CONVENTIONAL TO EMERGING NATURAL SWEETENERS:
Key Properties For Product Applications

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OUTLINE

► Consumer Perceptions: “Natural” & Clean Label

► Sweeteners for Clean Label: Options, Attributes and Selection Criteria

► Case Studies
What is “Natural”? 

► Currently FDA guidance:
  • “Nothing artificial or synthetic (including all color additives regardless of source) has been included in, or has been added to, a food that would not normally be expected to be in that food”

► Public comments sought:
  • Should “natural” be defined, and if so how?
  • How should FDA determine appropriate use of “natural” on food labels?
Industry’s Approach: Clean/Clear Label

From **Clean Label**…

► Shorter ingredient list
► Familiar ingredients
  • “Natural”
  • Naming
► Healthy

… to **Clear Label**

► Clearer, simpler claims
► Greater transparency:
  • origin of ingredients
  • sustainability
Consumer Perception

What does Clean Label mean to you?

- Free from artificial ingredients: 35%
- Has natural/organic claims: 35%
- Don't know: 20%
- No pesticides/chemicals/toxins: 30%
- Free from allergens: 25%
- No GMOs: 25%
- Minimally processed: 20%
- Simple/short ingredient list: 15%
- Transparent packaging: 10%

Strategies for “Cleaning” Labels…

► Connect with consumer
  • Understand
  • Educate: social media

► Ingredients choice
  • Understood by consumers
  • “Natural” perception

► Of particular interest:
  • Sweeteners
  • Thickeners
  • Colors
  • Stabilizers
  • Preservatives

Source: Innova Market Insights
SWEETENERS FOR CLEAN LABEL APPLICATIONS

► Options

► Selection Criteria
Sweetener “Tools” for Clean Label Applications…

► ‘Natural’ solutions
  • Bulk (nutritive)
  • High Intensity (non-nutritive)

► Well-Established vs. Emerging
... Are Significantly Growing

<table>
<thead>
<tr>
<th>Sweetener</th>
<th>% CAG: ‘07-’11</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stevia</td>
<td>30%</td>
</tr>
<tr>
<td>Evaporated cane juice</td>
<td>17%</td>
</tr>
<tr>
<td>Raw Sugar</td>
<td>6%</td>
</tr>
<tr>
<td>Honey</td>
<td>5%</td>
</tr>
<tr>
<td>Fruit sweeteners</td>
<td>4%</td>
</tr>
<tr>
<td>High fructose corn syrup</td>
<td>3%</td>
</tr>
<tr>
<td>Sugar alcohols</td>
<td>3%</td>
</tr>
<tr>
<td>Fructose</td>
<td>1%</td>
</tr>
<tr>
<td>Table Sugar</td>
<td>-2%</td>
</tr>
<tr>
<td>Sucralose</td>
<td>-5%</td>
</tr>
<tr>
<td>Saccharin</td>
<td>-6%</td>
</tr>
<tr>
<td>Aspartame</td>
<td>-6%</td>
</tr>
</tbody>
</table>

Source: Natural Marketing Institute
# ‘Natural’ Nutritive Sweeteners

<table>
<thead>
<tr>
<th>Sweetener</th>
<th>kCal/g</th>
<th>Intensity</th>
<th>GI</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Raw) Sugar / Turbinado / Demerara</td>
<td>3.8</td>
<td>1</td>
<td>65</td>
</tr>
<tr>
<td>Evaporated Cane Juice</td>
<td>3.8</td>
<td>1</td>
<td>55</td>
</tr>
<tr>
<td>Coconut (Palm) Sugar</td>
<td>3.75</td>
<td>1</td>
<td>35</td>
</tr>
<tr>
<td>Sweet Potato Juice Concentrate</td>
<td>~2.2</td>
<td>0.6</td>
<td></td>
</tr>
<tr>
<td>Honey</td>
<td>3.5</td>
<td>1</td>
<td>30</td>
</tr>
<tr>
<td>Agave Nectar</td>
<td>3.1</td>
<td>1.3</td>
<td>15</td>
</tr>
<tr>
<td>Maple Syrup</td>
<td>2.7</td>
<td>1</td>
<td>54</td>
</tr>
<tr>
<td>Barley Malt Syrup</td>
<td>3</td>
<td>0.5</td>
<td>42</td>
</tr>
<tr>
<td>Brown Rice Syrup</td>
<td>3.2</td>
<td>0.5</td>
<td>25</td>
</tr>
<tr>
<td>Blackstrap Molasses</td>
<td>2.9</td>
<td>0.8</td>
<td>55</td>
</tr>
<tr>
<td>Sorghum Syrup</td>
<td>2.9</td>
<td>0.5</td>
<td>50</td>
</tr>
<tr>
<td>Yacon Syrup</td>
<td>1.5</td>
<td>0.5</td>
<td>1</td>
</tr>
<tr>
<td>Xylitol</td>
<td>2.4</td>
<td>1</td>
<td>12</td>
</tr>
<tr>
<td>Erythritol</td>
<td>0.2</td>
<td>0.6 - 0.7</td>
<td>1</td>
</tr>
</tbody>
</table>

