Contents

Preface xv
A note on nomenclature xvii
Acknowledgements xix

Chapter 1 History of glucose syrups 1
  1.1 Historical developments 1
  1.2 Analytical developments 4
  1.3 Process developments 6

Chapter 2 Fructose containing syrups 9
  2.1 Introduction 9
  2.2 Commercial development 11
  2.3 Europe and the HFGS (isoglucose) production quota 13
  2.4 Inulin 17
  2.5 Conclusion 17

Chapter 3 Glucose syrup manufacture 19
  3.1 Introduction 19
  3.2 Reducing sugars 20
  3.3 Starch 21
  3.4 Enzymes
     3.4.1 α-amylase 24
     3.4.2 β-amylase 24
     3.4.3 Glucoamylase 24
     3.4.4 Pullulanase 25
     3.4.5 Isomerase 25
     3.4.6 Lesser enzymes 25
  3.5 The process 25
  3.6 Acid hydrolysis 27
  3.7 Acid enzyme hydrolysis 33
  3.8 Paste Enzyme Enzyme hydrolysis (PEE) 34
  3.9 Crystalline dextrose production 36
  3.10 Total sugar production 38
  3.11 Enzyme enzyme hydrolysis (E/E) 39
  3.12 Isomerisation 40
  3.13 Syrups for particular applications 43
  3.14 Summary of typical sugar spectra produced by different processes 43
Chapter 4  Explanation of glucose syrup specifications  45
  4.1 Introduction  45
  4.2 What specification details mean  45
  4.3 Dry products  53
  4.4 Syrup problems and their possible causes  54
  4.5 Bulk tank installation  57
  4.6 Bulk tank design  58

Chapter 5  Application properties of glucose syrups  61
  5.1 Introduction  61
  5.2 Summary of properties  63
  5.3 Bodying agent  64
  5.4 Browning reaction  64
  5.5 Cohesiveness  65
  5.6 Fermentability  65
  5.7 Flavour enhancement  65
  5.8 Flavour transfer medium  66
  5.9 Foam stabilisers  66
  5.10 Freezing point depression  66
  5.11 Humectancy  67
  5.12 Hygroscopicity  68
  5.13 Nutritive solids  68
  5.14 Osmotic pressure  68
  5.15 Prevention of sucrose crystallisation  70
  5.16 Prevention of coarse ice crystal formation  70
  5.17 Sheen producer  71
  5.18 Sweetness  71
  5.19 Viscosity  72
  5.20 Summary of properties  73
  5.21 Differences between glucose syrups and sucrose  74

