Sugar Functionality & the Challenge of Reformulation

Professor Julian M Cooper
Sugar Functionality & Reformulation Challenge

1. What is Sugar?

2. Sugar functionality

3. How can the functionality be replaced?

4. Reformulation considerations
What is sugar?

- Carbohydrates $C_x(H_2O)_y$ (-oses)
- Single units (mono-)
  - glucose, fructose, galactose
- Two units (di-)
  - sucrose, maltose, lactose
- More Units (3 – 10) (oligo-)
  - fructo-oligosaccharides
- Lots of Units (poly-)
  - starch, pectin, fibre

Sugars are not just sugar

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What is sugar?

α-D-Glucopyranosyl-β-D-fructofuranoside
Sugar - A Natural product from beet & cane

- root crop
- UK/European grown and processed
- sugars produced in the plant by photosynthesis
- sugar crystallises naturally white
- no difference between beet and cane

- tropical grass
- processed where it is grown
- shipped as raw sugar, refined in Europe
Functionality of sugar
Functionality of sugar

Structure

- Sugar provides structure in products – e.g. cakes, biscuits, cereals, preserves and confectionery

Texture

- Particle size is important
- Texture in fudge, snap in biscuits
Functionality of sugar

Colour and flavour formation

- Caramelisation
  - Action of heat on sugars
- Maillard reaction
  - Reaction between sugars and proteins
- Traditional colour and flavour generated in baking and processing
Functionality of sugar

Fermentation substrate
- Broken down by yeasts to give alcohol and carbon dioxide - bread & beer

Preservative
- Dissolves readily – high osmotic pressure
- Jams, preserves, chutneys
- Food safety
- Extends shelf life
Functionality of sugar

Sweetener

- Sucrose is the ‘Gold Standard’ for sweetness
- All sugars and sweeteners compared with it
- Relative sweetness of sugars
  - Fructose 1.2; Sucrose 1.0; Glucose 0.7; Lactose 0.4
- Profile of sweetness just as important as the intensity
What does sugar deliver?

- Recognised, natural, traditional ingredient
- Multifunctional
- Clean label – sugar
- 4 calories/g (cf fat 9 calories/g)
- Medium glycaemic index (65)
Why Reformulate?

- Replace/reduce certain ingredients
- Develop ‘functional’ products
- Provide choice for consumers
- Develop new products - innovation
- Reduce energy density in products
- **Reduce calories in products**
Sugar Reformulation – What can I use?

- **Sweetness** → High intensity sweeteners, polyols
- **Mouthfeel/Texture** → Hydrocolloids, polyols, sugars
- **Structure** → Bulking agents, polyols, fibres
- **Colour** → Colours
- **Flavour** → Flavours
- **Stability/Preservation** → Benzoates etc
- **Humectancy** → Polyols
Considerations when replacing sugar

- Multiple ingredients
- Increased labelling/warnings
- Gastro-intestinal consequences
- Food safety may be compromised
- Reducing sugar may increase calories (energy density)
- Taste and Consumer acceptance (manufacturer)
Regular Jam vs Sugar Free Preserve

- **Regular Jam**
  - Strawberries, sugar, glucose, glucose-fructose, pectin, citric acid

- **Sugar Free Preserve**
  - Water, strawberries, polydextrose, maltodextrin, locust bean gum, natural flavour, citric acid, potassium sorbate, sucralose, calcium chloride, Red 40 (colour)
# Regular Jam vs Sugar Free Preserve

<table>
<thead>
<tr>
<th>Regular Jam</th>
<th>Functionality</th>
<th>Sugar Free Preserve</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strawberries, sugar, glucose, glucose-fructose</td>
<td>Sweetness</td>
<td>Strawberries, sucralose</td>
</tr>
<tr>
<td>Strawberries, sugar, glucose, glucose-fructose, pectin</td>
<td>Bulk</td>
<td>Strawberries, water, polydextrose, fruit pectin, locust bean gum</td>
</tr>
<tr>
<td>Pectin, sugar, glucose, glucose-fructose</td>
<td>Gelling</td>
<td>Fruit pectin, calcium chloride</td>
</tr>
<tr>
<td>sugars</td>
<td>Preservative</td>
<td>Potassium sorbate</td>
</tr>
<tr>
<td>Citric acid</td>
<td>Acidity</td>
<td>Citric acid</td>
</tr>
<tr>
<td>sugars</td>
<td>Flavour</td>
<td>Natural flavour</td>
</tr>
<tr>
<td>sugars</td>
<td>colour</td>
<td>Red40</td>
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</table>
### Increased Energy Density (Calories/100g)

