On Trend Ingredients: Polyols Properties, Labeling & Emerging Areas of Interest

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Reasons for sugar reductions

- Obesity is still a concern according to the CDC.
- Increased Prevalence of Diabetes
- One of the key recommendations from the USDA is to reduce added sugar intake.
  - This is reflected in the new labeling that will require “added sugars” to be identified on the nutritional panel.
What is being replaced?

**Monosaccharides**
- Glucose, fructose

**Disaccharide’s**
- Sucrose, maltose

**Mixtures**
- Corn Syrups
  - Mixture of glucose, fructose, maltose, and other polysaccharides.
Sucrose: The Gold Standard

Although sucrose is not the only sugar used/present in the foods we eat it is the one to which all are compared.
Sucrose: The Gold Standard

Sweetness Profile

Figure 1. Time-intensity curves of fructose, glucose and sucrose.
Source: Shallenberger RS, Taste Chemistry, 1993
Sucrose: The Gold Standard

It also has its own unique functionality

• Solubility
• Melting Point/Characteristics
• Crystallization Characteristics
Replacing this can be challenging...

- One of the major ingredients used to replace sugars are a group of carbohydrates known as “polyols” or “sugar alcohols”.
How Can Polyols Help?

They are metabolized in a way which is different than traditional sugars/carbohydrates.

• Lower incidence of increased blood glucose levels

• Lower calories

• Non-cariogenic/Cariostatic (doesn’t cause cavities)
  • Dental caries claim – 21 CFR 101.80
Glycemic responses to polyols in adults: based on data pooled from literature
How Can Polyols Help?

They provide excellent bulk where “high potency sweeteners” do not

• Polyols provide excellent 1:1 replacement in traditional food products.

• HPS can be 100 – 8000 times sweeter than sucrose.
  • Sucralose, Aspartame, Saccharine, Stevia, etc.
Sugar alcohols (polyhydric alcohols) – carbohydrate derivatives that contain only hydroxyl groups as functional groups.

Industry production consists of catalytic hydrogenation or enzymatic conversion of different aldoses (erythrose, glucose and maltose) and ketones (fructose)

- Not recognized as sugars (21 CFR 101.9(c)(6)(ii))
Sugar Replacement - Various Claims Allowed

“No Sugar Added”

Products having no amount of sugars added during the processing or packaging.

“Reduced Sugar”

25% reduction in sugars per reference serving size - compared to the full sugar equivalent.

“Sugar Free”

It must contain less than 0.5 grams of sugar per reference serving size.
What are the choices?

Monomers
- Sorbitol, mannitol, xylitol, erythritol

Dimers
- Maltitol, lactitol, isomalt

Mixtures
- Maltitol syrup, polyglycitol (HSH)
**Maltitol and Polyglycitol Syrups**

- **Highest Sweetness**
- **Lowest A₆ (water activity)**
- **Shortest Texture**
- **Lowest Freezing Point**
- **Increased Boiling Point**
- **Increased Osmolality**
- **Better Humectant**

*Greater than 50% Maltitol (db) is considered a maltitol syrup*
Labeling of Polyols
Nutrition Facts Panel: Maltitol

- Allowable caloric content of “Maltitol” is 2.1 calories per gram dry basis.

It is calculated as part of “Total Carbohydrate” on a food nutrition facts label.

If any label claim is made regarding sugar (sugar-free or no sugar added) the grams of “Maltitol” and or other polyol must be sublinded as “sugar alcohol”
Formulating with Polyols
Step 1: Understand the role of the ingredient you’re replacing

Sucrose
• Sweetness
• Texture
• Crystallization
• Decreased viscosity
• Browning/Flavor Development

Corn Syrup
• Reduce sweetness
• Texture
• Controls crystallization
• Increase viscosity
• Browning/Flavor Development
Step 2: Understand the Physical Characteristics of Polyols

<table>
<thead>
<tr>
<th>Physical Characteristics</th>
<th>Caloric value</th>
<th>Glycemic properties</th>
<th>Cariogenicity</th>
<th>Solubility</th>
<th>Relative sweetness</th>
<th>Non-Browning</th>
<th>Heat of Solution</th>
<th>Physical form(s)</th>
<th>Stability</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Melting points</td>
<td>Molecular Weight</td>
<td>Glass Transition Temp ($T_g$)</td>
<td>Functionality</td>
<td>Laxative properties</td>
<td>Regulatory status</td>
<td>Consumer reaction</td>
<td>Availability</td>
<td>Cost</td>
</tr>
</tbody>
</table>


