Options for Sugar Reduction

Sarah Marshall

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Customer Focused, Science Driven, Results Led

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- Introduction
- Why replace sugar?
- Properties of sugar
- How do you replace sugar?
  - High potency sweeteners
  - Bulk sugar replacers
- Conclusions

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Introduction

- The term ‘sugars’ legally describes a range of products and not just sucrose
- ‘Sugars’ includes all the mono and disaccharides used in foods
  - Glucose, fructose, maltose, lactose and sucrose
- ‘Sugar’ is a reserved description for sucrose
- Not more than 0.5g of ‘sugars’ per 100g or 100ml where ‘sugar’ is any mono or disaccharide

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Caloric Value of Sugars

- Primary driver for sugar replacement and low-calorie sweetener use
- Sucrose = 4 kcal/g
- 330ml can carbonated soft drink
  = 130+ kcal
  =~5% recommended daily energy intake

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Cost

- Sweetening with high potency sweeteners = lower cost than nutritive sweeteners
- Polyols and other bulk sweeteners are all more expensive than sucrose
- Primary driver for potent sweetener use

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Tooth Decay

- Tooth decay is the third most widespread disease in the world
- Bacteria on the teeth metabolise sugars to produce acids and when the pH falls below 5.7 demineralisation of the tooth enamel occurs causing loss of calcium and eventually tooth decay
- The bacteria do not metabolise polyols or high potency sweeteners and polyols are thus considered to be safe for the teeth or tooth friendly

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Foods for Specific Diets

- Low glycaemic index
- Diabetics
- Sugar reduced/Sugar free claims

Foods for Specific Diets - Glycaemic Index

- This is a method of ranking foods on a scale according to how much the food raises blood glucose levels after eating
- Carbohydrate foods that break down quickly after digestion have high GI values - their blood glucose response is fast and high
- Carbohydrate foods that break down slowly have lower GI values - their blood glucose response is slower and lower

Foods for Specific Diets - Diabetics

- Glucose is the main energy source in the body
- Consumption of glucose leads to a rise in blood glucose levels and insulin is required to remove glucose from the bloodstream into the body tissues where it is broken down
- Diabetics do not produce sufficient insulin to do this
- Glucose, sugar and starch all produce rises in blood glucose whilst ingredients can be used to replace the sugar that either do not produce an increase or only a slight increase in blood glucose

Technical Innovation or Health Benefits

- Isomalt is used to replace sucrose and glucose in hard boilings and panned products
  - Less hygroscopic
  - Produces a more stable product with excellent shape definition
- Xylitol is recognised by EFSA for its unique health benefits
  - Helps reduce the development of cavities
  - Resists fermentation by oral bacteria and reduces plaque formation
  - Increases salivary flow to remineralise damaged tooth enamel

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Properties of Sugar

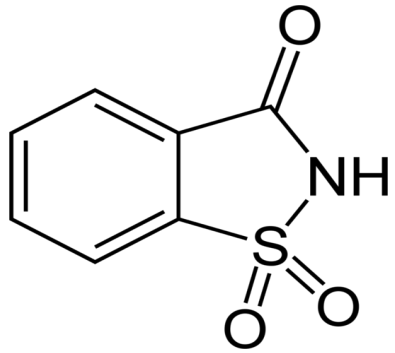
- Contributes sweetness
  - Pleasant rounded sweetness profile
  - No off notes
- Provides bulk, texture and mouthfeel
  - Building block of many products, e.g. cakes & biscuits, jams & conserves and sugar & chocolate confectionery
- Reduces available water
  - Preserves products from microbial growth
- Contributes colour and flavour

Considerations for Replacing Sugar

- Sugars provide bulk as well as sweetness and influence texture
- Sugars offer shelf-life benefits by controlling water activity
- When we replace sugar in foods we need to provide both bulk and sweetness
- When we replace sugar in beverages the contribution of solids/bulk is less apparent

High Potency Sweeteners

- Saccharin discovered in 1878 by Constantin Fahlberg
- Investigated by USDA in 1907 under the Pure Food and Drug Act
- Use became widespread during WWI



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High Potency Sweeteners

- Cyclamate discovered in 1937
- Aspartame discovered in 1965 and approved in Europe during 1980s
- Acesulfame-K discovered in 1967
- Sucralose discovered during 1970s, approved in UK in 2002 and EU in 2005

