Formulating healthy beverages using hydrocolloids

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San Diego R&D

The *What if...You CAN!* Company

What if...

- Reduce Sugar
- Sensory Attributes
- Gum Choice matters
- Same Properties

YOU CAN
What you will learn

- Beverages have more sensory attributes that you might suspect
- Quite a good match for sweetness can be made between sucrose and high intensity sweeteners
- Sensory aspects of taste and aroma are not influenced so much by the gums tested
- The mouthfeel parameters varied widely with the gum used
- Thickness in the mouth (body) has a viscosity as well as a density component
- Aftertaste can be balanced by the choice of hydrocolloid
Get The Sugar Out

- **Sugar from beverages represents a significant source of calories for consumers**
  - A 64 ounce Big Gulp from 7 Eleven contains approximately 800 calories -- Roughly 30% of the total daily requirements for a 16 year old male weighing 150 pounds

- **At the same time, sugar provides unique and positive sensory aspects to beverages**
  - Enhanced body
  - Reduced aftertaste
  - Better flavor

- **Consider the use of gums to reduce calories and maintain the important sensory attributes of beverages**
  - Enhanced body
  - Reduced aftertaste
  - Better flavor
Hidden Calories

• “...more than ever before, what and how much we drink may increase calorie intake and weight without our noticing”

• The problem of increasing waistlines and obesity in the United States has escalated in the last 30 years.
  • “...calorie consumption increased an average of 150 to 300 calories per day,
  • about half that increase coming from beverages.
  • The variety of calorie-dense beverages and number of soft-drink servings per day both grew.
  • Average portion size increased more than 50% from about 13 oz to almost 20 oz”

MSNBC, Feb. 16, 2007 Karen Collins, R.D.
Expelled from School

- **Due to health concerns, more and more school districts are banning high calorie beverages from vending machines and lunch programs**

- **In several states full sugar beverages cannot be sold**
  - "The country's top three soft-drink companies announced yesterday that beginning this fall they would start removing sweetened drinks like Coke, Pepsi and iced teas from school cafeterias and vending machines in response to the growing threat of lawsuits and state legislation."

NY Times, May 4, 2006, Marian Burros and Melanie Warner
Through Thick and Thin

- Some consumers are sensitive to changes in beverages and dislike the current “diet” products
- Can seem thin and watery or have other perceived defects
- High intensity (artificial) sweeteners have key differences with sugar and HFCS
  - Don’t add viscosity
  - Don’t add density
  - Cause flavors to partition differently
  - Create or enhance aftertaste
- All can be influenced by the use of hydrocolloids
Science to the Rescue

- Prepared a series of low pH fruit flavored beverages
  - Everything constant except for the hydrocolloid used
    - Cellulose gum, pectin, xanthan gum and gellan gum tested
- Detailed sensory analysis conducted on aroma, flavor, mouthfeel and aftertaste
  - Developed a list of 37 attributes
- Measured physical properties: viscosity, density and other properties
- Used statistical analysis to relate formulations, sensory and physical attributes

Result: In-depth understanding of how gums influence beverage properties
## Beverage base

