Sugar Substitutes and Functionality

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Consumer Use of Low-Calorie, Sugar-Free Foods and Beverages
(in millions of Americans consuming these products)

Source: Calorie Control Council National Surveys
<table>
<thead>
<tr>
<th>Food</th>
<th>Sugar Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cakes</td>
<td>25 to 38</td>
</tr>
<tr>
<td>Cookies</td>
<td>20 to 37</td>
</tr>
<tr>
<td>RTE Cereal</td>
<td>Up to 34</td>
</tr>
<tr>
<td>Fruit Yogurt</td>
<td>Up to 19</td>
</tr>
<tr>
<td>Canned Fruit</td>
<td>Up to 20</td>
</tr>
<tr>
<td>Ice Cream</td>
<td>14 to 18</td>
</tr>
<tr>
<td>Jelly Beans</td>
<td>70</td>
</tr>
<tr>
<td>Candy</td>
<td>45 to 60</td>
</tr>
<tr>
<td>Chocolate</td>
<td>50 to 60</td>
</tr>
<tr>
<td>Fruit juice</td>
<td>Up to 12</td>
</tr>
<tr>
<td>Soft Drink</td>
<td>9 to 14</td>
</tr>
</tbody>
</table>
# Relative Sweetness

<table>
<thead>
<tr>
<th>Sugar</th>
<th>Sweetness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sucrose</td>
<td>100</td>
</tr>
<tr>
<td>Glucose</td>
<td>70</td>
</tr>
<tr>
<td>Fructose</td>
<td>120</td>
</tr>
<tr>
<td>Maltose</td>
<td>45</td>
</tr>
<tr>
<td>Lactose</td>
<td>40</td>
</tr>
<tr>
<td>Corn Syrup (Glucose, Maltose)</td>
<td>30 - 50</td>
</tr>
<tr>
<td>High Fructose Corn Syrup</td>
<td>80 – 90</td>
</tr>
<tr>
<td>Invert Sugar</td>
<td>95</td>
</tr>
</tbody>
</table>
Functions of Sugars in Food

- Sweetness
- Texture
  - Adds bulk, texture cohesiveness
  - Crispness
  - Humectant
  - Freezing Point Depression
  - Preservative
  - Fermentation substrate
Alternative Sweeteners

- Expand Food Choices
- Control carbohydrate and calorie intake
- Weight management
- Diabetes
- Dental caries
- Enhance stability and delivery of pharmaceuticals
Factors Effecting Sweetness in Food

- **Texture:**
  - Viscosity
  - Solids
    - Amorphous, glass, crystallinity
  - Homogeneity
  - Foam

- **Temperature**

- **Taste:**
  - Acidity / Sour
  - Bitter
  - Salt
  - Other Flavors
# Intense Sweeteners

<table>
<thead>
<tr>
<th>Sweetener</th>
<th>Sweetness</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cylamate</td>
<td>30</td>
<td>Banned in United States</td>
</tr>
<tr>
<td>Acesulfame-K</td>
<td>200</td>
<td>Heat stable</td>
</tr>
<tr>
<td>Aspartame</td>
<td>180</td>
<td>Not stable for cooking</td>
</tr>
<tr>
<td>Saccharin</td>
<td>300</td>
<td>Heat stable</td>
</tr>
<tr>
<td>Neotame</td>
<td>8000</td>
<td>Heat stable</td>
</tr>
<tr>
<td>Stevioside</td>
<td>300</td>
<td>Plant source</td>
</tr>
<tr>
<td>Sucralose</td>
<td>600</td>
<td>Heat stable</td>
</tr>
</tbody>
</table>
Stevia

- Stevia Sweeteners
- Enliten®
- PureVia™
- Rebaudioside A/Reb A
- Rebaudiside B
- Rebaudioside C
- Rebaudioside D
- Rebiana
- Stevia
- Steviol Glycosides
- Stevioside
- Stevia in the Raw™
- Sun Crystals®
- Truvia™
If you remove the Sugar

- What do you replace it with?
  - Intense sweeteners lack bulk
    - Granulation
    - Texture
  - Beverages
    - Viscosity

- Sugar Alcohols
  - Limited Sweetness
  - Some texture
  - Side effects
Generic Cookie Composition

- Protein 6%
- Fat 30%
- Sugar 30%
- Flour 33%
Sugar Free Cookie Composition

- Protein 6%
- Flour 33%
- Fat 30%

What do we use?
Ideal sugar substitute

Sweetness

Functional Properties
  Crystallinity – White Sugar
  Glass – Peppermint Candy

Liquid
  Raises boiling point
  Lowers freezing Point

Preservative
Polyols or Sugar Alcohols

- Low digestibility
- Derived form sugars
- Sugar replacers
- Bulk
- Sweetness
- Same volume as Sugar
- Low calorie
Glucose

Sucrose

Sugar Alcohols

Sorbitol

Xylitol

Erythritol
Relative Sweetness of Bulking Agents

Sucrose, Fructose, Maltitol, Lactitol, Sorbitol, Xylitol
# Sugar Alcohols

<table>
<thead>
<tr>
<th>Sugar Alcohol</th>
<th>Caloric Value Kcal/g</th>
<th>Sweetness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Erythritol</td>
<td>0.2</td>
<td>70</td>
</tr>
<tr>
<td>Xylitol</td>
<td>2.4</td>
<td>100</td>
</tr>
<tr>
<td>Mannitol</td>
<td>1.6</td>
<td>70</td>
</tr>
<tr>
<td>Sorbitol</td>
<td>3.0</td>
<td>60</td>
</tr>
<tr>
<td>Maltitol</td>
<td>3.0</td>
<td>90</td>
</tr>
<tr>
<td>Lactitol</td>
<td>3.0</td>
<td>40</td>
</tr>
</tbody>
</table>
# Polyol Applications