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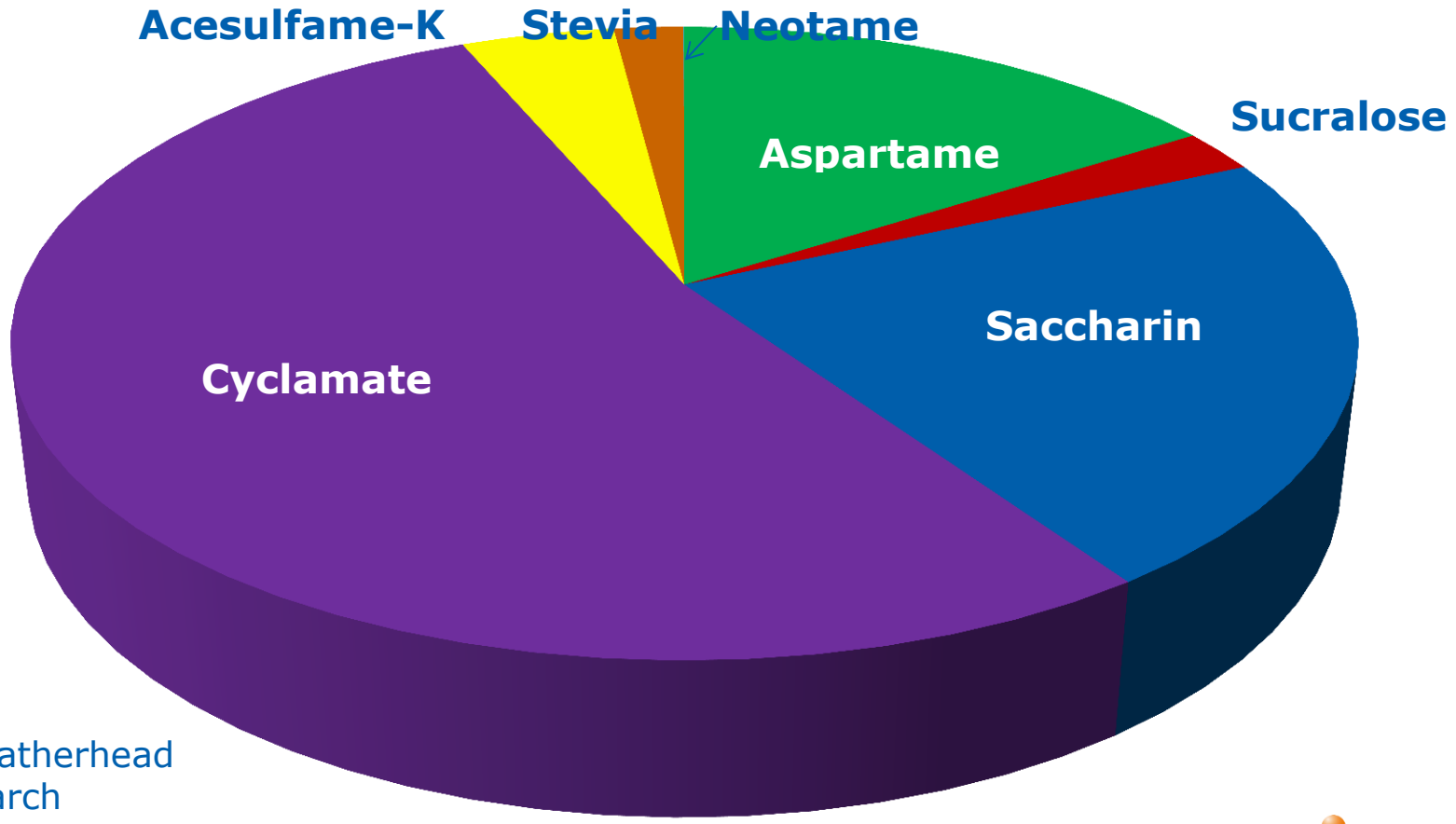
High Potency Sweeteners

- Synthetic
  - Saccharin
  - Cyclamate
  - Aspartame
  - Acesulfame-K
  - Sucralose
  - Neohesperidine DC
  - Neotame
  - Advatame
- Natural
  - Thaumatin
  - Stevia/Rebiana A
  - Luo Han Guo
  - Brazzein
  - Monatin

Global High Potency Sweetener Market (by Volume)



Source: Leatherhead Food Research

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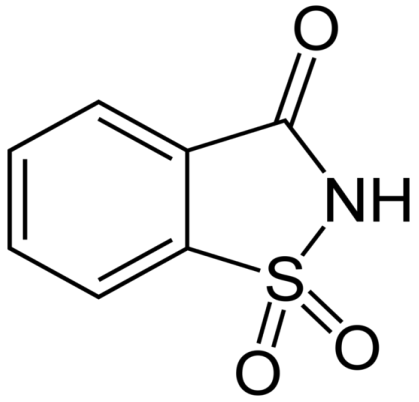
Saccharin



- ~300x sucrose
- Positives
  - Cheapest source of sweetness
  - Stable
  - Soluble
  - Blends well with other intense sweeteners
- Negatives
  - Bitter aftertaste
  - Negative consumer image – in the US products used to have to carry a warning

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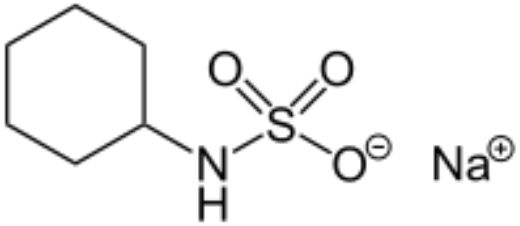
Cyclamate



- ~30x sucrose
- Positives
  - Economical source of sweetness
  - Stable
  - Soluble
  - Can result in a good quality sweetness in combination with other sweeteners
- Negatives
  - Described as having a 'chemical' sweet taste
  - Maximum permitted level in beverages 250ppm (=0.75%)
  - Not permitted in confectionery in EU

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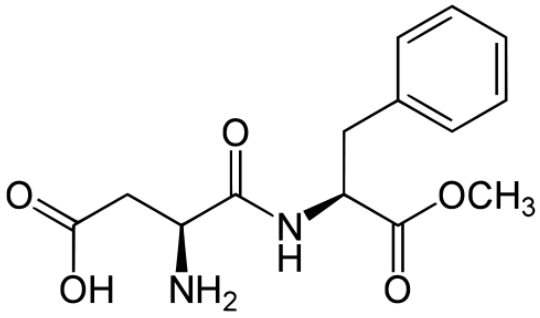
Aspartame



- 180-200x sucrose
- Positives
  - Wide consumer acceptance
  - Good quality sweet taste
  - Synergises with acesulfame-K
- Negatives
  - Unstable to low/high pH and temperature
  - Poorly soluble
  - Foams
  - 'Diet' aftertaste
  - Contains phenylalanine therefore products must have a PKU warning label

