.2	Purity criteria	83
6	Aspartame and Neotame	86
	Kay O'Donnell	
6.1	Aspartame	86
6.1.1	Synthesis	86
6.1.2	Sensory properties	87
6.1.3	Physicochemical properties	89
6.1.4	Physiological properties	92
6.1.5	Applications	93
6.1.6	Analysis	94
6.1.7	Safety	94
6.1.8	Regulatory status	95
6.2	Neotame	95
6.2.1	Neotame structure and synthesis	95
6.2.2	Sensory properties	96
6.2.3	Physicochemical properties	97
6.2.4	Physiological properties	98
6.2.5	Applications	99
6.2.6	Safety	99
6.2.7	Regulatory	100

7 Saccharin and Cyclamate	103
Grant E. DuBois	
7.1 Saccharin	104
7.1.1 History, manufacture and chemical composition	104
7.1.2 Organoleptic properties	105
7.1.3 Physical and chemical properties	109
7.1.4 Physiological properties	112
7.1.5 Applications	112
7.1.6 Safety	113
7.1.7 Regulatory status	115
7.2 Cyclamate	118
7.2.1 History, manufacture and chemical composition	118
7.2.2 Organoleptic properties	118
7.2.3 Physical and chemical properties	121
7.2.4 Physiological properties	122
7.2.5 Applications	123
7.2.6 Safety	124
7.2.7 Regulatory status	127
8 Sucratose	130
Sam V. Molinary and Mary E. Quinlan	
8.1 Introduction	130
8.2 History of development	130
8.3 Production	131
8.4 Organoleptic properties	132
8.5 Physico-chemical properties	133
8.6 Physiological properties	137
8.7 Applications	138
8.7.1 Beverages	139
8.7.2 Dairy products	139
8.7.3 Confectionery	140
8.7.4 Baked products	140
8.7.5 Pharmaceuticals	141
8.8 Analytical methods	141
8.9 Safety	141
8.10 Regulatory situation	143
Summary Table for Part Two	146
PART THREE: REDUCED-CALORIE BULK SWEETENERS	149
9 Erythritol	151
Ron Perko and Peter DeCock	
9.1 Description	151
9.1.1 History	151
9.1.2 Appearance and structure	151

9.1.3	Non-caloric	151
9.1.4	No glycaemic or insulinaemic response	152
9.1.5	Natural and organic	152
9.1.6	High digestive tolerance	152
9.1.7	Non-cariogenic	153
9.1.8	Antioxidant properties	153
9.1.9	Manufacturing process	153
9.2	Organoleptic properties	153
9.2.1	Sweetness intensity	153
9.2.2	Sweetness profile	154
9.2.3	Cooling effect	154
9.2.4	Synergy with other sweeteners	155
9.3	Physical and chemical properties	155
9.3.1	Stability	155
9.3.2	Solubility	155
9.3.3	Melting point and other thermal characteristics	156
9.3.4	Viscosity of solutions	157
9.3.5	Hygroscopicity	157
9.3.6	Boiling point elevation and freezing point depression	157
9.3.7	Water activity at various concentrations versus sucrose	158
9.4	Physiological properties and health benefits	158
9.4.1	Digestion of carbohydrates	158
9.4.2	Metabolic fate of erythritol	159
9.4.3	Caloric value	160
9.4.4	Digestive tolerance	160
9.4.5	Glycaemic and insulinaemic response	160
9.4.6	Dental health	161
9.4.7	Antioxidant properties	162
9.5	Applications	162
9.5.1	Tabletop sweeteners	162
9.5.2	Beverages	164
9.5.3	Chewing gum	166
9.5.4	Chocolate	168
9.5.5	Candies	169
9.5.6	Fondant	170
9.5.7	Lozenges	171
9.5.8	Bakery (pastry) products	172
9.6	Safety	174
9.6.1	Toxicologic studies	174
9.6.2	Clinical studies	174
9.6.3	Product specification and analyses	175
9.7	Regulatory status	175
10	Isomalt	177
	Anke Sentko and Ingrid Willibald-Ettle	
10.1	Description	177
10.2	Organoleptic properties	178
10.2.1	Sweetening potency versus sucrose	178

