Alternative Sweeteners in a High Sugar Price Environment

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Abstract

The world sugar market has seen markedly higher average prices since mid 2009, provoking the question: are higher sugar prices reshaping sweeteners demand? What is the potential for starch based alternative sweeteners, synthetic and natural high intensity sweeteners (HIS) as well as lower calorie sweeteners to take market share away from sugar? In this paper recent developments in the global sweeteners market are overviewed, highlighting stronger annual growth for high fructose syrup (HFS) and HIS relative to sugar over the past few years. Even so, sugar still by far dominates the global sweeteners market (an 83% share in global consumption) but could this be eroded over the longer term? Key demand, supply and regulatory issues and drivers are examined and discussed in this study for all the major sugar substitutes, with a view to understanding their growth potential over the coming years. Amongst HIS, whilst synthetic sweeteners such as saccharin, aspartame and sucralose will remain dominant, natural HIS -particularly stevia sweeteners and lou han guo - are poised for rapid growth. Stevia sweeteners have already significantly penetrated the US market, particularly in blends with other sweeteners, including sugar, and capitalising on market trends for less processed ingredients that favour usage of sweeteners that can be marketed as "natural". With recent regulatory approval in the EU there is considerable scope for rapid growth in Stevia sweeteners in the future. Generally, the global HIS market is anticipated to grow at a faster pace than both sugar and high fructose syrup, consistent with "diet" and "lite" food and beverage products becoming more "mainstream". HFS could penetrate further in the global sweeteners market; particularly in the EU should sugar production quotas be abandoned. China could also see further HFS penetration, although this remains sensitive to the outlook for both sugar and grains prices. Polyols, the major low calorie natural alternative to sugar are also likely to see robust demand growth on the back of consumer preference in key markets for natural food products.

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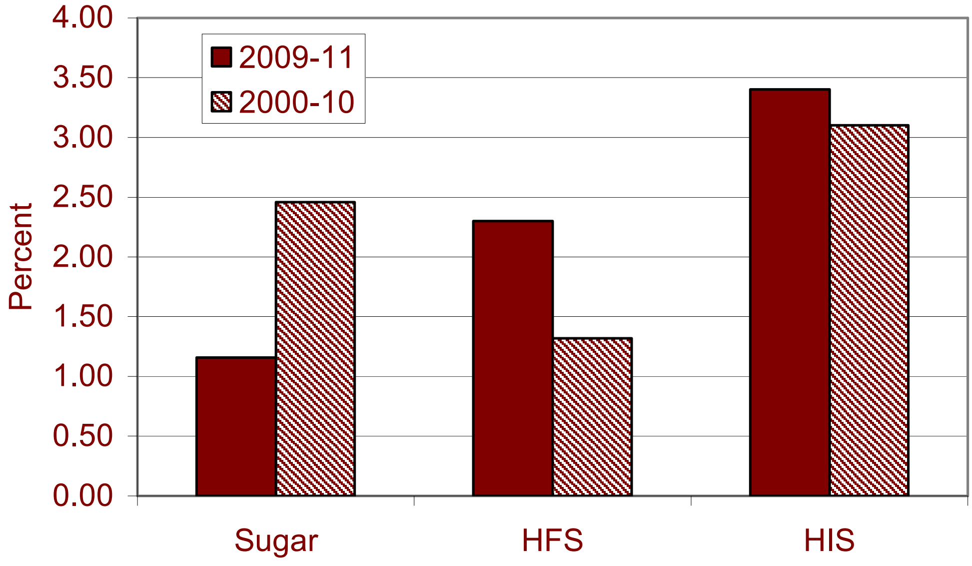
Introduction

The world sugar market has seen markedly higher average prices since mid 2009, provoking the question: are higher sugar prices reshaping caloric and non caloric sweetener demand. Do high sugar prices create a firm opportunity for alternative sweeteners to displace sugar? Or do key technical and economic issues limit potential? World market prices (the ISA market for raw sugar) averaged 18.2 US cents/lb in 2009, rising to 21.29 US cents/lb in 2010 and rising again to average 26.01 US cents/lb in 2011. This question is all the more relevant should sugar prices in future remain at levels above those seen only a few years ago (prices averaged 12.80 US cents in 2008).

Fig. 1 Annual Growth Rates in Global Sweeteners Demand



The global market for high intensity sweeteners (HIS)[1] continues to grow at a faster pace than both sugar and high fructose syrup (HFS). Over the period 2009-11 the world HIS market is estimated to have grown by 3.4% annually, outpacing a more modest 2.3% for high fructose syrup (HFS) (despite almost 10% growth in 2010) and 1.2% in sugar (which saw a contraction of -0.8% in 2009 in response to higher prices and the global financial crisis). As is also evident from Fig. 1, recent relative growth dynamics are different to those established during the last decade where growth in sugar was only broadly outperformed by HIS. Even though global sugar consumption has not grown as quickly as HIS and HFS over the past 3 years, as shown in table 1 its share of the world sweeteners market is still similar to that observed a decade earlier – at around 83%. In short, whilst HIS consumption is increasing, it remains small compared to sugar (although the situation can vary widely between countries). In contrast, the share of HFS in the global sweeteners

[1] Also termed non-nutritive high-intensity sweeteners.

market has fallen during the past decade – from 8.2% to 7.3%, chiefly reflecting a stagnant US market for caloric sweeteners (including sugar) until only recently. In 2010 and 2011 global HFS consumption grew by 9% and 4% respectively; much more rapidly than sugar despite soaring grains prices. This reflects in the most part surging consumption of HFS in Mexico with the commencement of free trade in sweeteners under the NAFTA. Looking ahead annual growth in global sugar consumption will likely rebound to around 2% with the recent poor performance being the exception rather than a new "norm".

Table 1: The Global Sweeteners market (wse)[2]

	Unit	1985	1990	1995	2000	2005	2009	2010	2011
Sugar	Mln tonnes	91.5	101.5	108.9	117.2	136.4	148.4	151.6	154.9
HIS	Mln tonnes	7.2	8.5	11.5	12.9	16.4	17.0	17.6	18.1
HFS	Mln tonnes	6.2	7.6	9.7	11.7	12.0	12.1	13.2	13.7
Polyols	Mln tonnes	0.5	0.6	0.7	0.7	0.8	0.8	0.9	1.0
Total	Mln tonnes	**105.4**	**118.2**	**130.8**	**142.5**	**165.6**	**178.3**	**183.3**	**187.7**
Sugar Share	%	86.8	85.9	83.3	82.2	82.3	83.2	82.7	82.5
HIS share	%	6.8	7.2	8.8	9.1	9.9	9.5	9.6	9.6
HFS share	%	5.9	6.4	7.4	8.2	7.3	6.8	7.2	7.3
Polyols	%	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5

Source: ISO estimates. HIS in white sugar equivalent (wse).

Whilst HIS represented a little less than 10 % of the global sweeteners market in 2011 and HFS around 7 %, there is wide variation amongst countries. HIS and HFS producers hope high sugar prices will create new demand for their sweeteners, as food and beverage manufacturers look for lower cost sweetener solutions.

In this study the markets for HFS, HIS and low calorie sweeteners are reviewed, in particular highlighting recent and prospective developments in terms of market growth, the factors driving demand, as well as identifying major producers and their recent and planned capacity expansions. The first part of the paper reviews developments and prospects for HFS, drawing attention to easing offtake in the globally dominant US market but massive growth in Mexico's use of HFS since free trade in sweeteners has been permitted under the NAFTA. China's rapid growth in HFS consumption is also investigated as are developments in EU production and consumption of

[2] Excluding starch sweeteners other than HFS. Glucose, fructose and dextrose for instance are not as sweet as sucrose and will not normally substitute for sugar in many food application. In the large US sweeteners market these "starch sugars" account for less than 1% of total caloric sweetener consumption of almost 20 mln tonnes.

isoglucose now that EU sugar reform is complete. A key focus is then the potential for other countries to develop a significant consumption of HFS. In the second part attention is turned to HIS including the well established artificial sweeteners including saccharin, cyclamate, aspartame and acesulfame-K, as well as second generation artificial sweeteners such as sucralose, neotame and advantame. Natural HIS (derived from sources such as leafs, berries and fruits) are considered separately, including stevia sweeteners (highlighted as having considerable potential given regulatory approval in the US in 2008 and in the EU late in 2011), Luo Han Guo and sweet proteins (such as Thaumatin). In the third part attention is turned to major low calorie sweeteners. These include polyhydric alcohols (polyols) , as well as the tagatose and trehalose sweeteners where consumption could boom in coming years. The final section of the study addresses the question of the extent to which the market trends and developments identified for HIS, low calorie sweeteners and HFS might impact consumption growth prospects for sugar.

ISO estimates of consumption levels have been gleaned from reviewing available literature, including but not limited to the websites of major HIS producers, press reports, press releases, and conference papers. There is very little data regarding production, trade and prices for sweeteners other than sugar and HFS in the public domain. Sweetener industries are reluctant to provide data and several alternative data sources are proprietary. This lack of data also explains a lack of a standard structure to the review of each sweetener in this document.

Background

Sweeteners can first be divided between caloric and non caloric, and then for non-caloric, between natural and synthetic sweeteners. Natural non-caloric sweeteners are then further divided between low potency sweeteners (chiefly sugar polyols, tagatose and trehalose) and high potency sweeteners such as stevia sweeteners and luo han guo –see box 1. This classification provides a general framework to the study. Non-caloric sweeteners are intensely sweet in general and only minute quantities are required for sweetening foods. As such, foods containing non-caloric sweeteners generate no or negligible calories from the sweeteners themselves, regardless of whether or not these sweeteners are caloric.

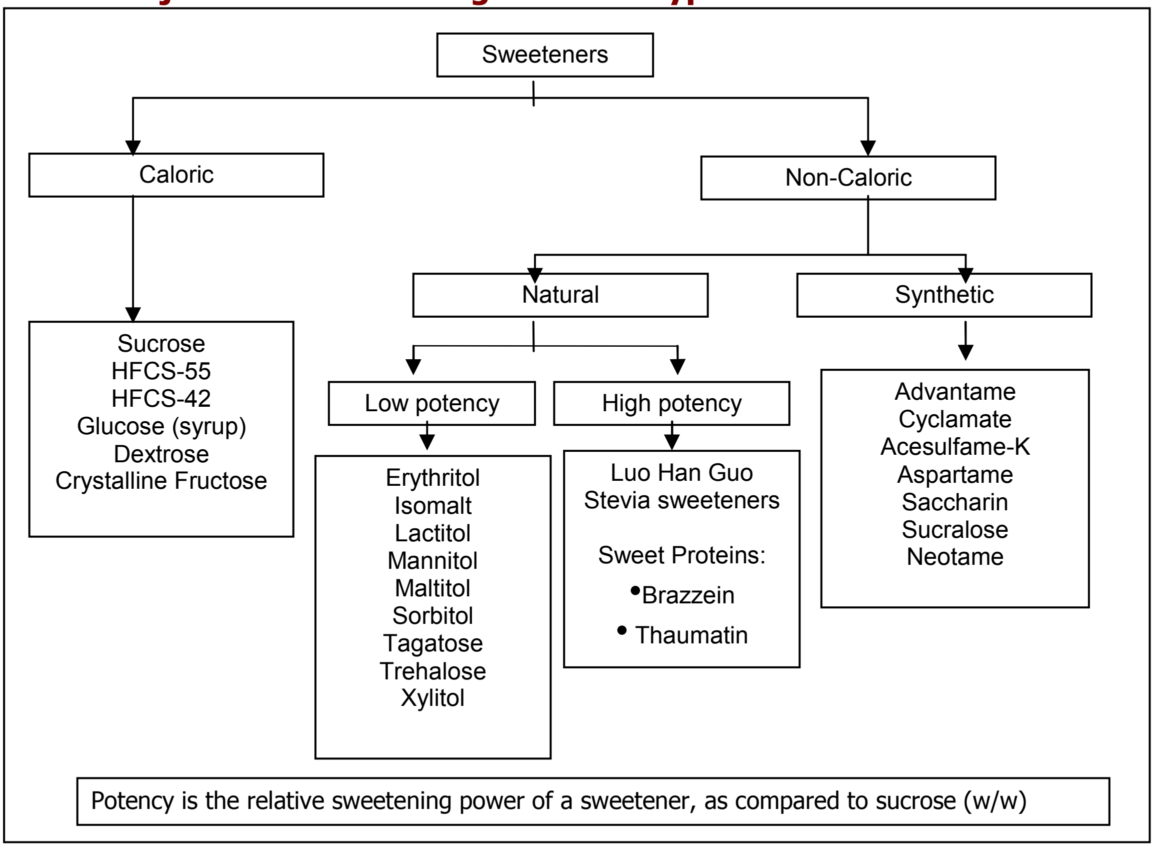
Functionality of Sugar and Alternative Sweeteners

Sweeteners vary considerably in their properties, even in terms of sweetness. The quality and type of sweetness can vary substantially between different sweeteners. Sugar[3] is described as having a clean taste with only a slight

[3] Sugar (sucrose) imparts a sweet taste that is quick, clean, and shortlived. These desirable qualities render sugar the gold standard for sweet taste. Sugar is also an important functional

lingering of the sweetness sensation. Thaumatin has a lingering sweet aftertaste and saccharin has a bitter aftertaste, as do stevia sweeteners. The extent to which particular sweeteners can be used in specific food and beverage applications also differs because of their considerable properties. In short, the functional and technical characteristics of sweeteners are critical, determining how they compete in the marketplace and determining the extent to which particular sweeteners can displace others from the end uses in which they compete.