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>(%)</th>
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<tbody>
<tr>
<td>Citric acid</td>
<td>0.394</td>
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<tr>
<td>Sodium citrate</td>
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<tr>
<td>Sodium benzoate</td>
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<td>FD&amp;C Yellow #5</td>
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<td>FD&amp;C Yellow #6</td>
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<td>Deionized water</td>
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<td>#</td>
<td>Sample</td>
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<td>----</td>
<td>---------------------------------------------</td>
</tr>
<tr>
<td>1</td>
<td>Negative Control, Artificial Sweetener</td>
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<tr>
<td>2</td>
<td>Positive Control, 12% Sugar</td>
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<tr>
<td>3</td>
<td>Slendid® 200 Pectin</td>
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<td>4</td>
<td>Genu® Vis Pectin</td>
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<tr>
<td>6</td>
<td>Cekol® 300 cellulose gum @ 4 mPa*s</td>
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<td>7</td>
<td>Cekol 300 cellulose gum @ 8 mPa*s</td>
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<td>8</td>
<td>Cekol 30000A cellulose gum @ 4 mPa*s</td>
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<td>9</td>
<td>Cekol 30000A cellulose gum @ 8 mPa*s</td>
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<tr>
<td>10</td>
<td>Keltrol® SFT xanthan gum @ 4 mPa*s</td>
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<tr>
<td>11</td>
<td>Keltrol SFT xanthan gum @ 8 mPa*s</td>
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<tr>
<td>12</td>
<td>Keltrol T xanthan gum @ 4 mPa*s</td>
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<td>13</td>
<td>Keltrol T xanthan gum @ 8 mPa*s</td>
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<td>14</td>
<td>Kelcogel® PS gellan gum</td>
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<td>Kelcogel F gellan gum @ 4 mPa*s</td>
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<td>16</td>
<td>Kelcogel HAB gellan gum @ 4 mPa*s</td>
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<td>17</td>
<td>Cekol EH 01 cellulose gum</td>
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<tr>
<td>18</td>
<td>Benefiber® guar</td>
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</table>
Sensory Attributes

- **Aroma**
  - overall, sweet, citrus, lemon, orange, grapefruit, tart, medicinal, powdery, artificial

- **Flavor**
  - overall, sweet, citrus, lemon, orange, grapefruit, sour, salty, artificial sweetener, bitter, medicinal

- **Aftertaste**
  - overall, citrus, lemon, sweet, artificial sweetener, tart bitter, mouth coating, lingering

- **Texture or mouthfeel**
  - Thickness *(body)*, smooth, tingling, syrupy *(sliminess)*, mouth coating, mouth watering
How AROMA Goes Wrong

...and how to fix it

• For each category aroma score was lower when sugar was used in place of Ace-K / Sucralose
  • The balance and intensity is not the same for sugar and so a match has not been made, more is not always better

• Adding 0.1% GENU® Pectin better mimicked sugar control
Orange Aroma Profile Ranking

- The effect of gums can change the perception of various aroma components.
- The sugar (positive control) was normalized to 1.0.
- Note: some gums tend to enhance the orange aroma and some suppress it.
- The “ideal” would match the aroma of the control for all attributes.
How FLAVOR goes wrong
…and how to fix it

• As with aroma, the flavor balance was different when using artificial sweetener
  • It’s not so much a question of “flavor release” or even intensity
  • as it is the balance of flavor notes
  • Adding gellan or xanthan improved.

• HAB gellan and smooth flow xanthan both improved the flavor profile of the artificial sweetener, making it more like sugar.
Overall Flavor Ranking

- As with the orange aroma ranking, control is set to 1.0

- Notice how some of the gums significantly increase overall flavor

- May not be a “good thing” since the objective is to match sugar.

- The best choices for that are HAB gellan gum and SF xanthan gum
The Lingering Problem—Aftertaste
...and how to minimize it

- **Aroma and flavor make a big impression on consumers** – but it’s aftertaste they remember the longest
  - Many of the problem with non-sugar sweeteners relates to their temporal profile of how they decay with time
- **Smooth flow xanthan is a gum that alters the artificial sweetener temporal profile to more closely match sugar**
Beverage Body Building

- An important but poorly understood quality of sugar-sweetened beverages is “body.”
  - Also referred to as “weight,” “mouthfeel,” and “consistency.”

- Without this characteristic a sugar-free beverage can seem watery, thin and “inferior”.

- Hydrocolloids are known to add thickness but sometimes are attributed to introducing “sliminess.”

