

Sugar Reduction and Using Sugar Substitutes (Low Calorie Sweeteners)

Outline



I. Metrics for Sweetener Commercial Viability

II. Synthetic Non-Caloric Sweeteners

I. Natural Non-Caloric Sweeteners

II. Low-Calorie Sweeteners

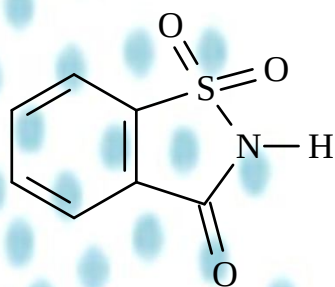
I. Sweetness Enhancers

I. Metrics for Sweetener Commercial Viability

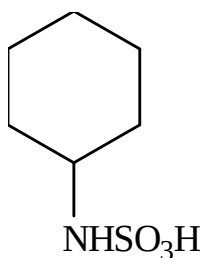


1. Safety
2. Taste Quality
3. Taste Quality
4. Taste Quality
5. Taste Quality
6. Stability
 - Hydrolytic
 - Light
7. Solubility
 - Equilibrium
 - Rate of Dissolution
8. Cost
9. Patentability

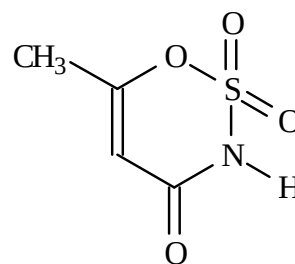
II. Synthetic Non-Caloric Sweeteners



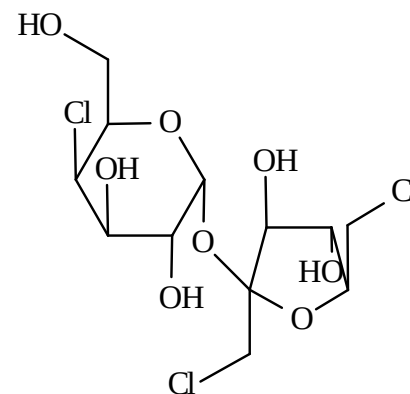
Saccharin



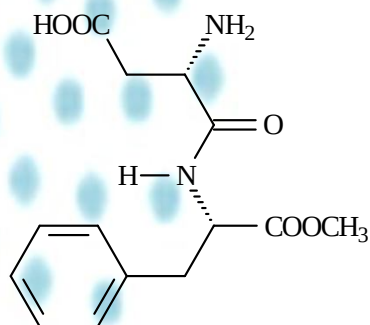
Cyclamate



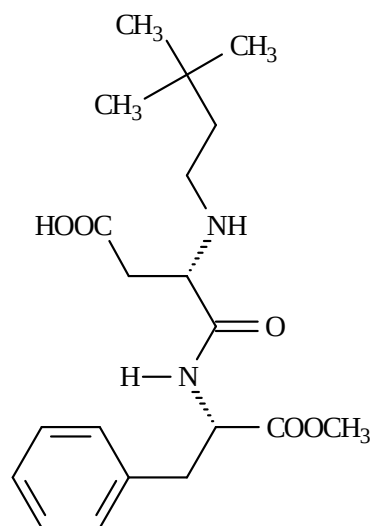
Acesulfame



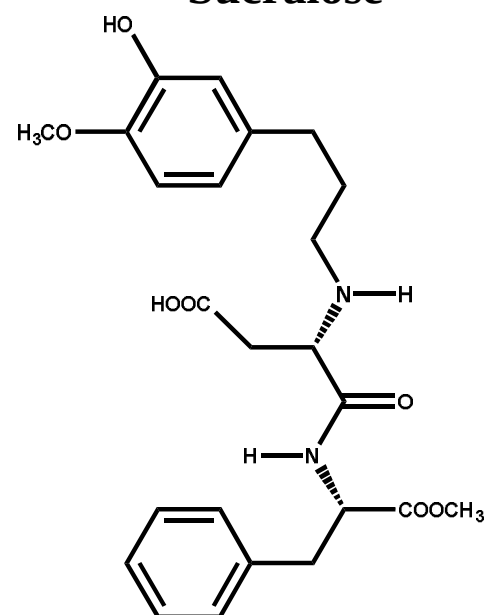
Sucralose



Aspartame



Neotame



Advantame

Synthetic Non-Caloric Sweeteners Relative to Commercial Viability Metrics



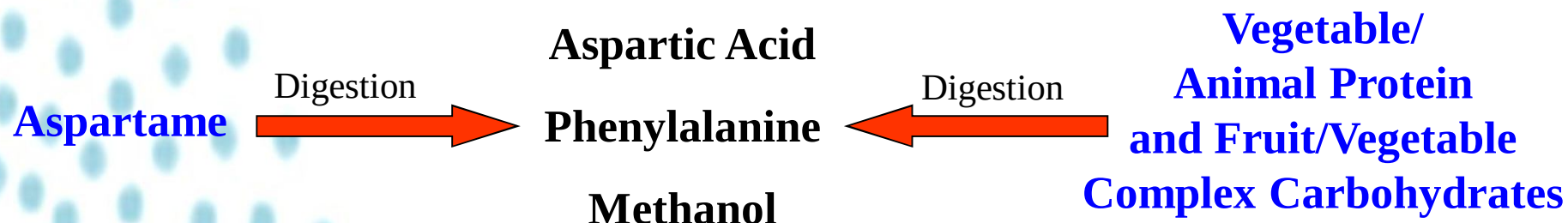
Metric	Sweetener			
	Saccharin	Cyclamate	Acesulfame	Sucralose
Sweetness Potency	440 (5)	32 (5)	140 (5)	680 (5)
Maximal Response (SE)	10.1	15.2	11.6	14.7
Flavor Profile	Bitter/Metallic	Weak Bitter	Bitter/Metallic	Clean
Temporal Profile	Quick Onset / Minimal SL	Quick Onset / No SL	Quick Onset / Minimal SL	Slight Onset Delay / Moderate SL
