



# **Overcoming the application challenges of formulating with stevia**

**Presented at Galam's Stevia Seminar**

**FIE Paris, 30 November 2011**

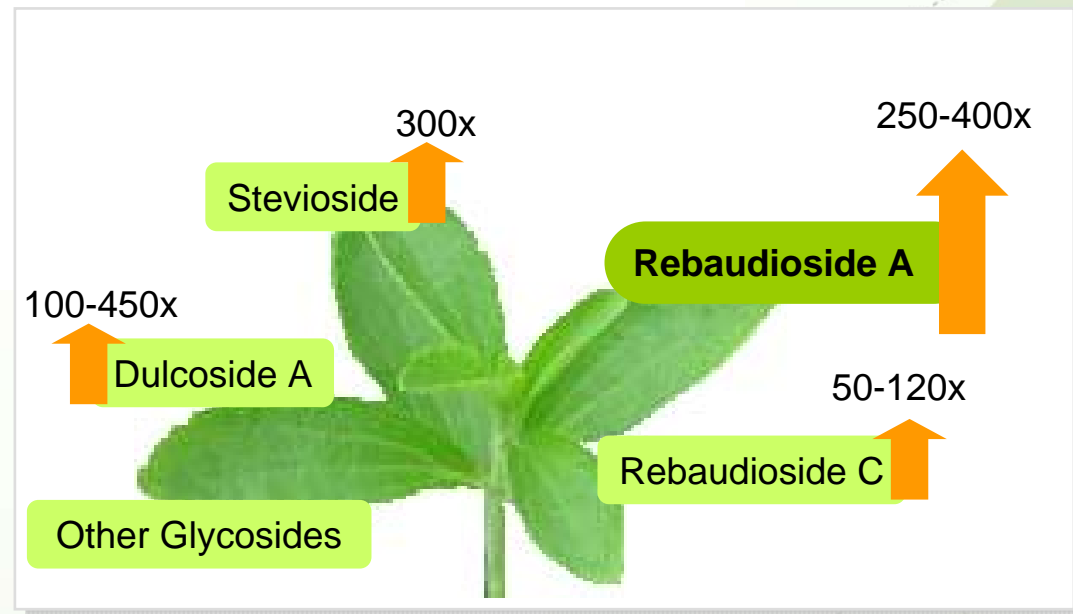
[www.enlitensteener.com](http://www.enlitensteener.com)



# stevia

a complex group of sweeteners

- There are hundreds of varieties of the stevia rebaudiana bertonii plant that have evolved over time.
- Within each variety, the plant leaves contain different sweet-tasting components, known as steviol glycosides.
- These components have different sweetness intensity and sweetness/bitterness profiles.



# what is Enliten<sup>®</sup> ?



- Enliten<sup>®</sup> contains over 95% of the best tasting component, **rebaudioside A**, or Reb A.
- Because it is made from a single plant variety, Enliten<sup>®</sup> has **superior consistency** in quality.
- **Corn Products** has exclusive license to grow Morita's patented strain, technology and manufacturing capabilities, as well as marketing and distribution rights for stevia products.

# supply chain

Corn Products' approach covers full control of the supply chain from field to production of the final product, providing reliability and consistency:



# value proposition

Enliten<sup>®</sup> consistently delivers great-tasting, “on trend” **sweetness solutions** resulting from world class formulation expertise, unparalleled safety and quality assurance from a proprietary Americas-based cultivar, and fine-tuned logistics.

Enliten<sup>®</sup>

Extracted from a plant that provides clean, sweet taste, traceability, “Real food, Real Ingredient”

Proprietary  
Natural  
Sourcing

Growing to  
Packaging in  
ONE location

Sustainable production where high control levels and expertise provide high level of assurance and

World Class  
Formulation &  
Support

The Right Balance of flavor, profile & body with the ingredient diversity and customer support to help speed the process and reduce costs

Let's Talk about  
**physical & functional  
attributes**



# acid stability

- Rebaudioside A is **pH and heat stable** in most manufacturing/production settings.
  - UHT (120°C and 140°C at 9 seconds)
  - Pasteurization (75°C at 15 minutes)
  - Extended storage at 25–50°C at various pH (2–6.5)
- **However** there is a limit.....
  - Extreme heat and pH with duration can cause degradation.