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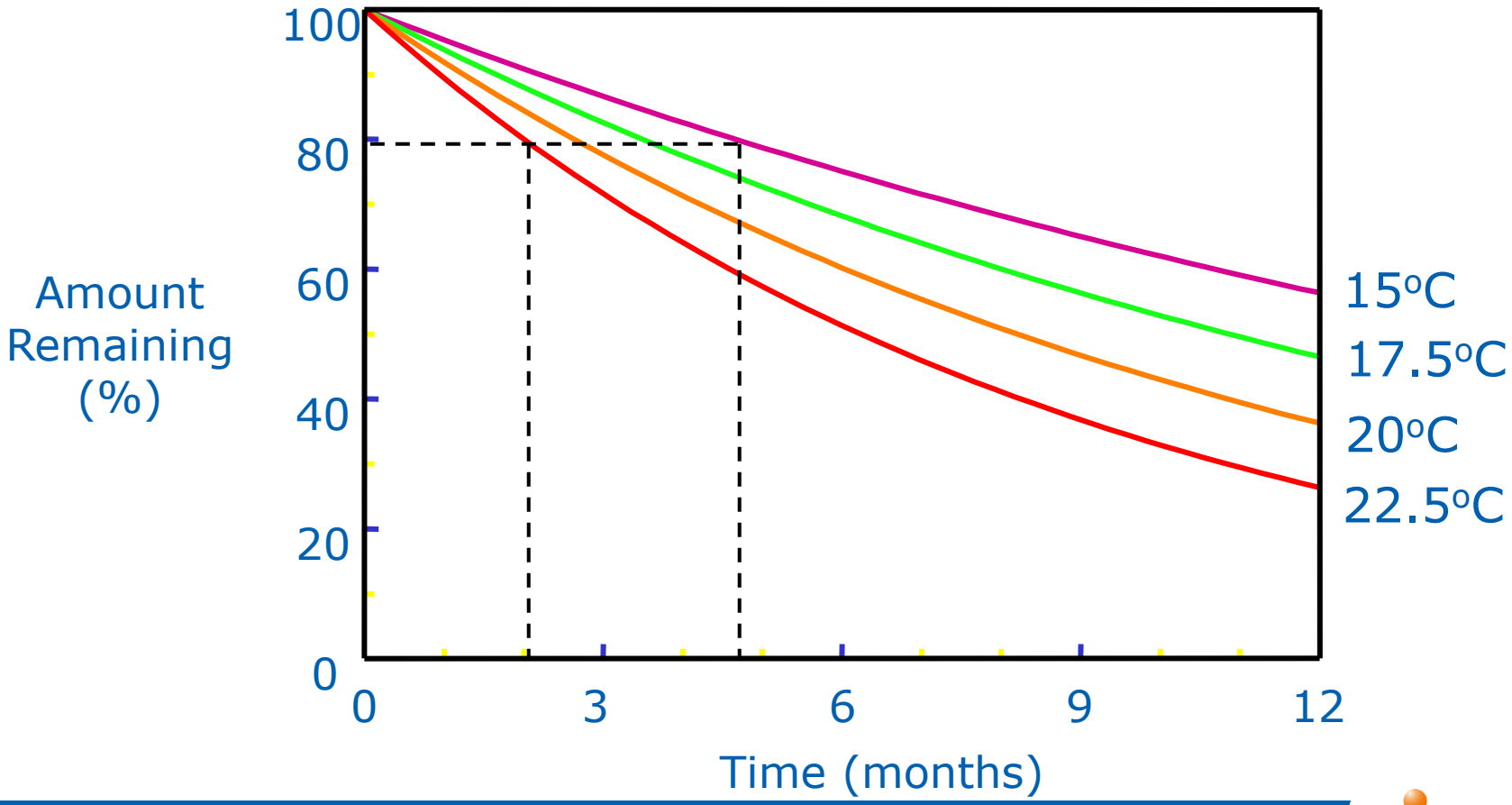
Aspartame Stability

Lemon/Lime Beverage



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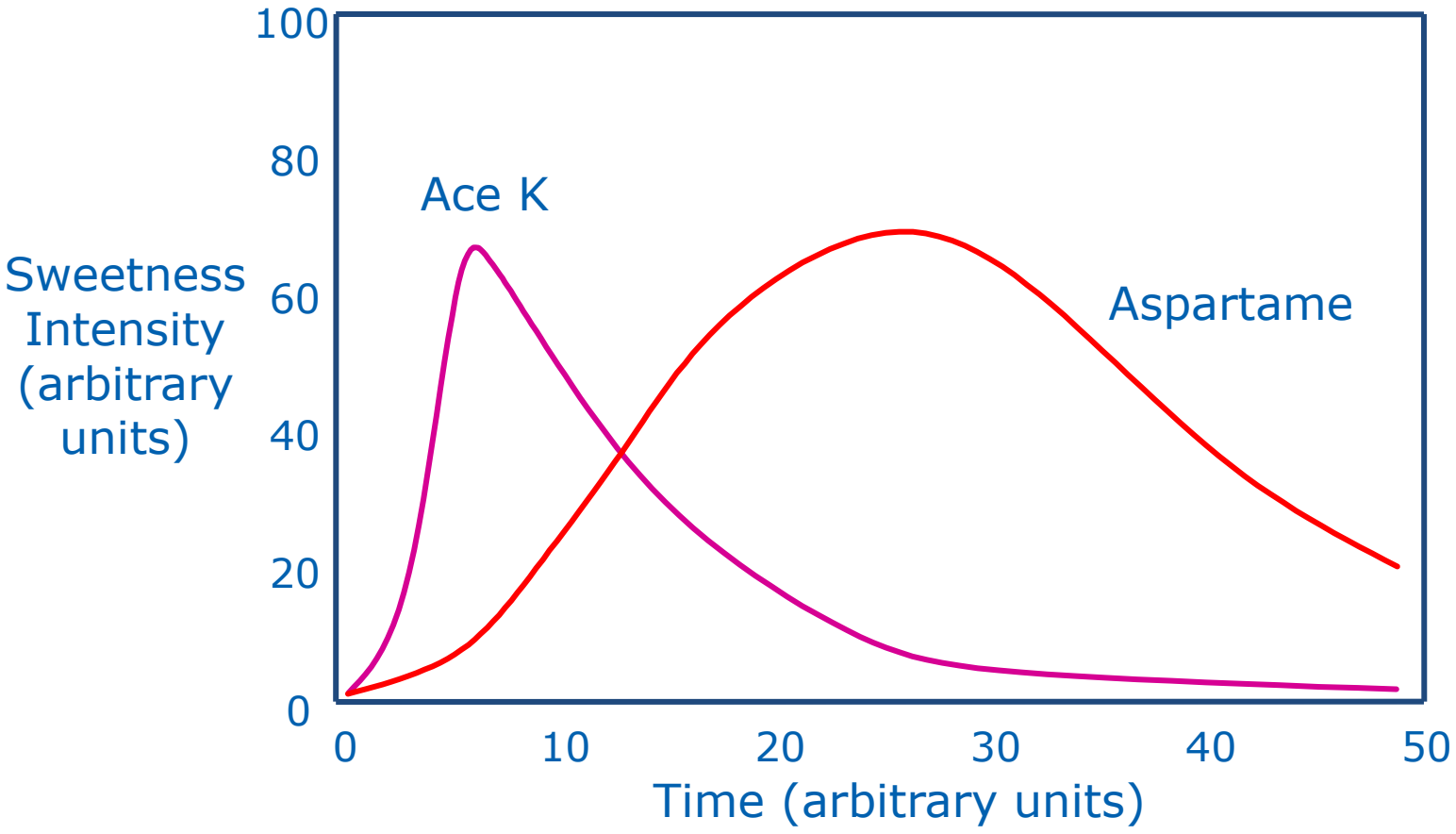
Acesulfame-K