Adaptation Profile	Significant	Significant	Significant	Significant
Safety (ADI in mg/kg/day)	Food Additive (5)	No US Approval (11)	Food Additive (15)	Food Additive (5)
Solubility	Good (Na Salt)	Good (Na Salt)	Good (K Salt)	Excellent
Stability	Excellent	Excellent	Excellent	Good
Cost	Excellent	Excellent	Good	High
IP	None	None	None	None

Synthetic Non-Caloric Sweeteners Relative to Commercial Viability Metrics (Cont'd)



Metric	Sweetener		
	Aspartame	Neotame	Advantame
Sweetness Potency	200 (5)	11,000 (5)	42,000 (5)
Maximal Response (SE)	16.0	15.1	11.6
Flavor Profile	Clean	Clean	Clean
Temporal Profile	Slight Onset Delay / Moderate SL	Signif Onset Delay / Very Signif SL	Signif Onset Delay / Very Signif SL
Adaptation Profile	Significant	Significant	Significant
Safety (ADI in mg/kg/day)	Food Additive (50)	Food Additive (0.3)	Food Additive (5)
Solubility	Good	Good	Good
Stability	Fair	Fair	Fair
Cost	Good	Excellent	Excellent
IP	None	None	Ajinomoto

Aspartame: Why such a High ADI?

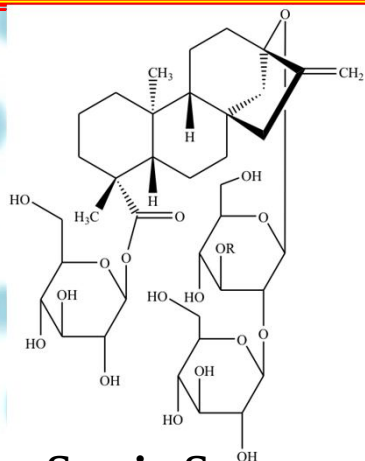


Aspartame Digestion Products in Common Foods in Comparison to a 12 oz (355mL) Diet Coke

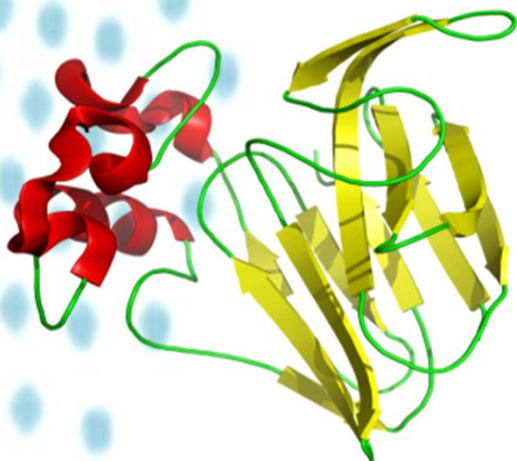
Food	Aspartic Acid	Phenylalanine	Methanol
100 g Roasted Chicken	36X	13X	-
12 oz Skim Milk	13X	6.6X	-
12 oz Orange Juice	-	-	1.3X
12 oz Apple Juice	-	-	1.6X
12 oz Tomato Juice	-	-	6.6X