# acid stability trials

- **Stability at 50°C, 4h, pH 2.0, pH 3.0, pH 4.0, pH 5.0**

- Phosphoric acid
- Citric acid
- Tartaric acid
- Malic acid
- Lactic acid

- **Stability at 100°C, 4h , pH 2.0, pH 3.0, pH 4.0, pH 5.0**

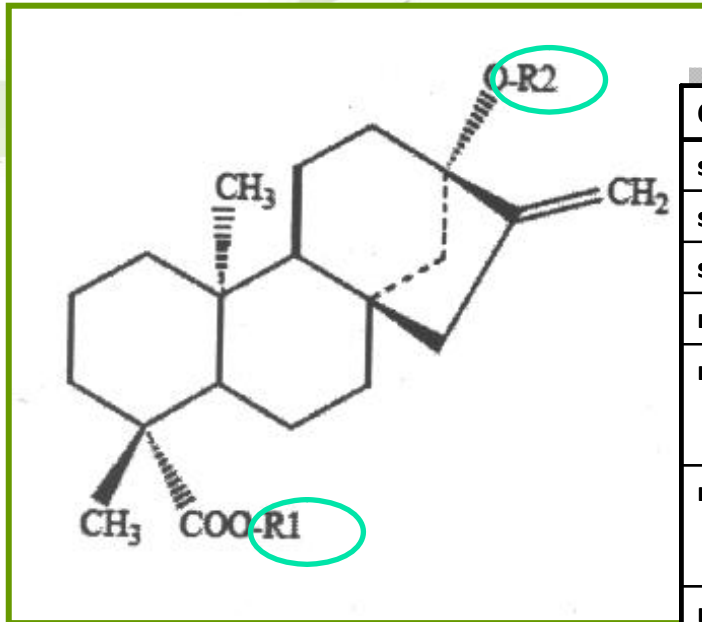
- Phosphoric acid
- Citric acid
- Tartaric acid
- Malic acid
- Lactic acid

- **Sterilization stability 120°C, pH 3.0 citric acid, 2h**

- **Stability at 120°C, pH 6.2, 2h**

- 10% and 20% loss





Compound name	R1	R2
steviol	H	H
steviolbioside	H	<i>b</i> -Glc- <i>b</i> -Glc(2-1)
stevioside	<i>b</i> -Glc	<i>b</i> -Glc- <i>b</i> -Glc(2-1)
rubside	<i>b</i> -Glc	<i>b</i> -Glc
rebaudioside A	<i>b</i> -Glc	<i>b</i> -Glc- <i>b</i> -Glc(2-1)   <i>b</i> -Glc(3-1)
rebaudioside B	H	<i>b</i> -Glc- <i>b</i> -Glc(2-1)   <i>b</i> -Glc(3-1)
rebaudioside C (dulcoside B)	<i>b</i> -Glc	<i>b</i> -Glc- <i>α</i> -Rha(2-1)   <i>b</i> -Glc(3-1)
rebaudioside D	<i>b</i> -Glc- <i>b</i> -Glc(2-1)	<i>b</i> -Glc- <i>b</i> -Glc(2-1)   <i>b</i> -Glc(3-1)
rebaudioside E	<i>b</i> -Glc- <i>b</i> -Glc(2-1)	<i>b</i> -Glc- <i>b</i> -Glc(2-1)
rebaudioside F	<i>b</i> -Glc	<i>b</i> -Glc- <i>b</i> -Xyl(2-1)   <i>b</i> -Glc(3-1)
dulcoside A	<i>b</i> -Glc	<i>b</i> -Glc- <i>α</i> -Rha(2-1)

Glc, Rha, and Xyl represent, respectively, glucose, rhamnose, and xylose sugar moieties.

stability ~  
crystallization



# crystallization

Evaluation of Enliten<sup>®</sup> (rebaudioside A) solubility over a range of percent solids levels while at various temperatures:

- 1, 5, 10, 15, 20, 30 and ~40% solutions
- 4°C, 22°C and 40°C



# crystallization



Samples at 4°C



Samples at 22°C



Samples at 40°C

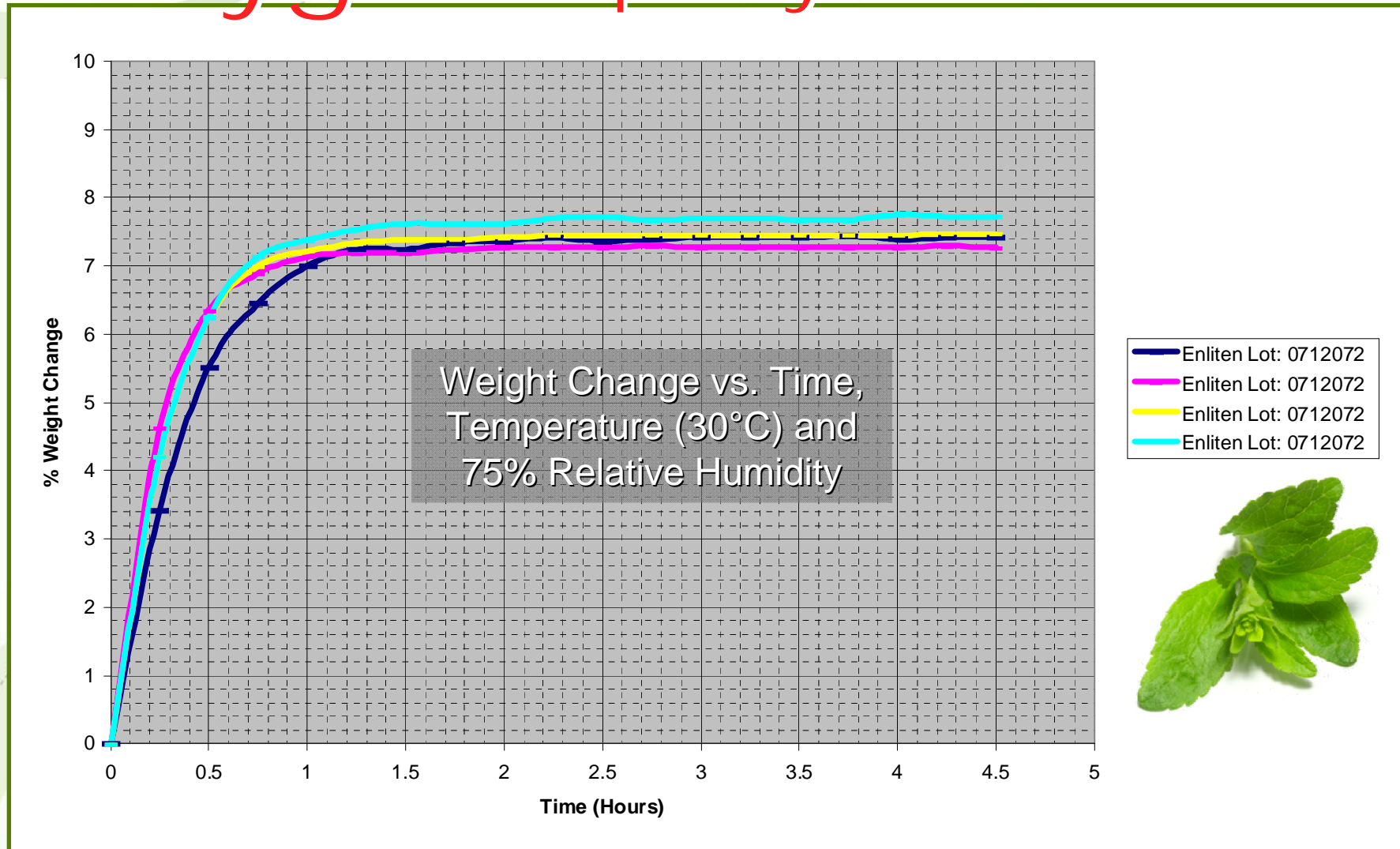
# crystallization summary

- Concentrations less than 1% are found to be most stable for extended periods.
- Anhydrous form ➔ Monohydrate form
- ↓ temperature = ↓ crystallization

# hygroscopicity



# hygroscopicity



# tips for product developers



# flavor/texture adjustment



- Sucrose is a **unique natural sweetener** – it provides the sweetness quality, viscosity and flavor profile (plus “brown” flavors) familiar to consumers.
- **Other high-potency sweeteners** have adjusted through combination with other less-natural sweeteners and texture agents.
- Every food category and every formulation offers **unique flavoring opportunities and/or challenges** for a high-potency sweetener...

There is no “quick-fix” or “flavor kit” that works in your unique product, just as there is no “one flavor” that works for everything.

# flavor issues

## QUESTION:

Is bitterness an issue?



This depends on several factors...