Source: Ingredient Suppliers
### ‘Natural’ Non-Nutritive Sweeteners

- Only Stevia and Monk fruit extracts approved in the US as general sweeteners

<table>
<thead>
<tr>
<th>Sweetener</th>
<th>From</th>
<th>kCal/g</th>
<th>Intensity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stevia extracts</td>
<td>Stevia</td>
<td>0</td>
<td>200 – 300</td>
</tr>
<tr>
<td>Monk fruit extracts</td>
<td>Luo Han Guo</td>
<td>0</td>
<td>150 – 250</td>
</tr>
<tr>
<td>Glycyrrhizin</td>
<td>Licorice</td>
<td>0</td>
<td>50-100</td>
</tr>
<tr>
<td>Thaumatin</td>
<td>African fruit (Katemfe berry)</td>
<td>4</td>
<td>2,000 – 3,000</td>
</tr>
<tr>
<td>Monatin</td>
<td>South African shrub</td>
<td>0</td>
<td>3,000</td>
</tr>
<tr>
<td>Brazzein</td>
<td>West African fruit (Oubli plant)</td>
<td>4</td>
<td>1,000</td>
</tr>
<tr>
<td>Monellin</td>
<td>West African fruit (Serendipity berry)</td>
<td>4</td>
<td>~1,500</td>
</tr>
<tr>
<td>Trilobatin</td>
<td>Chinese tree leaves (Lithocarpus)</td>
<td>0</td>
<td>~50</td>
</tr>
</tbody>
</table>
“…we have too many choices, too many decisions, too little time…”

How to Choose?

**Selecting Sweeteners**

- Market Insights
  - Consumer Perception
  - Trends
  - Competition

- Health & Nutrition
  - Calorie reduction
  - Glycemic response
  - Laxation threshold

- Cost
  - Absolute
  - Relative to sugar

- Physical Attributes
  - Viscosity, Solubility
  - Color
  - Stability

- Functionality
  - Sweetness quality, intensity and temporal profile
  - Application-specific aspects
Sweetness: Quality & Intensity

► Quality:
  - Source-driven: barley malt syrup, sweet potato conc., glycyrrhizin etc.
  - Compatibility with application

► Intensity depends on matrix:
  - pH/acidity, solids, flavors, carbonation etc.

► Sweetener blends: intensity while minimizing off-notes

Source: Prescott et al, 2001
Synergy

Benefits:
- Lower impact of flavor, taste or other issues
- Decrease costs

Documented: Reb A – sugar; Reb A – Thaumatin; Reb A – Monatin

<table>
<thead>
<tr>
<th>Monatin/RA Conc (ppm)</th>
<th>Predicted % SEV</th>
<th>Measured % SEV</th>
<th>Synergy (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5/340</td>
<td>6.9</td>
<td>8.3</td>
<td>20.3</td>
</tr>
<tr>
<td>8/240</td>
<td>7.1</td>
<td>8.9</td>
<td>25.3</td>
</tr>
<tr>
<td>11/175</td>
<td>7.4</td>
<td>8.9</td>
<td>20.3</td>
</tr>
<tr>
<td>15/120</td>
<td>7.7</td>
<td>8.5</td>
<td>10.4</td>
</tr>
<tr>
<td>19/65</td>
<td>7.6</td>
<td>8.4</td>
<td>10.5</td>
</tr>
</tbody>
</table>

Source: Pat# WO2012083251
Temporal Profile

Note: Sugar (sucrose) at a 3% solution, others equivalent sweetness to 3% sucrose solution.

