Sweetners: A Summary of their Properties

1. Introduction

Sweeteners are one of the more common ingredients found in food products. As well as providing a pleasing taste, sweeteners also provide a source of energy and can have an effect on blood glucose levels.

This summary serves to categorise sweeteners according to their use, provide details on their relative sweetness and additional information which will assist with formulation work for technologists.

For the purposes of this discussion we have classified sweeteners into three broad areas:

- **Carbohydrate Sweeteners** (i.e. naturally occurring sugars)
- **Bulking agents** (i.e. ingredients to replace sugars, also called bulking agents or modified carbohydrates)
- **High Intensity Sweeteners** (i.e. Sweeteners many times stronger than normal sugars)

For the purposes of this comparison we have used sucrose or normal cane sugar as the standard, with a relative sweetness factor of 1.0. We have also used the Glycemic index standard issued by the Australian-based Glycemic Index Foundation (Reference: www.gisymbol.com.au).

The sweetness potency has also been standardised to sucrose (equal to 1.0), However actual sweetness potency is dependent on the temperature, pH of the solution and the concentration of the sugar or high intensity sweetener. In some cases perceived sweetness is higher at cold temperature and in slightly acidic solutions.

According to the Food Standards Code, Section 2.8.1, ***Sugar*** is defined as:

(a) Hexose monosccharides and disaccharides, including dextrose, fructose, sucrose and lactose; or
(b) Starch hydrolysate; or
(c) Glucose syrups, Maltodextrin and similar products; or
(d) products derived at a sugar refinery, including brown sugar and molasses; or
(e) Icing sugar; or
(f) Invert sugar; or
(g) fruit sugar syrup; derived from any source.

Sugar does not include:

(h) Malt or Malt extracts; or
(i) Sorbitol, Mannitol, Glycerol, Xylitol, Polydextrose, Isomalt, Maltitol, Maltitol syrup or Lactitol.

2. Carbohydrate Sweeteners

Carbohydrate sweeteners are typically single or multiple five- or six- carbon ring molecules. The size of the molecule and its overall molecular weight can have an important bearing on its solubility and its ability to interact with water. For instance, glucose syrup is often added to Ice Cream to enhance scoopability without significantly affecting the overall sweetness of the final product. All figures in this tabled are from the www.gisymbol.com source, unless otherwise denoted.

Sugar	Relative Sweetness	Energy	Impact on Blood Sugar	Comments
Sucrose	1.0 (Reference)	16.7 kJ or 4 cal / g	GI = 65	A di-saccharide composed of glucose and fructose. Sucrose is better known as table sugar, castor sugar, cane sugar or beet sugar.
Glucose	0.74	16.7 kJ or 4 cal / g	GI = 100	A monosaccharide also known as dextrose. When ingested glucose can cause blood glucose levels to rise quickly in products such as sports beverages.
Fructose	1.6 – 1.9	16.7 kJ or 4 cal / g	GI = 19	A monosaccharide naturally occurring in fruit, fructose can also be derived from corn syrup or sucrose. It is available in a crystalline form, or as a syrup (e.g. High Fructose Corn Syrup, which can contain other sugars).
Maltose	0.32	16.7 kJ or 4 cal / g	GI = 105	A disaccharide composed of two glucose molecules, maltose is usually found in a syrup form. Maltose can cause the blood glucose levels to rise quickly.
Lactose	0.16	16.7 kJ or 4 cal / g	GI = 46	A disaccharide composed of glucose and galactose, lactose is the naturally occurring sugar found in milk and has a low level of sweetness. Can form crystals in dairy products.
Maltodextrin	0.05 – 0.7	16.7 kJ or 4 cal / g	GI = 80 – 120 [2]	Maltodextrin is made from starch molecules, which are essentially chains of glucose molecules. The degree of hydrolysis into smaller chains and individual mono saccharides can have a direct effect on the sweetness of the ingredient. Maltodextrin with low degrees of hydrolysis (Dextrose Equivalent or “DE”) such as Maltodextrin DE5 have very little sweetness, while Maltodextrin of DE 28 – 40 approaches the sweetness of glucose and are often called glucose syrup solids.
Honey	0.97	16.7 kJ or 4 cal / g	GI = 35 – 64	Honey is a combination of sugars, but primarily Fructose. It has a moderate effect on blood glucose levels and around the same sweetness level as sucrose, although honey flavours may enhance sweetness.
Juice Concentrate	0.8 – 1.2	16.7 kJ or 4 cal / g (on a dry basis)	GI = 50 – 80 [3]	For various reasons, many manufacturers use various forms of juice concentrates such as apple, grape and pineapple juice concentrates. These usually contain 65 – 72% soluble solids composed of the various sugars found naturally in the original fruit.

3. Bulking Agents

Bulking agents are carbohydrates that have been modified to reduce their absorption by the body and reduce their true caloric content. Due to the reduced absorption they usually have a lower glycemic index and commonly used in reduced calorie products. However as a result of the reduced absorption they may also have a laxative effect if consumed in large quantities.

