

Sugar and sweeteners

The basic product: sugar

1. Sugar is the conventional name for sucrose, which is extracted from sugar beet or from sugar cane. Chemically, sugar from both sources is identical, consisting of 99.9 per cent sucrose.
2. Sugar can be divided into three broad categories:
 - (a) *white granulated sugar* (European E2 grade) constitutes the vast majority of sugar sold in Britain. It is supplied in solid crystallized form, with the crystals having an average size of 0.6mm;
 - (b) *liquid sugar* is mainly used by the food processing industry, and is produced either by dissolving granulated sugar in water, or as a product of the sugar cane refining process; and
 - (c) *speciality sugars* include a huge variety of products, typically derived by processing granulated sugars (eg grinding granulated sugar to produce icing sugar, or screening granulated sugar to produce castor sugar) or by stopping the production process at a different stage (eg unrefined sugar).
3. Sugar's most obvious characteristic is its *sweet taste*. However, sugar also has a variety of other functional properties, impacting on the texture, appearance, flavour and preservation of products to which it is added. A few of these functional properties are discussed below.
4. *Taste*: In addition to contributing its own flavour, the addition of sugar to foods and drinks increases the perception of other flavours by encouraging their release.¹
5. *Colour and aroma*: When heated, sugar reacts by caramelizing or by reacting with amino acids, leading to browning and the formation of aromas. Therefore, sugar is important in determining the colour of products to which it is added. In addition, by heating sugar to over 180°C, it is possible to manufacture a caramel colourant (E150).
6. *Texture and bulk*: Increasing the sugar content of biscuit mixtures allows gelatinization of the starch and denaturation of the proteins to be delayed, influencing the properties of the mixture and the bulk and density of the final product. (Note that using glucose, fructose or isoglucose as a substitute for sugar has a much less marked effect on the transformation of starch. The substitutability of these natural sweeteners is discussed in greater detail below.) In addition, sugar is responsible for the characteristic appearance of cookies, is important in the stabilization of sponges and pastries, and improves the incorporation of air in fatty mixtures.

¹According to the Comité Européen des Fabricants de Sucre (CEFS), it does this by increasing the partition coefficient of volatile substances, especially flavours.

7. *Preservative*: Sucrose has a high affinity for water, and in fact 'immobilizes' water molecules when used above a certain concentration, resulting in insufficient water for the harmful growth of bacteria, yeasts or moulds. This property of sugar has been exploited for centuries to preserve fruit and vegetables in the form of jams, jellies and crystallized fruit. Sugar also encourages the pectin molecules in fruit to move closer together, thus helping jam to set.
8. *Chaptalization*: A small quantity of sugar given to yeasts in appropriate conditions leads to fermentation, producing alcohol through the process of chaptalization.² Bakers also use sugar with yeast to release carbon dioxide, which makes dough rise.

Other sweeteners

9. As discussed above, the sweet taste of sugar is perhaps its most obvious characteristic, and as such sugar could be considered as one of a range of products with sweetening properties. Broadly, sweeteners can be separated into three main categories:
 - (a) natural sweeteners;
 - (b) polyols; and
 - (c) high intensity sweeteners.
10. *Natural sweeteners* include a variety of products. As discussed above, sugar (or sucrose) is derived from either sugar beet or sugar cane. However, other natural sweeteners may also be derived from maize, potato starch, wheat or rice starch. In addition to glucose and dextrose, natural sweeteners also include:
 - (a) High Fructose Syrup (HFS), also known as isoglucose, isomerase, or high fructose corn syrup (HFCS), is glucose syrup in which around half of the glucose has been isomerized to fructose. HFS with 50 per cent fructose has about the same sweetness as sugar. It is a liquid, and is mainly used by producers of drinks, although it is also used to some extent by the bakery, dairy and ice-cream industries.
 - (b) Inulin syrup, produced by hydrolysis of inulin extracted from chicory roots, and consisting of 80–85 per cent fructose and 10–15 per cent glucose. Inulin syrup has similar characteristics to HFS and liquid sugar, and is used mainly in the production of soft drinks, ice cream and bakery products.
11. *Polyols* are alcohols, produced through the hydrogenation of saccharides such as glucose, dextrose and fructose. They have a lower sweetness than sugar, and also have a low calorie content. However, they have a laxative effect if taken in large quantities. The polyols that are approved for food use in the EU are Sorbitol, Xylitol, Lactitol, Mannitol, Maltitol and Isomalt.³ Demand for polyols has in the past been limited because of their product characteristics and their higher price compared with sugar.
12. *High intensity sweeteners (HIS)* are synthetically produced. They have a higher sweetness than sugar, but lack its bulk and preservative qualities. They are mainly used in diet products and diabetic food due to their low calorie content. The main

²This process owes its name to Count Jean-Antoine Chaptal.