Source: Morita Kagaku Kogyo, adapted
Other Physical Attributes of Interest

- Stability (heat, pH, etc.)
- Viscosity
- Solubility
- Color
- Particle size distribution
- Water binding
- Crystallization
- Enthalpy of dissolution
Functionality

► Flavor
  • Clean sweet to fruity, bitter, metallic, licorice etc.
  • In most food applications
    ➔ **Strategy**: blends, modifiers/flavors

► Color
  • Maillard reaction and/or caramelization
  • In baked goods, selected beverages, confectionery, jams/preserves
    ➔ **Strategy**: some sugars, amino acids/proteins

► Humectant
  • Bind and hold moisture, keeping foods palatable and appealing
  • In baked goods, confectionery, processed fruits/vegetables
    ➔ **Strategy**: honey, some sugars and syrups
Functionality (cont.)

► Body/Texture/Volume
  • Contribute solids, increased viscosity and/or mouthfeel
  • May stabilize proteins structure, delay starch gelatinization
  • In baked goods, beverages, confectionery, ice cream, sauces
    ➤ **Strategy**: bulk sweeteners

► Freeze Point Depression
  • Prevents large ice crystals for a smoother texture
  • In ice cream, frozen desserts
    ➤ **Strategy**: small sugars, sugar alcohols

► Preservative / Shelf Life
  • Decrease Aw and increase osmotic pressure
  • Control moistness and crystallization
  • In jams, jellies, confectionery, sauces and dressings
    ➤ **Strategy**: sugar, syrups
Nutritional Aspects

► Calories and Sugars Content

<table>
<thead>
<tr>
<th>Category</th>
<th>Calories (kcal/g)</th>
<th>Sugars (g/100g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mono- and disaccharides</td>
<td>~ 4</td>
<td>~100</td>
</tr>
<tr>
<td>Syrups &amp; Liquid Sweeteners</td>
<td>1.5 - 3</td>
<td>35 – 75</td>
</tr>
<tr>
<td>Xylitol</td>
<td>2.4</td>
<td>0</td>
</tr>
<tr>
<td>Erythritol</td>
<td>0.2</td>
<td>0</td>
</tr>
<tr>
<td>High Intensity Sweeteners</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

- Decision: consider calories and sweetness intensity & functionality
Nutritional Aspects (cont.)

► Glycemic Index

(GlycemicIndex.com & Suppliers)
Cost Considerations

- Sugar most efficient on $/lb basis

- Decision based on cost in use:

<table>
<thead>
<tr>
<th>Sweetener</th>
<th>Sugar</th>
<th>White Sorghum Syrup</th>
<th>High Intensity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost ($/lb)</td>
<td>0.48</td>
<td>0.65</td>
<td>90</td>
</tr>
<tr>
<td>Sweetness (equiv. g. sugar)</td>
<td>1</td>
<td>0.5</td>
<td>200</td>
</tr>
<tr>
<td>Usage Level (g/serving)</td>
<td>15</td>
<td>30</td>
<td>0.075</td>
</tr>
<tr>
<td>Cost in Use ($/serving)</td>
<td>0.0158</td>
<td>0.0430</td>
<td>0.0149</td>
</tr>
</tbody>
</table>

... but also process adjustments, functionality...
Fine Tuning Sweetness

► Modulators to address:
  • Off-flavor: bitterness, metallic, astringent
  • Temporal profile: slow onset, linger

► Main approaches:
  • Enhancing: potentiators
  • Blocking: Positive Allosteric Modulators, bitterness blockers
  • Masking: phantom aromas, congruent flavors

► However:
  • May impact other taste modalities
CASE STUDIES
Example #1: Sweetener Blend

► Objective:
  • Formulate sweetener blend for beverages

► Criteria:
  • Clean label-friendly ingredients
  • 2g serving to provide 2tsp sugar sweetness at zero calories
  • Similar performance to sugar
Example #1: Sweetener Blend (cont.)

► Identify/address functionality potential issues:
  • Sweetness quality and intensity
  • Body and mouthfeel
  • Flavor

► Strategies:
  • Sugar, up to level maintaining zero calorie
  • Erythritol, to help with body and mouthfeel
  • Natural HIS: blend to minimize specific limitations, synergy?
  • Natural flavors and/or maskers if needed
Example #1: Sweetener Blend (cont.)