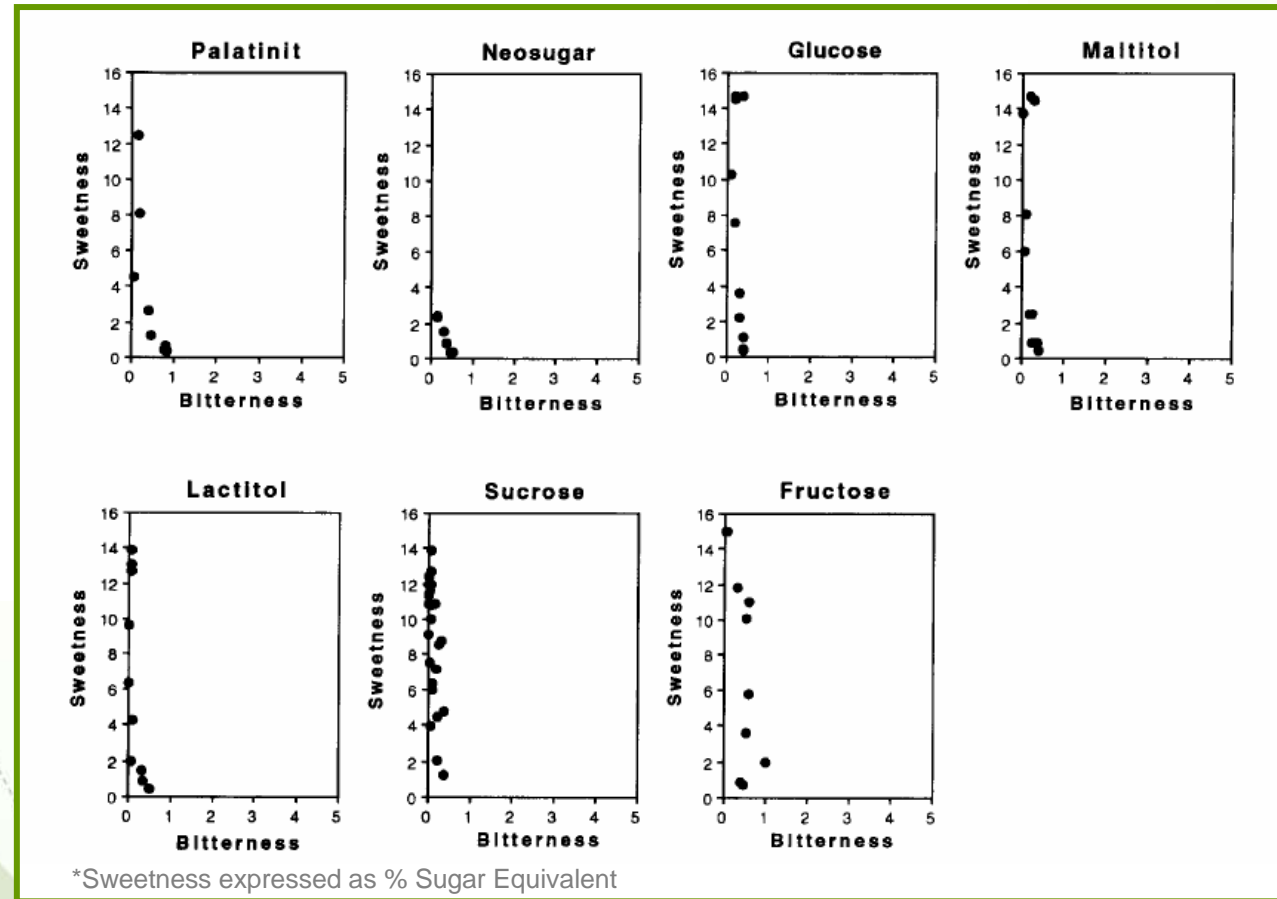


1. **Level of sweetness** (sugar equivalence)
2. **Other ingredients** and their impact on overall sweetness profile of the product
  - Other sweeteners
  - Flavors
  - Modifying agents



# bulk sweeteners sweetness vs. bitterness

Bitterness **decreases** with increasing sweetness in many bulk sweeteners.

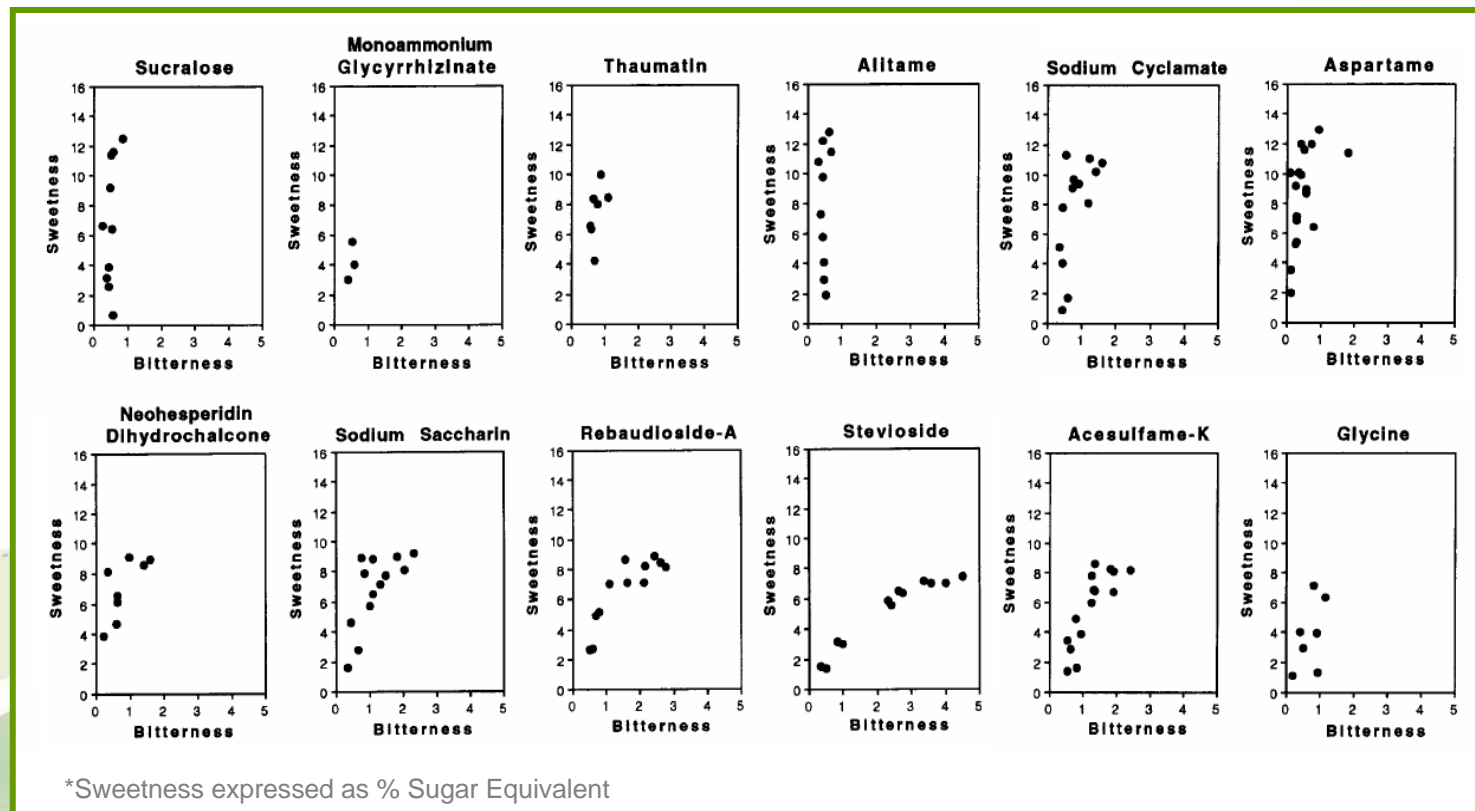


Source: Schiffman, et al. 1995 - "Bitterness of Sweeteners as a Function of Concentration"