Chapter 6  Syrup applications: an overview  77
  6.1 Introduction  77
  6.2 42 DE Glucose Syrup  77
  6.3 28 and 35 DE Glucose Syrup  79
  6.4 Glucose syrup solids  80
  6.5 Maltose and high maltose syrups  80
  6.6 63 DE Glucose Syrup  82
  6.7 95 DE Glucose Syrup  84
  6.8 Dextrose monohydrate  88
  6.9 HFGS and fructose syrups  91
  6.10 Maltodextrins  95
<table>
<thead>
<tr>
<th>Chapter 7</th>
<th>Trehalose</th>
<th>101</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.1</td>
<td>Introduction</td>
<td>101</td>
</tr>
<tr>
<td>7.2</td>
<td>Production</td>
<td>101</td>
</tr>
<tr>
<td>7.3</td>
<td>Properties</td>
<td>103</td>
</tr>
<tr>
<td>7.4</td>
<td>Applications</td>
<td>104</td>
</tr>
<tr>
<td>7.4.1</td>
<td>Confectionery</td>
<td>105</td>
</tr>
<tr>
<td>7.4.2</td>
<td>Dairy</td>
<td>105</td>
</tr>
<tr>
<td>7.4.3</td>
<td>Jams and fruit fillings</td>
<td>106</td>
</tr>
<tr>
<td>7.4.4</td>
<td>Cosmetic and personal hygiene products</td>
<td>106</td>
</tr>
<tr>
<td>7.4.5</td>
<td>Pharmaceuticals</td>
<td>106</td>
</tr>
<tr>
<td>7.4.6</td>
<td>Medical applications</td>
<td>106</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Chapter 8</th>
<th>Sugar alcohols: an overview</th>
<th>107</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.1</td>
<td>Introduction</td>
<td>107</td>
</tr>
<tr>
<td>8.2</td>
<td>Production</td>
<td>108</td>
</tr>
<tr>
<td>8.3</td>
<td>Overview of polyol properties</td>
<td>111</td>
</tr>
<tr>
<td>8.4</td>
<td>Applications overview</td>
<td>113</td>
</tr>
<tr>
<td>8.4.1</td>
<td>Sorbitol</td>
<td>113</td>
</tr>
<tr>
<td>8.4.2</td>
<td>Maltitol</td>
<td>115</td>
</tr>
<tr>
<td>8.4.3</td>
<td>Mannitol</td>
<td>116</td>
</tr>
<tr>
<td>8.4.4</td>
<td>Erythritol</td>
<td>117</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Chapter 9</th>
<th>Glucose syrups in baking and biscuit products</th>
<th>119</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.1</td>
<td>Introduction</td>
<td>119</td>
</tr>
<tr>
<td>9.2</td>
<td>Fermented goods</td>
<td>120</td>
</tr>
<tr>
<td>9.3</td>
<td>Non-fermented goods</td>
<td>121</td>
</tr>
<tr>
<td>9.4</td>
<td>Biscuits</td>
<td>123</td>
</tr>
<tr>
<td>9.5</td>
<td>Biscuit fillings</td>
<td>124</td>
</tr>
<tr>
<td>9.6</td>
<td>Wafer fillings</td>
<td>124</td>
</tr>
<tr>
<td>9.7</td>
<td>Bakery sundries</td>
<td>125</td>
</tr>
<tr>
<td>9.7.1</td>
<td>Fondant</td>
<td>125</td>
</tr>
<tr>
<td>9.7.2</td>
<td>Hundred and thousands</td>
<td>126</td>
</tr>
<tr>
<td>9.7.3</td>
<td>Icings</td>
<td>126</td>
</tr>
<tr>
<td>9.7.4</td>
<td>Marshmallows</td>
<td>127</td>
</tr>
<tr>
<td>9.7.5</td>
<td>Marzipan</td>
<td>128</td>
</tr>
<tr>
<td>9.7.6</td>
<td>Fruit flavoured pieces</td>
<td>128</td>
</tr>
<tr>
<td>9.7.7</td>
<td>Piping jelly</td>
<td>129</td>
</tr>
<tr>
<td>9.7.8</td>
<td>Bakery glaze</td>
<td>129</td>
</tr>
<tr>
<td>9.8</td>
<td>Reduced calorie products</td>
<td>130</td>
</tr>
<tr>
<td>9.9</td>
<td>Breakfast cereals</td>
<td>131</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Chapter 10</th>
<th>Glucose syrups in brewing</th>
<th>133</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.1</td>
<td>Introduction</td>
<td>133</td>
</tr>
<tr>
<td>10.2</td>
<td>Brewing process</td>
<td>134</td>
</tr>
<tr>
<td>10.3</td>
<td>Historical use of glucose syrups</td>
<td>135</td>
</tr>
</tbody>
</table>
## Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.4 The role of glucose syrups</td>
<td>137</td>
</tr>
<tr>
<td>10.5 Low alcohol and low calorie beer</td>
<td>138</td>
</tr>
<tr>
<td>10.6 De-ionised glucose syrups</td>
<td>139</td>
</tr>
<tr>
<td>10.7 High gravity brewing</td>
<td>140</td>
</tr>
<tr>
<td>10.7.1 High gravity brewing calculations</td>
<td>140</td>
</tr>
<tr>
<td>10.8 Brewer's extract – cost calculations</td>
<td>141</td>
</tr>
<tr>
<td>10.8.1 Typical extract values (hot water)</td>
<td>143</td>
</tr>
<tr>
<td>10.8.2 Brewing syrup addition calculations</td>
<td>145</td>
</tr>
<tr>
<td>10.9 Chip sugar</td>
<td>146</td>
</tr>
<tr>
<td>10.9.1 How to make chip sugar</td>
<td>147</td>
</tr>
</tbody>
</table>