H. Butchko,
The NutraSweet Company

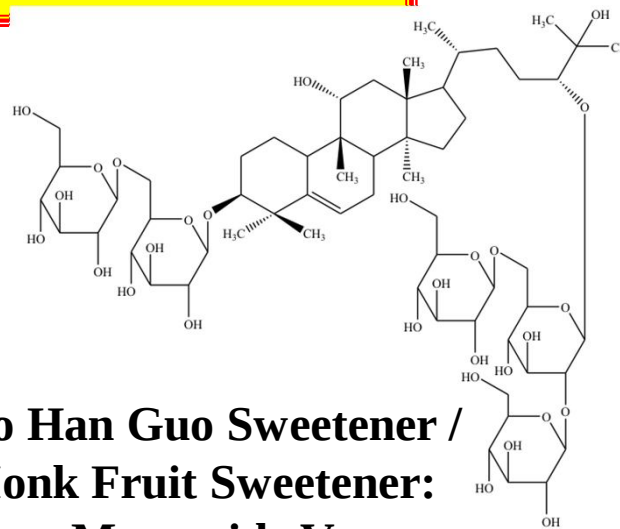
III. Natural Non-Caloric Sweeteners



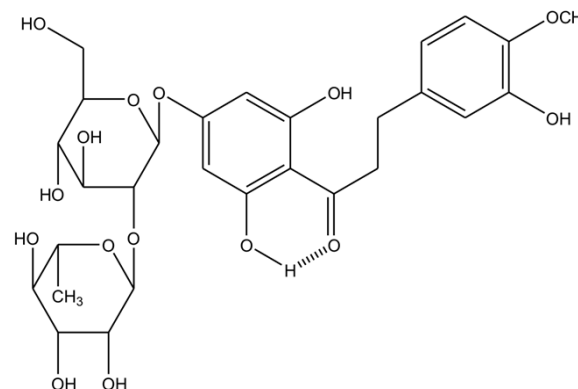
**Stevia Sweeteners:
Rebaudioside A, D and M**



**Thaumatococcus
Thaumatococcus**



**Luo Han Guo Sweetener /
Monk Fruit Sweetener:
Mogroside V**



Neohesperidin Dihydrochalcone

Natural Non-Caloric Sweeteners Relative to Commercial Viability Metrics



Metric	Sweetener		
	Rebaudioside A	Rebaudioside D	Rebaudioside M
Sweetness Potency	250 (5)	NA	350 (5)
Maximal Response (SE)	10.0	NA	14.2
Flavor Profile	Weak Bitterness*	Clean	Clean
Temporal Profile	Signif Onset Delay / Very Signif SL	Onset Delay / Signif SL	Onset Delay / Signif SL
Adaptation Profile	Significant	Significant	Significant
Safety (ADI in mg/kg/day)	GRAS No. 253 / Cargill / 2008 (12.2)	GRAS No. 456 / Pure Circle / 2013 (14.2)	GRAS No. 512 / GLG / 2014 (16.3)
Solubility	8000PPM	1000PPM	2600PPM
Stability	Excellent	Excellent	Excellent
Cost	~\$150/kg	NA	TBD
IP	Process & Formulation	Process & Formulation	Process & Formulation
Source	<i>Stevia rebaudiana</i> (Bertoni): 2-4%	<i>Stevia rebaudiana</i> (Bertoni): 0.03%	<i>Stevia rebaudiana</i> (Bertoni): 0.05%**

*Very weak in ultra high-purity REBA (>= 99.5%)

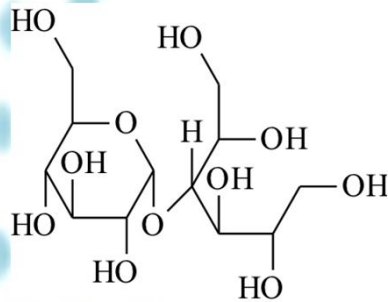
**High REBA Cultivar

Natural Non-Caloric Sweeteners Relative to Commercial Viability Metrics (Cont'd)