# high intensity sweeteners sweetness vs. bitterness

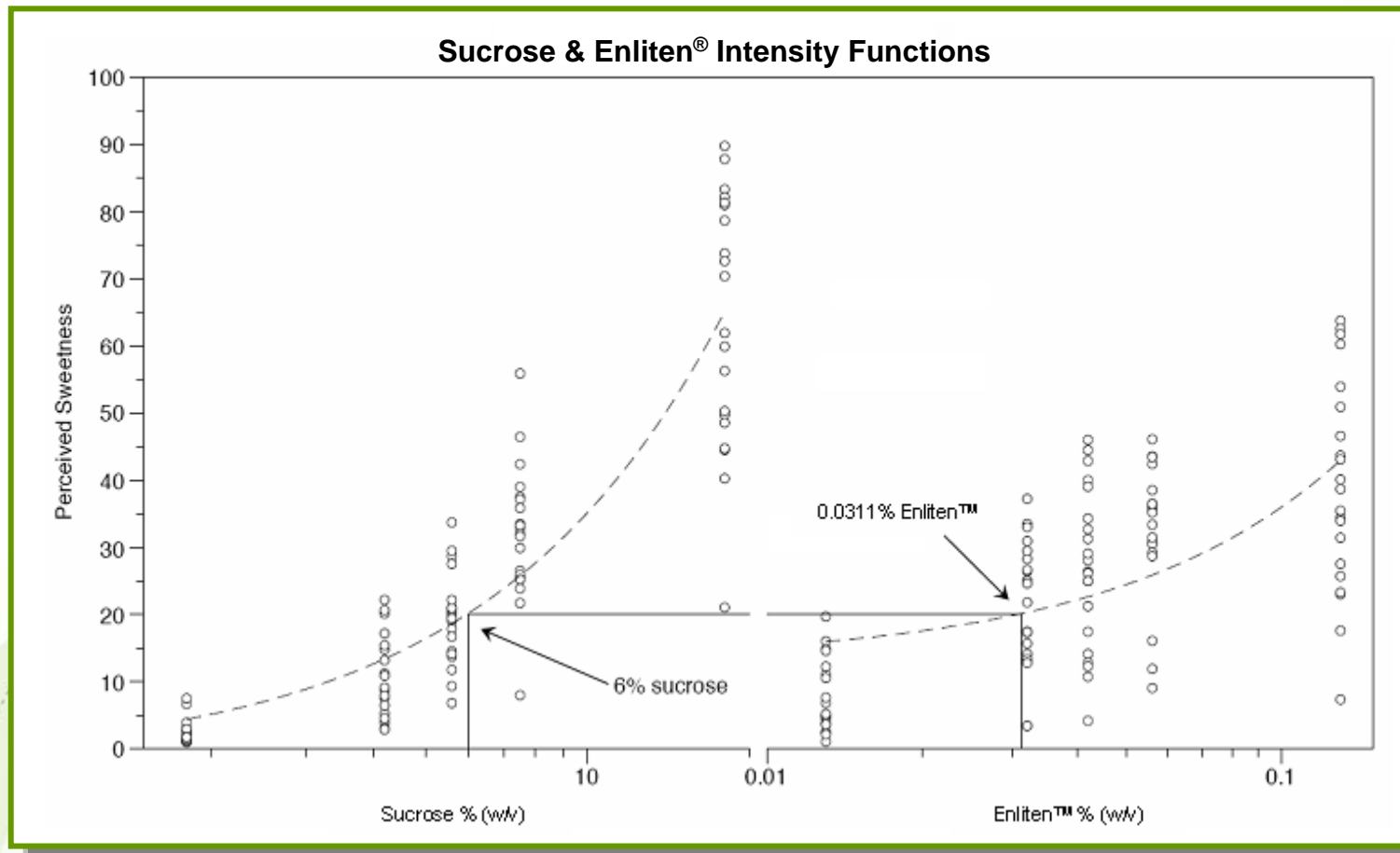
Bitterness **increases** with increasing sweetness in most HIS.

A **sweetness threshold** is often reached where bitterness suppresses any additional sweetness, notably for stevioside and much improved for Reb A.