- ~150x sucrose
- Positives
  - Soluble
  - Stable
  - Synergises with aspartame
  - Can result in good quality sweetness profiles in blends with aspartame, sucralose and neotame
- Negatives
  - Bitter metallic aftertaste
  - Expensive form of saccharin

Aspartame/Acesulfame-K Synergy



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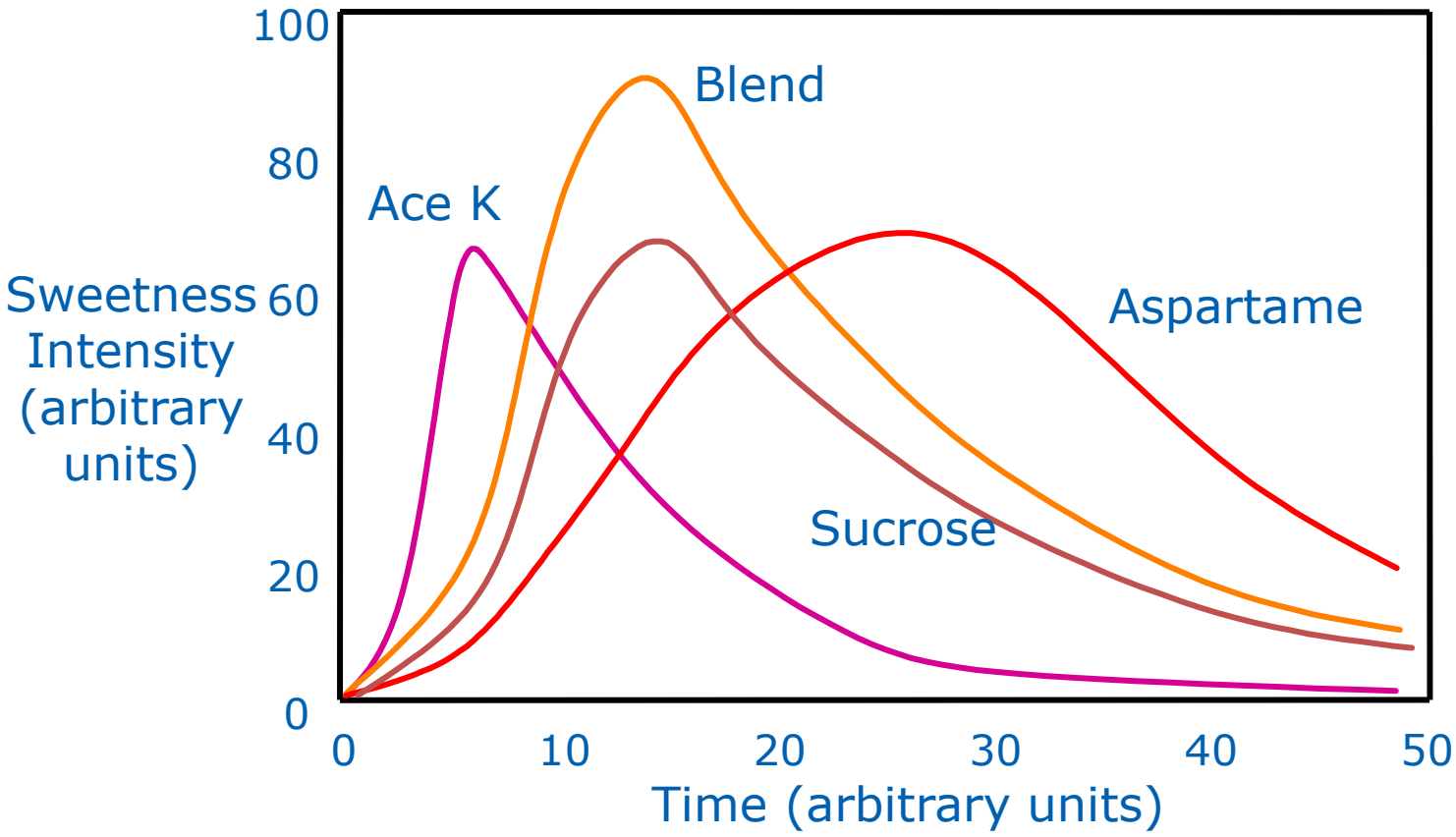
Aspartame/Acesulfame-K Synergy



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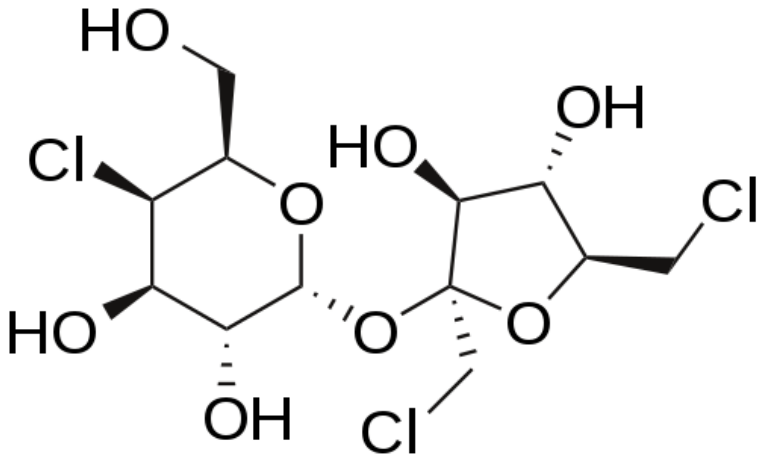
Sucralose



- ~600x sucrose
- Positves
  - Stable to high temperature
  - Stable to low/high pH
  - Soluble
  - Good quality sweetness profile (similar to aspartame)
- Negatives
  - Lingering sweet aftertaste
  - No quantitative with other sweeteners