### Chapter 11 Glucose syrups in confectionery

#### 11.1 Introduction

11.2 What can glucose syrups offer the confectioner?

11.2.1 Control of sucrose crystallisation and graining

11.2.2 Reduce moisture pickup

11.2.3 Reduce cold flow

11.2.4 Improve processing

11.2.5 Modify the sweetness

11.2.6 Modifying texture

11.3 Which glucose syrup to use?

11.4 Typical glucose syrup inclusion rates

11.5 Some basic confectionery recipes

11.5.1 High boilings

11.5.2 Pulled sugar confectionery

11.5.3 Fondant

11.5.4 Toffee and caramel

11.5.5 Fudge

11.5.6 Gums and jellies

11.5.7 Chews

11.5.8 Marshmallows

11.5.9 Turkish delight

11.5.10 Muesli bars

11.5.11 Confectionery centres

11.6 Calorie reduced products

### Chapter 12 Glucose syrups in fermentations: an overview

#### 12.1 Introduction

12.2 Choice of substrate

12.3 Basic fermentation process

12.4 Products of fermentation

12.4.1 Pharmaceutical

12.4.2 Enzymes

12.4.3 Food grade products

12.4.4 Industrial products
Chapter 13  Glucose syrups in ice creams and similar products  185
  13.1  Introduction  185
  13.2  Ingredients and process  185
    13.2.1  Fats  185
    13.2.2  Milk solids  187
    13.2.3  Sugars  187
    13.2.4  Emulsifiers and stabilisers  187
    13.2.5  Solids  187
    13.2.6  Pasteurisation  188
    13.2.7  Homogenisation  188
    13.2.8  Cooling, ageing and freezing  188
  13.3  Glucose syrups – freezing point and relative sweetness values  188
    13.3.1  How to reformulate using glucose syrups  190
    13.3.2  How sweeteners can be re-balanced  190
  13.4  Quick process checks  194
    13.4.1  Viscosity  194
    13.4.2  Overrun  194
    13.4.3  Solids  194
    13.4.4  Fats  194
  13.5  Soft serve ice creams  194
  13.6  Other types of frozen dessert  195
  13.7  Yoghurts  195
  13.8  Sorbet  196
  13.9  Mousse  196
  13.10  Ice lollies  197
  13.11  Fruit lollies  197
  13.12  Ripple syrups  197
  13.13  Topping or dessert syrup  198
    13.13.1  A simple economy topping syrup  199
    13.13.2  Fruit-flavoured topping syrup  199
    13.13.3  All syrup fruit-flavoured topping syrup  200
    13.13.4  Chocolate topping  200
    13.13.5  All syrup chocolate topping  200
    13.13.6  Caramel topping  200
    13.13.7  All syrup caramel topping syrup  201
  13.14  Reduced calorie products  201

Chapter 14  Glucose syrups in jams  203
  14.1  Introduction  203
  14.2  Effects of boiling  203
  14.3  Use of glucose syrups  205
  14.4  Domestic jam  208
  14.5  Jelly jams  209
  14.6  Honey type spread  209
Contents

14.7 Chocolate spread 210
14.8 Peanut spread 211
14.9 Industrial jams 211
  14.9.1 Bake-stable jams 212
  14.9.2 Biscuit jams 212
  14.9.3 Spreadable jams 212
  14.9.4 Jam fillings 212
  14.9.5 Flan jellies 212
  14.9.6 Fruit and pie fillings 214
  14.9.7 Tablet jellies 214
  14.9.8 Mincemeat 215
  14.9.9 Fruit curds 216
14.10 Diabetic and reduced calorie products 217
14.11 How to calculate a recipe? 217

Chapter 15 Glucose syrups in tomato products and other types of dressings and sauces 221
  15.1 Introduction 221
  15.2 Which glucose syrup to use? 221
  15.3 Tomato products 222
  15.4 Other dressings 224
  15.5 Other sauces, marinades and pickles 225
  15.6 Reduced calorie products 226

