How, Where & Why Low Calorie Sweeteners Can Be Used in Foods & Drinks

Mary Quinlan; Manager, Sweetener Technology Development
Tate & Lyle
How, Where & Why Low Calorie Sweeteners Can Be Used in Foods & Drinks

Agenda

• Why low calorie sweeteners are used in foods & drinks

• Where sweeteners can be used and the choices available

• How to formulate with low calorie sweeteners
Why low calorie sweeteners are used in foods & drinks

Obesity is a significant public policy issue

British women are now officially the most overweight in Europe and men aren’t far behind
Conclusions on sugar, obesity and health

- All experts agree sugar can contribute part of a healthy diet
- Most do not believe that it is possible or necessary to define a quantitative limit on sugar (sugars) intake
- None suggest that sugar has any special role as cause of obesity or any other lifestyle disease (except dental caries through frequency of consumption)
Why low calorie sweeteners are used in foods & drinks

BMJ

Move a little more, eat a little less

Both sides of the energy equation must be tackled
Why low calorie sweeteners are used in foods & drinks

What the consumers say
Consumer Insights Methodology

- Online survey of consumers in France, Germany, Italy, Spain and UK

<table>
<thead>
<tr>
<th></th>
<th>France</th>
<th>Germany</th>
<th>Italy</th>
<th>Spain</th>
<th>UK</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. Interviews</td>
<td>311</td>
<td>313</td>
<td>322</td>
<td>311</td>
<td>308</td>
</tr>
</tbody>
</table>

- Adults aged 18-65 who purchase dairy, bakery, beverages or condiments at least once a month
- Data has been weighted to be nationally representative by age, gender, region, number of children in household, income and education
- Fieldwork took place between 6th - 14th July 2009

Source: Harris Interactive – Tate & Lyle Ingredient Perceptions Research 2009
Consumers want products they perceive as “healthy”

I actively look for food and drink products that are healthy

<table>
<thead>
<tr>
<th>Agreeance Level</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Completely agree (5)</td>
<td>34%</td>
</tr>
<tr>
<td>Slightly agree</td>
<td>28%</td>
</tr>
<tr>
<td>Neither agree nor disagree</td>
<td>7%</td>
</tr>
<tr>
<td>Slightly disagree</td>
<td>7%</td>
</tr>
<tr>
<td>Completely disagree (1)</td>
<td>7%</td>
</tr>
</tbody>
</table>

58% agreement

Source: Harris Interactive – Tate & Lyle Ingredient Perceptions Research 2009

Q811. How much do you agree or disagree with each of the following statements?

Base: All respondents – FR (311), DE (313), IT (322), ES (311), UK (308)

Significantly lower than other countries
Consumers look for products to help manage their calorie intake

I actively look for food and drink that contains reduced levels of sugar

<table>
<thead>
<tr>
<th>Compl. disagree (1)</th>
<th>Slight. disagree</th>
<th>Neither agree nor disagree</th>
<th>Slight. agree</th>
<th>Compl. agree (5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>13</td>
<td>27</td>
<td>32</td>
<td>19</td>
</tr>
</tbody>
</table>

51% agreement

Source: Harris Interactive – Tate & Lyle Ingredient Perceptions Research 2009

Q811. How much do you agree or disagree with each of the following statements?
Base: All respondents – FR (311), DE (313), IT (322), ES (311), UK (308)
Consumers will not compromise on taste!

As long as the product is healthy, I am prepared to compromise on taste

- Completely disagree (1)
- Slightly disagree
- Neither agree nor disagree
- Slightly agree
- Completely agree (5)

Source: Harris Interactive – Tate & Lyle Ingredient Perceptions Research 2009

811. How much do you agree or disagree with each of the following statements?
Base: All respondents – FR (311), DE (313), IT (322), ES (311), UK (308)
Where sweeteners can be used and the choices available
Where sweeteners can be used and the choices available

• High potency sweeteners are normally used to replace the sweetness of sugar or other nutritive sweeteners in reduced sugar products

• High potency sweeteners permitted for use in Europe include:-
  – Acesulfame-K
  – Aspartame
  – Cyclamate
  – Neotame
  – Saccharin
  – Sucralose
Where sweeteners can be used and the choices available

• The EU Categories of Use define the applications that can be explored

• Energy Reduced
  – Product must show at least a 30% caloric reduction over a typical full-calorie product