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Steviol Glycosides

- Extracted from the leaves of *Stevia rebaudiana*
- At least 8 sweet principles including stevioside and rebaudioside A (reb A)
- Reb A is considered to be the most commercially viable, occurring in relatively high quantities and has a reasonable taste profile with less bitterness and licorice off-tastes than some of the other sweet principles (inc. stevioside)
- Slower onset and more lingeringly sweet than sucrose
- EU-wide approval received in 2011
- Stevia extract approved in US and EU must contain ≥95% steviol glycosides

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Market Products Containing Stevia

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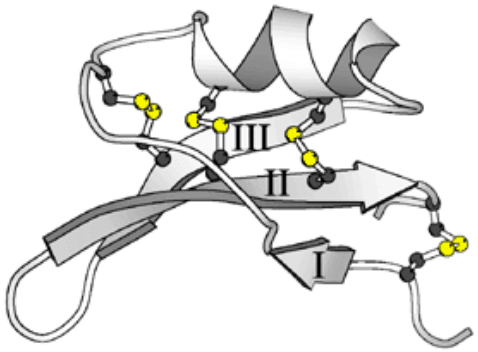
Other High Potency Sweeteners

- Lo han guo
- Brazzein
- Monatin
- Thaumatin
- Neohesperidine diHydrochalcone
- Neotame
- Advantame

Lo Han Guo

- Extracted from Chinese monk fruit (*Siratia grosvenorii*)
- Sweet principles are triterpene glycosides known as Mogrosides, Mogroside V is the sweetest at approximately 200-250x sucrose
- Lingering, licorice-like and slightly bitter aftertaste
- Being developed by Biovittoria under the brand name Fruit Sweetness
- Biovittoria has GRAS status in USA

Brazzein



- A protein in the fruit of *Pentadiplanadra brazzeana*
- Reported to be 500x sucrose
- Slower onset than other high potency sweeteners
- Lingering sweet/cool aftertaste
- No regulatory status
- May be synthesized using GM techniques
- Under development by Natur Research under the brand name Cweet
- Natural designation will depend on production method

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Monatin

- Derivative of the amino acid trytophan
- Extracted from *Schlerochiton ilicifolius*, as South African shrub (0.007% in dried bark)
- Reported to be 800 – 1,200x sucrose
- Rapid onset of sweetness, rapid decay
- Amenable to biotechnological preparation
- Under development by Cargill and Ajinomoto
- Approval in US anticipated in next few years

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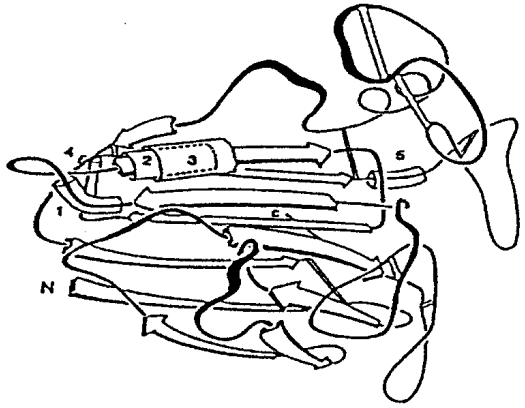
Thaumatin



- Natural sweetener
- Extracted from *Thamatococcus danielli*
- Marketed as Talin
- ~2000x sucrose
- Slow onset of sweetness and liquorice-like aftertaste
- Best used with other sweeteners
- Used as a flavour and mouthfeel modifier

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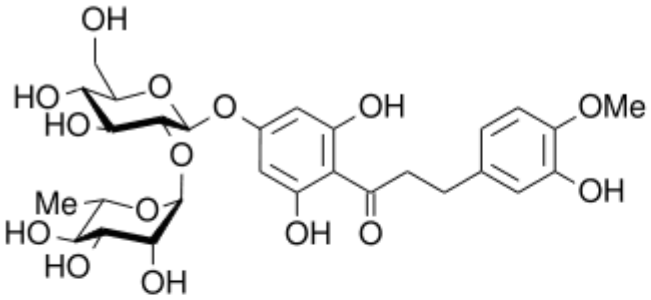
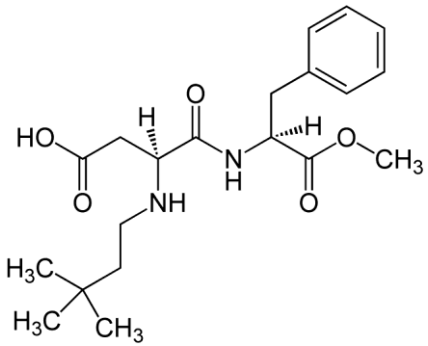
Neohesperidine diHydrochalcone



- ~1800x sucrose
  (at threshold, in use ~400x)
- Slow onset and slow sweetness decay with liquorice/cooling aftertaste
- Stable
- Synergistic with other sweeteners but can only be used to contribute a small % of total sweetness
- Flavour modifier

Neotame



- Developed by NutraSweet
- Made from aspartame by addition of neohexyl group
- ~7,000 – 13,000x sucrose
- Delayed onset and lingering sweetness
- Similar stability to aspartame at acidic pH, more stable at neutral pH
- No need for phenylalanine labelling
- Potential to be a strong economic conpetitor
- Widely approved for use, including the EU

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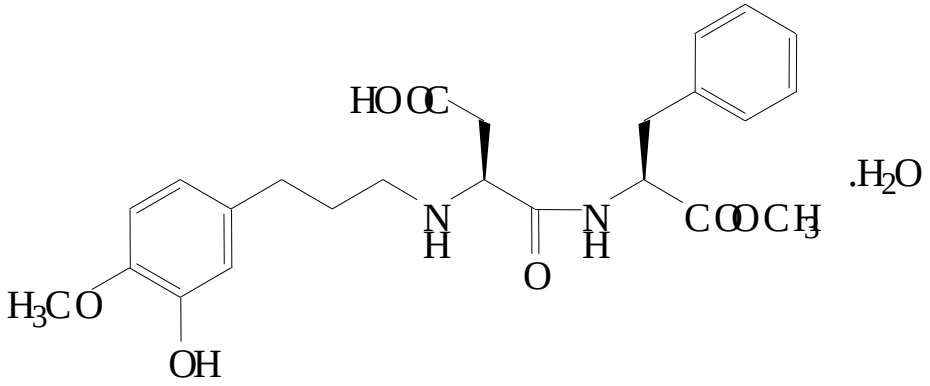
Advantame