- So, what is body and how it different from thickness and sliminess?
How to Define Mouthfeel

- A trained QDA panel evaluated a well-characterized set of orange flavored beverages aroma, flavor, mouthfeel and aftertaste components
- **Mouthfeel included terms for “thickness” as well as “syrupy mouthfeel.”**
  - Thickness = what we call “body”
  - Syrupy mouthfeel = often termed “sliminess”
- **Thickness**
  - Found to be related to the density of a beverage and its viscosity
- **Syrupy mouthfeel**
  - Related to the viscosity as well as to degree of pseudoplasticity
  - Pseudoplasticity is how much the viscosity decreases when a liquid is forced to flow at a higher shear rate
 Thickness or Body

• **Summary:** An excellent prediction of “thick mouthfeel” was obtained with a multiple regression of specific gravity and viscosity at 110 s⁻¹. **Density and viscosity matter!**

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Thick mouthfeel = -2536 + (2544 * S gravity) + (0.9117 * Viscosity @ 110)
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<table>
<thead>
<tr>
<th>Parameter Estimates</th>
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<tr>
<td>Term</td>
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<tr>
<td>Intercept</td>
</tr>
<tr>
<td>S gravity</td>
</tr>
<tr>
<td>Eta @ 110</td>
</tr>
</tbody>
</table>
Thickness or Body – Described

- The oral sensation of body appears to originate from more than one source
  - Viscosity or the resistance to flow of the material
  - Density or the weight of the sample
- These two factors are integrated and we form an impression of the body of a beverage
- This means that formulators can use hydrocolloids that increase viscosity at low use levels
  - Xanthan gum or high viscosity cellulose gum
- Formulators can also use higher levels of low viscosity products to increase the beverage density
  - Pectin or low viscosity cellulose gum
- They can also use a combination of viscosity and density to achieve a non-watery mouthfeel
Another Part of Mouthfeel

- Some products can seem more like a syrup, sometimes this is called “sliminess”
  - Which is thicker, honey or mayonnaise?
    - Honey seems thick if you try to stir it, mayo does not
    - Mayo seems thick if you stand the spoon in it, honey does not
  - This paradox of thickness is commonly encountered in foods
- In general, materials that are more constant in viscosity like honey are thought to be more syrup like
- When the viscosity decreases at higher shear rates (pseudoplasticity) the product seems thinner in the mouth
Syrupiness Defined

- **Summary**: Syrupy mouthfeel comes from a combination of a relatively high viscosity and Newtonian flow. The index predicts sensory scores very well.

Syrupy index = (pseudoplasticity index “n”) * viscosity @ 110s-1
Putting It All Together

- Sugar and other similar sweeteners have significant impacts on the sensory characteristics of beverages.
- Simply replacing the sweetness supplied by the sugar does not result in a successful product.
- Aroma, flavor and aftertaste can be changed by the hydrocolloid used.
- Even more dramatically, the mouthfeel is effected by gum choice.
- The best solution will depend on the end product.
- Choice of hydrocolloid needs to be made in collaboration with a knowledgeable supplier.
Hydrocolloid references

- **Pectin**
  - Confers mouthfeel without a high viscosity due to its higher use level and thus greater density contribution
  - Stable at pH values of < 5
  - Fair at suspension, may provide protein protection

- **Cellulose gum**
  - This gum is less pseudoplastic than others and so has a more syrupy mouthfeel for a given body or thickness than other gums
  - Stable at pH values > 3.5
  - Only fair at suspension, may also stabilize proteins

- **Xanthan**
  - Highly pseudoplastic, so syrupy mouthfeel is low but use levels are low so body and thickness must be built with viscosity alone
  - Stable at pH values from 2-12, can be used universally
  - Good at suspension

- **Gellan gum**
  - Unique product that forms “fluid gels” that are low in viscosity but high in structure
  - Use requires control of cation levels and pH values of 3.0 to 7
  - The best at suspending pulp and insoluble solids
In conclusion

- Most calorie reduction is accomplished by diluting juice content or replacing sugar leading to a beverage that is very thin and watery.

- CP Kelco hydrocolloids replace the lost body and mouthfeel allowing the beverage to have texture and sensory properties that meet consumer expectations.

- The use of hydrocolloids can also improve the suspension of functional fortifying ingredients providing uniform appearance and delivery.
CP Kelco has the right tools for your next What If.....