Box 1: Major Sweetener Categories and Types



Sugar as a nutritive sweetener in all main downstream uses (except softdrinks) imparts other qualities besides sweetness to the product, creating obstacles to its direct displacement by alternatives. Typical sugar functionalities include: sweetness, flavour, texture/structure, crystallisation, humectancy, solubility, low hygroscopicity, freezing point, depression, osmotic effects, heat stability and stability in acid. The relative importance of these key sugar functionalities differ between the major categories of food and beverages.

ingredient for preparing foods. It provides the support for bulkiness, texture, preservation, flavour, and colour. However, sugar is a nutritive sweetener, easily metabolized, yielding an energy of 4kcal/g (16.7kJ/g).

Table 2: Sweetness of major caloric sweeteners

Sucrose (raw)	0.92
Sucrose (white)	1.00
HFCS-55	0.95
HFCS-42	0.85
Glucose (syrup)	0.70
Dextrose	0.85
Crystalline Fructose	1.30

Generally speaking HIS, aside from diet softdrinks, cannot directly substitute for sugar in many food manufacturing processes. However, the technical characteristics of HIS in some instances can be overcome by the addition of soluble bulking agents (polyols in particular), thickeners, gelling agents and preservatives. Even so there are many instances where sugar is difficult to displace. For instance chemical stability allows sucrose to be used in baking and other processes which require high temperatures to create the product. Some HIS, e.g. aspartame, are unstable at high temperatures. Unlike other artificial sweeteners, sucralose is stable when heated and can therefore be used in baked and fried goods.

HFS-55 can be a perfect substitute for sugar in softdrinks but in the chocolate industry it remains unsuitable as a substitute. Indeed, the success of HFS has varied significantly among different food categories. Its liquid properties mean it has had greatest success in beverages, also in dairy products and as syrup in canned fruits. Where HFCS competes less well with sugar is in processes where sugar is valued as a bulking agent – baked goods and confectionary products in particular. Per relative sweetness, HFCS-55 is comparable to sucrose (see table 2). HFCS-90 is sweeter than sucrose; HFCS-42 is less sweet than sucrose.

Natural Sugar Substitutes

The sweetness and energy densities of “natural” HIS (found in berries, fruit, vegetables, mushrooms, leafs) in comparison to those of sucrose are shown in Table 3. Stevia sweeteners and Luo Han Guo are the 2 most well known natural HIS but sweet proteins are also beginning to be commercialised. Low calorie sweeteners such as Polyols are the other main group of naturally derived sugar substitutes.

Synthetic Sugar Substitutes

Long known artificial HIS (artificially-synthesised compounds and sometimes called chemical sweeteners) include saccharin, cyclamates, aspartame, and acesulfame-potassium (k). More recent sweeteners include sucralose[4] and Neotame, whilst Alitame was ultimately not pursued by its manufacturer, Pfizer. Most artificial HIS have little or no food energy, so comparison of sweetness based on energy content is not meaningful. Relative sweetness by

[4] Sucralose is produced from sucrose when three chlorine atoms replace three hydroxyl groups.

weight is shown in table 4. HIS tend to impart lingering sweetness and various degrees of aftertaste (eg. Bitterness and metallic), so many companies market temporal and aftertaste modifiers.

Table 3: Relative Sweetness of Natural Sugar Substitutes

Name	Sweetness by weight	Sweetness by food energy	Energy density
Natural HIS			
Stevia*	250		
Luo han guo	300		
Sweet Proteins			
Thaumatin	2,000		
Mabinlin	NA		
Monellin	3,000		
Pentadin	500		
Brazzein	500-2000		
Curculin	550		
Miraculin	NA		
Low Calorie Sweeteners			
Polyols			
Erythritol	0.7	14	0.05
Isomalt	0.45-0.65	0.9-1.3	0.5
Hydrogenated Starch Hydrolysates	0.4-0.9	0.5-1.2	0.75
Lactitol	0.4	0.8	0.5
Maltitol	0.9	1.7	0.525
Mannitol	0.5	1.2	0.4
Sorbitol	0.6	0.9	0.65
Xylitol	1.0	1.7	0.6
Others			
Tagatose	0.92	2.4	0.38
Trehalose			

*(mainly containing Rebaudioside A, a steviol glycoside)

Blending of non caloric HIS has gained popularity in the beverage and the food industry because of better taste and cost savings. A blend of sweeteners tends to impart a more rounded aftertaste with reduced shortcomings of individual sweeteners. This is referred to as qualitative synergy. A combination of sweeteners may also impart a total sweetness higher than the sum of sweetness from the respective sweeteners. This is called quantitative synergy. The most significant example of quantitative synergy is a blend of aspartame and acesulfame-K.

Finally HIS are not immune to competition with new challenges emerging from high tech alternatives in the form of sweetness enhancers – as explained in box 2. The potential impact of sweetness enhancers which effectively allow the use of 30-50% less sugar or HFS while maintaining the taste of a full complement of sugar or HFS in some food products remains a wild card for the future.

Table 4: Relative Sweetness of Artificial HIS

Name	Sweetness (by weight)
Acesulfame potassium	200
Alitame	2,000
Aspartame	160–200
Salt of aspartame-acesulfame	350
Cyclamate	30
Neohesperidin dihydrochalcone	1,500
Neotame	8,000
Saccharin	300
Sucralose	600

Regulation and Approvals

Non-caloric sweeteners (natural and synthetic HIS) are highly regulated by relevant authorities in all countries. These regulations can be complex. Not only do the limits in different food categories vary, in some countries combination of non-caloric and caloric sweeteners is not allowed. Definitions for diet, zero calorie, low calorie, and reduced calorie also vary among different countries. Recently, for instance, last year the EU's food safety authority (EFSA)[5] endorsed the use of the stevia sweetener Reb-A, some considerable time after the US's Food and Drug Administration (FDA) gave generally recognised as safe (GRAS) approval to the sweetener. In Australia the Food Standards Agency of Australia and New Zealand (FSANZ) approved Ajinomoto's new sweetener – Advantame. All the well known HIS have had to be approved by relevant regulatory authorities in every country where they are marketed.

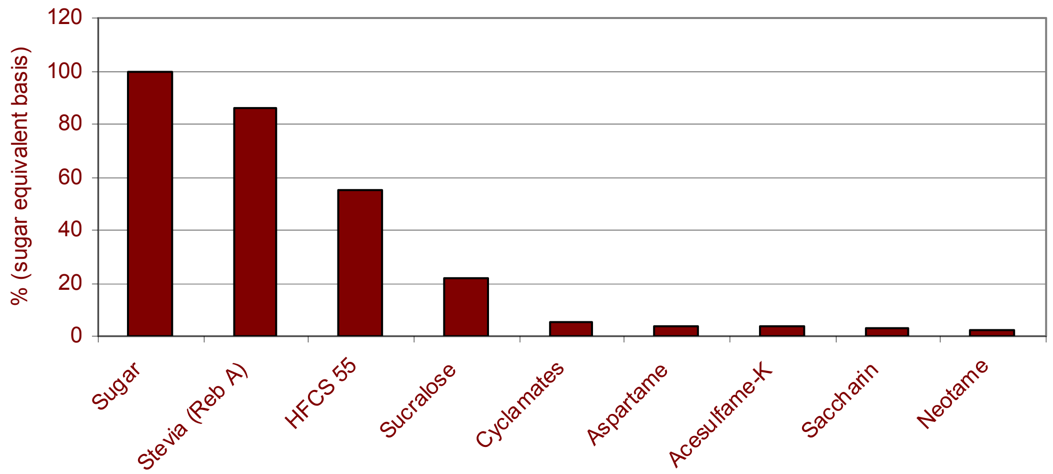
Sugar Substitute Prices

As can be seen in table 5 and Fig. 2, there is a price advantage to using HIS (but not always polyols), which together with their lack of calories, supports market expansion. However, higher and more volatile sugar prices in many markets may have seen food and beverage companies reconsidering their options. In the US, early in 2011 wholesale prices of intense sweeteners such

[5] The European Union directive 94/35/EC (also known as the "Sweeteners Directive") with four amendments 96/83/EC,2003/115/EC, 2006/52/EC and 2009/163/EU is important tool that restricts the level at which certain sweeteners may be present in a specific type of food.

as Splenda (sucralose) and aspartame were less than one-fifth and one-tenth respectively of the price of refined sugar. Even a subtle 90:10 sugar intense sweetener blends would help to keep sweetening costs down with little compromise in functionality.

Fig. 2 North America: Sweetener Prices vs Sugar



Source: USDA

Table 5: Ex factory prices of Sweeteners in China, June 2011

	Price USD/tonne	Sweetness compared with Sugar	Price per unit of sweetness
Sucrose	1,115	1	1,115
Stevia Glycosides	182,120	450	360
Sucralose	102,878	800	171
Acesulfame K	8,183	200	41
Aspartame	15,800	200	78
Glycyrrhizin	13,896	150	93
Saccharin	5,200	300	17
Cyclamate	2,470	30	82
Neotame	100,230	8,000	13
Erythritol	5,188	0.7	7,411
Mannitol	3,011	0.8	5,018
Maltose syrup (80%)	478	0.9	531
Sorbitol (70%)	844	0.7	920
Xylitol	918	0.8	10,149
HFCS-42	509	1	509
HFCS-55	847	1.1	588
Crystal Isomalitol	4,839	0.55	8,435
Malitol(75% liquid)	727	0.90	808

Source: CCM International

Box2: Sweetness Enhancers: a High-tech Alternative to HIS?

Sweetness enhancers are compounds used in tiny amounts to amplify the sweetness of sucrose (and other sweeteners). In a nutshell they provide more sweetness from a given amount of sugar, yielding costs savings and caloric reduction in beverages and foods. Senomyx and Redpoint Bio are leaders in this technology. Senomyx is partnering with Firmenich to launch a sucrose enhancer in 2012, whilst Redpoint Bio is working with International Flavors and Fragrances for commercialisation of a stevia based sweetness enhancer.

Senomyx's Sweet Taste Programme has led to the discovery and development of a sucrose enhancer and a sucralose enhancer, both of which have received regulatory approval in the US. In October 2009 Senomyx received GRAS status for its S6973 sucrose enhancer, but has continued work on additional sweetness enhancers. In October 2010 it announced that it would collaborate with Firmenich for commercial development of its S6973 enhancer in beverage applications whilst earlier in the year Firmenich had made a decision to proceed with commercialisation of the same sucrose sweetness enhancer for virtually all food product categories and in selected powdered beverages. Senomyx receives licence fees, milestone payments and annual royalties on all S6973 sales. In December the agreement was extended to include discovery, development, and commercialisation of natural sweet enhancers for sucrose, fructose and Rebaudioside. In April 2011, Senomyx was granted US patent for production of S2383, an enhancer for Sucralose.

2011 had been a "pivotal year" for Senomyx due to commercial launches of branded products containing its 'Sweet Taste' modulators: for sucrose reduction (S6973) and reduction in concentration of sucralose (S2383). There are no other products on the market like S6973, which has no sweet taste on its own, and allows manufacturers to reduce sucrose in the products by up to 50%, while maintaining the taste of a full complement of this sugar. This meant calorie reductions and cost savings that multinationals were now planning their first product launches using S6973, although large firms were naturally protective of international brands and only reformulated after careful consideration and consumer testing. Early in 2012 Senomyx hinted at PepsiCo's interest in its work on developing a sucrose enhancer (S9632) to reduce HFCS levels in beverages and foods by up to 33%, while retaining the preferred sweetness profile and taste test.

Redpoint Bio first announced that it had identified RP44, an all natural sweetness enhancer, in June 2009. RP44 is Reb C, a component of the stevia plant. In June 2010 Redpoint Bio entered into a licence and commercialisation agreement with International Flavor and Fragrances for RP44. It received GRAS approval from the Flavor and Extract Manufacturers Association (FEMA) in October 2010. Redpoint Bio reveals that taste tests reveal that RP44 enables the reduction of up to 25% of the caloric sweetener content in various product prototypes, including for use with sugar, fructose and HFCS.

Elsewhere, stevia producer PureCircle, in July 2011 agreed a multi-year global distribution agreement with Firmenich to accelerate commercialization of the company's new natural flavor, NSF-02. NSF-02 has FEMA GRAS status in the US and is part of PureCircle Flavor's new range, which also includes NSF-01. The flavours have been specifically designed to enhance flavour, sweetness and taste in combination with the stevia sweeteners, Reb A and SG-95, and sugar or high fructose corn syrup. According to the terms of the new agreement, Firmenich will get exclusive rights to commercialize NSF-02 as both a stand-alone ingredient and within the company's flavour systems. The agreement also allows for further collaboration between the companies to accelerate the adoption of the new flavour modifier beyond the US.

Its clear from Fig. 2 and table 5 that the natural HIS stevia is considerably higher cost relative to artificial HIS such as cyclamates, aspartame, saccharin, acesulfame-K and neotame. Sucralose is the highest cost artificial HIS. Polyols are considerably more expensive than HIS but typically are used as bulking agents rather than directly used to substitute sugar. HFCS-55 is around 50% cheaper than sugar in both the US and China.