10.2.2	Sweetness profiles versus sucrose	178
10.2.3	Synergy and/or compatibility with other sweeteners	178
10.3	Physical and chemical properties	180
10.3.1	Stability	180
10.3.2	Solubility	180
10.3.3	Viscosity	181
10.3.4	Heat of solution	182
10.3.5	Boiling point elevation	182
10.3.6	Hygroscopicity: moisture content at various relative humidities	182
10.3.7	Water activity at various concentrations versus sucrose	183
10.4	Physiological properties	184
10.5	Applications	186
10.5.1	Hard candies	186
10.5.2	Chocolates	190
10.5.3	Low boilings	193
10.5.4	Chewing gums	194
10.5.5	Pan coating	195
10.5.6	Compressed tablets	197
10.5.7	Baked goods	198
10.5.8	Fruit spreads	199
10.5.9	Breakfast cereals, cereal bars and muesli	199
10.6	Safety	202
10.7	Regulatory status: worldwide	202
10.8	Conclusion	202
11	Lactitol	205
	Helen Young	
11.1	History	205
11.2	Organoleptic properties	205
11.3	Physical and chemical properties	207
11.3.1	Stability	207
11.3.2	Solubility	207
11.3.3	Viscosity	208
11.3.4	Heat of solution	209
11.3.5	Boiling point elevation	209
11.3.6	Hygroscopicity	210
11.3.7	Water activity	210
11.4	Physiological properties	211
11.4.1	Metabolism	211
11.5	Health benefits	212
11.5.1	Lactitol as a prebiotic	212
11.5.2	Lactitol to treat hepatic encephalopathy	215
11.5.3	Lactitol and diabetes	215
11.5.4	Tooth-protective properties	215
11.6	Applications	216
11.6.1	Chocolate	217
11.6.2	Baked goods	217
11.6.3	Chewing gum and confectionery	218

11.6.4	Ice cream and frozen desserts	219
11.6.5	Preserves	219
11.6.6	Tablets	219
11.7	Regulatory status	220
11.8	Conclusion	221
12	Maltitol and Maltitol Syrups	223
Malcolm W. Kearsley and Ronald C. Deis		
12.1	Introduction	223
12.2	Production	224
12.2.1	Maltitol powder	224
12.2.2	Maltitol syrups	225
12.2.3	Polyglycitol	225
12.3	Hydrogenation	226
12.4	Structure	227
12.5	Physico-chemical characteristics	227
12.5.1	Chemical reactivity	229
12.5.2	Compressibility	229
12.5.3	Cooling effect (heat of solution)	229
12.5.4	Humectancy	229
12.5.5	Hygroscopicity	230
12.5.6	Molecular weight	230
12.5.7	Solubility	232
12.5.8	Viscosity	233
12.6	Physiological properties	233
12.6.1	Calorific value	233
12.6.2	Dental aspects	234
12.6.3	Diabetic suitability	234
12.6.4	Glycaemic response	235
12.6.5	Toleration	237
12.6.6	Sweetness	238
12.6.7	Conclusion	240
12.7	Applications in foods	242
12.7.1	Chocolate	243
12.7.2	Hard candy	243
12.7.3	Caramels	244
12.7.4	Sugar-free panning	245
12.7.5	Dairy applications	245
12.7.6	Bakery applications	246
12.8	Legal status	246
12.9	Safety	247
12.10	Conclusion	247
13	Sorbitol and Mannitol	249
Malcolm W. Kearsley and Ronald C. Deis		
13.1	Introduction	249
13.2	Production	249
13.2.1	Sorbitol powder	250

