Low calorie sweeteners – what they are, what they do and how they work

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Sweeteners

Sugars
- Sucrose
- Fructose
- Maltose

Sugar Replacers
- Glucose
- Lactose
- Isomalt
- Sorbitol
- Xylitol
- Maltitol
- Mannitol

Intense Sweeteners
- Aspartame
- Acesulfame K
- Saccharin
- Cyclamate
- Sucralose
Polyol = sugar replacer

Intense sweeteners
Polyols: Their Chemical Nature

- Carbohydrates
- Hydrogenated forms of mono, di and oligo-saccharides

Sucrose → Isomalt
Starch → Sorbitol, Maltitol, Mannitol
Xylan (e.g. from straw or wood) → Xylitol
## Polyols: Their Chemical Nature

<table>
<thead>
<tr>
<th>Saccharide Type</th>
<th>Polyol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monosaccharide Type</td>
<td>Sorbitol</td>
</tr>
<tr>
<td></td>
<td>Mannitol</td>
</tr>
<tr>
<td></td>
<td>Xylitol</td>
</tr>
<tr>
<td>Disaccharide Type</td>
<td>Isomalt</td>
</tr>
<tr>
<td></td>
<td>Maltitol</td>
</tr>
<tr>
<td></td>
<td>Lactitol</td>
</tr>
<tr>
<td>Mixtures incl. Oligo- Saccharide Type</td>
<td>Maltitol- Syrup</td>
</tr>
</tbody>
</table>
Bulk sweeteners

- Provide volume, texture, osmolarity, vary with regard to hygroscopicity and heat of solution
- Minimal digestion in small intestine
- Less sweet than sugar
### Sweetening power
(sucrose = 1)

<table>
<thead>
<tr>
<th>Sugar Replacers (bulk sweeteners)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Isomalt</td>
<td>0.5</td>
</tr>
<tr>
<td>Maltitol</td>
<td>0.8</td>
</tr>
<tr>
<td>Mannitol</td>
<td>0.5</td>
</tr>
<tr>
<td>Sorbitol</td>
<td>0.6</td>
</tr>
<tr>
<td>Xylitol</td>
<td>1.0</td>
</tr>
</tbody>
</table>
Sugar-free confectionery
Sugar-free cough drop, USA

Product: HALLS cough drop sugarfree (25 drops)

Manufacturer: Pfizer/Adams, USA

Positioning: Sugarfree Cough Drop
1) cough suppressant
2) soothes throat
Use of polyol to replace sugar in sugar-free candy

Sweet: weight of 1 candy = 3 gram

Sugar based:
- > 2.94 gram sugars
- < 0.06 gram
  - organic acids
  - etheric oils
  - flavours

Sugar-free:
- > 2.94 gram Polyol (e.g. Isomalt)
- < 0.06 gram
  - intense sweetener (e.g. 0.003 g Aspartame)
  - organic acids
  - etheric oils
  - flavours
Low Hygroscopicity of ISOMALT

Moisture absorption of unwrapped high-boiled sweets at 25 °C and 80 % RH after 7 days

Conclusion: Sweets made from Isomalt do not become sticky (contrary to Sorbitol-based candies)
Combination of polyols: Chewing gums

Soft center

Sorbitol

Isomalt

Crispy, crunchy shell
Cooling effect - heat of solution

Conclusion: Isomalt is close to sugar while Xylitol has a very pronounced cooling effect
Polyols in the small intestine

Limited absorption in the small intestine → Increase in osmotic pressure and water

Chyme that reaches the large intestine is • richer in water and • richer in substrates for the gut flora
Polyols are fermented in the colon similar to other low digestible carbohydrates.

The short chain fatty acids can be used as a source of food energy.

As a rule, polyols provide 2 kcal/g compared with sucrose 4 kcal/g.
EU Scientific Committee on Food (1987):

- “Laxation may be observed at high doses, consumption of the order of 20 g/person/day of polyols is unlikely to cause undesirable laxative symptoms. The level for individual polyols ingested singly is higher in many cases”

- EU Regulation 96/21/EC: “Excess consumption may produce laxative effects”
Sugar-free chewing gum, UK

Product: AIRWAVES Chewing Gum
10 pellets

Manufacturer: Wrigley, UK

Positioning: Sugarfree Chewing Gum for young adults
1) with extra strong flavor
2) plus inhaling effect
Tooth-friendly confectionery
pH-telemetric curve in the mouth after Xylitol compared with sugar
Sugar-free gum

• Convincing evidence that it helps prevent dental caries
• Permitted EU Health Claim Q-2008-321)

“Information to the consumer that the beneficial effect is obtained with consumption of 2-3g of chewing gum sweetened with 100% xylitol at least 3 times per day after meals”
### Intense sweeteners