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Regular cake</th>
<th>Cal reduced' cake</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wt (g)</td>
<td>cals</td>
<td></td>
</tr>
<tr>
<td>Fat</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>900</td>
<td>900</td>
</tr>
<tr>
<td>Sugar</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td></td>
<td>400</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>200</td>
<td></td>
</tr>
<tr>
<td>Flour</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td></td>
<td>400</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>400</td>
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<tr>
<td>Totals</td>
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<tr>
<td></td>
<td>1700</td>
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<td>250</td>
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<tr>
<td></td>
<td></td>
<td>1500</td>
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**Calories increase/100g:** 567

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Stepwise Reduction

Shortbread recipe
Butter 110g; Flour 175g; Caster sugar 50g

<table>
<thead>
<tr>
<th>Weight of sugar g</th>
<th>‘Calories reduced’</th>
<th>Sugar g/100g</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>0</td>
<td>14.9</td>
</tr>
<tr>
<td>45</td>
<td>20</td>
<td>13.6</td>
</tr>
<tr>
<td>40</td>
<td>40</td>
<td>12.3</td>
</tr>
<tr>
<td>35</td>
<td>60</td>
<td>10.9</td>
</tr>
</tbody>
</table>

‘Calories reduced’ = wt of sugar removed x 4cals
# Stepwise Sugar Reduction

## Shortbread Recipe

<table>
<thead>
<tr>
<th>Recipe</th>
<th>Fat g</th>
<th>Carb g</th>
<th>Protein g</th>
<th>Sugars g</th>
</tr>
</thead>
<tbody>
<tr>
<td>Butter</td>
<td>110</td>
<td>88</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flour</td>
<td>175</td>
<td>122.5</td>
<td>17.5</td>
<td></td>
</tr>
<tr>
<td>Sugar</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>50</td>
</tr>
</tbody>
</table>

**% composition**

- 26.3
- 51.5
- 5.2
- 14.9

**Total Recipe Wt g**

- 335

**Calories**

- 792
- 690
- 70

**Total Cals**

- 1552

**Cals/100g**

- 463
Stepwise Reduction

Shortbread recipe
Butter 110g; Flour 175g; Caster sugar 50g

<table>
<thead>
<tr>
<th>Weight of sugar g</th>
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<th>Sugar g/100g</th>
<th>Actual Calories/100g</th>
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<tbody>
<tr>
<td>50</td>
<td>0</td>
<td>14.9</td>
<td>463</td>
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‘Calories reduced’ = wt of sugar removed x 4cals
Reduced Sugars – Consumer Expectations

‘Reduced Sugar’ products

<table>
<thead>
<tr>
<th>Product</th>
<th>Sugar g/100g</th>
<th>Energy cals/100g</th>
<th>Salt g/100g</th>
<th>Fat g/100g</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regular Sugar coated Product</td>
<td>37</td>
<td>371</td>
<td>1.15</td>
<td>0.6</td>
</tr>
<tr>
<td>‘Reduced Sugar’ Product</td>
<td>25</td>
<td>369</td>
<td>1.4</td>
<td>0.6</td>
</tr>
<tr>
<td>Regular Product</td>
<td>8</td>
<td>373</td>
<td>1.75</td>
<td>0.9</td>
</tr>
</tbody>
</table>
Consumer Expectations

- Research at Leatherhead Food Research
- Consumer focus groups and web questionnaire
- Good awareness of product claims eg ‘no added sugars’ etc
- Little awareness of the level of reduction or the associated calorie reduction
- Expect a reduction in sugar content to deliver a reduction in calorie content
- Consumer confusion around calorie content of different nutrients

Summary

- Sugar - natural, traditional, multifunctional ingredient
- “Sugars” on nutrition labels are not just sugar
- No unique sugar replacer for all applications
- Reformulation should deliver an improved nutrition profile and preferably reduction in calories
- Stepwise reduction may have unintended consequences