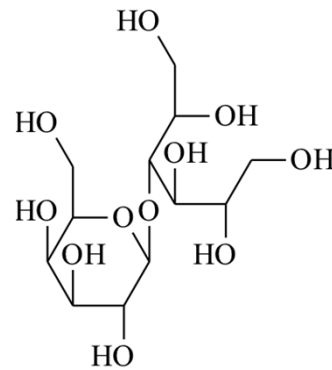


Metric	Sweetener		
	Luo Han Guo Sweetener	Thaumatococcus	Neohesperidin DHC
Sweetness Potency	256 (5.1) / Mogroside V	14,000 (5)	900 (5)
Maximal Response (SE)	NA	10.1	9.8
Flavor Profile	Weak Bitterness	Bitter & Licorice-Like	Bitter & Licorice-Like
Temporal Profile	Signif Onset Delay / Very Signif SL	Very Signif Onset Delay / Very Signif SL	Signif Onset Delay / Very Signif SL
Adaptation Profile	Significant	Very Significant	Significant
Safety	GRAS No. 301 / 2010 / Biovittoria	FEMA GRAS as natural flavor	FEMA GRAS as artificial flavor
Solubility	NA	60,000PPM	500PPM
Stability	NA	High	High
Cost	\$400/kg (80% Mog)	Negotiable	Negotiable
IP	Process & Formulation	None	None
Source	<i>Siraitia grosvenorii</i> (Swingle) ~1%	<i>Thaumatococcus danieli</i> (Benth.)	Synthetic

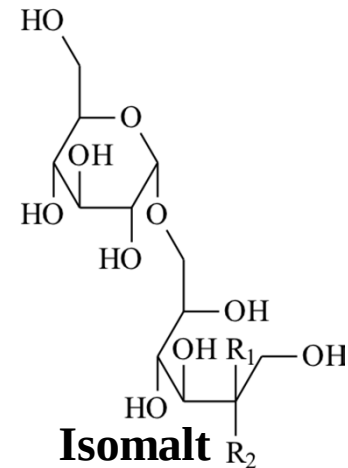
IV. Low-Calorie Sweeteners



Maltitol

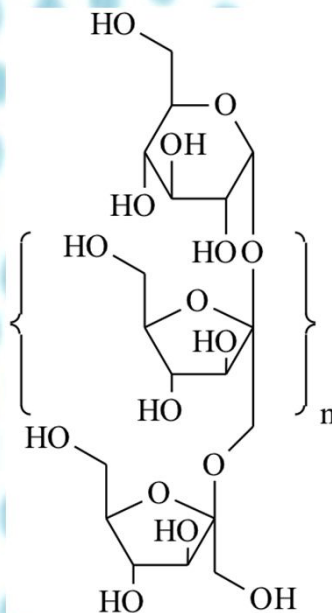


Lactitol



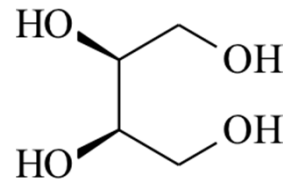
Isomalt

($R_1 = H, R_2 = OH$ /
 $R_1 = OH, R_2 = H$
 Mixture)

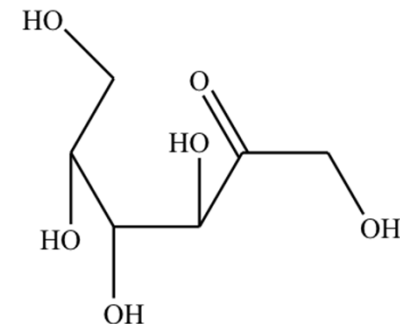


**Fructooligosaccharide
Sweetener (FOS)**

($n = 1-3$)



Erythritol



D-Tagatose: 4 Fructose Epimer

D-Allulose: 5 Fructose Epimer

Low-Calorie Sweeteners Relative to Commercial Viability Metrics



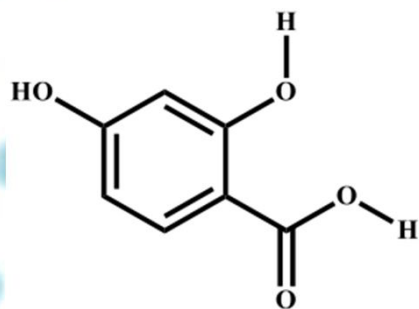
Metric	Sweetener			
	Maltitol	Lactitol	Isomalt	FOS
Sweetness Potency	0.71	0.41	0.43	0.27
Maximal Response (SE)	High	High	High	High
Flavor Profile	Clean	Clean	Clean	Clean
Temporal Profile	Sucrose-like	Sucrose-like	Sucrose-like	Sucrose-like
Adaptation Profile	Sucrose-like	Sucrose-like	Sucrose-like	Sucrose-like
Safety	GRAS	GRAS / 1993	GRAS / Palatinit of America / 1990	GRAS No. 44 / GTC Nutr / 2000
Solubility	Excellent	Excellent	Excellent	Excellent
Stability	Excellent	Excellent	Excellent	Excellent
Cost	-	-	-	-
IP	None	None	None	None
Bioavailable Kcal/g	3.0	2.0	2.0	2.0