• No-added Sugar
  – Product must not contain any added mono- or disaccharides, or any other food used for its sweetening properties (e.g. honey)
Where sweeteners can be used and the choices available

<table>
<thead>
<tr>
<th>Category</th>
<th>Max dose of sucralose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Non-alcoholic drinks</strong></td>
<td></td>
</tr>
<tr>
<td>Water-based flavoured drinks, energy-reduced or with no added sugar</td>
<td>300 mg/l</td>
</tr>
<tr>
<td>Milk- and milk-derivative-based or fruit-juice-based drinks, energy-reduced or with no added sugar</td>
<td>300 mg/l</td>
</tr>
<tr>
<td><strong>Desserts and similar products</strong></td>
<td></td>
</tr>
<tr>
<td>Water-based flavoured desserts, energy-reduced or with no added sugar</td>
<td>400 mg/kg</td>
</tr>
<tr>
<td>Milk-and milk-derivative-based preparations, energy- reduced or with no added sugar</td>
<td>400 mg/kg</td>
</tr>
<tr>
<td>Fruit- and vegetable-based desserts, energy-reduced or with no added sugar</td>
<td>400 mg/kg</td>
</tr>
<tr>
<td>Egg-based desserts, energy-reduced or with no added sugar</td>
<td>400 mg/kg</td>
</tr>
<tr>
<td>Cereal-based desserts, energy-reduced or with no added sugar</td>
<td>400 mg/kg</td>
</tr>
<tr>
<td>Fat-based desserts, energy-reduced or with no added sugar</td>
<td>400 mg/kg</td>
</tr>
</tbody>
</table>
Where sweeteners can be used and the choices available

<table>
<thead>
<tr>
<th>Confectionery</th>
<th>Max dose of sucralose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Confectionery with no added sugar</td>
<td>1000 mg/kg</td>
</tr>
<tr>
<td>Breath-freshening micro-sweets, with no added sugar</td>
<td>2400 mg/kg</td>
</tr>
<tr>
<td>Energy-reduced tablet form confectionery</td>
<td>200 mg/kg</td>
</tr>
<tr>
<td>Cocoa- or dried-fruit-based confectionery, energy-reduced or with no added sugar</td>
<td>800 mg/kg</td>
</tr>
<tr>
<td>Starch-based confectionery, energy-reduced or with no added sugar</td>
<td>1000 mg/kg</td>
</tr>
<tr>
<td>Chewing gum with no added sugar</td>
<td>3000 mg/kg</td>
</tr>
<tr>
<td>Strongly flavoured freshening throat pastilles with no added sugar</td>
<td>1000 mg/kg</td>
</tr>
</tbody>
</table>

**Miscellaneous**

| Fine bakery products for special nutritional uses                           | 700 mg/kg             |
| Breakfast cereals with a fibre content of 15% AND containing at least 20% bran, energy reduced, or with no-added sugar | 400 mg/kg             |
## Where sweeteners can be used and the choices available

<table>
<thead>
<tr>
<th>Labelling</th>
<th>Ace -K</th>
<th>Aspartame</th>
<th>Neotame</th>
<th>Saccharin</th>
<th>Sucralose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sweetness Potency</td>
<td>200</td>
<td>200</td>
<td>7,000 – 13,000</td>
<td>300</td>
<td>600</td>
</tr>
<tr>
<td>Sweetness Quality</td>
<td>Fast on-set of sweetness but bitter aftertaste</td>
<td>Close to sugar</td>
<td>Delayed onset of sweetness and liquorice aftertaste</td>
<td>Fast on-set of sweetness but bitter/metallic aftertaste</td>
<td>Close to sugar</td>
</tr>
<tr>
<td>Stability</td>
<td>Good</td>
<td>Limited at low and neutral pH</td>
<td>Similar stability to aspartame at lower pH's but more stable at neutral pH</td>
<td>Good</td>
<td>Good</td>
</tr>
<tr>
<td>Solubility</td>
<td>Good</td>
<td>Poor solubility</td>
<td>Poor solubility</td>
<td>Sodium salt - good</td>
<td>Good</td>
</tr>
<tr>
<td>Labelling</td>
<td>Acesulfame-K E 950</td>
<td>Aspartame E 951 “contains a source of phenylalanine”</td>
<td>Neotame E 961</td>
<td>Saccharin E 954</td>
<td>Sucralose E 955</td>
</tr>
</tbody>
</table>
Where sweeteners can be used and the choices available