Polyols are non-reactive

Since the functional group is reduced, it no longer reacts to yield caramel flavors or browning.
Non-reactive considerations

1. Very stable at high temperatures (>330F).
   - No discoloration or undesirable flavor development

2. Does not react with colors, flavors, or actives.

3. No Browning
   - Caramel (confectionery)
   - Baking
Example: Cheese Cake

Sucrose

Maltitol
Sensory Effects: What is Heat of Solution?

The amount of heat absorbed or released in the formation of a solution that contains one mole of solute.

- **Negative Value:** energy is absorbed (Cooling Sensation!)
- **Positive Value:** energy is released (Warming Sensation!)

For most polyols, the solid form exhibits the most dramatic effect.
Heat of Solution
Solubility in water

- Baked Goods
  - Starch Gelatinization
  - Hydration Rate
  - Re-crystallization
  - Shelf-life

- Confectionery
  - Graining
  - Glass transition temperature
  - Texture
  - Manufacture
  - Shelf-life

- Beverages
  - Mixing
  - Re-crystallization
  - Shelf-life

- Variegates
  - Graining
  - Texture
  - Manufacture
  - Shelf-life
Solubility
Molecular Weight

Monomers
- Sorbitol, mannitol, xylitol, erythritol

Dimers
- Maltitol, lactitol, isomalt

Mixtures
- Maltitol syrup, polyglycitol (HSH)

Choose a polyol that is most similar to the sugar being substituted.

- Viscosity (confectionery)
- Freeze Point Depression (Frozen Desserts)
- Starch Gelatinization (Baked Goods)
Example: Cakes

Isomalt
MW: 344.32

Maltitol
MW: 344

Sucrose
MW: 342

Sorbitol
MW: 182

Erythritol
MW: 122

Source: Polyols.org
Relative Sweetness

- Xylitol
- Sucrose
- Maltitol
- Erythritol
- Sorbitol
- Mannitol
- Isomalt
- Lactitol

Graph showing sweetness versus sucrose for various sweeteners.
What else do you need to know about polyols?
Polyols are Low Digestible Carbohydrates

<table>
<thead>
<tr>
<th>Polyols</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oligosaccharides</td>
</tr>
<tr>
<td>Polysaccharides</td>
</tr>
<tr>
<td>Sugars</td>
</tr>
</tbody>
</table>

- Polydextrose
- Fructooligosaccharides
- Pectins
- Inulin
- Celluloses
- Allulose
- Fructose
- Isomaltulose
- Tagatose
Laxation Associated with “LDC”

Each has a different degree of impact and depends on many factors, such as size and digestibility

Two Forms

• Osmotic Laxation
  • What is not digested/absorbed in the upper GI tract ends up in the lower GI such as the colon.
  • Osmotic pressures by these LDC’s tend to remove water from the body to equalize the concentration differences.

• Fermentation by microflora in GI.
The type of GI Tolerance varies

Table 3. Approximate absorption, fermentation and urinary excretion of polyols

<table>
<thead>
<tr>
<th>Polyol</th>
<th>Absorption (g/100 g)</th>
<th>Fermentation (g/100 g)</th>
<th>Urinary excretion (g/100 g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Erythritol</td>
<td>90</td>
<td>10</td>
<td>90</td>
</tr>
<tr>
<td>Xylitol</td>
<td>50</td>
<td>50</td>
<td>&lt;2</td>
</tr>
<tr>
<td>Sorbitol</td>
<td>25</td>
<td>75</td>
<td>&lt;2</td>
</tr>
<tr>
<td>Mannitol</td>
<td>25</td>
<td>75</td>
<td>25</td>
</tr>
<tr>
<td>Isomalt</td>
<td>10</td>
<td>90</td>
<td>&lt;2</td>
</tr>
<tr>
<td>Lactitol</td>
<td>2</td>
<td>98</td>
<td>&lt;2</td>
</tr>
<tr>
<td>Maltitol</td>
<td>40</td>
<td>60</td>
<td>&gt;2</td>
</tr>
<tr>
<td>Maltitol syrup</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Regular</td>
<td>about 50†</td>
<td>about 50†</td>
<td>&lt;2</td>
</tr>
<tr>
<td>Intermediate</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High-polymer</td>
<td>about 40‡</td>
<td>about 60‡</td>
<td></td>
</tr>
<tr>
<td>Polyglycerol</td>
<td>about 40†</td>
<td>about 60†</td>
<td></td>
</tr>
</tbody>
</table>