Chapter 16 Glucose syrups in soft drinks 227
  16.1 Introduction 227
  16.2 Ingredients 228
  16.3 Effect of process inversion 228
  16.4 Use of glucose syrups 231
  16.5 Quality considerations 233
  16.6 Laboratory evaluation of glucose syrups in soft drinks 233
    16.6.1 Water 234
    16.6.2 Sweeteners 234
    16.6.3 Acidulants 235
  16.7 Soft drink recipes 236
    16.7.1 Carbonated drinks, for example lemonade 237
    16.7.2 Dilutable drinks, for example orange squash 237
  16.8 Powdered drinks 238
  16.9 Reduced calorie drinks 238

Chapter 17 Glucose syrups in health and sports drinks 239
  17.1 Introduction 239
  17.2 The energy source 239
  17.3 Classification of health drinks 240
  17.4 Osmotic pressure of health drinks 241
17.5 Sucrose in sports or health drinks 243
17.6 Formulating a sports drink 244
17.7 Energy values 246
17.8 Oral rehydration 247
17.9 Geriatric drinks and liquid foods 248
17.10 Slimming foods 249

Chapter 18 Carbohydrate metabolism and caloric values 251
18.1 Introduction 251
18.2 Human digestive system 252
18.3 Carbohydrate absorption 253
18.4 Summary of carbohydrate metabolism 254
18.4.1 Sugars 254
18.4.2 Starch 255
18.4.3 Fibre (that is roughage) and non-starch polysaccharides (that is cellulose) 255
18.4.4 Polyols 256
18.5 Carbohydrate metabolic problems 257
18.5.1 Diabetes mellitus 257
18.5.2 Fructose and diabetes 257
18.5.3 Lactose intolerance 258
18.5.4 Fructose intolerance 258
18.5.5 Galactosaemia 258
18.5.6 Gaucher's disease 259
18.5.7 Coeliac disease (also known as gluten intolerance) 259
18.5.8 Phenylketonuria and aspartame 259
18.6 Caloric values 260

Chapter 19 Caramel – the colouring 261
19.1 Introduction 261
19.2 Process 261
19.3 Properties 262
19.4 Applications 262

Glossary 265

Appendix A Simple analytical information 297
A.1 Introduction 297
A.2 The ingredient declaration panel 297
A.3 Does it contain glucose syrup? 299
A.4 What HPLC sugar analysis can tell? 301

Appendix B Simple calculations 305
B.1 Introduction 305
B.2 Adjusting syrup solids 305
B.3 Altering the sugar spectra of a glucose syrup blend 308
B.4 How to calculate equivalent sweetness values? 311
B.5 Relationship between density, volume and weight of glucose syrups 312
B.6 How much syrup is required to obtain a given weight of syrup solids? 312
B.7 Brix, RI and RI Solids, % Solids and Baumé 313
B.8 Recipe costings 314
B.9 Colligative properties 315
B.9.1 How to calculate boiling point elevation? 315
B.9.2 How to calculate freezing point depression? 317
B.9.3 How to calculate osmotic pressure? 318

Appendix C Sugars data 321
C.1 Approximate % sugar spectra of different glucose syrups 321
C.2 Theoretical molecular weights 322
C.3 Sweetness values 323
C.4 Approximate sugar spectra of domestic sweeteners 324
C.5 Typical particle size for different grades of sucrose 326
C.6 Melting points 327
C.7 Glass transition temperatures – $T_g$ values 327
C.8 Solubility – grams per 100 ml 328
  C.8.1 In water 328
  C.8.2 In 80% alcohol at 20°C 328

Appendix D Tables 329
D.1 Temperature conversion 329
D.2 Viscosity of glucose syrups at different Dextrose Equivalents and temperatures. Reproduced by courtesy of The Corn Refiners Association. 334
D.3 Maize starch Baumé tables. Reproduced by courtesy of The Corn Refiners Association. 348
D.4 Sucrose Brix table – Brix – % sucrose w/w, specific gravity and Baumé (145 modulus) 349
D.5 Sucrose Brix – refractive indices at 20°C 351
D.6 Glucose syrup tables – commercial Baumé, DE, % solids – at 60°C (140°F) 352
D.7 Sieve specifications 352

Bibliography 357
Index 361