Acesulfame-K
- Non-caloric sweetener

- At low concentrations (ca 3% SE), approximately 200X sweeter than sugar. At higher levels a bitter aftertaste is perceived

- Stable sweetener, both under acid and neutral conditions

- Normally used in sweetener blends

- Rapid on-set of sweetness

- Very synergistic with aspartame and cyclamate

- Moderate synergy with sucralose

- Little synergy with saccharin
Where sweeteners can be used and the choices available

Aspartame
• Strictly, aspartame is a nutritive sweetener, providing 4 kcal/g

• Sweetness potency 180 – 200X sugar

• Most stable in pH range pH 4 – 5

• Very synergistic with ace-K, saccharin and cyclamate

• Potency of a 50/50 aspartame/ace-K blend is typically 270 – 300X sugar

• Little synergy with sucralose

• Any product sweetened with aspartame requires a statement that it “contains a source of phenylalanine”
Where sweeteners can be used and the choices available

Neotame

- Derivative of aspartame
- Potency 7,000 – 13,000 times that of sugar
- Neotame has a slower sweetness onset than aspartame and a lingering aftertaste.
- Stability of neotame under acid conditions is similar to that of aspartame but hydrolysis does not give phenylalanine, so no warning statement is required
- The stability under neutral conditions is better than aspartame
- Neotame is not very synergistic with any sweeteners except saccharin
Where sweeteners can be used and the choices available

Sucralose
- Only no-calorie sweetener made from sugar
- Good sugar-like sweetness
- On average, 600 times sweeter than sugar
- Shelf and process stable
- Non-caloric and kind to teeth
- Readily soluble and easy to use
- Moderately synergist with acesulfame-K and saccharin but little synergy with aspartame or neotame
How to formulate with low calorie sweeteners
How to formulate with low calorie sweeteners

• Replacing sugar in beverages is relatively straightforward
  – Important to match the sweetness level correctly and to ensure a consistent sweetness throughout the shelf life of the product
  – There may be a reduction in perceived “mouthfeel” and syrupiness of the drink
  – Flavour and acid systems may need to be optimised
  – Use of sweetener blends to help match the taste of an existing product or to reduce costs
How to formulate with low calorie sweeteners

Getting the sweetness level right: the level of sweetness replaced by sucralose has an impact on the potency

% sugar equivalence

ppm sucralose

Phosphoric acid (pH 2.5)

Potency ca. 750X
Potency ca. 600X
Potency ca. 480X
How to formulate with low calorie sweeteners

Optimise the flavour system for the sweeteners

Design-Expert® Software

Citrus Complex

Design Points

A: sucralose
B: aspartame
C: acesulfame K

X1 = A: sucralose
X2 = B: aspartame
X3 = C: acesulfame K

Sugar = 2.0
How to formulate with low calorie sweeteners

Sourness intensity (arbitrary units)

Time (arbitrary units)

Tartaric
Citric
Malic
Lactic
How to formulate with low calorie sweeteners

Citric
Sucralose
Malic

Sweetness / sourness intensity (arbitrary units)

Time (arbitrary units)
How to formulate with low calorie sweeteners

Use of sweetener blends
- To help reduce costs through synergy or use of low cost sweeteners
- Achieve particular taste characteristics
- Off-set the impact of less stable sweeteners
Sweetener Stability in Cola (pH 3.2) at 35°C

How to formulate with low calorie sweeteners

- Sucralose
- Acesulfame-K
- Aspartame

% Sweetener Remaining vs. Time (weeks)
How to formulate with low calorie sweeteners

Reduced sugar beverages

- Partial replacement of nutritive sweetener
  - Allows for nutrition label claim
  - Lower in calories
  - Reduced sugar
- Little or no difference in taste/sweetener perception
- Cost savings

Beverages

Carbonated
- Cola
- Lemon Lime
- Orange
- Shandy

Non-carbonated
- Lemonade
- Cranberry Juice
- Tea
- Juice Drink
- Nectars
How to formulate with low calorie sweeteners

Reduced Sugar Beverages

• **Fizzy Optimize™**: Orange carbonated beverage with 30% caloric reduction

• **Juice Optimize™**: Multi juice drink with 30% caloric reduction

• Sugar replaced by either
  - Sugar / sucralose
  - Glucose-fructose syrup (F42) / sucralose