* Data are given to the nearest 5%, except when close to zero, when data are to the nearest 2% or for urinary excretion where an upper limit of 2% appears. For references, see pp. 166–168.
† Data are based solely on glycaemic and insulinaemic responses, which may give a lower limit.
‡ Based on in vitro digestion.
Laxation Associated with “LDC”

In 2009, a review of 68 clinical studies evaluated reported GI effects of polyols and other LDC’s.

“Although the prevalence of low-digestible carbohydrates in the food supply is increasing, it appears that normal intakes of foods with these added carbohydrates are below the levels that would cause significant gastrointestinal effects.”

Calories

- Sucrose
- Sorbitol
- Xylitol
- Maltitol
- Isomalt
- Lactitol
- Mannitol
- Erythritol
Emerging areas of interest
In the past, it was either remove all of the sugars or don’t remove them at all.

There is an opportunity to have very successful products with only a partial replacement.

Do you really need to remove all of the sugar?
# Cake - Example

## Nutrition Facts

### 100% Sucrose
- **Calories**: 260
- **Calories % Daily Value**:
  - Total Fat: 11g (14%)
  - Saturated Fat: 2.5g (13%)
  - Trans Fat: 0g
  - Cholesterol: 55mg (18%)
  - Sodium: 180mg (8%)
  - Total Carbohydrate: 37g (13%)
  - Dietary Fiber: 1g (4%)
  - Total Sugars: 22g
  - Includes 20g Added Sugars (40%)
- **Protein**: 5g
- **Vitamin D**: 0mcg (0%)
- **Calcium**: 208mg (15%)
- **Iron**: 1mg (6%)
- **Potassium**: 53mg (2%)

### 25% Reduction with Maltitol
- **Calories**: 250
- **Calories % Daily Value**:
  - Total Fat: 11g (14%)
  - Saturated Fat: 2.5g (13%)
  - Trans Fat: 0g
  - Cholesterol: 55mg (18%)
  - Sodium: 180mg (8%)
  - Total Carbohydrate: 37g (13%)
  - Dietary Fiber: 1g (4%)
  - Total Sugars: 16g
  - Includes 15g Added Sugars (30%)
- **Sugar Alcohol**: 5g
- **Vitamin D**: 0mcg (0%)
- **Calcium**: 208mg (15%)
- **Iron**: 1mg (6%)
- **Potassium**: 53mg (2%)

### 50% Reduction with Maltitol
- **Calories**: 240
- **Calories % Daily Value**:
  - Total Fat: 11g (14%)
  - Saturated Fat: 2.5g (13%)
  - Trans Fat: 0g
  - Cholesterol: 55mg (18%)
  - Sodium: 180mg (8%)
  - Total Carbohydrate: 37g (13%)
  - Dietary Fiber: 1g (4%)
  - Total Sugars: 11g
  - Includes 10g Added Sugars (20%)
- **Sugar Alcohol**: 10g
- **Vitamin D**: 0mcg (0%)
- **Calcium**: 208mg (15%)
- **Iron**: 1mg (6%)
- **Potassium**: 53mg (2%)

*The % Daily Value tells you how much a nutrient in a serving of food contributes to a daily diet. 2,000 calories a day is used for general nutrition advice.
Low Digestible Sugars
Low Digestible Carbohydrates: Sugars

- Allulose
- Tagatose
- Isomaltulose
These are still sugars however....
Polyols (LDC’s) are very effective tools in reducing sugars while maintaining functionality.

One polyol (LDC) does not always fit all applications.

Do your homework!

- It's important to understand the functionality of the sugars you're looking to replace as well as the LDC you're looking to replace it with.