³In the EU, food additives must be approved by the Scientific Committee for Food (SCF).

types of HIS used in industrially-produced food and drinks are Aspartame, Saccharine, Cyclamate and Acesulfame-K. A new HIS, sucralose, was approved by the EU Scientific Committee for Food (SCF) in September 2000. The SCF has set a value for the maximum amount of HIS that may be used in different types of foods. In practice, the maximum level is rarely reached, since the optimal taste of products tends to be reached at lower HIS levels.

Sweeteners: EU quotas

13. Isoglucose and inulin syrup are both subject to control by the EU Sugar Regime, having been included in the CMO Sugar in 1980 and 1994 respectively. Therefore, they are both subject to production quotas and production levies, and are eligible for export refunds. They were included due to the fact that they can both be used as substitutes for sugar to some extent. The total quotas in force at present are as follows:⁴
 - (a) Isoglucose (HFS): 2.1 per cent of the total sugar quota, corresponding to 300,725 tonnes (dry matter). Spain and Belgium are the main producers of isoglucose, jointly accounting for just over half of the total EU quota.
 - (b) Inulin syrup: 2.2 per cent of the total sugar quota, corresponding to 320,691 tonnes (white sugar equivalent). Note that, in recent years, declining demand has resulted in production lower than the quota.
14. The effect of the quota-regulation of isoglucose and inulin syrup in the EU has been to restrict substitution away from sugar to these other natural sweeteners. It is possible that, in the absence of the CMO Sugar, these products might become more viable substitutes for sugar in certain industries (such as the soft drinks industry).

Sweeteners: feasibility of substitution

15. In order to assess how substitutable sweeteners are for sugar, two key questions are of relevance:
 - (a) Are sweeteners *technically feasible* substitutes for sugar?
 - (b) Are sweeteners *economically viable* substitutes for sugar?However, given the operation of the EU Sugar Regime, we must also consider a third question:
 - (c) Are there any regulatory restrictions that limit the potential for substitution between sugar and other sweeteners?
16. Table 1 presents a summary of the key issues relating to substitutability, considering for each type of sweetener the technical feasibility of substitution, the economic viability of substitution, and any regulatory barriers to substitution.

⁴Source: *Sweet Fifteen: The Competition on the EU Sugar Markets*, Swedish Competition Authority Report 2002:7, p18.

TABLE 1 **Sweeteners: substitutability for sugar**

<i>Product</i>	<i>Technical feasibility</i>	<i>Economic viability</i>	<i>Regulatory restrictions</i>
HFS/isoglucose	Technically substitutable in certain industries: - Drinks industry: could use HFS for up to 95% cent of sweeteners. - Jam industry could use HFS for 50% of sweeteners. - Bakery, dairy and ice cream industry limited to 25%.	HFS production costs lower than those for sugar produced in the EU, but higher than low-cost sugar producing countries. HFS poorer storage quality and higher transport costs.	Regulated by quota in the EU, so potential substitution is limited.
Inulin	Similar characteristics to HFS.	Low demand for inulin syrup suggests not economically viable compared with sugar.	Regulated by quota in the EU, so potential substitution is limited.
Polyols	Different functional properties to sugar. Have a laxative effect in large quantities. Only feasible in low-calorie products.	Price higher than sugar, so not economically viable.	Approval required from Scientific Committee for Food.
High intensity sweeteners (HIS)	Different functional properties to sugar. Lack preserving and bulk characteristics. Only feasible in low-calorie products.	Price equal or lower than sugar.	Approval required from Scientific Committee for Food.

Source: *Sweet Fifteen: The Competition on the EU Sugar Markets: Swedish Competition Authority Report 2002:7*. December 2002, with CC analysis.

17. HFS is technically substitutable for sugar in certain industries, particularly in the manufacture of soft drinks, although in other industrial processes HFS lacks some important properties of sugar (for example, its bulking properties are inferior to those of sugar and it is not possible to produce a jam that sets by just using HFS). The production costs of HFS are below those of EU-produced sugar, and so could potentially be an economically attractive alternative to manufacturers. However, since HFS is regulated by a quota under the Sugar Regime, it is at present not possible to use HFS as a substitute for sugar on a significant scale.
18. Inulin syrup is technically substitutable for sugar in certain industries (similar to HFS), but low demand for inulin syrup suggests that it is not an economically viable alternative. It is also subject to a quota restriction in the EU, and so is not a viable substitute for sugar.
19. Polyols have different characteristics to sugar, and so are generally only technically feasible substitutes for sugar in the production of diet products and diabetic foods. Polyols are more expensive than sugar, and so are not economically viable alternatives.
20. HIS are cheaper than sugar and so are economically viable substitutes. However, HIS have different characteristics to sugar, and so, like polyols, they are generally only technically feasible substitutes for sugar in the production of diet products and diabetic foods.
21. Given problems with technical feasibility of substitution, economic viability of substitution and regulatory restrictions on substitution, other sweeteners do not appear to form viable close substitutes for sugar.