• Sensory testing, using a duo-trio test, confirmed no significant overall difference when sugar was replaced with either the sugar/sucralose or glucose-fructose/sucralose blend
How to formulate with low calorie sweeteners

**Juice drink with 40% calorie reduction**

- Synergistic sweetening system including sucralose and fructose
- 40% reduction in calories and total sugars
- Can offer up to a 30% reduction in the cost of the sweetener system
- No warning statements
- No change in sweetness profile (proved by sensory panel)
- A reduction in mouthfeel can be utilised to produce a lighter more refreshing taste profile for fruit juices and nectars. Less syrupy and enhanced fruitiness.
How to formulate with low calorie sweeteners

Diet / “No-added Sugar” Beverages

- Harder to match the taste of the full sugar product, particularly with respect to mouthfeel
- Flavour and acid system optimisation often required to achieve the best taste
- Important to use a stable sweetener system to prevent changes to the sweetness and flavour during the shelf life of the product

![Cola - fresh](chart)

![Cola - 6 months](chart)
How to formulate with low calorie sweeteners

But what happens when you want to take sugar out of ice cream, cakes, sweets........
How to formulate with low calorie sweeteners

• Sugar is not just sweet, it provides a unique combination of physical and chemical properties, including:

  ➢ Freezing point depression; important for ice creams and frozen desserts

  ➢ Boiling point elevation; important for confectionery and condiments

  ➢ Decrease in water activity achieved with high concentrations of sugar, which helps in preservation
How to formulate with low calorie sweeteners

- Sugar provides bulk, texture and physical structure to foods

- It impacts on starch gelatinization; in baked products sugar delays the onset of gelatinization allowing more time for the product to rise

- Sugar provides the base for yeast fermentation
  - It undergoes browning reactions to create colour and flavour
  - The humectancy properties help to extend shelf life
How to formulate with low calorie sweeteners

• High potency sweeteners will only replace the sweetness of sugar and not the bulk
  – For products with a high sugar level, high potency sweeteners will need to be used in combination with bulking agents

• Potential Bulking Agents
  – Polydextrose
  – Polyols
  – Other soluble fibres
  – Combinations of above
How to formulate with low calorie sweeteners

<table>
<thead>
<tr>
<th></th>
<th>Erythritol</th>
<th>Sorbitol</th>
<th>Xylitol</th>
<th>Isomalt</th>
<th>Lactitol</th>
<th>Maltitol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relative Sweetness</td>
<td>0.7</td>
<td>0.6</td>
<td>0.95</td>
<td>0.4</td>
<td>0.4</td>
<td>0.9</td>
</tr>
<tr>
<td>Cooling effect</td>
<td>Very strong</td>
<td>Strong</td>
<td>Very strong</td>
<td>Weak</td>
<td>Moderate</td>
<td>Weak</td>
</tr>
<tr>
<td>Caloric value</td>
<td>0 kcal/g</td>
<td>2.4 kcal/g</td>
<td>2.4 kcal/g</td>
<td>2.4 kcal/g</td>
<td>2.4 kcal/g</td>
<td>2.4 kcal/g</td>
</tr>
<tr>
<td>Aqueous solubility</td>
<td>37%</td>
<td>70%</td>
<td>64%</td>
<td>25%</td>
<td>57%</td>
<td>60%</td>
</tr>
<tr>
<td>Molecular weight</td>
<td>122</td>
<td>182</td>
<td>152</td>
<td>344</td>
<td>344</td>
<td>344</td>
</tr>
</tbody>
</table>

Ref: Sweeteners and Sugar Alternatives in Food Technology, Edited by Helen Mitchell; Blackwell Publishing 2006
How to formulate with low calorie sweeteners

Soluble fibres can also be used to replace the bulking properties of sugar but provide little / no sweetness

- **Polydextrose**
  - Random polymer of glucose with some sorbitol end-groups
  - Caloric value - 1 Kcal/g
  - Sugar like rheology with non-sweet, neutral taste
  - Stable
  - Meets the criteria of the EU definition of dietary fibre
  - Is well tolerated with a laxative threshold of 90 g/day

- **Soluble gluco fibre**
  - Oligomer of glucose
  - Caloric value – 2 Kcal/g
  - Functionality similar to a glucose syrup
  - Meets the criteria of the EU definition of dietary fibre

- **Inulin and Fructose oligosaccharides**
  - Linear fructo-oligosaccharides
  - Sweetness
    - Inulin: very little sweetness
    - FOS: 30 – 65% sweetness of sugar
  - Caloric value – 2 kcal / g
  - Meets the criteria of the EU definition of dietary fibre
How to formulate with low calorie sweeteners

Laxative Threshold

![Bar chart showing laxative thresholds for different bulk agents.](chart.png)

- Polydex: 100 grams/serving
- Inulin: 80 grams/serving
- Sorbitol: 60 grams/serving
- Maltitol: 40 grams/serving
- Isomalt: 30 grams/serving
- Xylitol: 20 grams/serving

Legend:
- Blue: Single serving
- Green: Daily consumption
How to formulate with low calorie sweeteners

Which bulk sugar replacer to use?

