Non-nutritive sweeteners

A brief overview of their use in foods, potential health effects, recommendations and policies

02 June 2016
Scope

- Brief overview: use of sweeteners in foods and beverages, implications for public health & existing policy recommendations

Structure

- Terminology
- Types of sweeteners
- Application in food
- Health implications
- Policies
Terminology

- Dir. 94/35/EC\(^1\) on sweeteners for use in foodstuffs
  - "refers to sweeteners *as food additives which are used to impart a sweet taste to foodstuffs and as table top sweeteners*

- WHO Nutrient Profile model\(^{19}\):
  - Non-sugar sweeteners: "*food additives (other than a mono- or disaccharide sugar) which impart a sweet taste to food."

- Reg. (EC) No 1333/2008\(^2\) on food additives specifies conditions for an additive to be classified as a sweetener:
  - "*replacing sugars for the production of energy-reduced food, non-cariogenic food or food with no added sugars*" or
  - "*replacing sugars where this permits an increase in the shelf life of the food*" or
  - "*producing food intended for particular nutritional uses*"
Nutritive sweeteners (NS)

- "caloric sweeteners", provide energy in the form of carbohydrates (e.g. sugar)

Non-nutritive sweeteners (NNS)

- Zero or low-calorie alternatives. Terminology variable: low caloric sweeteners, hypo caloric sweeteners, low energy sweeteners, high intensity sweeteners, intense sweeteners etc.

"Sugar replacers"

Replacing the sweet taste of sugar: Intense sweeteners

- substances with an intense sweet taste and with no energy value that are used to replace sugars in foods (e.g. acesulfame K; aspartame)

Replacing mainly other technological properties of sugar: Polyols

- Also "sugar alcohols" (e.g. xylitol, sorbitol), often used as bulking agents
Labelling

- Table top sweeteners:
  - Exempted from mandatory nutrition declaration (Reg. 1169/2011)

- Sweeteners authorised as additives in Reg. (EC) 1333/2008
  - Name of food should be accompanied by "with sweetener" statement or "with sugar and sweetener".
  - Aspartame containing foods should state "contains aspartame (a source of phenylalanine)". If designated only by E-number or not present fully written in ingredient list (in that case: "contains a source of phenylalanine")
  - More than 10% polyols: "excessive consumption may produce laxative effects"
## Types & applications

<table>
<thead>
<tr>
<th>Sweetener</th>
<th>Energy (Kcal/g)</th>
<th>Sweetness Index</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sucrose</strong></td>
<td>4,0</td>
<td>1</td>
</tr>
<tr>
<td>Acesulfame K (E950)</td>
<td>0</td>
<td>130-200</td>
</tr>
<tr>
<td>Aspartame (E951)</td>
<td>4,0</td>
<td>200</td>
</tr>
<tr>
<td>Advantame (E969)</td>
<td>0</td>
<td>20000</td>
</tr>
<tr>
<td>Cyclamates (E952)</td>
<td>0</td>
<td>30-50</td>
</tr>
<tr>
<td>Neohesperidine DC (E959)</td>
<td>0</td>
<td>1500-1800</td>
</tr>
<tr>
<td>Neotame (E961)</td>
<td>0</td>
<td>7000-13000</td>
</tr>
<tr>
<td>Saccharin (E954)</td>
<td>0</td>
<td>300-500</td>
</tr>
<tr>
<td>Salt of Aspartame-Acesulfame (E962)</td>
<td>3,0</td>
<td>350</td>
</tr>
<tr>
<td>Steviol glycosides (E960)</td>
<td>0</td>
<td>480</td>
</tr>
<tr>
<td>Sucralose (E955)</td>
<td>0</td>
<td>600</td>
</tr>
<tr>
<td>Thaumatin (E957)</td>
<td>4,1</td>
<td>2000-3000</td>
</tr>
<tr>
<td><strong>Polyols</strong> (Sorbitol, Mannitol, Isomalt, Maltitol, Lactitol, Xylitol, Erythritol (E420, 421, 422, 953, 965 966, 967, 968))</td>
<td>2,4</td>
<td>0,4-2</td>
</tr>
</tbody>
</table>