Bulking Agent	Relative Sweetness	Energy	Impact on Blood Sugar	Comments
Sorbitol	0.6 (4)	10.9 kJ or 2.6 cal / g (4)	Low (4)	Sorbitol occurs naturally in many stone fruit and some berries. It has some nutritive value (about 60% of normal sugars and carbohydrates. It is an excellent humectant and is often used in bakery product to retain moistness.
Polydextrose	0.05 (1)	4.2 kJ or 1.0 cal / g (1)	GI = 7 (1)	Polydextrose was one of the first bulking agents launched onto the market. It has very little sweetness and is often used in combination with fructose or a high intensity sweetener.
Lactitol	0.74 (1)	8.2 kJ or 2 cal / g (4)	Low (4)	As a product with similar characteristics to sucrose, but with only half the calories, Lactitol is often used as a sugar replacer on a 1:1 basis. It has a mild effect on blood glucose levels. Lactitol is available in either an anhydrous or monohydrate form and is widely used in reduced calorie dairy and confectionery products.
Isomalt	0.45 – 0.65 (4)	11 kJ or 2.6 cal / g (1)	GI = 60 (1)	Isomalt is a disaccharide composed of Glucose and Mannitol. It can be found naturally in sugar beet. It has around half the sweetness of sucrose and is not absorbed by the body, although it can be fermented in the gut. Accordingly it has half the calories of sugar and minimal effect on blood glucose. Isomalt can also be used in sugar sculpture as it does not crystallise as quickly as sucrose.
Mannitol	0.70 (1)	6.7 kJ or 1.6 cal / g (4)	Low (4)	Mannitol is an isomer of Sorbitol and is found in plant exudates and seaweed. Unlike Sorbitol, Mannitol it is not a good humectant and is often used as a dusting powder on sugar-free confectionery.
Maltitol	0.9 (4)	8.8 kJ or 2.1 cal / g (4)	Low (4)	Maltitol is available in either syrup or powder form. It has 90% the sweetness of sucrose but only around 55% of the calorific content. It has a mild effect on blood glucose levels.
Xylitol	1.0 (1)	10 kJ or 2.4 cal / g (4)	GI = 21 (1)	Xylitol is perhaps the first sugar replacer to perform better than sugar. It is often used in compressed mints as it gives a cooling effect upon dissolving in the mouth. It has approximately the same sweetness as sucrose but only 75% of the calories and minimal effect on blood glucose levels.

4. High Intensity Sweetners

High Intensity Sweeteners can be either naturally occurring or chemically synthesised. Some of the high intensity sweeteners have a calorific content, but their use is usually so small that their contribution to the overall calorific content of the final product is minimal. The maximum dose rate of many high intensity sweeteners is controlled by the Food Standards Code, which should be consulted to ensure compliance.

The relative sweetness of these high intensity sweeteners varies according to the application. As an example, a high intensity sweetener will often have a different level of intensity when matching a 2% sucrose solution versus a 10% sucrose equivalent.

Sugar	Relative Sweetness	Comments
Stevia	280 – 300 times	A natural sweetener derived from a plant, Stevia consists of several Stevio Glycosides, of which the Rebaudiside A is of most interest. Stevia has only been approved for use in Australia and New Zealand since 2008, and initial development work indicates that it works well in a number of beverage, dairy and fruit applications replacing 50 – 100% of the sugar.
Saccharine	200 – 500 times [5]	Sodium Saccharine has been used since the 1970's in table-top sweeteners and in beverages. It has a lingering sweetness profile and is often used in combination with Sodium Cyclamate. The sweetness of Saccharine varies according to the application. Saccharine is 200 x sucrose when matching a 20% sucrose solution but about 500 X when matching a 2% sucrose solution. [5]
Cyclamate	15 – 50 times	Sodium Cyclamate has around 30X the sweetness of sucrose and is often used in conjunction with Saccharine.
Aspartame	150 – 250 times	Aspartame (originally sold under the trade name "Nutrasweet") has around 200 x the sweetness of sucrose. Its sweetness profile has been found to have been enhanced by using 4 parts sweetness from Aspartame to 1 part Ace K. Depending on the application, Aspartame can lose its sweetness over time.
Acesulphame K	200 times [5]	Potassium Acesulphame has around 300X the sweetness of sucrose and has been found to enhance other sweeteners such as Aspartame and Sucralose. It has been used as the primary sweetener in some US school lunch box products.
Sucralose	400 [1] – 600 [5] times	Sucralose is based on the chemical substitution of a sucrose molecule. It is available as a table top sweetener under the "Splenda" brandname. Sucralose has a similar sweetness profile to Aspartame but has better stability over time. It is often used in conjunction with Ace K to improve overall sweetness profile.
Neotame	8,000 times [6]	Neotame is derived from citrus fruit and has between 7,000 and 13,000 times the sweetness of sugar. However its sweetness taste profile is not widely accepted and neotame is therefore used a low levels (such as 50 – 100 ppm) and often in conjunction with other sweeteners.

References

(1) http://www.gisymbol.com.au/
(2) Personal communication ADM Corn Products 2005
(3) Estimated from grape juice analysis and monosaccharide contents
(4) www.polyol.com
(5) Bakel, A., 1997, Prepared Foods March 1997
(6) http://www.neotame-sweetener.com/Sweetness_potency.html

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