13.2.2	Sorbitol syrups	250
13.2.3	Mannitol	251
13.3	Hydrogenation	252
13.4	Storage	252
13.5	Structure	252
13.6	Physico-chemical characteristics	253
13.6.1	Chemical reactivity	254
13.6.2	Compressibility	254
13.6.3	Cooling effect	254
13.6.4	Humectancy	254
13.6.5	Hygroscopicity	254
13.6.6	Molecular weight	255
13.6.7	Solubility	255
13.6.8	Viscosity	255
13.7	Physiological properties	255
13.7.1	Calorific value	255
13.7.2	Dental aspects	256
13.7.3	Diabetic suitability	256
13.7.4	Glycaemic response	256
13.7.5	Toleration	257
13.7.6	Sweetness	257
13.8	Applications in foods	258
13.8.1	Gum	258
13.8.2	Hard candy	258
13.8.3	Tabletting	259
13.8.4	Surimi	259
13.8.5	Cooked sausages	259
13.8.6	Baked goods	259
13.8.7	Panning	260
13.8.8	Over the counter products	260
13.8.9	Toothpaste and mouthwash	260
13.8.10	Chocolate	260
13.9	Legal status	260
13.10	Conclusion	261
14	Tagatose	262
	Ulla Petersen Skytte	
14.1	Introduction	262
14.2	Tagatose facts	262
14.2.1	Chemical properties	262
14.2.2	Physical properties	263
14.2.3	Production process	265
14.2.4	Legal status of tagatose	266
14.2.5	Analyses	266
14.3	Health properties	268
14.3.1	Prebiotic properties: low-calorie value	268
14.3.2	Glycaemic and insulinaemic responses	271
14.3.3	Safe for teeth	274

14.4	Application: tagatose as a flavour enhancer	275
14.4.1	Flavour enhancement in beverage systems	275
14.4.2	Flavour enhancement in reaction flavour	276
14.4.3	Flavour enhancement in chocolate	280
14.4.4	Flavour enhancement in chewing gum	283
14.4.5	Flavour enhancement in mints	284
14.5	Application: tagatose as a healthy bulk sweetener	284
14.5.1	Chocolate	284
14.5.2	Health bars	286
14.5.3	Cereals	286
14.5.4	Sugar confectionery: toffee production	289
14.6	Conclusion	292
15	Xylitol	295
	Michael Bond and Nicholas Dunning	
15.1	Description	295
15.2	Organoleptic properties	297
15.2.1	Sweetness	297
15.2.2	Sweetness synergy	297
15.3	Physical and chemical properties	298
15.3.1	Heat of solution	298
15.3.2	Stability	298
15.3.3	Solubility	299
15.3.4	Viscosity	300
15.3.5	Boiling point elevation	300
15.3.6	Water activity	300
15.3.7	Hygroscopicity	302
15.4	Physiological properties	302
15.4.1	Metabolism	302
15.4.2	Suitability for diabetics	303
15.4.3	Tolerance	303
15.4.4	Caloric value	304
15.4.5	Health benefits	305
15.4.6	Other health benefits associated with xylitol	311
15.5	Applications	313
15.5.1	Confectionery	313
15.5.2	Chewing gum	314
15.5.3	Hard coating applications	314
15.5.4	Chocolate	314
15.5.5	Dairy products and frozen desserts	315
15.5.6	Baked goods	315
15.5.7	Non-food applications	316
15.6	Safety	316
15.7	Regulatory status	317
	Summary Table for Part Three	325

PART FOUR: OTHER SWEETENERS	329
16 Other Sweeteners	331
Mike Lindley	
16.1 Introduction	331
16.2 Synthetic high-potency sweeteners	332
16.2.1 Alitame	332
16.2.2 Neohesperidin dihydrochalcone (NHDC)	337
16.3 Natural high-potency sweeteners	342
16.3.1 Stevioside/rebaudioside A	342
16.3.2 Thaumatin	347
16.3.3 Lo han guo (mogroside)	350
16.4 Carbohydrate sweeteners	353
16.4.1 Isomaltulose	353
16.4.2 α,α -Trehalose	355
Summary Table for Part Four	361
PART FIVE: BULKING AGENTS: MULTI-FUNCTIONAL INGREDIENTS	365
17 Bulking Agents: Multi-functional Ingredients	367
Michael Auerbach, Stuart Craig and Helen Mitchell	
17.1 Introduction	367
17.2 Gluco-polysaccharides	369
17.2.1 Polydextrose	369
17.3 Resistant starches and resistant maltodextrins	380
17.3.1 Fibersol-2 [®]	381
17.3.2 Nutriose [®] FB	383
17.4 Fructo-oligosaccharides (FOS)	385
17.4.1 Inulin and low molecular weight FOS	385
Summary Table for Part Five	398
<i>Index</i>	401