A: High Fructose Syrup (HFS)

There are a variety of starch based caloric sweeteners including glucose, dextrose, maltose, and fructose syrups. Not all of these can be truly regarded as sugar substitutes, since some of their use is driven by factors other than sweetness (bulking properties, control of crystallation, maintenance of humidity, for instance). Amongst these starch sweeteners (sometimes called starch sugars and starch syrups), attention is focussed only upon high fructose syrup (HFS) which can directly substitute for sugar in several beverage and food categories (see earlier section). Since HFS basically has the same features as liquid sugar, it has had most success in beverages: in the US market accounting for 94% of sweeteners consumed by the sector. The sweetener has had the least success in applications where sugar is valued as a bulking agent, as in most baked goods and confectionary products. Although the bulk of HFS (and other starched based sweeteners) is produced from corn, and therefore termed high fructose corn syrup (HFCS), in several countries other starch rich sources are used, such as tapioca or potato starch.

Consumption Growth Surge for HFS

From a period of sustained and strong market expansion during the 1990s, market growth has proven elusive for HFS producers in many years since 2000. Producers have faced unstable feedstock costs and surging energy prices. Between the year 2000 and 2009 world sugar consumption grew by 31 mln tonnes (wse) (26%) whereas the HFS level in 2009 of 12.1 mln tonnes was only 4% higher than in the year 2000. During the intervening period HFS consumption had peaked in 2007 at 12.8 mln tonnes, some 10 % higher than the 2000 level. However in 2010 and 2011 global HFS consumption has seen faster growth than global sugar consumption - see Fig. 3. In 2000, on a global scale, one tonne of HFS was consumed for each 9.8 tonnes of sugar, whereas in 2011 the ratio had fallen to one tonne of HFS to each 8.9 tonnes of sugar.

The US industry dominates the world scene accounting for 60% of world production and it is also here where HFS consumption has been stagnant or declining during much of the past decade[6]. Fig. 4 shows a regional

[6] HFCS first began making an impact in the US sweetener market in the mid 1970s when sugar prices soared and new enzyme technologies became available. In short, the US satisfied all of the prerequisites needed for successful development of a HFCS industry, including:

breakdown of global production. Generally speaking the high cost and logistics of transporting and handling HFS over long distances means trade is very limited. Regional consumption is consequently broadly the same as regional production. The increase in US production seen over the past 2 years is driven by surging exports to Mexico with the commencement of free trade in sweeteners under the NAFTA. As can be seen in Fig. 5, HFCS penetration is greatest in the US with Japan, Canada, Mexico and Taiwan also showing considerable use of HFCS. Fastest growth in HFCS penetration has been seen in Mexico and China over the past few years.

Fig. 3 Annual Growth in World Sugar and HFS Consumption

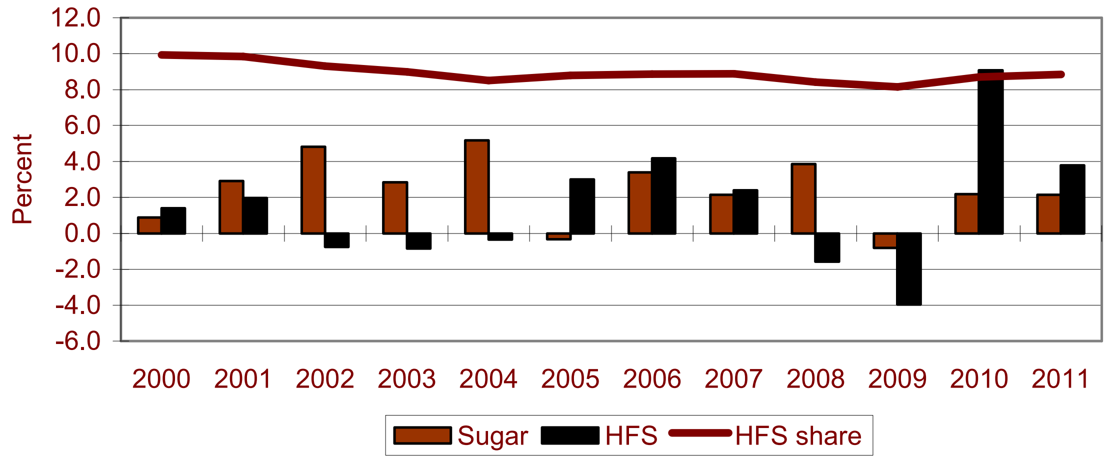
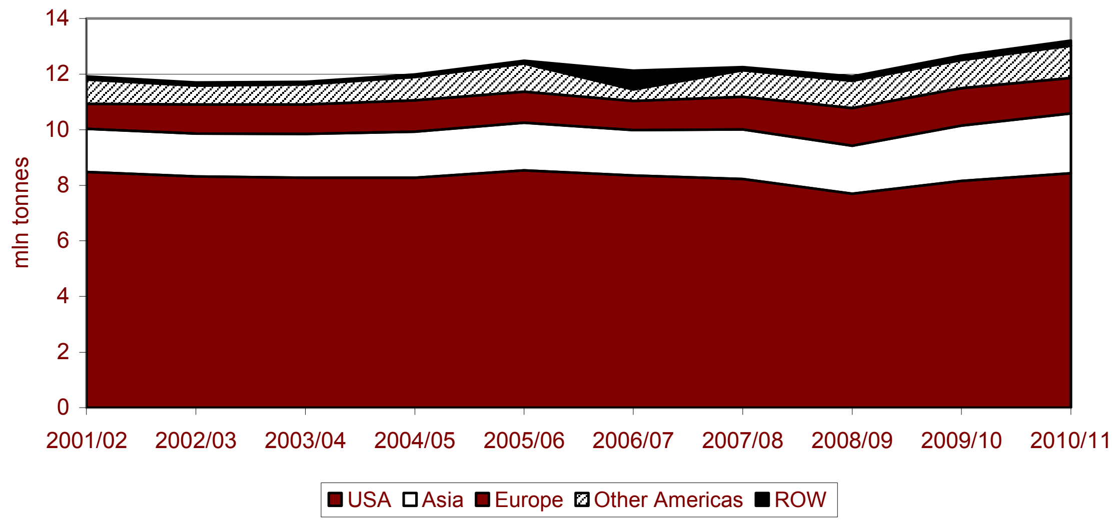
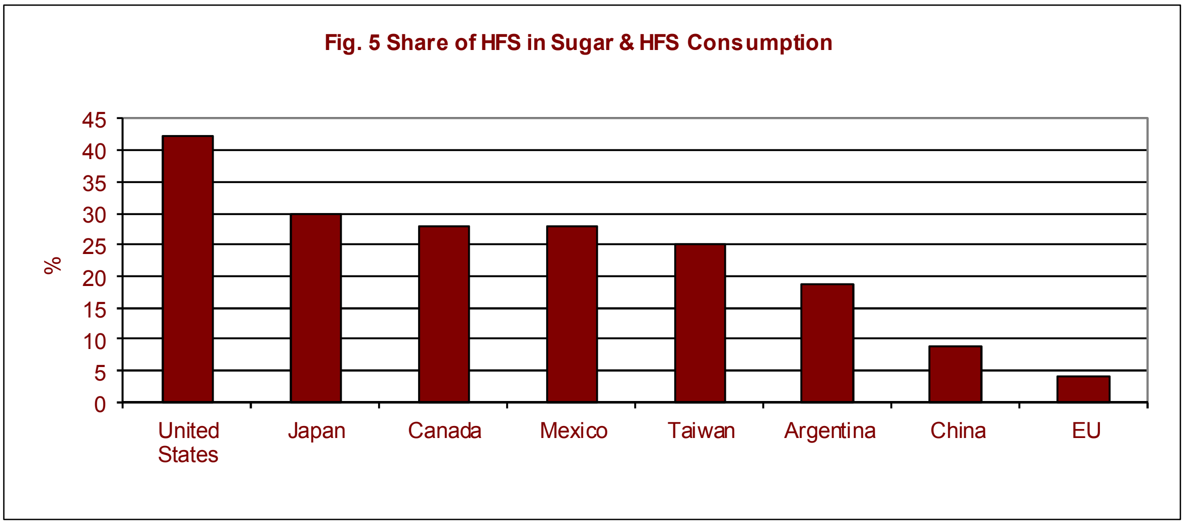


Fig. 4 World HFS Production by Region



(1) a domestic deficit of sugar and a high internal sugar price;
(2) sufficient supplies of low cost starch;
(3) a well developed food production and consumption infrastructure;
(4) availability of capital for investment in research and development and plant and equipment; and
(5) favourable government policy.



NAFTA and HFCS

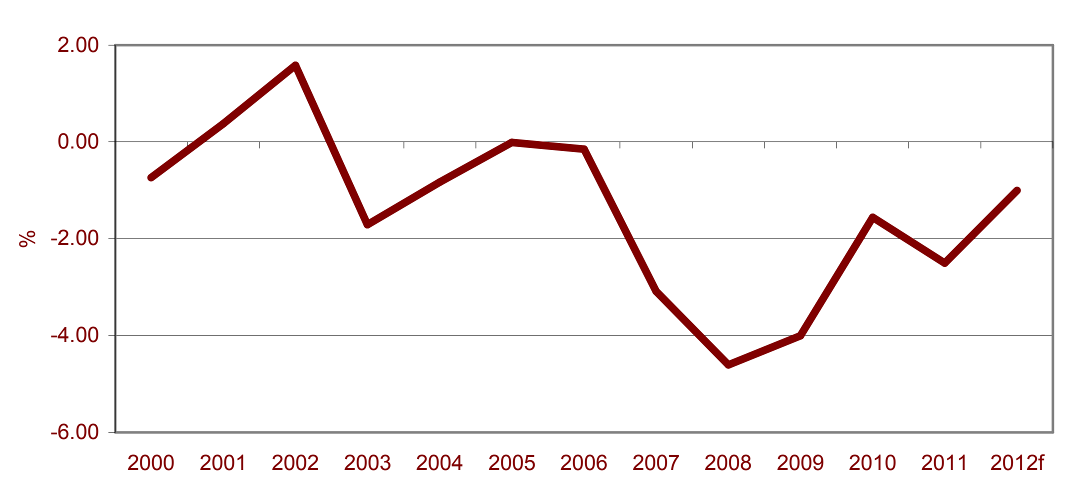
HFCS is at the core of the integrated Mexican/USA sweeteners market. In the US demand has been waning for much of the past decade. USDA data show that US HFCS consumption declined from 9.1 mln tonnes recorded in 2000 to around 7.5 mln tonnes (dry weight) forecast for 2012, with an approximate 42% share of the country's sugar and HFCS market. In the meantime, HFCS exports to Mexico, despite high year-on-year volatility, had begun to increase significantly in the later part of last decade, even before the free trade provisions of NAFTA came into effect. Mexico is typically a large importer of HFCS since its production is only a fraction of consumption, but in the first half of the 2000s, Mexico acted to constrain HFCS imports as part of a decade-long dispute over the sugar provisions of NAFTA. Whilst the HFS market in Mexico is still considerably smaller than in the US, use in the beverage sector - mainly sourced from the US – has surged in the past few years under the NAFTA free trade environment (whilst the US receives close to 1.0 mln tonnes of raw and white sugar from Mexico). HFCS consumption has risen from only 0.4 mln tonnes in 2005 to a record 1.6 mln tonnes in 2011. Penetration of HFCS however seems to be reaching a plateau after 3 years of rapid gains.

US HFCS Consumption in the Doldrums

US sugar consumption is rising at the same time as HFCS consumption declines. The share of the caloric sweetener market held by HFCS is estimated to have fallen to 44.5% in 2011, after having peaked at 50.3% in 2006 -see Fig. 6 and Fig. 7. A significant improvement in the price competitiveness of HFCS as against sugar has seemingly not boosted HFCS inclusion by food and beverage manufacturers. In the first half of the 2000s HFCS typically sold at 40% below wholesale refined sugar prices. However HFCS prices surged on the back of high corn prices mid decade, and even brought a premium to sugar in 2008. This was short lived and HFCS has become steadily more competitive over recent years in an environment of sustained high sugar values on the US market– see Fig. 8.

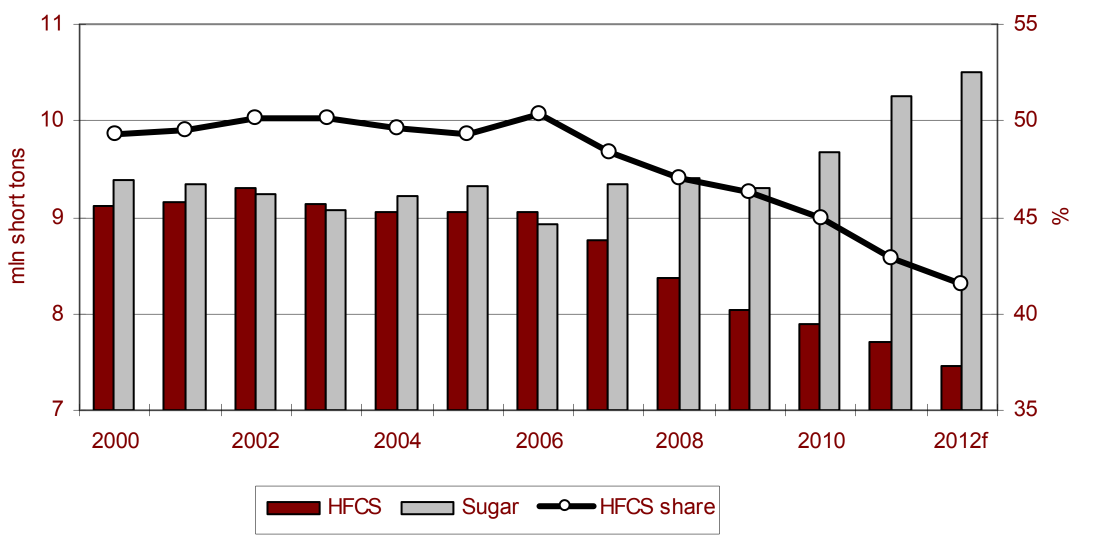
HFCS offtake is forecasted to fall modestly further in 2012 - by 1% to 7,447 thousand short tons, dry basis- after shrinking last year by an estimated 2.5%. At the same time sugar consumption is forecast to rise again in 2012, pushing the share of HFCS in total sugar and HFCS consumption to only 42% - see Fig. 7.