No appreciable energy value

<table>
<thead>
<tr>
<th>Sweetness compared with sucrose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Aspartame</strong></td>
</tr>
<tr>
<td><strong>Acesulfame</strong></td>
</tr>
<tr>
<td><strong>Saccharin</strong></td>
</tr>
<tr>
<td><strong>Cyclamate</strong></td>
</tr>
<tr>
<td><strong>Sucralose</strong></td>
</tr>
<tr>
<td><strong>Neotame</strong></td>
</tr>
<tr>
<td><strong>Stevioside</strong></td>
</tr>
</tbody>
</table>
Saccharin
Aspartame (artificial) aspartyl-phenylalaline methyl ester
Neotame
Sucralose
Stevioside (naturally occurring)
Thaumatin
protein based natural sweetener
Sweeteners mechanism of action

- Bind to taste receptors on the tongue
- Enhance activity of the taste receptor
Uses of intense sweeteners

- Table top sweeteners e.g. Canderel™, Sweet & Low™, Spenda™
- Low calorie drinks e.g. Diet Coke, Diet Pepsi, Pepsi Max (usually blends of sweeteners e.g. AcesulfameK/aspartame)
- Reduced sugar products e.g. fruit yoghurt
- Chewing gum
Low calorie drinks

- 330 ml can cola drink 120 kcal
- 333 ml can diet cola 0 kcal

• Do low calorie drinks help promote weight loss on an energy restricted diet?
• Does using low calorie drinks instead of full sugar varieties prevent weight gain?
• Reverse causality – overweight/obese subjects are more likely to chose artificial sweeteners/diet drinks
Meta-analysis of short-term studies of replacing sugar with aspartame on weight change

<table>
<thead>
<tr>
<th>Study authors</th>
<th>Significance of effect</th>
<th>Effect size (SD)</th>
<th>Confidence limits (95%) of effect</th>
<th>Study duration (weeks)</th>
<th>Mean effect and 95% CI (units are SDs)</th>
<th>Type of control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reid &amp; Hammersley, 1998</td>
<td>1.000</td>
<td>0.000</td>
<td>0.793</td>
<td>1</td>
<td>-4.00 - 0.00</td>
<td>Sucrose parallel</td>
</tr>
<tr>
<td>Tordoff &amp; Alleva, 1990</td>
<td>0.564</td>
<td>-0.265</td>
<td>-1.269</td>
<td>3</td>
<td>-4.00 - 0.00</td>
<td>Other</td>
</tr>
<tr>
<td>Tordoff &amp; Alleva, 1990</td>
<td>0.050</td>
<td>0.612</td>
<td>-0.028</td>
<td>1</td>
<td>-4.00 - 0.00</td>
<td>Other</td>
</tr>
<tr>
<td>Raben et al, 2002</td>
<td>0.087</td>
<td>0.545</td>
<td>-0.109</td>
<td>10</td>
<td>-4.00 - 0.00</td>
<td>Base</td>
</tr>
<tr>
<td>Gatenby et al, 1997</td>
<td>0.175</td>
<td>0.487</td>
<td>-0.260</td>
<td>10</td>
<td>-4.00 - 0.00</td>
<td>Sucrose parallel</td>
</tr>
<tr>
<td>Kanders et al, 1988</td>
<td>0.102</td>
<td>0.490</td>
<td>-0.122</td>
<td>12</td>
<td>-4.00 - 0.00</td>
<td>Sucrose parallel</td>
</tr>
<tr>
<td>Kanders et al, 1988</td>
<td>0.623</td>
<td>-0.292</td>
<td>-1.721</td>
<td>12</td>
<td>-4.00 - 0.00</td>
<td>Sucrose parallel</td>
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<tr>
<td>Blackburn et al, 1997</td>
<td>0.919</td>
<td>0.016</td>
<td>-0.294</td>
<td>52</td>
<td>-4.00 - 0.00</td>
<td>Sucrose parallel</td>
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<tr>
<td>Kanders et al, 1990</td>
<td>0.040</td>
<td>0.613</td>
<td>0.004</td>
<td>71</td>
<td>-4.00 - 0.00</td>
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<tr>
<td>Blackburn et al, 1997</td>
<td>0.143</td>
<td>0.318</td>
<td>-0.117</td>
<td>175</td>
<td>-4.00 - 0.00</td>
<td>Sucrose parallel</td>
</tr>
<tr>
<td>Blackburn et al, 1997</td>
<td>0.028</td>
<td>0.487</td>
<td>0.043</td>
<td>175</td>
<td>-4.00 - 0.00</td>
<td>Sucrose parallel</td>
</tr>
</tbody>
</table>

**Fixed Combined (11)**: 0.000 0.292 0.129 0.456
**Random Combined (11)**: 0.001 0.295 0.129 0.460

**Figure 3** Meta-analysis of studies of weight loss with sweetener (excluding outcomes with weight gain on sucrose regime). CI, confidence intervals; SD, standardised difference.

Systematic reviews of artificial sweetened drinks and weight gain

- Possible evidence that sugar sweetened beverage (SSB) consumption is associated with weight gain\(^1\)

- Insufficient evidence to show that replacement of SSB with artificial sweetened beverages prevents weight gain\(^1,2\)