- Developed by Ajinomoto
- Aspartame derivative
- Reported to be 20,000x sucrose
- Delayed onset and lingering sweetness
- Similar stability to aspartame at acidic pH, more stable to neutral pH
- No requirement for phenylalanine labelling
- USA approval anticipated 2013

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Bulk Sugar Replacers

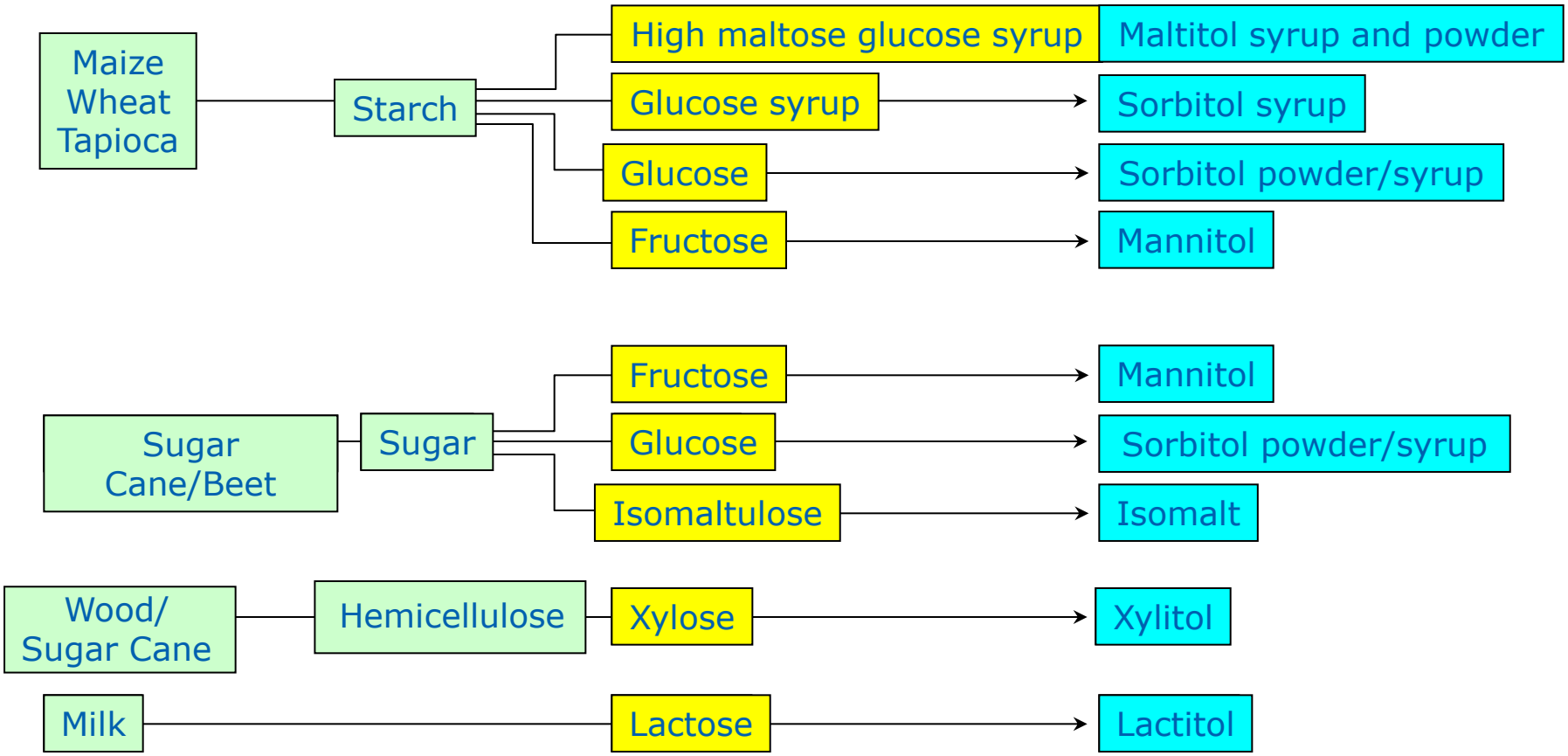
- Sugars can be replaced by a number of other ingredients such as fibres or proteins, but typically polyols are most commonly used because they have many properties like sugars
- Polyols or sugar alcohols are derivatives of sugars
- Many occur naturally e.g. sorbitol in fruits, but all are made industrially by hydrogenation
- Polyols do provide some sweetness typically blended with high potency sweeteners to match full sugar products

EU Food Polyols

- Sorbitol powder and syrups
- Mannitol
- Xylitol
- Erythritol
- Maltitol powder and syrups
- Isomalt
- Lactitol