Fig. 6 US HFCS: Annual Change in Domestic Deliveries

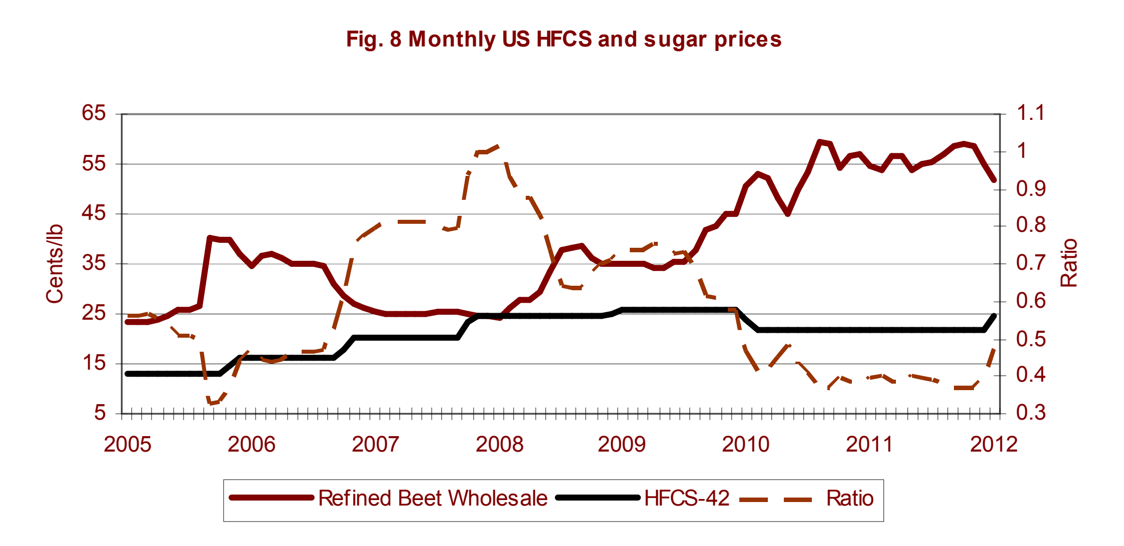


Source: USDA and ISO

Fig. 7 US HFCS and Sugar Consumption



Source: USDA and ISO



Source: USDA

The above-mentioned decline in demand for HFCS is being driven by falling carbonated soft drinks (CSD)[7] consumption, coupled with imports of liquid sugar from Mexico, which has displaced HFCS-42 in many traditional applications. Even though CSD remain by far the largest beverage category, CSD volume slipped 0.8% in 2010. This resulted in the CSD market share moving down from 48% to 47%. Diet drinks continue to gain market share at the expense of regularly sweetened CSDs. During 2011 CSD manufacturers continued to pursue formulations which use both so called more "natural" ingredients (such as fruit juices and Stevia derived sweeteners) and contain fewer calories than sugar.

Furthermore, consumer concerns over possible links between HFCS consumption and obesity, cardiovascular disease, diabetes, and non-alcoholic fatty liver disease[8] means some food and beverage manufacturers switched from HFCS to sugar in their product formulations starting in 2009. According to market researcher Packaged Facts, while the number of new product launches containing HFCS nearly doubled between 2009 and 2010, there was also a corresponding rise in the number of new products pursuing market gains by declaring a "no HFCS" claim. In 2010, there were 150 products

[7] The basic elements in carbonated soft drinks are sweetener, water and flavouring.

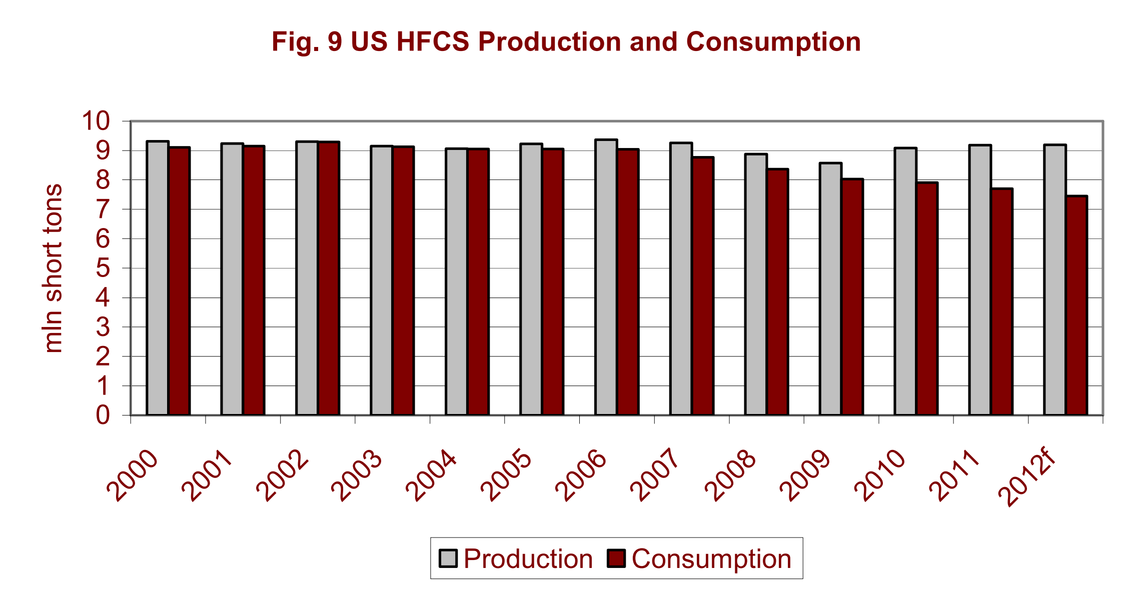
[8] There is no consensus regarding HFCS and its dangers to health compared to sugar. There are studies that demonstrate that it is more harmful and other studies that demonstrate it is not more harmful. General scientific consensus is that there needs to be more research on the impact HFCS has on the body and whether this is more dangerous than other types of sweeteners. To make HFCS corn refiners must extract the starch from corn, treat the starch with an enzyme to break it into glucose, and treat the glucose with another enzyme to turn about half of it into fructose. This is "natural," according to the FDA, because the enzymes are fixed to a column, do not actually mix with the starch, and HFCS does not contain added colours or flavours. However others consider that since manufacturing HFCS requires a long series of mechanical processes and chemical reactions, including the introduction of three different enzymes to incite molecular rearrangements, HFCS cannot be considered a natural food.

introduced in 55 categories that had this claim, with breads and rolls, functional drinks and other savoury snacks as the three leading categories.

The Corn Refiners Association (CRA) has made a concerted effort through advertising and marketing campaigns to convince the public that HFCS used in foods and beverages is not dissimilar in its makeup to sugar (sucrose), which contains 50 % glucose and 50 % fructose. Furthermore in September 2010 the organisation petitioned the US FDA asking it to allow the term 'corn sugar' as an alternative label declaration for HFCS. It is expected to take up to two years for the FDA to come to a decision on whether to approve the renaming. However, sugar producers responded by filing a lawsuit in April 2011. Three sugar distributors say that equating HFCS with real sugar -- with slogans like "your body can't tell the difference" -- misleads consumers. They accuse defendants, including Archer Daniels Midland Co and Cargill, of using the publicity campaign to offset growing customer concerns about obesity. Meanwhile, non-profit consumer group Citizens for Health is the latest organization to oppose the Corn Refiners Association's petition. The National Consumers League also continues to urge the FDA to oppose the CRA's petition to change the name of HFCS, under the grounds that the name change would be contrary to public policy, inconsistent with emerging scientific evidence, and not in accordance with the Food, Drug, and Cosmetic act.

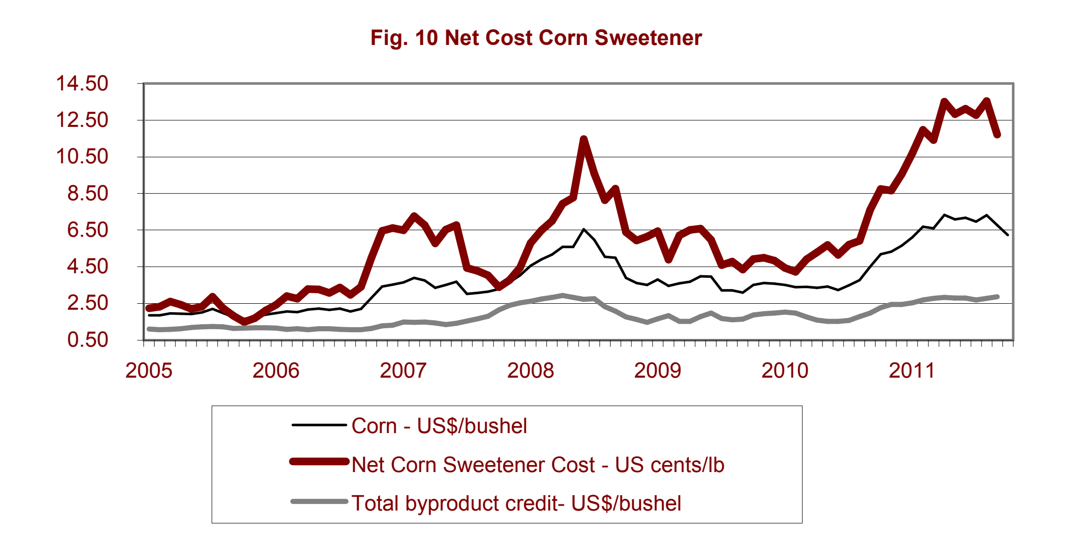
US Production, Feedstock Costs and Prices

This year's HFCS production is anticipated to be on par with the estimated 2011 level of 8,180 thousand short tons, after rising strongly by 6% in 2010 and around 1% in 2011- see Fig. 9. Weaker HFCS demand in the US is being compensated by high exports to Mexico. Indeed exports to Mexico continue to be a strong contributor to keeping overall utilisation rates high at US HFCS producing plants. Major producing companies in the US include Archer Daniels Midland Company; Cargill, Incorporated; Corn Products International, Inc.; National Starch LLC; Penford Products Co.; Roquette America, Inc. and Tate & Lyle Americas. In 2010 there were 26 corn refining millers in 11 States.



Source: USDA

As can be seen in Fig. 10, feedstock costs for HFS producers have been historically volatile. Prospects for continuing relatively tight corn supplies suggest net corn sweetener costs (that is the price of corn minus co-product credits) will remain relatively high over coming months. Corn sweetener costs during January-September 2011 averaged USD0.12/lb, up from the 2010 average level of only USD0.06/lb. Costs were held lower than otherwise by high values for both corn gluten feed and corn oil, 2 key byproducts of corn wet milling.



Source: USDA

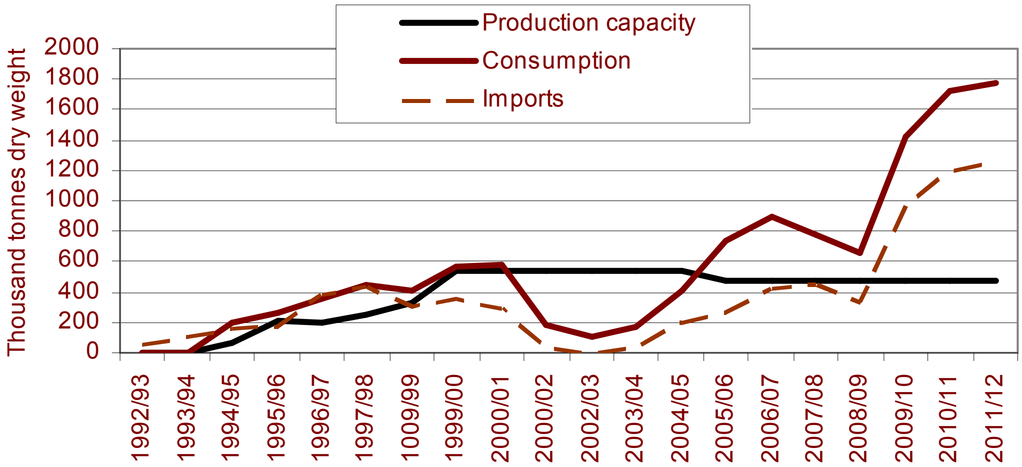
Rising net corn costs have been a key reason leading to substantially higher US HFCS prices in 2011 and again in 2012. Market leader Archer Daniel Midland Co. said that it had finalised contracts for corn sweetener shipments in 2011 with HFCS prices jumping by 25%. By contrast, Tate & Lyle reportedly said that, in the annual pricing round on high fructose corn syrup, it had achieved only "slightly higher" margins on deals with buyers on annual, fixed-term contracts. Price negotiations between HFCS producers and large food and drink manufacturers for the supply of HFCS in 2012 resulted in increased prices on the back of continuing high corn costs. Wet millers were able to achieve increases close to 20% for HFCS-55, and a 10 to 15% increase HFCS-42. This rise in contract prices was immediately reflected in spot prices: the January quotation was 13% over the static 2011 level of US21.65 cents/lb dry weight. Given likely continuing high sugar prices in NAFTA, this rise in HFCS prices is unlikely to hasten contracting demand for the product.