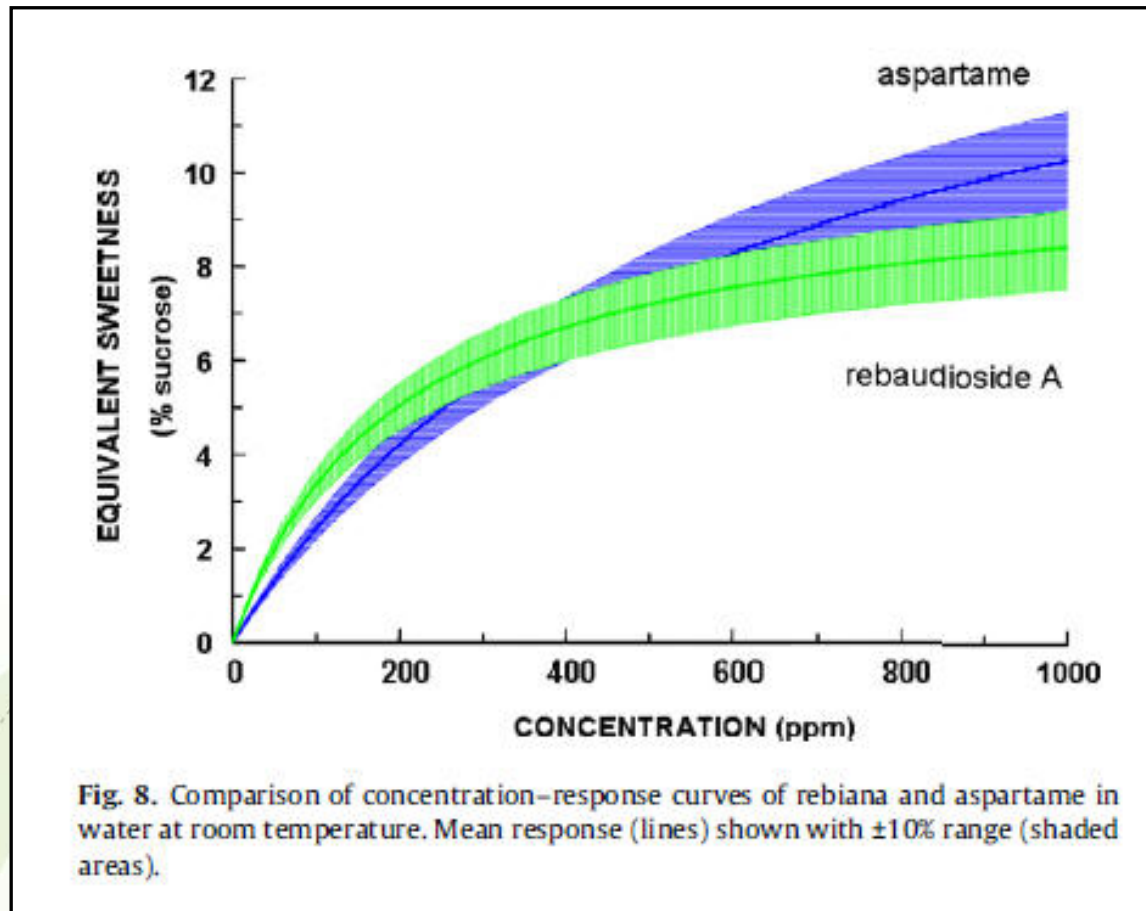
Source: Schiffman, et al. 1995 - "Bitterness of Sweeteners as a Function of Concentration"

# perceived sweetness vs. Concentration



Above 6% sucrose equivalency, **increasing bitterness** of Reb A will become more noticeable and will begin to suppress sweetness.