All have E numbers and are classed as food additives

Polyol Manufacture



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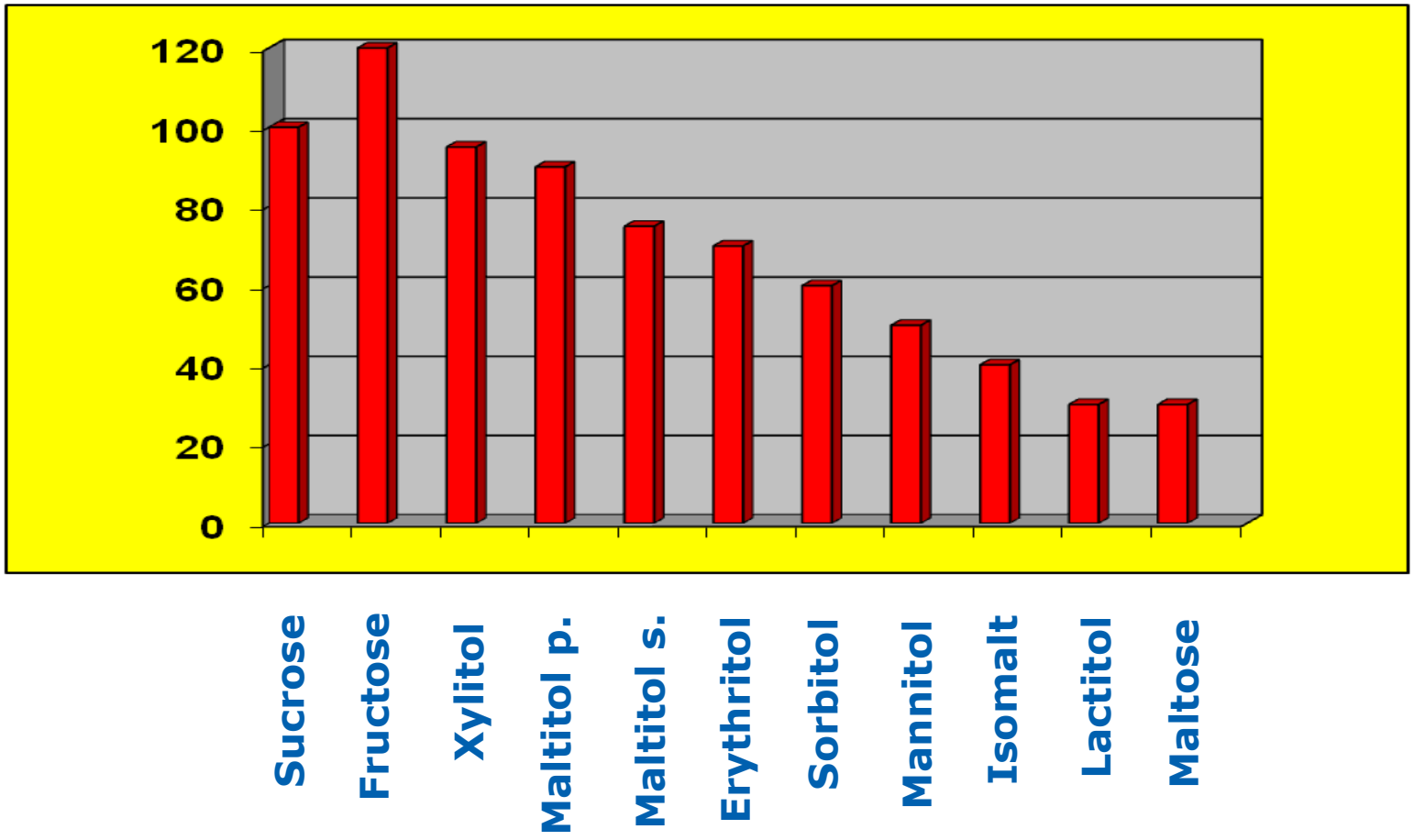
Relative Sweetness



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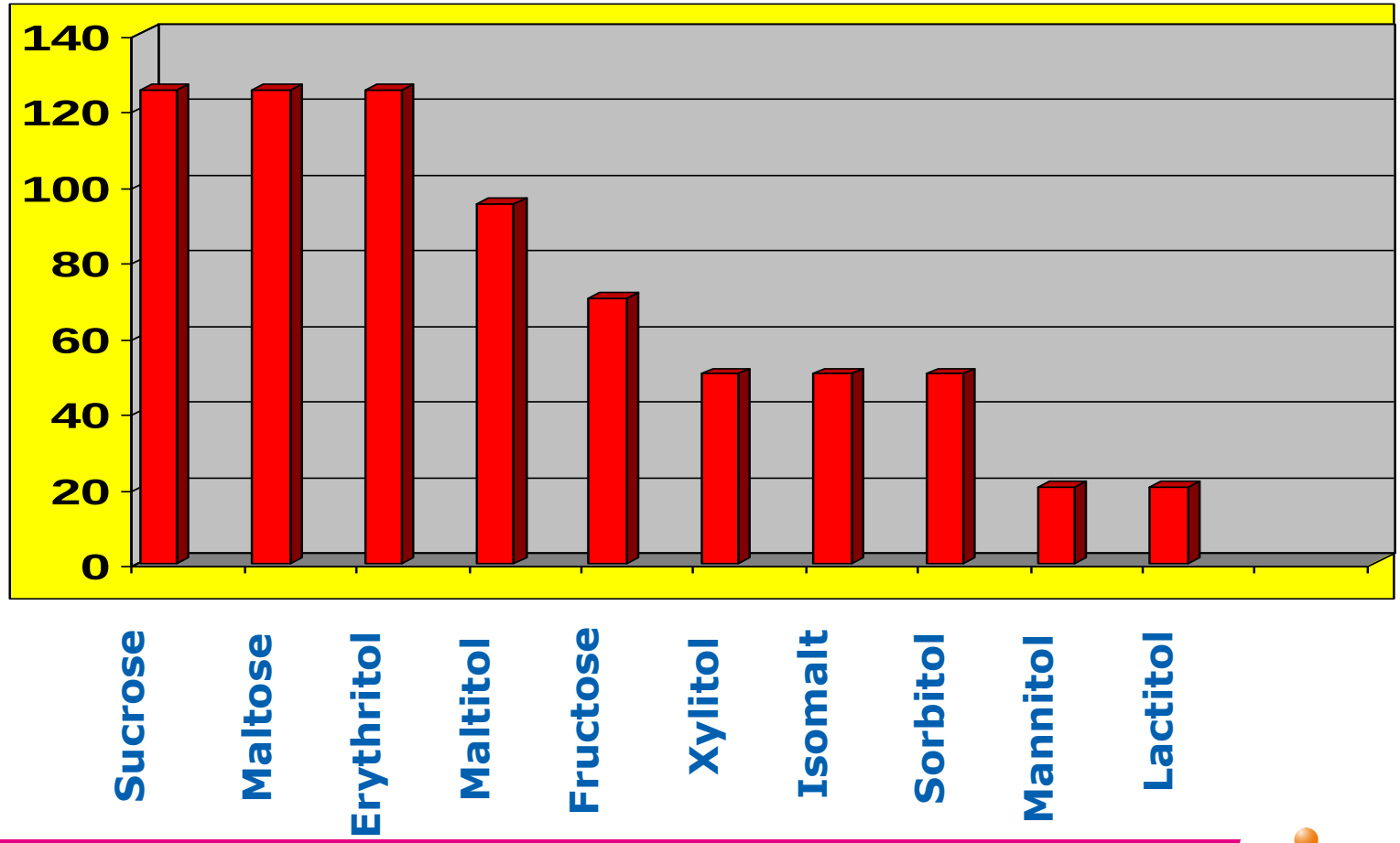
Laxative Properties