Final formula at 2g serving:

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Sweetness Equivalence (g sugar)</th>
<th>Calories</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sugar</td>
<td>1.11</td>
<td>4.29</td>
</tr>
<tr>
<td>Erythritol</td>
<td>0.52</td>
<td>0.17</td>
</tr>
<tr>
<td>Stevia Extract</td>
<td>4.63</td>
<td>-</td>
</tr>
<tr>
<td>Monk Fruit Extract</td>
<td>1.45</td>
<td>0.04</td>
</tr>
<tr>
<td>Flavor System</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Serving size</strong></td>
<td><strong>7.7</strong>*</td>
<td><strong>4.50</strong></td>
</tr>
</tbody>
</table>

* Theoretical, not including synergy
Example #2: Protein Bar Reformulation

► Objective:
  • Reformulate chocolate protein bar

► Existing formula:

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>g/serving</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maltitol syrup 65%</td>
<td>3</td>
<td>5.9</td>
</tr>
<tr>
<td>Maltodextrin</td>
<td>2.5</td>
<td>4.9</td>
</tr>
<tr>
<td>Sucralose</td>
<td>0.03</td>
<td>0.06</td>
</tr>
<tr>
<td>Water</td>
<td>3.5</td>
<td>6.9</td>
</tr>
<tr>
<td>Other ingredients</td>
<td>41.9</td>
<td>82.2</td>
</tr>
<tr>
<td><strong>Serving size</strong></td>
<td><strong>50.9</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>
Example #2: Protein Bar Reformulation (cont.)

Criteria:

- “Clean label”-friendly ingredients
- No additional sugar
- Similar or improved performance
Example #2: Protein Bar Reformulation (cont.)

- Identify/address functionality potential issues:
  - Sweetness intensity and quality
  - Body and texture
  - Moistness

- Strategies:
  - Replace sucralose with Stevia extract
  - Replace maltitol syrup + maltodextrin with erythritol + water
  - Add glycerin as humectant
  - Address linger/off-note: stevia masker, dark chocolate flavor
Example #2: Protein Bar Reformulation (cont.)

“Cleaned” formula:

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>g/serving</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Erythritol</td>
<td>4.9</td>
<td>9.2</td>
</tr>
<tr>
<td>Stevia Extract</td>
<td>0.053</td>
<td>0.1</td>
</tr>
<tr>
<td>Chocolate Nat. Flavor</td>
<td>0.4</td>
<td>0.75</td>
</tr>
<tr>
<td>Stevia masker</td>
<td>0.009</td>
<td>0.017</td>
</tr>
<tr>
<td>Water</td>
<td>5</td>
<td>9.4</td>
</tr>
<tr>
<td>Other ingredients</td>
<td>43.0</td>
<td>80.5</td>
</tr>
<tr>
<td><strong>Serving size</strong></td>
<td><strong>53.4</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>
Example #2: Protein Bar Reformulation (cont.)

► Sweetness Intensity:

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Original Formula</th>
<th>“Cleaned” Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>g</td>
<td>Sweetness (g sugar)</td>
</tr>
<tr>
<td>Maltitol Syrup 65%</td>
<td>3</td>
<td>1.2</td>
</tr>
<tr>
<td>Maltodextrin</td>
<td>2.5</td>
<td>0.25</td>
</tr>
<tr>
<td>Sucralose</td>
<td>0.03</td>
<td>15</td>
</tr>
<tr>
<td>Erythritol</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stevia Extract</td>
<td>0.053</td>
<td>13.25</td>
</tr>
<tr>
<td>Stevia Masker</td>
<td>0.09</td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>5.53</strong></td>
<td><strong>16.45</strong></td>
</tr>
</tbody>
</table>

► Sweetness Quality:
  - Onset & linger
To Summarize

► Connect with consumer
  • Understand and educate

► CL-compatible sweeteners options available
  • Selection important– ‘sweet spot’
  • Tailored blends

► Emerging sweeteners

► Sweetness modulator tools: maskers, flavors, enhancers
What’s Next?

► Definition of ‘natural’

► ‘Natural’-compatible processes, e.g. fermentation
  • Next gen sweeteners: Reb-D, Reb-M, others?

► Impact of ‘added sugar’ regulations

► More tools to address limitations of ‘natural’ sweeteners
  • Understanding sweet taste receptors & signaling
  • Combined strategies

► Focus on other nutritional and/or health benefits
THANK YOU!

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