<table>
<thead>
<tr>
<th>Erythritol</th>
<th>Xylitol</th>
<th>Sorbitol</th>
<th>Maltitol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excellent for blending Crystals</td>
<td>Stimulates Salivary Flow</td>
<td>Texturizing Anticrystlizing</td>
<td>Bulk</td>
</tr>
<tr>
<td>Beverages</td>
<td>Gum</td>
<td>Candy Gum Frozen Desserts Baked Goods</td>
<td>Chocolate Sugar Free Foods</td>
</tr>
<tr>
<td>Candies</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yogurt</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baked Goods</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No Dental Caries</td>
<td>Reduces Plaque</td>
<td>No Dental Caries</td>
<td>No Dental Caries</td>
</tr>
<tr>
<td>Zero</td>
<td>2.4</td>
<td>2.6</td>
<td>2.1</td>
</tr>
</tbody>
</table>
Polyol Applications

- **Food Uses**
  - Chewing gum
  - Candy
  - Ice Cream
  - Chocolate
  - Cookies
  - Cakes
  - Fruit spreads

- **Healthcare**
  - Toothpaste
  - Breath mints
  - Mouthwash
  - Cough syrups / Drops
Oligofructans
Fructose polymers from Inulin

- Prebiotic dietary fiber

- Sugar replacement
  - Dairy Products
    - Body and mouth feel
    - Foam stability
  - Baked Products
    - Bulk
    - Moisture retention
Physical Properties are Important

- Molecular Weight – Small is better
  - Influence on Water Activity
  - Bacteriostatic Effects
  - Lower freezing Point
  - Raise boiling point
- Crystallinity
  - Important for texture
- Glass
  - Important for Hard Candy
- Humectant
  - Attract and Retain moisture
<table>
<thead>
<tr>
<th>Bulking Agent</th>
<th>Molecular Weight</th>
<th>Melt Point</th>
<th>Hydroscopic 85% RH, 25°C</th>
<th>Solubility</th>
<th>Fr Pt Depression</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sucrose</td>
<td>342</td>
<td>190 d</td>
<td>0</td>
<td>68</td>
<td>-2.7</td>
</tr>
<tr>
<td>Maltitol</td>
<td>344</td>
<td>154</td>
<td>0</td>
<td>65</td>
<td>-2.6</td>
</tr>
<tr>
<td>Sorbitol</td>
<td>160</td>
<td>110</td>
<td>23</td>
<td>70</td>
<td>-4.5</td>
</tr>
<tr>
<td>Erytritol</td>
<td>122</td>
<td>122</td>
<td>0</td>
<td>33</td>
<td>-7.8</td>
</tr>
<tr>
<td>Polydextrose</td>
<td>1400</td>
<td>154</td>
<td>19</td>
<td>80+</td>
<td>-0.2</td>
</tr>
<tr>
<td>FOS</td>
<td>1000</td>
<td></td>
<td>19</td>
<td>80+</td>
<td>-1.3</td>
</tr>
</tbody>
</table>
## Cookie Properties

<table>
<thead>
<tr>
<th>Sweetener</th>
<th>Spread</th>
<th>Thickness</th>
<th>Color L</th>
<th>Water Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sucrose</td>
<td>17.2</td>
<td>7.5</td>
<td>70.1</td>
<td>15.8</td>
</tr>
<tr>
<td>Fructose</td>
<td>13.3</td>
<td>6.3</td>
<td>55.0</td>
<td>28.2</td>
</tr>
<tr>
<td>Lactitol</td>
<td>19.4</td>
<td>6.5</td>
<td>71.0</td>
<td>17.5</td>
</tr>
<tr>
<td>Sorbitol</td>
<td>15.6</td>
<td>6.6</td>
<td>70.4</td>
<td>22.6</td>
</tr>
<tr>
<td>Mannitol</td>
<td>1.3</td>
<td>13.1</td>
<td>79.0</td>
<td>25.7</td>
</tr>
<tr>
<td>Xylitol</td>
<td>13.5</td>
<td>7.5</td>
<td>70.6</td>
<td>37.1</td>
</tr>
</tbody>
</table>
Product Optimization

- Combinations of
  - Intense sweeteners
  - Sugar alcohols
  - Inulin or polydextrose
FORMULATING COOKIES WITH ERYTHRITOL ALLOWS FOR PARTIAL REPLACEMENT OF SUGAR

No difference by consumers

Up to 50 per cent of the sugar content of Danish cookies was replaced with erytritol

No noticeable changes to color, sweetness, hardness, flavor and overall liking

Journal of Food Quality.
Chocolate Crackles

From The Big Book of Diabetic Desserts, by Jackie Mills
© 2007

Ingredients

1 1/2 cups all-purpose flour
3/4 cup unsweetened cocoa
1 1/2 tsp baking powder
1/4 tsp salt
1/2 cup 67% vegetable oil butter-flavored spread, at room temperature

1 cup dark brown sugar
2 large eggs
2 tsp vanilla extract
3 Tbsp confectioners’ sugar
Swerve™ Sugar Cookies

Ingredients:

- 1½ cups organic all purpose flour
- ½ tsp baking powder
- ½ tsp salt
- ½ cup unsalted butter, softened
- 1/3 cup Swerve™ Regular Granulated
- ¼ cup Swerve™ Confectioners
- 2 tsp corn starch
- zest of 1 lemon
- 1 egg
- 2 tsp heavy cream
Final Decision

- Functional / Sensory Properties
- Government Regulation
- Nutritional Impact
- Availability/Price
Thank You