Laxation Threshold (grams/day)



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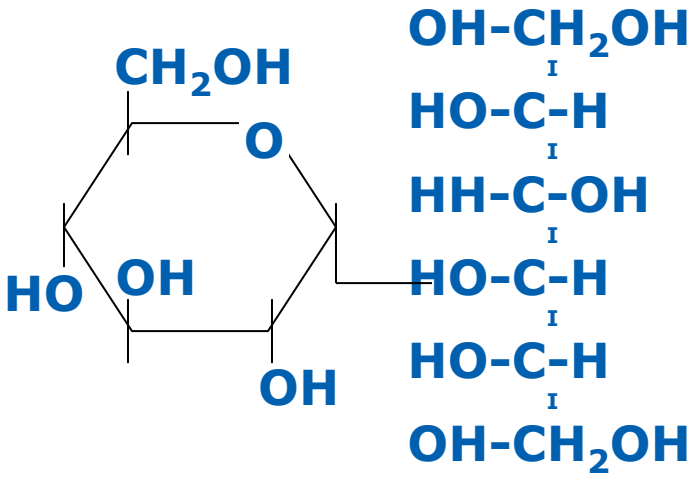
Laxative Properties

- Labelling is required when the polyol content exceeds 10% of the product
- ‘Excessive Consumption May Produce Laxative Effects’
- Erythritol is exempt

Caloric Value

- It is important to know the calorific value of the polyols and what calorie claims can be made when using polyols in foods
- These vary from country to country
- In the EU all polyols have the same calorific value
  - 2.4 kcal/g (10 kJ/g)

Maltitol Powder



- Disaccharide polyol
- Non cariogenic
- Does not significantly raise blood glucose
- Similar in sweetness to sucrose
- 60% calories of sucrose
- Of all the polyols, maltitol functions most like sugar

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Maltitol Powder vs. Sucrose

	Sucrose	Maltitol
Molecular Weight	342	344
Sweetness	1.0	0.90
Calories (kcal/g)	4.0	2.4 (EU)
Solubility @ 22°C	67%	65%
Melting Point (°C)	168-170	144-152
Heat of Solution (cal/g)	-4.3	-5.5
ERH @ 20°C	84%	89%

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Maltitol Syrup

- Maltitol syrup is made from high maltose glucose syrup
- In the EU it must contain a minimum of 50% maltitol on a dry basis
- Less than 50% solids are hydrogenated starch hydrolysates or polyglycitols
- In the USA a range of products is available containing from 2-95% maltitol

Isomalt

- Isomalt is made by hydrogenating isomaltulose which is a disaccharide derived from sucrose and consists of glucose joined to fructose via a (1-6) linkage
- Hydrogenation gives a mixture of glucose sorbitol and glucose mannitol

Erythritol

- Produced by fermentation unlike other polyols
- High digestive tolerance and zero calories
- Large negative heat of solution – cooling mouthfeel
- Potential to replace sugar with a greater calorie reduction than other polyols

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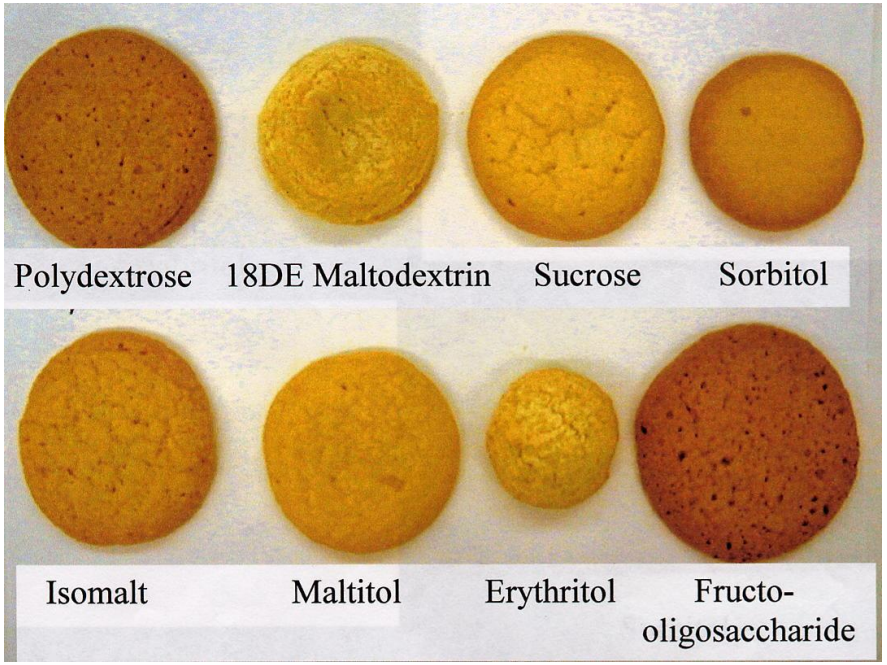
As a General Rule…..

- Choose a polyol which most closely mimics the sugar to be substituted



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Other Materials Used to Replace Sugars

- Polydextrose
  - Soluble fibre, prebiotic
  - Litesse from Danisco and Sta-lite from Tate & Lyle
- Nutriose
  - High fibre food dextrin from Roquette
- Fibersol-2
  - Soluble fibre from ADM / Matsutani
- Promitor
  - Soluble corn fibre from Tate & Lyle
- Inulin, Fructo & galacto oligosaccharides
  - Soluble fibre derived from chicory & milk respectively

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Conclusions

- Sugar has many properties
- Many reasons to replace sugar
- Sugar replacement has a long history
- To create the most acceptable sugar free product a blend of ingredients is required to replace the sugar
  - High potency sweeteners
  - Bulk sugar replacers
- Replacement blends need to be tailored to fit the application

Options for Sugar Reduction

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