- **Polydextrose**
  - Works like conventional glucose syrup therefore is a good replacement in formulations where texture is important, i.e. Toffees and Chews.
  - High level can lead to viscosity issue and can effect the setting of gelatin and pectin therefore other bulking agents should be considered.

- **Polyols**
  - Maltitol best for chocolate as processing is the closest to sugar.
  - Isomalt preferred for boiled sweets as moisture pick up is low.
  - Sorbitol syrup is a great humectant and plasticiser and can help to reduce the viscosity of Polydextrose based confectionery, i.e. Toffees and Chews. Too high addition and texture of final product can be too soft. Maltitol syrup will also act as a plasticiser but give a tougher texture.
  - Maltitol syrup excellent in gums and jellies. Does not effect gelatin but can give more brittle gels with pectin.
How to formulate with low calorie sweeteners

**Frozen Dessert REBALANCE™** – A powder sweetening and texturizing system for use in the preparation of “no-added sugars” frozen desserts.

<table>
<thead>
<tr>
<th><strong>Built with</strong></th>
<th><strong>Benefits</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Powdered sorbitol</td>
<td>• Suitable for “no-added sugar” formulations</td>
</tr>
<tr>
<td>• Polydextrose (fibre)</td>
<td>• Reduces the total caloric count</td>
</tr>
<tr>
<td>• Maltodextrin</td>
<td>• Easy sugar replacement 1:1</td>
</tr>
<tr>
<td>• Sucralose</td>
<td>• Equivalent sweetness level to sugar</td>
</tr>
<tr>
<td></td>
<td>• Clean aftertaste</td>
</tr>
<tr>
<td></td>
<td>• Rich, creamy mouthfeel</td>
</tr>
<tr>
<td></td>
<td>• Controls the freezing point</td>
</tr>
<tr>
<td></td>
<td>• Improves heat shock stability</td>
</tr>
<tr>
<td></td>
<td>• Process stable</td>
</tr>
<tr>
<td></td>
<td>• Quick dissolution, no lumps, no dust</td>
</tr>
</tbody>
</table>
How to formulate with low calorie sweeteners

**Fruit yogurt REBALANCE™** - Energy Reduced fruit preparation to aid in weight management

<table>
<thead>
<tr>
<th>Built with</th>
<th>Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Polydextrose</td>
<td>• Compared to a full calorie yogurt, the formula contains:</td>
</tr>
<tr>
<td>• Fructose</td>
<td>– 56% fewer calories</td>
</tr>
<tr>
<td>• Sucralose</td>
<td>– 63% less sugars</td>
</tr>
<tr>
<td></td>
<td>– 96% less fat</td>
</tr>
<tr>
<td></td>
<td>• Fruity flavour enhanced</td>
</tr>
<tr>
<td></td>
<td>• Smooth &amp; silky texture</td>
</tr>
<tr>
<td></td>
<td>• Intact fibre content throughout the shelf life</td>
</tr>
</tbody>
</table>
How, Where & Why Low Calorie Sweeteners Can Be Used in Foods & Drinks

• A selection of low calorie sweeteners, are available for use in reduced calorie and diet products, often used in combination to achieve similar taste and textural characteristics to the regular product.

• Low calorie sweeteners can be used in a range of food product categories in Europe but care must be taken to ensure the products comply with the appropriate category definition.

• Consumers want choices including “healthier” options. These can include a reduction in calories by replacing sugars – provided the products taste good.

• By skilful formulation of the different sugar alternatives, great tasting reduce calorie and no-added sugar products can be developed to give the consumers the choice they want.
Thank you

Mary Quinlan, Manager Sweetener Technology Development
Tate & Lyle

“Stronger”  “Tastier”  “Crunchier”  “Stretchier”  “Healthier”  “Lighter”  “Smarter”