Boosted HFCS Penetration in Mexico

Coupled with domestic production of around 400 thousand tonnes, Mexico is consuming close to 1.6 mln tonnes of HFCS annually. However the USDA points to Mexico's consumption stagnating in 2011/12 as major softdrink bottlers are unlikely to further increase HFCS incorporation rates in the short term. The sharp increase achieved in recent years may have resulted in the market having become already saturated – with HFCS accounting for around 28% of total for HFCS and sugar consumption (compared to 43% in the US). Moreover, because the outlook is for sugar prices to ease somewhat while corn prices could likely stay very firm, further penetration of HFCS seem unlikely in the near term. This implies sugar consumption would recover slightly after falling significantly between 2009 and 2011 (by 0.8 mln tonnes to 4.3 mln tonnes) Increased HFCS use has weakened sugar consumption in Mexico. Put simply, Mexico is exporting more sugar to the US, where it is priced against the domestic sugar futures contract, and importing HFCS as a less costly substitute.

US exports of HFCS to Mexico for the period January-November 2011 reached 891 thousand tonnes, fractionally higher than for the corresponding period of 2010 and maintaining a record high level. Coupled with domestic production of around 400 thousand tonnes, Mexico is consuming close to 1.6 mln tonnes of HFCS annually. Another driver impacting on HFCS penetration in Mexico is the price of US corn, the main feedstock of HFCS production. Despite higher global corn prices HFCS production is forecast to rise somewhat as the product remains competitive as compared to sugar. Despite this there is no investment in new capacity as competitive pressure from imported HFCS also remains strong. In Fig. 11 a longer term perspective on Mexico's HFCS production capacity and local consumption is provided, according to data compiled by McKeany-Flavell, a commodity consultancy firm. Capacity peaked in 2000 and stagnated at around 533 thousand tonnes (dry weight) until 2006 when it is estimated to have fallen back to 478 thousand tonnes. Even domestic production strongly depends on imported corn from the US. According to IDAQUIM, the industry group that represents HFCS producers, the industry consumes about two million tonnes of yellow corn of which 80 to 90% is imported. The US will remain the main supplier of corn to Mexico for the near future not only for logistical reasons but also because of its preferential status under the North American Free Trade Agreement (NAFTA).

Fig. 11 - Mexico - Estmated HFCS Production Capacity, Consumption and Imports



Source: McKeany-Flavell

Canada and HFCS

Canada is a long-standing HFCS producer producing around 0.5 mln tonnes annually for the past 5 years. The country typically exports HFCS to the United States. However in 2010/11 Canada imported considerable volumes from its neighbour (around 30 thousand tonnes): a direct consequence of the very high world sugar prices to which consumers are exposed. The largest producer of HFCS and other corn sweeteners in Canada is the CASCO Company, a division of Corn Products' International. CASCO has three corn refining facilities in Ontario — Cardinal, Port Colborne and London — that produce high-fructose and glucose syrups and dextrose. While CASCO markets these products mainly in Canada, the Port Colborne plant also produces HFCS for the northeast US.

Isoglucose in the European Union Hit by Sugar Reform

Europe shows a relatively low rate of HFS penetration (less than 3 % of sugar and HFS consumption combined) because the sugar regime has ensured that binding production quotas apply to HFS, known locally as isoglucose. These quotas were imposed during the 1970s in response to the competitive threat of HFS to the EU sugar industry. Furthermore, any excess production above quota must be exported, without subsidy, onto the world market - an unviable option as it is logistically difficult to ship HFS long distances. Out-of-quota production did not occur except in 2006/07 in Slovakia, Hungary and the UK, to a very low extent. Therefore, the dynamics of isoglucose production have been directly linked to the quota changes.

2010/11 (October/September) was the first year after the conclusion of the EU's sugar market reform. Reform gave the opportunity to isoglucose producers to increase their quotas. Depending on its profile (technical constraints, investment required, demand, overall activity, location and competition with beet sugar or imports), each company could decide to increase its production thanks to the additional quotas, renounce them, or abandon isoglucose production totally.

During the reform process the reference price for white sugar fell to EUR404.4 per tonne from EUR631.9 pre-reform. At the same time, the overall isoglucose quota (mainly produced from wheat) was decreased to around 690 thousand tonnes from 820 thousand tonnes in 2008/09. As there is almost no out-of-quota isoglucose produced, the EU production level is directly linked to the quantities of quota. Even though changes in volumes are limited, the geographical distribution of the production has significantly changed: whereas isoglucose was produced in 15 Member States before the reform, it is now concentrated in 9 Member States. Belgium and Hungary clearly dominate the EU's isoglucose production.

Capacity was taken out of production following the EU reforms with the result that there is hardly any ability to increase output. As can be seen in table 6, six member states fully renounced their quotas and two renounced much of their quotas. Hungary and Belgium remain as the two largest producers. All inulin syrup[9] quotas were renounced during the reform transition period. Half of the isoglucose production units have been dismantled within the restructuring scheme because: quotas were considered as insufficient to maintain cost-effective production in a context of low sugar prices; profitability of isoglucose was impacted by the reform, as the raw material prices did not fall in line with the sugar reference price; or the restructuring fund was a source of immediate cash flow. No investments were made to increase production capacities; only already existing production lines were optimized to integrate the additional quotas. As a result, the average quantities processed per site have increased.

In 2010/11 while grain prices were high the increase was not as sharp as for sugar and demand for isoglucose reportedly increased. However, this increase in consumption came at an unfortunate time as all starch plants were operating at capacity. Therefore the starch-based sweetener industry was not really able to alleviate the tightness on the European sugar market in 2010 and in 2011.

9 Inulins are a group of naturally occurring polysaccharides produced by many types of plants. Its flavour ranges from bland to subtly sweet (approx. 10% sweetness of sugar/sucrose) and contains 25-35% of the food energy of carbohydrates (starch and sugar).

Table 6: EU Isoglucose production quotas at the beginning and the end of reform

Countries	Initial Quotas	Additional Quota purchased	Quota Renounced	Final Quota (2009/10)
Countries renouncing all of Quota				
Greece	12,893	7,743	20,636	0
France	19,846	7,818	27,664	0
Netherlands	9,099	5,464	14,563	0
Romania	9,981	5,898	15,879	0
Finland	11,872	7,128	19,000	0
United Kingdom	27,237	16,355	43,592	0
Total	90,928	50,406	141,334	0
Countries renouncing most of Quota				
Spain	82,579	48,844	77,613	53,810
Portugal	9,917	5,954	3,371	12,500
Total	92,496	54,798	80,984	66,310
Countries not renouncing Quota				
Belgium	71,592	42,988	0	114,580
Bulgaria	56,063	33,135	0	89,198
Germany	35,389	21,249	0	56,638
Italy	20,302	12,191	0	32,493
Hungary	137,627	82,639	0	220,266
Poland	26,781	16,080	0	42,861
Slovakia	42,547	25,548	0	68,095
Total	390,301	233,830	0	624,131
EU27 TOTAL	**573,725**	**339,034**	**222,318**	**690,441**

The average annual price of isoglucose, fructose and fructose syrup is typically between 70% and 84% of that of sugar. The isoglucose price depends largely on the in-quota sugar price because both products are substitutable (for the most part). And indeed, they have followed the same trend. Thus, the impact of the reform on the isoglucose price is the same as the impact on the quota sugar. Nevertheless, differently from the sugar sector, the price of raw materials does not depend on the sugar CMO and they did not fall according to the sugar reference price decrease However, whilst the isoglucose price may have initially been "squeezed" between the in-quota sugar price and the soft wheat price, the market price of sugar in the

EU rose significantly in 2010 and has remained high. Domestic prices (refined quota sugar, trade weighted average) have risen sharply over the past few months, from EUR 564/tonne in August 2011 to EUR 654/tonne in December. The last time domestic prices traded above this level in the EU was before the onset of the EU Sugar Reform in July 2006. The new price level constitutes a premium of EUR 250/tonne relative to the reference price for quota sugar in the EU, which has been EUR 404.4/tonne since October 2009.

Asia: Japan Remains Dominant but all Eyes on China.

As can be seen in Fig.12, Japan remains the dominant consumer/producer of HFS in Asia[10], with South Korea and Taiwan also large consumers relative to their sugar consumption (around 25% each). Fastest growth however has been in China, and this is likely to remain the case.

Japan

HFCS output (manufactured mostly from imported US corn) continues to be limited by government (The Ministry of Agriculture, Forestry and Fisheries - MAFF -calculates quarterly targets volumes for each manufacturer) and this practice together with a system of government surcharges and levies ensures that the market balance between sugar and HFCS does not quickly change. The share of HFCS in total consumption of sugar and HFCS has been relatively stable over the past 5 years at 27-30%. Production in 2010/11 was 803 thousand tonnes, a small increase from the previous year. Japan's sweetener market is mature and is unlikely to grow under the current policy settings. Growth will also remain relatively lacklustre due to a poor economic outlook. HFCS is primarily used in soft drinks and low alcoholic drinks like *happoshu* (light beer).

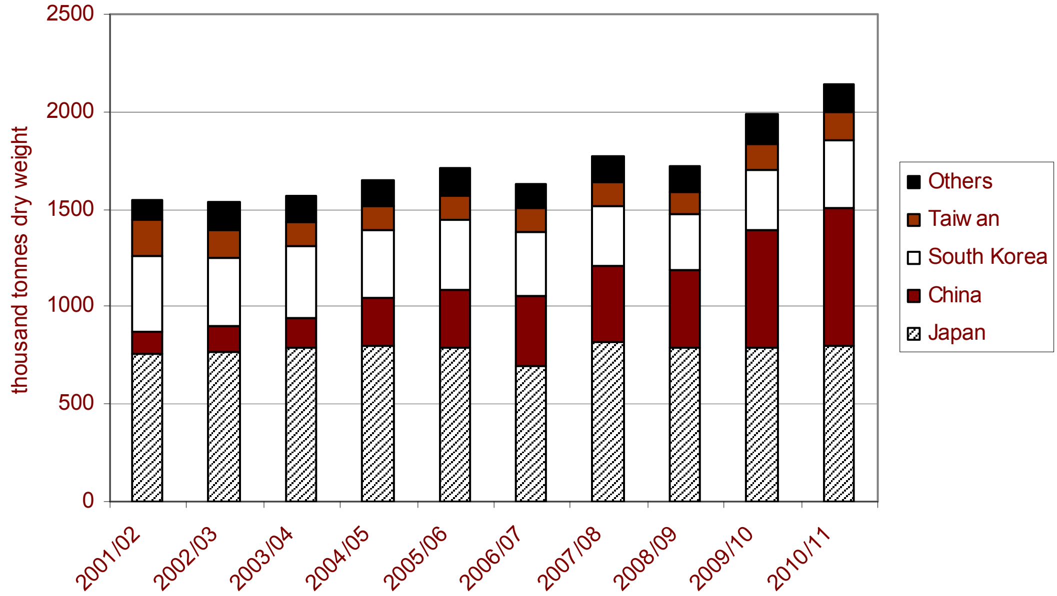
China

In China the beverage industry continues to expand rapidly and demand for liquid sweeteners is on the rise. There is a lack of official data but F.O. Licht estimates HFCS production reached 0.7 mln tonnes dry basis in 2010/11. Other estimates suggest HFCS production of as high as 1.3 mln tonnes. Production has increased from only 110 thousand tonnes during the past decade. Even so, as a share of sugar and HFCS consumption together, HFCS still accounts for less than 10%, albeit this share has increased rapidly from only around 1% 6 years ago.

[10] Japan's starch feedstock comes from domestically produced potatoes and large-scale imports of corn from the United States. Japan also has a well developed handling system for liquid sweeteners and a significant portion of total sweetener consumption is in the industrially prepared beverages and foods sectors. Government policy supporting high domestic prices for sugar were also a key factor supporting development of a significant HFS industry. Planned corn starch production must be matched by purchases of domestic potato and sweet potato starch in the ration of 1 part potato to 12 parts corn. Effectively, corn sweetener producers can import at zero tariff, up to 12 times the volume of potato starch they use.

Importantly China has a very large starch sweetener industry with total output in 2011 estimated at around 9-10 mln tonnes. The most important products in this category are glucose and malt sugar which account for about two thirds of the total starch sweetener segment. See Box 3 for additional explanation of China's starch sweeteners sector. According to the USDA FAS, during the past few years, major sugar end-users, including the beverage, food processing, and pharmacy sector began substituting starch sugar because of high domestic sugar prices. For instance, according to CSA's estimate, starch sugar (HFCS) used by Coca and Pepsi accounts for 50% and 35 % of their total sweeteners use.

Fig. 12 Asia's HFS Producton



Other Asia

There's evidence that there have been substantially higher imports of HFS by several Asian sugar producing countries in 2010 and 2011, where domestic sugar prices have been high and where corn production is low. For instance the Philippines imported only 5 thousand tonnes of US HFCS in 2009, but this surged to 47 thousand tonnes in 2010 (as reported by the USDA), and is estimated to have reached 80 thousand tonnes in 2011.