### Applications

- **Soft drinks, carbonated or non-carbonated, teas, flavoured waters**
- **Dairy drinks (milk & yoghurt based)**
- **Fruit juices and drinks**
- **Bakeries, candies**
- **Jams, jellies, gums**
- **Table-top**
- **Others: chocolate drinks, energy drinks**
Per Capita (on-trade & off-trade) sales of low-calorie cola carbonates in 2014 (Euromonitor)

Change of per capita sales (on-trade & off-trade volumes) of low calorie cola carbonates between 2010 and 2014 (Euromonitor)
Approach of this overview

- Focus: NNS and diet related NCDs

- Authoritative sources:
  - Organisations, authorities, e.g. WHO, EFSA, FDA, AHA

- Peer-reviewed literature included where needed information could not be obtained from the above sources, e.g. very recent developments, scarcity of data.
  - We did not perform a systematic analysis of the literature
  - Included systematic reviews (2010 onwards)

- Safety of NNS extensively reviewed – not within scope of presentation
Weight Management

- Effects of NNS when replacing sugar
  - Energy intake, weight management
  - EFSA, American Heart Association (AHA) & American Diabetes Association (ADA), Scientific Advisory committee on Nutrition UK (SACN), ANSES (FR)
  - Few recent systematic reviews
# Weight Management

<table>
<thead>
<tr>
<th>Source</th>
<th>Statement/Opinion/Finding</th>
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| EFSA health-claim related opinion (2011) ⁴ | - no cause and effect relationship between total sugar intake & body weight gain  
- **no cause and effect relationships** between consumption of foods/beverages with sugars replaced by sweeteners for maintenance/achievement of normal body weight |
| AHA & ADA (2012) ⁵ | - **Insufficient data** to conclude if replacing NS with NNS reduces added sugars, or carbohydrate intakes, benefits appetite, energy balance, or body weight.  
- some data suggests that **NNS can be used in a structured diet to replace added sugars**; that this may result in **modest reduction of energy intake & subsequently weight loss**.  
- when used judiciously, (and with no energy compensation), **NNS could help reduce added sugar intake**, resulting in decreased energy intake and weight control or loss. |
| ANSES (2015)²¹ | - Use of intense sweetener as sugar substitutes results in a decrease in **short term energy intake due to their low calorie content and the lack of compensation**.  
- However, the **available data cover insufficient time periods to guarantee the maintenance of this effect over the medium or long term**.  
- **no conclusions** can be drawn as to the **long term effect** of replacing caloric sweeteners with ISs on the **weight of regular adult consumers** of sweet products. **Similar** for **children and adolescents**. |
| SACN UK, Public Health England (2015)⁶ | - RCTs in adults indicate that increasing or decreasing the percentage of total dietary energy as sugars when consuming an ad libitum diet leads to a corresponding increase or decrease in energy intake.  
- RCTs in children & adolescents indicate **consumption of SSBs, as compared with non-calorically sweetened beverages, results in greater weight gain & BMI increase**.  
- replacing foods and drinks sweetened with sugars with those sweetened with no/low calorie sweeteners can be useful in the management of energy intake and weight |
## Weight Management

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| Am J Clin Nutr (2014)⁷  | - observational studies show a small positive association of NNS intake with BMI and no association with body weight or fat mass  
- RCTs indicate that replacing **caloric dense alternatives with NNS** results in a **modest reduction of body weight, BMI, fat mass and waist circumference & may be a useful dietary tool** |
| Int J Obes (2016)⁸      | - Majority of evidence from human RCTs indicate that **NNS do not increase energy intake or body weight**, compared with caloric or non-caloric controls  
- Balance of evidence indicates that using **NNS as a sugar replacer**, in both children and adults, **leads to reduced energy intake and body weight** |
Effects of NNS when replacing sugar:

- Post prandial glucose levels, normal blood glucose concentration maintenance, Type 2 Diabetes

- EFSA, ANSES, American Heart Association (AHA) & American Diabetes Association (ADA)

