Welcome

Beyond Sweetness
The Functional Roles of Sugar in Foods
And the Challenges in Replacing/Reducing it

Time: Thursday, February 04, 2016 at 1:00-2:00 PM EST
Speakers:

Prof. Douglas Goff

Prof. Julian Cooper

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Beyond Sweetness: The Functional Roles of Sugar in Foods and the Challenges in Replacing/Reducing It

Prof. H. Douglas Goff
Dept. of Food Science
University of Guelph
“Sugar”, Sugars and Sweeteners

**Monosaccharides**
- Glucose, Fructose and Galactose

**Disaccharides**
- Sucrose (“sugar”), Maltose and Lactose

**Sugar Alcohols**
- Sorbitol, Xylitol and Erythritol
- Maltitol and Lactitol

**High-potency Sweeteners**
- Aspartame, Acesulfame K, Sucralose, Saccharin, Stevia
Functional Properties of Sugar in Foods

Sensory
- Sweetness and flavour perception and enhancement
- Texture and appearance

Microbial
- Preservation
- Fermentation

Chemical
- Caramelization
- Maillard Browning
- Plasticization of polymers

Phase Transitions
- Crystallization and candies
- Freezing point depression
Functional Properties of Sugar in Foods

**Sensory**
- Sweetness and flavour perception and enhancement
  - Sweetness time-intensity profile of sugar is the standard
  - Flavour modification and perception: e.g., releasing aromas, balancing the bitterness of cocoa in chocolate, the sourness of yogurt, the acidity of tomatoes
Functional Properties of Sugar in Foods

**Sensory**
- Sweetness and flavour perception and enhancement
- Texture and appearance
  - Interaction of sugar with water to create viscosity
- “Syrupy” mouthfeel
- For example, juice and other sugar-sweetened beverages, low calorie vs. regular jello.
Functional Properties of Sugar in Foods

**Microbial**

- Preservation
  - Lowering “water activity” (the availability of water to support microbial growth) and thereby reducing microbial growth potential and increasing ambient-temperature shelf-life
  - e.g., strawberry jam, fruit cakes, sweetened condensed milk
Functional Properties of Sugar in Foods

**Microbial**

- Preservation
- Fermentation
  - Growth substrate for microorganisms in various foods (e.g., bread and yeast-leavened baked products)
  - Sugar produces carbon dioxide
Functional Properties of Sugar in Foods

**Chemical**

- **Caramelization**
  - Heat causes the formation of brown colours and different flavours
  - E.g., peanut brittle, caramels and toffees, molasses, also hints of caramelization in many other heated foods
Chemical
  • Caramelization
  • Maillard Browning
    • Colour and flavour changes with heat and amino acids (sucrose conversion to glucose initiates Maillard reactions)
    • Occurs in bread and bakery products (crusts or making toast) and many whole foods that are heated
Functional Properties of Sugar in Foods

**Chemical**
- Caramelization
- Maillard Browning
- Plasticization ("softening") of polymers
  - Modifies water absorption and mobility characteristics, e.g., the effects of sugar on starch gels or gluten networks
Functional Properties of Sugar in Foods

**Phase Transitions**

- Crystallization and candies
  - Confectionery industry based on controlled crystallization of sugar to give different textures, e.g., smoothness of fondants and fudge

- Amorphous sugar glasses, e.g., hard candies
Functional Properties of Sugar in Foods

**Phase Transitions**
- Crystallization and candies
- Freezing point depression
  - Colligative property based on molecular weight of the sugar and its concentration
  - Results in “unfrozen phase” in sugar-containing foods at freezer temperatures, which can affect stability and shelf-life
  - Softness and scoopability in ice cream
Example of Sugar Reduction Challenge: Ice Cream/ Frozen Desserts

Global Diabetes trend suggest the market for low Glycemic Index (GI) Products should be strong and growing
In this example, maltitol (disaccharide) provides the freezing characteristics of sugar but at a lower glycemic index. Sucralose is needed to boost the sweetness of maltitol to sugar-equivalence. But, no reduction in calories.
Ice Cream Mix Composition

- **(Milk) fat**  
  (4-8) - >10% - 16%

- **Milk solids-not-fat**  
  9% - 12%

- **Sweeteners**
  - **Sucrose**  
    10% - 14%
  - **Corn syrup solids**  
    (Glucose solids)  
    4% - 5%

- **Stabilizers**  
  0% - 0.4%

- **Emulsifiers**  
  0% - 0.25%

- **Water**  
  55% - 64%
In determining appropriate blend of sweeteners for ice cream...

**You have to consider:**

- **Sweetness**
- **Freezing pt. depression,** which leads to softness/scoopability
- **Total solids/water level desired in the formulation**
Ice Cream Freezing Curves

Temperature

Percentage of Water Frozen

(Typical scooping temperature)

Ice Cream Mix A - Firmer
(lower concentration of sugars and/or higher mol. wt.)