Argentina

Argentina has five companies which produce high fructose corn syrup. There are two companies which dominate the market and all were operating at full capacity in 2010, producing an estimated 300-400 thousand tonnes dry basis. One of the leading companies will expand its capacity by 40-50% in 2011, focusing primarily in the domestic market which is operating with strong demand as the high fructose corn syrup price is reportedly lower than sugar.

Box 3: China's Starch Sweetener Sector

Cargill Starches & Sweeteners Asia (SSA) currently operates four plants in China producing corn sweeteners (also known locally as starch sugars): the Cargill Bio-Chemical Co., Ltd, a corn processing plant which produces starch, glucose, dextrose, malto-dextrin and modified starch in Songyuan, Jilin Province; the GBT- Cargill High Fructose (Shanghai) Co., Ltd, a JV between Cargill and Global Bio-Chem Technologies which produces high fructose-42 corn syrup; and the fructose-55 and glucose operations in Tianjin and Pinghu, Zhejiang Province.

One of the market leaders, Global Sweeteners Holdings Limited – a subsidiary to Global Biochem Technology Group Co Ltd (annual capacity of 100 thousand tonnes) - plans to build a new 60 thousand tonne HFCS-55 plant at its existing starch plant in Shanghai. In addition, a 100 thousand tonne plant will be built in Jinzhou. The projects will be completed by mid-2012. Global Biochem also took over Shanghai Hao Cheng, which manufacturers HFCS (output of 50 thousand tonnes a year), liquid glucose, liquid maltose and modified starch. The company's joint venture with Cargill sold a total of 50 thousand tonnes of HFCS in 2010 against 47 thousand tonnes in 2009.

Industry sources expected that starch sugar production would rise over 10% to 9 mln tonnes in calendar year 2011, somewhat below the 5-year average of 13%, and down on 2010 growth of 15%. Shandong, Hebei and Jilin province are the top three starch sweetener producing provinces, responsible for over 85% of China's total output. In the last few years, high sugar cane and beet prices caused starch sugar usage to grow. Major starch sugar end-users include the beverage, food processing, and pharmaceutical sector. High international sugar prices also caused starch sugar exports to rise in recent years.

Longer Term Potential for HFS

United States/Mexico

According to the USDA the general decline in HFS use since 2002 has moderated in recent years as the decrease in carbonated soft drink consumption has slowed. As a result, HFCS use is projected to level out for several years at the start of coming decade. Use is projected to rise somewhat over the latter part of the decade as sweetener demand increases and relative prices between HFCS and sugar become more stable[11]. An important corollary to this projection is that increased Mexican sugar exports to the United States under NAFTA has helped to facilitate the shift away from HFCS use by US food and beverage manufacturers. These exports are projected to average 1.64 mln tonnes, raw value over the next decade, representing about 15% of US sugar consumption. Three conditions in Mexico underlie this projection. First, beverage and food manufacturers in Mexico continue to substitute lower cost HFCS (mostly imported from the United States) for more expensive domestic sugar. Second, remunerative prices in

[11] USDA, 2012, USDA Agricultural Projections to 2021, Long Term Projections Report OCE-2012-1, February.

Mexico favour modest expansion of sugarcane area and increased sugar production. Third, the Mexican Government will continue to show willingness to import sugar from other nations to replenish low sugar supplies caused by large exports to the US market.

European Union

The European Commission's proposal to eliminate production quotas for sugar and isoglucose from October 2015 onwards would, if implemented (presently considered unlikely), create a significant opportunity for the EU isoglucose industry. In short the industry could boost capacities and benefit from economies of scale. Important determinants to the extent such an outcome would emerge include the future relative prices of wheat and sugar. Isoglucose would have the potential to displace as much as 3-4 mln tonnes of sugar demand.

China

China's HFS (and other corn sweetener consumption) is a relatively recent phenomenon and its growth in market share has been substantial. There would appear to be significant future potential for further HFS penetration from the current estimated 9% share of total sugar and HFS consumption. While production of corn-based alternatives helped to ease tight sweetener supplies in the past this could change in the future. The Chinese government is increasingly trying to rein in the use of corn for industrial applications and corn sweeteners are considered a non-food product. Even so there are new corn wet mills under development in China. For instance ADM made an announcement late in 2011 to construct a new mill in Tianjin with a local partner.

Creation of New HFS Markets?

Identifying in which other countries corn sweeteners could play a more substantial role in the future is a key challenge. Analysts tend to refer to the case of the United States where sugar prices were relatively high under the provisions of the US sugar programme and where grain prices were lower than average. Identifying countries where there may be general expectations for expensive sugar but relatively low priced grains would be a first step. Adding to these criteria would be relatively low HFS penetration at present. Countries that export sugar but import grains are unlikely to undergo a massive shift away for sugar to HFS, such as in Thailand, Turkey, Philippines, Colombia and Vietnam. The obvious exception of course is Mexico given its particular incentives under NAFTA. India and Pakistan are also unlikely to develop significant HFS consumption as both countries are cyclical in their production of grains and sugar.
Aside from the EU (discussed above) Russia potentially could see significant potential for HFS to displace sugar consumption[12]. The HFS market is presently small providing less than 10% of total consumption of starch syrups

[12] This section draws on an article from prepared by the Center of Investment and Industrial Analysis and Forecast at http://www.foodmarket.spb.ru/eng/current.php?article=877

in volume (50 thousand tonnes HFS out of a total of 563 thousand tonnes for all syrups). About 10 manufacturers produce starch syrups. This segment is the only one where domestic supply significantly exceeds import volumes. A key player controlling more than half of this category is "Glukozno-Patochny Kombinat (Glucose and Syrup Facility) "Efremovsky" OJSC (Tula Region, owned by Cargill). In terms of potential growth HFS is the most promising category among syrups but its development is restrained by several factors including:

1. the traditional devotion of Russian food processing industry to sugar and – in case of substitutes – to syrups (glucose syrup, maltose syrup, high-glucose syrup);
2. the dominance of one producer of HFS– Cargill's "Efremovsky" plant - with inevitable limits to pricing and supply terms; and
3. the significant geographical distance of the HFS manufacturer from the majority of would-be consumers (this factor is the major stumbling block in the development of product distribution due to the problem of syrup crystallizing during long transfers).

All this hampers full-scale development of the HFS market in Russia. Meanwhile positive drivers which could support future development of the market include an increasing interest in HFS. Several years ago major HFS consumers in Russia were branches of foreign corporations owning production facilities in the country and which had experience of HFS applications in the USA or Europe. The consumer base has been extended with the establishment of Russian manufacturers of fermented dairy products, juices, ice cream and fruit flavourings.

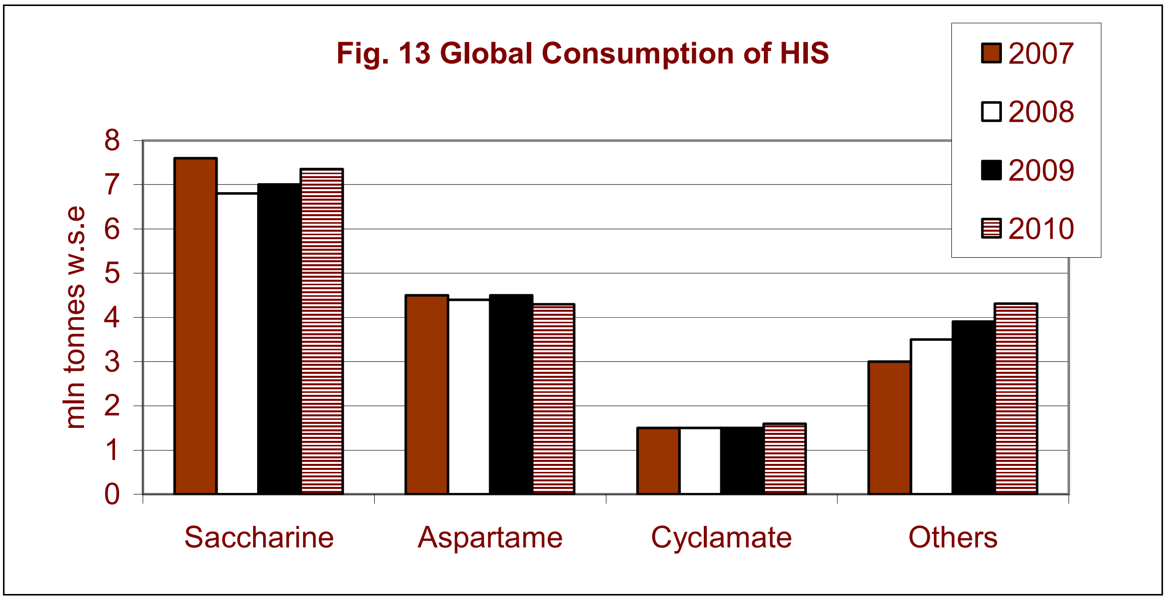
B. High Intensity Sweeteners (synthetic and natural)

High intensity sweeteners (HIS) - both synthetic and natural - represented 9.6 % of the global sweeteners market in 2010.˙ Yearly growth in HIS was around 4%, with global consumption rising to an estimated level of 17.6 mln tonnes wse. HIS[13] are significantly sweeter than sugar and because of their intensity, small quantities only are required to achieve a desired sweetness level in foods or beverages appealing to health and weight conscious consumers. By reducing the volume of sweetener required, their use permits lowers costs of transportation, storage and other costs typically associated with sugar. Whilst generally speaking, the absence of "bulk" and the low heat resistance limits the extent to which HIS can directly substitute for sugar, there is evidence of some direct substitution of HIS for sugar, particularly through blending of caloric sweeteners and HIS in non-diet products. However, data limitations mean that it is difficult to gauge the extent to which sugar loses market share through such a blending practice. Substitution of this type can most readily occur in the softdrinks sector, as for other foods, manufacturers would need to find suitable low calorie bulking agents (to replace the bulk previously provided by sugar) that lessen the cost savings from using HIS. The advent of

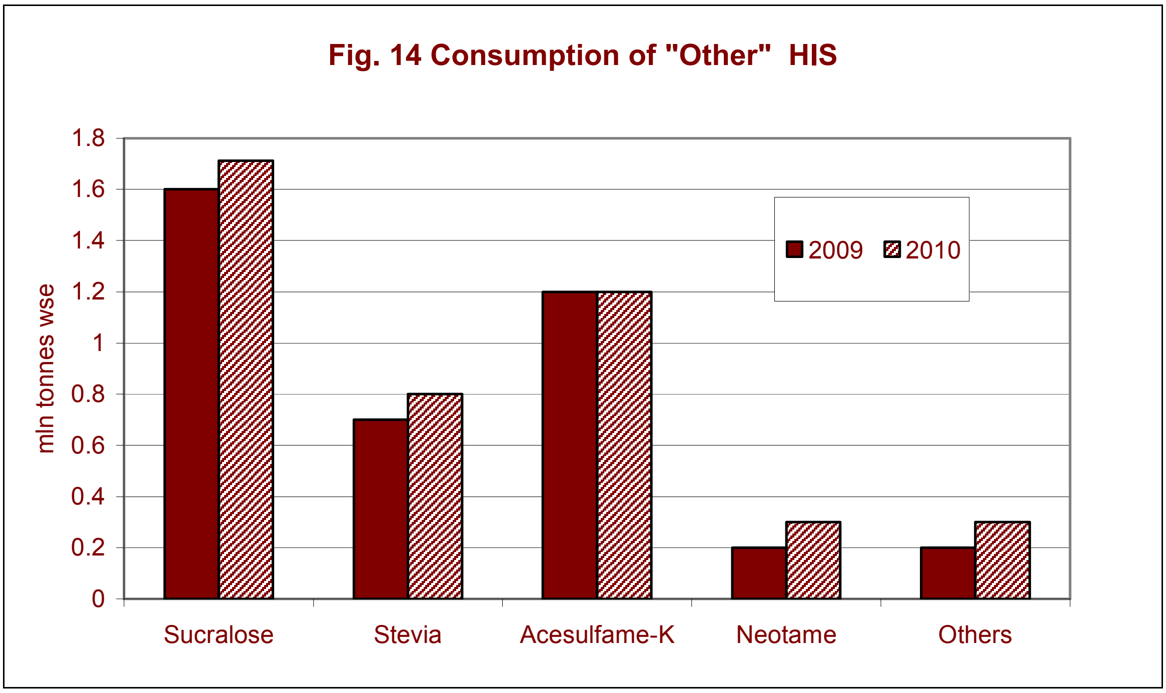
[13] Also often termed non-caloric sweeteners or intensive sweeteners.

even more potent HIS (neotame and advantame for instance) is compounding incentives for food/beverage manufactures to substitute sugar (and HFCS) with HIS in non-diet products.

Saccharin continues to dominate the global HIS market in terms of consumption levels (see Fig. 13)– around 7.4 mln tonnes wse in 2010 – with production and consumption centred in China. Aspartame, the second largest HIS with consumption at around 4.3 mln tonnes wse is seemingly losing ground in some markets to sucralose and in the US tabletop market to Stevia sweeteners. Acesulfame-K, with consumption at an estimated level of 1.2 mln tonnes wse (see Fig. 14), is seeing little growth. Whilst NutraSweet's Neotame sweetener has enjoyed additional success since 2010, and whilst Ajinomoto advances its newest sweetener, Advantame, it's been the spectacular hype surrounding naturally derived stevia based sweeteners that has caught the attention of market participants and commentators alike, even more so with its approval for use in the EU only last November. Stevia offtake is thought to have reached as much as 1.3 mln tonnes wse in 2011, up 53% over the estimated 2010 level with growth focussed in the United States.