- Some recent systematic reviews
## Metabolic parameters

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<td>EFSA health-claim related opinion (2011)&lt;sup&gt;4&lt;/sup&gt;</td>
<td>- <strong>no cause and effect relationship</strong> between the consumption of foods and beverages in which sugars have been replaced by intense sweeteners and <strong>maintenance of normal blood glucose concentrations</strong>.</td>
</tr>
<tr>
<td>EFSA health-claim related opinion (2011)&lt;sup&gt;9&lt;/sup&gt;</td>
<td>- “<strong>cause and effect relationship has been established</strong>” between the consumption of foods/drinks containing xylitol, sorbitol, mannitol, maltitol, lactitol, isomalt, erythritol, D-tagatose, isomaltulose, sucralose or polydextrose instead of sugar and <strong>reduction in post-prandial blood glucose responses</strong> (without disproportionally increasing post-prandial insulinaemic responses) as compared to sugar-containing foods/drinks”</td>
</tr>
<tr>
<td>EFSA health-claim related opinion (2011)&lt;sup&gt;9&lt;/sup&gt;</td>
<td>- <strong>the above claim also applies to intense sweeteners</strong></td>
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<td>AHA &amp; ADA (2012)&lt;sup&gt;5&lt;/sup&gt;</td>
<td>- <strong>Insufficient data</strong> to conclude if “displacing caloric sweeteners with NNS in beverages and foods […] benefit […] cardiometabolic risk factors”</td>
</tr>
<tr>
<td>AHA &amp; ADA (2012)&lt;sup&gt;5&lt;/sup&gt;</td>
<td>- <strong>when used judiciously</strong>, (and with no energy compensation), <strong>NNS could help reduce added sugar intake</strong>, resulting in <strong>decreased energy intake and weight control or loss</strong>, and promoting <strong>beneficial effects on related metabolic parameters</strong></td>
</tr>
<tr>
<td>ANSES Opinion (2015)&lt;sup&gt;21&lt;/sup&gt;</td>
<td>- consumption has <strong>no effect on short and medium term blood glucose parameters in healthy subjects or in diabetics</strong>.</td>
</tr>
<tr>
<td>ANSES Opinion (2015)&lt;sup&gt;21&lt;/sup&gt;</td>
<td>- Long term epidemiological studies on the <strong>risk of developing T2D show heterogeneous results, but the most robust studies do not report any effects</strong>.</td>
</tr>
<tr>
<td>In J Pediatr Obes (2010)&lt;sup&gt;10&lt;/sup&gt;</td>
<td>- <strong>Lack of strong clinical evidence</strong> to support <strong>causality regarding artificial sweetener use and metabolic health effects in youth</strong> (&lt;18 yrs.), both adverse and harmful.</td>
</tr>
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| BMC Medicine (2011)<sup>11</sup> | - little high quality research has been done to identify potential harms and benefits of NNS  
  - Since even small weight reductions can prevent chronic disease, NNS could play an important role in public health strategies to reduce and manage obesity-related comorbidities  
  - need for long-term, adequately powered RCTs to confirm this hypothesis |
| Br J Nutr (2014)<sup>12</sup> | - comparing the positive association between SSBs and T2D, there is a less consistent trend for artificially sweetened soft drinks and together with the effect of adjusting for BMI, this may indicate an alternative explanation for the observed association, such as lifestyle factors or reverse causality”  
  - “Recommendations to limit the consumption of sugar-sweetened soft drinks by promoting the supply of sugar-free alternatives depend, in part, on the nature of the association with obesity and whether alternatives to artificially sweetened soft drinks also have negative consequences” |
| Eur J Prev Cardiol (2015)<sup>13</sup> | - RCTs suggest that steviol glycosides may generate reductions in blood pressure and fasting blood glucose. The sizes of the effects are small, and the substantial heterogeneity limits the robustness of any conclusions”  
  - RCTs vary in reporting quality and design, inadequate sample sizes, while participants have high CVD risk. Further RCTs are required. |
| Br Med J (2015)<sup>14</sup> | - Habitual consumption of sugar sweetened beverages associated with a greater incidence of Type 2 diabetes  
  - Artificially sweetened beverages also showed a positive association with incidence of Type 2 diabetes. However quality of evidence is limited by potential bias and heterogeneity by study design.  
  - Findings support that artificial sweetened beverages are unlikely to be health alternatives to SSBs for T2D prevention. |
| Pediatrics (2016)<sup>20</sup> | - Limited and inconsistent evidence of the long-term metabolic effects of NNS exposure during gestation, infancy and childhood.  
  - Further research is need to inform recommendations |
# Dental health