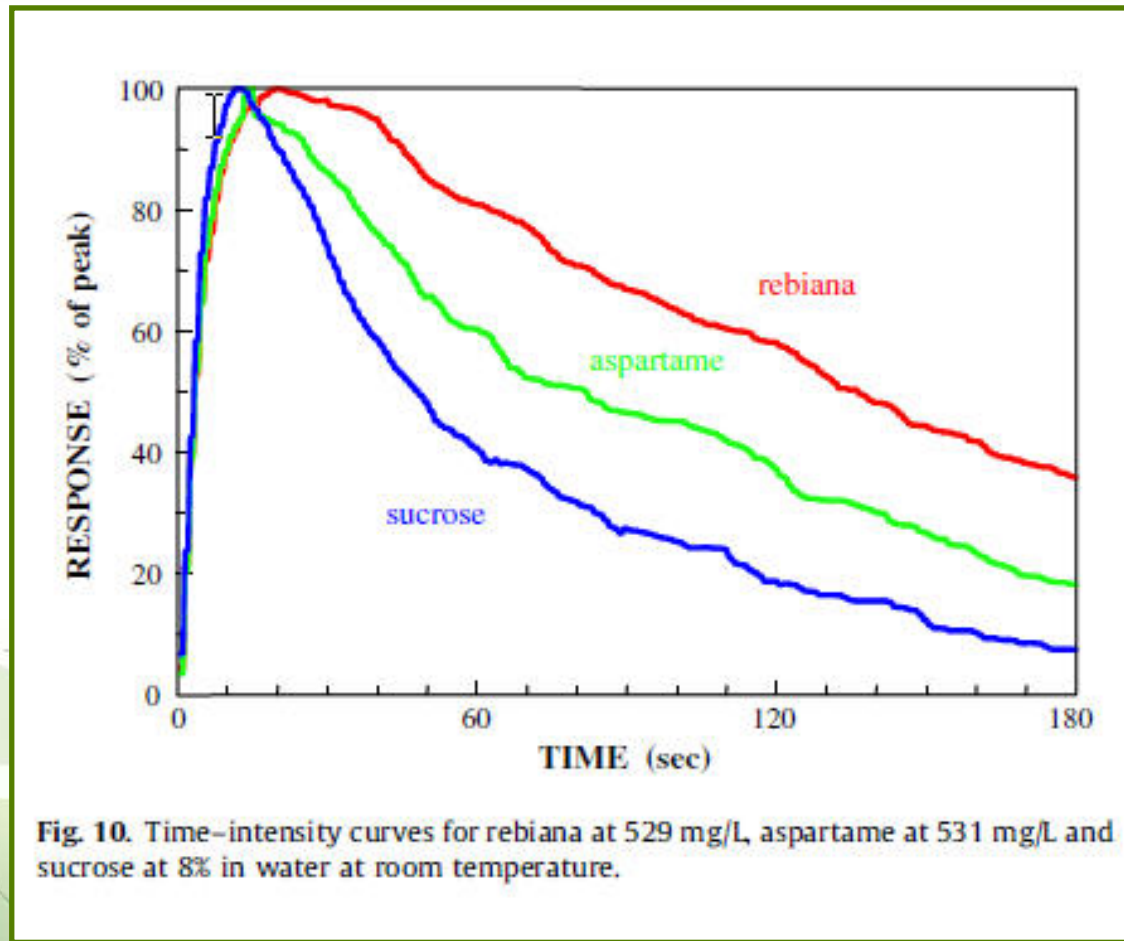
# sweetness equivalence to sucrose



Dubois and Prakash, 2008

- There is a **sweetness ceiling** to be aware of.
- SSE **above 8-9%** is difficult to obtain.
- Beyond 6%, **combination** with other ingredients is recommended to optimize sweetness.

# sweetness time & intensity curves



Dubois and Prakash, 2008

- “Sweetness” **timing** is everything!
- Too long or short can **change** the way a flavor is perceived.

# sensory trials: beverages

## TESTING

# PROCEDURE

- Sensory evaluation of beverages sweetened exclusively with Enliten<sup>®</sup> or sucrose
- No masking agent or bitter blocker used in formulation
- Balanced mix in sample group
  - Age group
  - Male/female
  - Sweetener users
- Sensory run in preference testing
- Panelists given samples served cold (40-42° F)
  - 8 ounces of each sample in clear plastic cup
  - Crackers to cleanse palate between samples

*Trials conducted at Penn State University, 2009*

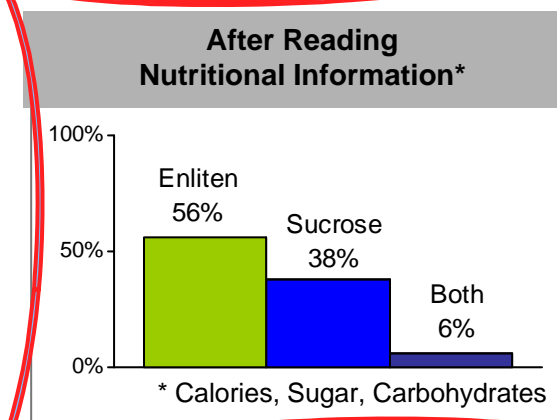
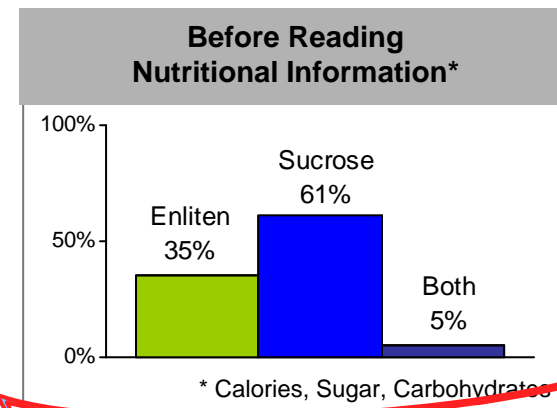
# sensory trials: orange flavored water

**Comparison by Sensory Attributes**



- Beverage with Enliten® @ 0.0265% or 6% sugar equivalent
- Beverage with sugar @ 6% Sucrose
- Other Ingredients: Water, Orange Flavor, Citric Acid, Potassium Citrate, Antifoam Solution

**Preference**



# sensory trials: Phase 2 beverages

TESTING

0.100 + 0.100

Combinations with other  
sugars/carbohydrates

*Trials conducted at Penn State University, 2009*

# sensory evaluation: combination with sugars

## TESTING

# PROCEDURE

- 61 panelists
  - 60% Women, 40% Men
  - Ages 18–55
- Evaluated the following at 50%, 70% and 90% sugar reductions with Enliten<sup>®</sup> in grape flavored beverage (9% SSE):
  - Fructose
  - Dextrose
  - Sucrose
  - Erythritol

*Trials conducted at Penn State University, 2009*

# sensory evaluation: combination with sugars

## TESTING

# SUMMARY

As the level of fructose, sucrose, dextrose and erythritol was increased, while Enliten<sup>®</sup> was decreased, **sweetness** and **preference** moved closer to that of the control (sucrose).