Source: ISO Estimates



Source: ISO Estimates

Synthetic HIS

Saccharin: Still Dominant HIS

Saccharin continues to dominate the global HIS market in terms of consumption levels – around 7.4 mln tonnes wse in 2010. However this is considerably below a production peak of 8.1 mln tonnes wse achieved mid last decade. A production slump in the globe's dominant producer – China - started in 2007. Saccharin production is officially regulated and stricter environmental rules forced one of the largest of China's 5 designated production facilities to cease production (watercourse pollution). Then there were reportedly temporary production controls placed on industrial plants during the time of the Beijing Olympics.

With such a supply shock – (production falling by as much as 20%), saccharin prices rose severely - a 6-fold rise before easing back in the second half of 2009. China's production rose again in 2009 (back up to an estimated level of 7 mln tonnes wse and accounting for 41% of the global market for HIS), but is not yet risen back to the 2007 level, due to government set production quotas imposed on the four remaining producing companies in China (Kaifeng Xinghua Refinery, Tianjin North Food Ltd., Shanghai Fuxin Chemical Ltd. and Tianjin Changjie Chemical Ltd.). In short, the China Sugar Association (an association of sugar and saccharin producers), limits domestic saccharin sales to promote domestic sugarcane and beet production.

Saccharin production at China's remaining four national producers reached 16,976 tonnes (5.1 mln tonnes wse) in calendar 2010, according to China Sugar Association data. Domestic sales were pegged at 3,051 tonnes (0.9 mln tonnes wse) and saccharin exports at 13,884 tonnes (4.2 mln tonnes wse). Also according to the Sugar Association, saccharin production reached 14,428 tonnes (4.3 mln tonnes wse) in the first ten months of 2011, up 9.8% from the same period last year. Domestic sales were up 4.5% at 2,179 tonnes (0.65 mln tonnes wse), perhaps suggesting high sugar and HFCS prices contributed to expanded use. Exports rose by only 2.5% in comparison, to 10,710 tonnes (3.21 mln tonnes wse). Key export markets include the US, the EU, Brazil, India, Indonesia, Thailand, Mexico, Pakistan and South Africa. In 2010, a few small plants were opened illegally in Henan and Hubei province to take advantage of high domestic sugar prices. It's not known whether the plants have been shut down.

Whilst Asia remains by far the globe's major consumer of saccharin, the US government in June 2009 chose to continue imposing anti-dumping duties on saccharin from China (first applied in 2003). The decision to extend the duties for a further 5 years came after the ITC review concluded that cheaper imports of the sweetener would continue to damage the domestic sweeteners market. The antidumping order was first introduced in the US in 2003 after the Ohio-based company PMC Specialties Group, which claimed to be the sole domestic producer of saccharin in the US, filed a trade petition. This claimed that saccharin producers from the People's Republic of China (PRC) *"dumped"* their products in the US at prices lower than the normal value in China. PMC had all but ceased domestic production of saccharin and instead has been importing from the one Chinese company exempt from the anti-dumping duties and also from Korea.

Aspartame: US Remains the Stronghold

Global aspartame consumption (200 times sweeter than sugar) in 2010 is thought to have contracted slightly. Production at an estimated level of 4.3 mln tonnes wse in 2010 accounted for 24% of the estimated global HIS market. There has been limited consumption growth in Latin America and Asia whilst the loss of market share to sucralose in the UK has already been noted in the preceding section. The globe's 3 large aspartame producers – NutraSweet (the original patent holder), Ajinomoto (Japan) and Daesang (South Korea)– secured improved prices and higher production margins in 2009, partly due to lower saccharin supply. A return to more normal saccharin availability after the removal of the exceptional constraints on China's production during 2008 – which saw production there shrink by as much as one-fifth- saw a retreat in saccharin prices and consequently little room for higher aspartame prices – in the US at least. Ajinomoto is set to introduce new production methods to increase cost competitiveness.

According to UK market analysts Leatherhead, aspartame remains one of the most widely used and widely recognised of the intense sweeteners, mainly as a result of its strong position in the US, which accounts for 60% of global demand. The US is the biggest aspartame producing and consuming country.

However, the sector has come under increasing pressure from sucralose and stevia-based sweeteners, with its share of the US table-top sweeteners market having decreased by more than 15% in 2010, according to their report on the global additives market.

Leatherhead reports that the global market for aspartame decreased by 2.8% in 2010. The global aspartame market has been in a period of decline since the middle of the last decade, with global oversupply having eroded prices. This was a major reason for Holland Sweetener Company ceasing production in 2006. The aspartame industry has also been hit by falling demand in other parts of the world, such as Latin America and the Asia-Pacific region. The report also claims that neotame could make inroads into aspartame's territory in the soft drinks industry in the near future, which would result in a further decline for the category.

Aspartame, whilst being permitted in foods and beverages in both the EU and the US since the early 1980s, continues to be the subject of suspicion over food safety. The European Food Safety Authority recently conducted a detailed review of all the available scientific evidence and concluded that there is no new evidence that would require the EFSA to reassess its opinion that aspartame is safe. Although some studies have suggested possible adverse effects, the EFSA has scrutinised the methodology and findings of safety studies and has repeatedly reaffirmed its positive safety opinion. Ajinomoto, has also launched a PR offensive to change consumer perceptions of aspartame by branding it 'AminoSweet'[14] (with the catch-phrase "only sugar tastes as good").

There is significant production (and use) of Aspartame in China. From 2006 to 2010 production capacity for aspartame in China increased from 10,250 tonnes/year to 14,545 tonnes/year, in response to rising global demand for the HIS – see table 7.

Table 7: Aspartame Production Capacity in China

Company Name	Capacity (tonnes)
Jiangau SinoSweet Col Ltd	5000
Jiangau Changzhou Niutang Chemical Plant Co. Ltd	3000
Changzhou Yabang Kelong Col Ltd	2500
Changmao Biochemcial Engineering Co. Ltd	2000
Shaoxing Yamei Biochemsitry Co. Ltd	1000
Bejing VitaSweet co. Ltd	1000
Wujang Dechang Food Additives Co. Ltd	40
TOTAL	**14,545**

Source CCM international

[14] see http://www.aminosweet.info/

Cyclamate: Mostly Used in Asia

Asia continues as the dominant consumer: around 60% of world consumption of 1.6 mln tonnes wse in 2010. China is a major cyclamate producer and supplier in the world. Exported volumes of cyclamate from China increased rapidly last decade. There are around 10 major producers including Sinopec Nanjing Chemical Industry Co., Ltd., Jintian Enterprises (Nanjing) Co., Ltd., Hebei Jizhong Chemical Co., Ltd. and Shandong Hengda Chemical (Group) Co., Ltd. One of the largest producers is Zhong Hua Fang Da (HK) Ltd, manufacturing 35 thousand tonnes a year at their Shen Zhen plant and their Yang Quan plant. Key export markets include South Africa, Brazil, Argentina, Pakistan, Russia, Vietnam, Malaysia, Bangladesh, Turkey, Myanmar, Indonesia and in the EU, Germany and the Netherlands.

The conclusion that cyclamate can be safely consumed has been reached by an increasing number of governments throughout the world, having gained regulatory approval in more than 50 countries around. In the European Union, the EU Commission diminished the legal use of cyclamate in the EU Sweeteners Directive (94/35/EC) cleared in November 2002, forcing some food manufacturers to reformulate the sweetening system of their products. This was because the new directive restricted the use of cyclamate in water, milk and fruit juice based drinks as well as energy-reduced and no-added sugar drinks and a range of confectionery products, including sugar-free chewing gum and breath-freshening sweets.

In the United States cyclamate was designated GRAS in 1958 only to be later banned from sale by the FDA in 1970 after laboratory tests had indicated that large amounts of cyclamate had caused bladder cancer in rats. A petition for cyclamate reapproval is currently under review by the U.S. Food and Drug Administration (FDA).

Due to its relatively low sweetness intensity, cyclamate is always used in association with another low calorie sweetener, usually saccharin in a 10:1 mix which masks the off-tastes of both sweeteners. However it also has synergetic qualities when combined with acesulfame-K and aspartame (the combinations are sweeter than the sum of the individual low-calorie sweeteners). The maximum allowable usage level for cyclamate in the EU[15] means that it is not possible to use cyclamate on its own to produce an acceptable sweet taste.

Stable market for Acesulfame-K

Consumption of Acesulfame-K, the sweetener invented and supplied under the Sunett brand by the Germany based company Nutrinova is estimated to have reached 1.2 mln tonnes wse, or around 7 % of the global HIS market. According to Nutrinova the sweetener is approved in over 100 countries and

15 250ppm (as cyclamic acid).

used in more than 4000 products including; tabletop sweeteners (under the brand names Sunett, Sweet One, Swiss Sweet), desserts, puddings, baked goods, soft drinks, candies and canned foods. It is also used in oral hygiene and pharmaceutical products.

Nutrinova had successfully defended its sweetener in 2007 and 2008 against importation of generic acesulfame-K into the United States by the Ingredient House, which agreed to refrain from selling the sweetener in the US for the life of Nutrinova's US Patent until 2015, and in other countries until 2013.

Meanwhile Acesulfame-K is also produced by other companies in China. From 2006 to 2010 production capacity for acesulfame K in China increased from 13,620 tonnes/year to 20,520 tonnes/year. However output decreased from 7,325 to 4,185 tonnes. Some producers invested heavily on the basis of high prices before 2008. Intense competition between domestic and overseas producers led to an oversupply, resulting in very low operating rates and declining output. Domestic demand and overseas demand was also adversely impacted by the global financial crisis. (source CCM international).

Sucralose: Tate & Lyle Still Dominant

Sucralose – the HIS made from sugar - for several years provided a lucrative sweetener for Tate & Lyle (T&L) - the only company initially allowed to produce it and marketed as Splenda. T&L claim that in terms of value, since its launch, SPLENDA Sucralose has become the second largest HIS in the world, the largest in the US, and the largest in food globally[16]. Sucralose was granted approval by the US FDA on April 1, 1998 and approved for use in 15 food and beverage categories. In August 1999, the FDA approved sucralose for use as a general purpose sweetener, expanding the categories to include all food and beverage applications. Sucralose has been approved for use in foods and beverages in more than 80 countries including Canada, Australia and Mexico. It was fully cleared just in February 2004 by the European Commission for use throughout the EU under an amendment to the 1994 EU Sweeteners Directive (94/35/EC).

Global sucralose consumption is estimated to have risen by around 7 % in 2010, compared to around 10% growth in 2009, reaching 1.7 mln tonnes wse, and accounting for almost 12% of the global HIS market. Greater market penetration in the food and beverage markets of Europe and the US, as well as a lower price is thought to explain the healthy growth. In the UK, major supermarkets have replaced other intensive sweeteners with sucralose in the own-store brand products.

In May 2011 T&L announced it would re-start production at its mothballed sucralose plant in the US by mid-2012, as strong demand for the sweetener meant it needed more capacity from 2 global sites. The company put a pause

[16] http://www.tateandlyle.com/AboutUs/ourindustry/Pages/Ourindustry.aspx

on production at its site in McIntosh, Alabama, in May 2009, to concentrate production at its new, state-of-the-art facility in Singapore, opened in 2007 and using more efficient fourth generation production technology.

Splenda Sucralose's share of the global market for sucralose is still around 90% according to T&L. In its results statement issued at the time T&L said it saw good sales volume for HIS during the year (MAY 2011), but average selling prices were lower than the previous year as it had been securing long-term sucralose contracts with volume incentive arrangements. However, the decline in selling prices for sucralose is expected to moderate towards the end of this financial year as contracts are renewed.

T&L's third quarter results for 2011 showed that sucralose volumes grew further but below the particularly strong levels seen in the first half of the year. The report noted growth in the sucralose market but added that "despite press reports it is difficult to pinpoint any definite new global capacity". T&L's future focus is to ensure they don't lose any contracts to competitors. In a competitive sucralose market, analysts note that T&L should price the sweetener keenly to ensure significant market share in the future.

Producers in China have been actively operating their sucralose production lines or expanding their sucralose capacity since domestic surcalose producers effectively won an International Trade Commission (ITC) case instigated by T&L. In a final ruling early April 2009 the ITC found Chinese manufacturers of generic sucralose did not infringe T&L patents . In Mid-2011 there were reportedly 19 active sucralose producers in China. China's total output of sucralose reached around 700 tonnes in 2010 as against installed production capacity of as much as 1,000 tonnes. JK Sucralose Inc., Techno (Fujian) Biotechnology Co., Ltd. and Changzhou Niutang Chemical Plant Co., Ltd. Ranked as the top three producers in 2010, their combined output accounted for over 40% of the country's total. Apart from a limited amount used domestically, most sucralose produced in China is exported.

According to JK Sucralose (reckoned to be the globe's second largest producer) the market for the sweetener is poised for growth. The US in 2010 was the largest market, using more than 1.5 thousand tonnes (900 thousand tonnes wse) a year of the sweetener, followed by Europe, which consumes around 400 tonnes (240 thousand tonnes wse) a year. However, in the next few years, JK Sucralose expects the dynamic to shift, with China, India and South America emerging as the major growth engines. The company has recently received government approval for a major expansion of its facility, in a bid to cater to new demand. The company's new production facility is in the Bio-food Technopark, Yancheng City, in China's Jiangsu Province. JK Sucralose currently has production capacity of 500 tonnes of sucralose annually and expects to reach 1 thousand tonnes by the end of 2012. The expansion, which will be implemented in four phases, will see the company's capacity swell to 4 thousand tonnes within the next 6-8 years.