- Effects of NNS when replacing sugar for dental health
  - EFSA, SACN

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<tr>
<th>Source</th>
<th>Statement/Opinion/Finding on DENTAL HEALTH</th>
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</table>
| EFSA health-claim related opinion (2011)⁹ | - established cause and effect relationship *“between consumption of sugar-containing foods/drinks at an exposure frequency of four times daily or more and an increased tooth demineralisation”*
- *“the consumption of foods/drinks containing xylitol, sorbitol, mannitol, maltitol, lactitol, isomalt, erythritol, D-tagatose, isomaltulose, sucralose or polydextrose, instead of sugar in sugar-containing foods/drinks, may maintain tooth mineralisation compared with sugar-containing foods, provided that such foods/drinks do not lead to dental erosion.”*  
- the above claim **also applies to intense sweeteners** |
| SACN UK (2015)⁶ | - moderate evidence of an effect of polyols on dental caries  
- *use of chewing gum containing polyols*, compared to not using a chewing gum, is **beneficial to oral health** (mixed and permanent dentition)  
- **insufficient/inconsistent evidence** on effects of polyols on deciduous dentition, confectionary containing polyols in mixed and permanent dentition |
### Effects of NNS in intestinal health

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</table>
| SACN UK (2015)<sup>6</sup> | - Limited evidence of effect of polyols on faecal weight. Effect could be biologically relevant, and higher consumption of polyols can be potentially beneficial to health; however effects likely to be limited by low levels of polyols in the diet.  
- Limited evidence of effects on faecal mass  
- Limited evidence of no effects on faecal pH, faecal SCFA or faecal bacterial content  
- Insufficient/inconsistent evidence on effects of polyols on: intestinal transit time, constipation |
| J Neurogastrenterol Motil (2016)<sup>15</sup> | - General lack of evidence, especially human studies; some data suggest that artificial sweeteners can affect GI tract motility and gut microbiome composition.  
- Further research required to assess the potential effects of artificial sweeteners on gastronintestinal health. |
## Policies – School foods

<table>
<thead>
<tr>
<th>Source</th>
<th>School food policies examples</th>
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<tbody>
<tr>
<td>IoM (2007)(^{16})</td>
<td>No recommendations made for NNS for US school food policies, due to limited and inconsistent evidence</td>
</tr>
</tbody>
</table>
| EC/JRC (2014)\(^{17}\)       | - Austria: No artificial sweeteners in soft drinks or other drinks  
- Greece: Artificial sweeteners are not allowed in junior high school and high school canteens for some beverages (chamomile, tea, sage)  
- Hungary: no artificial sweetened soft drinks for school children < 6 yrs.  
- Latvia: Soft drinks with food additives (incl. sweeteners) not allowed, except for lunch  
- Spain: Foods should be free from artificial sweeteners.  
- UK:  
  - Scotland: sugar-free soft drinks, including low or no added sugar versions not allowed  
  - Wales: fizzy soft drinks including diet or sugar free versions in primary and secondary schools are not allowed  
  - Northern Ireland: artificial sweeteners permitted for combination drinks (water, milk, unsweetened fruit or veggie juice, yoghurt or milk drinks) |
| Lancet Diabet Endocrinol (2016)\(^{3}\) | Australia, Brasil: include NNS beverages in school food policy restrictions (due to minimal nutritional value)                                                                                                                  |
Other policies

- France
  - Sugar tax on SSBs includes NNS alternatives (apparently due to no specific category in custom codifications)\(^{18}\)

- Finland
  - Sugar tax on SSBs includes sweetener-based soft drinks and waters\(^{18}\)

- UK
  - Change4Life campaign, Smart-Swaps: recommends swapping SSBs with water, drinks with no added sugars or drinks containing low-calorie sweeteners\(^3\)

- WHO Nutrient Profile model (2015)\(^{19}\)
  - Certain beverage categories not to be marketed to children if the contain non-sugar sweeteners (0% w/w)
  - Other beverages (cola, lemonade, other soft drinks, flavoured waters)
  - Milk drinks
Conclusions

- No readily available and comprehensive data on NNS intakes in EU

- Lack of conclusive evidence from literature on benefits or drawbacks of replacing sugars with NNS

- Some recommendations or policies that deal specifically with NNS

Thank you for your attention
References

9. EFSA Journal (2011) 9(4);2076
17. European commission Joint Research Centre (2014) School Food Policy Country Factsheets. Country Profiles on national school food policies across the EU 28 plus Norway and Switzerland
20. Pediatrics (2016) 137:3 e20153603
21. ANSES Opinion the assessment of the nutritional benefits and risks related to intense sweeteners (2015)