- **50% reduced sugar (RS):** Fructose was most preferred (ranked) out of the RS combinations. It was also ranked almost the same as the sucrose control.
- **70% reduced sugar (RS):** Fructose, Sucrose, Dextrose RS combinations were all preferred (ranked) approximately the same. Preference was half that of control.
- **90% reduced sugar (RS):** Fructose was most preferred (ranked) out of the RS combinations, followed by sucrose.



# product development opportunities

- When formulating with reduced or no sugar, there are likely **challenges** to be addressed related to sensorial attributes, such as:

- Sweetness level
- Sweetness profile
- Lingering sweetness
- Bitterness
- Flavor
- Texture

- Every food category and every formulation offers **unique** flavoring opportunities and/or challenges – there is no “magic bullet” or “flavor kit” that works in your unique product, just as there is no “one flavor” that works for everything.
- When necessary, adjustments are usually possible through **combination** with other ingredients such as sweeteners, texture agents, acidulants, salts, flavor enhancers/systems, etc.

# flavor/texture adjustment

## Combination with **other** sweeteners

- Sucrose
- Fructose
- HFCS
- Corn syrups
- Agave syrup
- Fruit juices/extracts
- Glycyrrhizinate
- Erythritol

## Acid Balance

- Lactic/Citric/Malic

## Texture

- Fiber (FOS, GOS, inulin)
- Maltodextrin
- Erythritol
- Hydrocolloids  
(modified starches, pectin,  
gum arabic, other gums)

## Flavor Systems

- Maltol
- Modifying flavors
- Other potential masking or  
sweetness enhancers



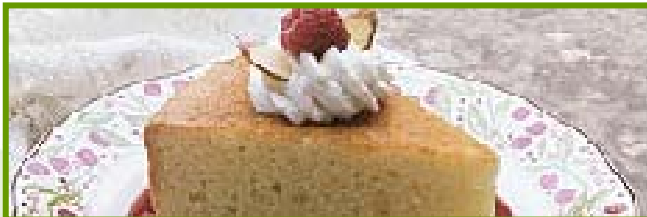
**Beverages**  
Juices  
Carbonated Soft Drinks  
Sport Drinks  
Ice Tea  
Powder Mix Drinks



**Confectionery**  
Chewing Gum  
Chocolate  
Hard and Soft Candy  
Mints  
Gum & Jellies



**Dairy Products**  
Yogurt  
Dairy Desserts  
Flavored Milk Drinks  
Ice Cream & Sorbets



**Baked Goods**  
Cakes and Pastries



**Breakfast Cereals**  
Jams and Fruit Preserves  
Tabletop Sweeteners  
Nutritional Supplements  
Slimming Products

# potential applications for Enliten<sup>®</sup>

# What about **REGULATIONS?**

## Key applications where Stevia is permitted in Europe

Category	Maximum level of steviol equivalents (mg/l or mg/kg as appropriate)	Restrictions
Flavoured fermented milk products	100	Only energy reduced products or with no added sugar
Fruit and vegetable preparations excluding compotes	200	Only energy reduced
Breakfast cereals	330	Only cereals with a fibre content of >15%, and containing at least 20% bran, energy reduced or with no added sugar
Fine bakery wares	330	Only essoblaten – wafer paper
Soups and broths	40	Only energy reduced
Sauces	120 175	Except soy-bean sauce Only soy-bean sauce
Fruit nectars and veg nectars	100	Only energy reduced products or with no added sugar
Desserts	100	Only energy reduced products or with no added sugar
Fillings excl. fruit based fillings (see above)	330 270	Only confectionary with no added sugar Only cocoa or dried fruit based, energy reduced or with no added sugar
Flavoured drinks	80	Only energy reduced products or with no added sugar

**Stevia is permitted for use in selected other categories – please see Commission Regulation No. 1131/2011 for full details.**

## European Regulatory Status: Natural Positioning

### ○ Natural Positioning

- No harmonised, pan EU definition of the term “natural”
- Natural guidance in place in France & UK
- Our internal regulatory reviews suggest that Enliten cannot be labelled as natural in Europe. It is however derived from the stevia plant and is therefore a more natural alternative to artificial sweeteners and still a compelling option for consumers
- Steviol glycosides are **derived from natural sources** but **not likely to meet the criteria for natural**

*It is necessary that our customers satisfy themselves of the labelling obligations, in accordance with relevant legislation, for their products as sold to the ultimate consumer. National Starch cannot accept any liability in this regard.*

**Enliten**<sup>™</sup>  
*Sweeten the senses. Naturally.*

For more information visit:

[www.enlitenSweetener.com](http://www.enlitenSweetener.com)

**Thank You!**

  
**CornProducts**  
INTERNATIONAL