Low-Calorie Sweeteners Relative to Commercial Viability Metrics (Cont'd)

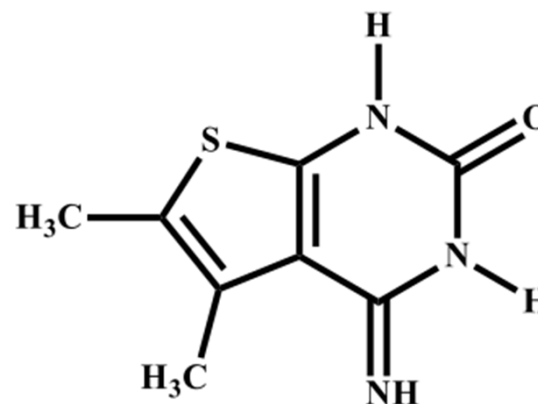


Metric	Sweetener		
	Erythritol	D-Tagatose	D-Allulose
Sweetness Potency	0.65	0.92	0.70
Maximal Response (SE)	High	High	High
Flavor Profile	Clean	Clean	Clean
Temporal Profile	Sucrose-like	Sucrose-like	Sucrose-like
Adaptation Profile	Sucrose-like	Sucrose-like	Sucrose-like
Safety	GRAS No. 76 / Cerestar / 2001	GRAS No. 78 / Arla Food Ingredients / 2001	GRAS No. 400 / Cheiljedang / 2011
Solubility	37% w/v	Excellent	Excellent
Stability	Excellent	Excellent	Excellent
Cost	~\$4/kg	-	-
IP	None	None	None
Bioavailable Kcal/g	0.2	1.5	0.2

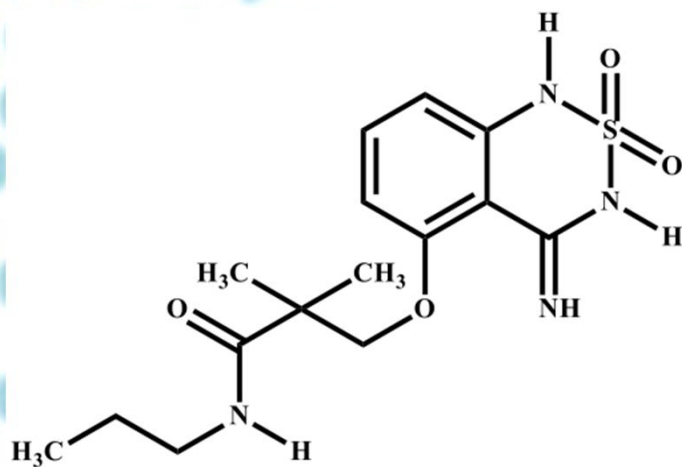
V. Sweetness Enhancers



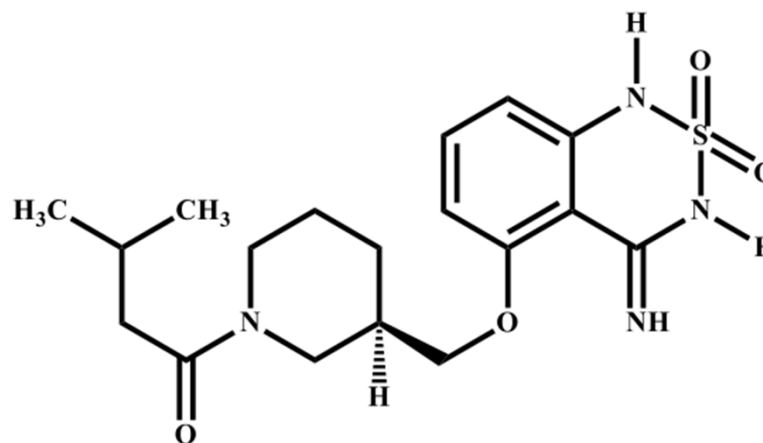
**2, 4-Dihydroxy
Benzoic Acid**



SucralGEM™



SucroGEM™



Sweetmyx™