Ice Cream Mix B - Softer
(higher concentration of sugars and/or lower mol. wt.)

(0°C)

(20 40 60 80)

(20 40 60 80)

(0°C)

(0°C)

(0°C)

(0°C)
Conclusions

• Sugars contribute many functional properties to foods beyond sweetness; the high-potency sweeteners are not an option in many cases.

• Sugar reduction/replacement is an application-specific product development challenge that in many cases is difficult to overcome.

• Another important consideration: what is sugar being replaced with and, in the end, what has been accomplished?
Dr. Julian Cooper

Professor
University of Reading
Fellow of the Royal Society of Chemistry, UK
Fellow of the Institute of Food Science and Technology, UK

• Internationally renowned sugar and carbohydrate expert in process and product development, carbohydrate chemistry, product reformulation and research and development in the food sector
Sugar Reformulation Challenge

Professor Julian M Cooper

4 February 2016
Sugar & the Reformulation Challenge

1. What does sugar deliver?

2. Why Reformulate?

3. How can the multi-functionality of sugar be replaced?

4. Reformulation considerations
What does sugar deliver?

- Recognised, natural, traditional ingredient
- Multifunctional
- Clean label – sugar
- 4 calories/g (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
Replacing Sugar functionality – What can I use?

- Sweetness → High intensity sweeteners, polyols
- Mouth feel/Texture → Hydrocolloids, polyols, sugars
- Structure → Bulking agents, polyols, fibres
- Colour → Colours
- Flavour → Flavours
- Stability/Preservation → Preservatives
Considerations when replacing/reducing sugar

- Multiple ingredients
- Increased labelling/warnings (e.g. polyols, aspartame, etc.)
- Gastro-intestinal consequences (polyols, etc.)
- 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></th>
<th>Functionality</th>
<th>Sugar Free Preserve</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Regular Jam</strong></td>
<td></td>
<td></td>
</tr>
<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>
</tr>
</tbody>
</table>
### Increased Energy Density (Calories/100g)

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Regular cake</th>
<th></th>
<th>‘Cal reduced’ cake</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wt (g)</td>
<td>Cals</td>
<td>Ingredient</td>
<td>Wt (g)</td>
</tr>
<tr>
<td>100</td>
<td>900</td>
<td>Fat</td>
<td>100</td>
</tr>
<tr>
<td>100</td>
<td>400</td>
<td>Sugar</td>
<td>50</td>
</tr>
<tr>
<td>100</td>
<td>400</td>
<td>Flour</td>
<td>100</td>
</tr>
<tr>
<td>300</td>
<td>1700</td>
<td>Totals</td>
<td>250</td>
</tr>
</tbody>
</table>

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### Increased Energy Density (Calories/100g)

<table>
<thead>
<tr>
<th></th>
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<th>‘Cal reduced’ cake</th>
</tr>
</thead>
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<td>100</td>
<td>400</td>
<td>Flour</td>
</tr>
<tr>
<td>300</td>
<td>1700</td>
<td>Totals</td>
</tr>
<tr>
<td><strong>567</strong></td>
<td><strong>Calories increase/100g</strong></td>
<td></td>
</tr>
</tbody>
</table>
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 Reduction

**Shortbread**

<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>

<table>
<thead>
<tr>
<th>% composition</th>
<th>26.3</th>
<th>51.5</th>
<th>5.2</th>
<th>14.9</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Total Recipe Wt g</th>
<th>335</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Calories</th>
<th>792</th>
<th>690</th>
<th>70</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Total Cals</th>
<th>1552</th>
</tr>
</thead>
</table>

**Cals/100g** 463
## 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>
<th>Actual Calories/100g</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>0</td>
<td>14.9</td>
<td>463</td>
</tr>
<tr>
<td>45</td>
<td>20</td>
<td>13.6</td>
<td>464</td>
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<td>60</td>
<td>10.9</td>
<td>466</td>
</tr>
</tbody>
</table>

‘Calories reduced’ = weight of sugar removed x 4 Cals
## Reduced Sugars – Cereal Products

### ‘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

Consumer Expectations—cont’d

- A survey among Canadian dietitians (n=140) revealed similar expectations of **Calorie reduction** in products carrying the claim “Reduced in Sugar”

<table>
<thead>
<tr>
<th>% of respondents (dietitians)</th>
<th>10%</th>
<th>15%</th>
<th>25%</th>
<th>No Need</th>
</tr>
</thead>
<tbody>
<tr>
<td>% of respondents</td>
<td>14%</td>
<td>11%</td>
<td>47%</td>
<td>28%</td>
</tr>
</tbody>
</table>

Summary

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

• Please type your questions in the Comment Window

• Please share your learnings on Twitter using #NotJustSweetness
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