Niutang Sucralose claims to have completed significant expansion of its manufacturing facilities for sucralose, (and aspartame) to meet rising demand for these products. In 2010 the company produced about 110 tonnes whilst having a total capacity of 200 tonnes. The company plans to expand production capacity by 1 thousand tonnes/year. Techno (Fujian) Biotechnology Co., Ltd produced around 60 tonnes of sucralose in 2010 and has plans to extend capacity. Overall, China's sucralose production increased by 30% in 2010 due to strong demand in overseas markets.

Neotame Gains Ground

The NutraSweet Company reported that it's sales of HIS neotame grew by 20% between 2009 and 2010 – and the same percentage was expected in 2011. Neotame (a dipeptide sweetener derived from aspartame) is 8000 times sweeter than sugar, and is always used in sweetener blends, either with sugar and/or other HIS. When used with sugar, neotame is most commonly used to replace between 20 and 25% of the sugar. Because only trace amounts of neotame are required to mimic the sweetness of sugar, it contributes no calories.

Greater take up of neotame by new European users was also expected to make a significant contribution to growth in 2011, the first full year since the sweetener gained novel foods approval in the bloc (published in the Official Journal of the EU on 23 December 2009 as an amendment to directive 94/35/EC; assigned the E-number E961). The EU comes relatively late to the new sweetener, as it has been permitted for use in the US since 2002 and has also been given the green light by JECFA (the Joint FAO/WHO Expert Committee on Food Additives). NutraSweet's European distribution partners are Brenntag, covering Western and Eastern Europe, and Disproquima, covering Spain and Portugal. The sweetener has also recently gained approval in Norway, Turkey, Hong Kong, Vietnam and Israel. At present 90% of NutraSweet's neotame sales are outside the US – mostly in Latin America and Asia.

The NutraSweet Company, in a press release issued during May 2011, commended steps taken by The General Office of China's State Council to crackdown on food additive counterfeiters in the country where the company is battling against the counterfeit production of neotame. Local Chinese counterfeit production of neotame has increased significantly, flooding the Chinese market with substandard versions of the sweetener. The company said counterfeit product was having an adverse effect on their business in China and could pose a safety threat to consumers as there is no national product standard for locally produced neotame and thus no way of assuring proper manufacturing and handling of the company's patented additive. Nutrasweet reiterated that only neotame supplied by The NutraSweet Company or its official Chinese sales distribution partners was guaranteed to have been produced in accordance with the highest quality and safety standards.

Thumbs Up to Advantame?

Advantame is a HIS derived from the same amino acids as aspartame. While aspartame is around 200 times sweeter than sugar, Advantame is said to be 20,000 to 40,000 times sweeter than sugar. Ajinomoto's plan is to make composite products combining aspartame, Advantame and other artificial sweeteners in various proportions. As a first step, Ajinomoto set up equipment for making composite sweeteners at its plant in Shanghai. The company indicated it would begin operating similar equipment at its Tokai facility in Japan's Mie Prefecture late in 2010. In 2011 it would install the machinery at its US factory, followed up in 2013 at its plants in Brazil and Indonesia. The company expected to launch Advantame in the US early in 2011; Brazil, Philippines, India and Taiwan in 2012; and Japan, Europe and China in 2013[17].

Advantame has been approved for use in Australia and New Zealand. It had been deemed GRAS as a flavour for use in non-alcoholic beverages, chewing gum, milk products and frozen dairy products. A Food Additive Petition was submitted in April 2009 to the US FDA seeking approval for use of advantame as a sweetener in powdered beverages and for tabletop use and it is under review by the European Food Safety Authority (EFSA).

Natural HIS

Stevia: From Hype to Reality?

Key regulatory approvals

Stevia sweeteners from the native Paraguayan plant have attracted great interest recently. This follows the US FDA in 2008 awarding GRAS[18] status to a version of the stevia based sweetener Rebaudioside A (Reb-A) as a general purpose sweetener for food and beverages, and subsequently to other steviol glycosides. The FDA issued additional GRAS to GLG Life Tech for its Rebpure 97 sweetener, BlendSure sweetening system and for its PureSTV purified stevioside product. PureCircle also won a GRAS letter of no objection its blend – SG95 – containing 7 previously approved steviol glycosides as well as Reb-D and Reb-F. Elsewhere, private label stevia supplier Pyure Brands introduced a line of organic stevia extracts with GRAS status. The sweetener

[17] Ajinomoto has a second generation high intensity natural sweetener – **Monatin** – (1,400 times sweeter than sugar) which it hopes to acquire permits to lauch in the US market in 2014. Monatin is a natural amino acid derivative isolated from the root bark of a native plant (*Schlerochiton ilicifolius*) of northern Transvaal of South Africa.

[18] In the United States, food additives are subject to the FDA's GRAS process, and self-affirmed GRAS, assessed by a panel of independent experts, helps to reassure potential customers of an ingredient's safety.

was also approved by the Australian and New Zealand food and safety regulatory body FSANZ and Swiss authorities in the same year and by the French Food Safety Authority (AFSAA) in September 2009, after the country successfully applied for a two-year window to use it in advance of anticipated EU-wide go ahead. Stevia sweeteners did not receive approval by the European Commission for use in foods and beverages until November 2011. Stevia has already established itself as a significant sweetener in the French market where the beverage industry is currently the biggest user. Coca-Cola has used Truvia Rebiana in its Fanta Still product and in Eckes-Granini fruit juices under the Réa and Joker brand names. The dairy industry has also shown significant interest in stevia; Danone began using the ingredient in its Taillefine yoghurts in July last year. Table 8 lists all countries having granted approval to stevia sweeteners.

Stevia consists of 11 major steviol glycosides, as listed in table 9 the steviol glycosides are responsible for the sweet taste of the leaves of the stevia plant (*Stevia rebaudiana* Bertoni). The 3 major steviol glycosides found in the stevia plant tissue are: 5–10% stevioside; 2–4% rebaudioside A — most sweet and least bitter; 1–2% rebaudioside C. The use of stevia in beverage and food applications is not easy because of the number of steviol glycosides that exist in stevia extract. Rebaudioside A (Reb-A) and Stevioside (STV) are the two steviol glycosides that taste closest to sugar whereas Rebaudioside B (Reb-B) and Rebaudioside D (Reb-D) are the main causes of after-taste. To get the taste as close to sugar as possible, it is necessary to have the Reb-A and STV as pure as possible and to remove as much of the Reb-B and Reb-D as possible to trace amounts. If Reb-D and Reb-B levels are not controlled to trace levels within a limited range, they will not only affect the taste but also it will affect the consistency of the extract from one production batch to the next.

Rising health concerns, all-natural credentials and growing regulatory approval are all driving significant potential for stevia's markets to grow rapidly. The positioning of stevia sweeteners to complement sugar in stevia/sucrose blends in order to achieve a 10-20% saving in the use of sugar in some food products also underlies the considerable prospects for stevia use. Even so, the market for stevia sweeteners remains in its infancy. Estimates of market size vary but around 0.8 mln tonnes wse is thought to have been consumed world wide in 2010. Asia Pacific, where the ingredient has been used as a sweetener in some regions for decades, has the largest global market share at 35%, followed by North America (30%) and South America (24%). In Europe where its use has been limited due to pending regulatory approval until November 2011, the region has a much smaller 9 % share of the market.

Table 8: Regulatory Approval for Stevia Sweeteners

Country	Type of Approval (As of November 2011)*
North America	
USA	Food additive
Canada	Dietary supplement
Mexico	Food additive
Latin America	
Argentina	Food additive
Brazil	Dietary supplement
Chile	Food additive
Colombia	Food additive
Ecuador	Food additive
Paraguay	Food additive
Peru	Food additive
Uruguay	Food additive
Venezuela	Food additive
Asia Pacific	
Australia	Food additive
Brunei	Food additive
China	Food additive
Hong Kong	Food additive
Indonesia	Dietary supplement
Japan	Food additive
Malaysia	Food additive
New Zealand	Food additive
Singapore	Food additive
South Korea	Food additive
Taiwan	Food additive
Thailand	Dietary supplement
Vietnam	Dietary supplement
Europe	
EU	Food additive
Switzerland	Food additive
Russia	Food additive

*Food additive are substances added to food to preserve flavour or enhance its taste and appearance. A dietary supplement, also known as food supplement or nutritional supplement, is a preparation intended to supplement the diet and provide nutrients, such as vitamins, minerals, fiber, fatty acids, or amino acids, that may be missing or may not be consumed in sufficient quantities in a person's diet. Some countries define dietary supplements as foods, while in others they are defined as drugs or natural health products.

Coca-Cola and **Cargill**; Pepsi and **PureCircle** (the globe's larger producer of stevia sweeteners – see Box 4); immediately announced alliances to produce and market Reb-A in response to the December 2008 FDA approval. Coca-Cola and Cargill developed the Truvia brand stevia sweetener (also containing erythritol) – claimed as the first stevia based zero calorie sweetener to come to the market. **GLG Life Tech** also agreed to supply Cargill with high grade stevia extract beginning October 2009. Cargill has recently renegotiated its

10-year supply agreement with GLG Life Tech and consequently Cargill is no longer obliged to purchase the sweetener exclusively from GLG from September 30, 2011.

Table 9: Steviol Glycosides in Stevia Leaves

Steviol Glyosides	Sweetening power relative to Sucrose
Stevioside	150-300
Rebaudioside A	200-400
Rebaudioside B	300-350
Rebaudioside C	50-120
Rebaudioside D	200-300
Rebaudioside E	250-300
Rebaudioside F	NA
Rubusoside	110
Steviolmonoside	NA
Steviolbioside H	100-125
Steviolbioside	50-120

Cargill's Truvia tabletop sweetener reportedly is now the number two sugar substitute in the US behind Splenda (sucralose) with a 13% market share, ahead of Equal (aspartame) and Sweet'N Low (saccharin). After less than three years on the US market, Truvia sweetener has fundamentally changed the sweetener category and contributed to the growth of a previously stagnant retail segment. The category has grown 18% in three years.

Pepsi partnered with **PureCircle** to market the PureVia brand of the Reb A sweetener. PureCirlce is a UK-listed holding company headquartered in Bermuda with a purification plant in Malaysia, in 2010 claimed to produce 80% of the worlds high purity Reb A. PureCircle has also aligned itself with Cargill (and its partner Coca-Cola).

Box 4: China's key role in Stevia sweetener production

There are 6 major stevia sweetener producers in China, four of which are big companies, including **GLG Life Tech Corporation (GLG)**, **PureCircle (Jiangxi) Co.,Ltd** (Jiangxi Purecircle), Shandong Huaxian Stevia Co., Ltd. (Shandong Huaxian) and Qufu Haigen Stevia Products Co., Ltd. (Qufu Haigen). The remaining two are small-size and medium-size companies: Jining Aoxing Stevia Products Co., Ltd. (Jining Aoxing) and Heilongjiang Land Reclamation Huiju Hailin Stevioside Co., Ltd. (Heilongjiang Hailin). Stevia sweeteners are export-oriented products and estimated export volume account for about 60%-70% of total output of stevia sweeteners. China's producers are reportedly gearing up to satisfy an expected substantial market potential of high purity stevia sweeteners in the EU, including Reb-A80, Reb-A95 and Reb-A97. China's Stevia sweetener producers are choosing different ways to enter the EU market. Among them, Jining Aoxing and Jiangxi Purecirlce will enter directly on their own, while the other four are seeking to cooperate with overseas distributors and traders.

Alliances Emerge between Stevia and Sugar Producers

Major stevia suppliers have aligned themselves with sugar producers and distributers in many regions of the world. This is seemingly the first time sugar producers have worked with an alternative sweetener to such a broad extent. Stevia sweeteners are being positioned as a complement to sucrose, as they can be used to replace 10 to 20% of the sugar in food products. Propriety blends of sugar and stevia sweeteners can also be marketed as "low calorie sugar", and meet consumer preferences for an all natural sweetener.

GLG Life Tech Alliances

Sugar Australia (Australia's largest sugar refiner) signed a binding memorandum of understanding with GLG Life Tech in April 2010 to market a reduced calorie sugar/stevia blend. In Mexico, Grupo Azucarero Mexico (GAM) (the largest private producer of sugar in Mexico) will market GLG LifeTech's full line of stevia based sweeteners including Blendsure, Rebpure and RebSweet, as well as its Anysweet and SweetSuccess branded stevia extract-based sweeteners. GLG Life Tech also in October 2010 finalised a joint venture with Global Agrisystem Private Limited (Global Agri), a Katra Group company, for the marketing, development and distribution of GLG Life Tech's portfolio of stevia extracts in India and the Middle East. In China, GLG Life Tech signed an exclusive supply agreement with Fengyang Xiaogangcun Yongkang Foods High Tech Co. Ltd. (FXY) for distribution of its stevia products in the country. Late March 2011 GLG Life Tech announced that FXY had started to develop the production capacity necessary to support the supply of one mln tonnes of low calorie sugar (LCS) for the Chinese sweetener market. The LCS formulation will be one third the calories or two-thirds calorie reduction from regular sugar using GLG's BlendSure stevia extract product. In Europe, GLG LifeTech has announced the establishment of long-term deals with seven key ingredient distributors for the European market. The company said the new distribution network includes: Caldic Ingredients, ChemPoint, Emilio Pena, Gusto Faravelli, Keyser & Mackay; Nordmann, Rassmann and PK Chemicals.

PureCircle Alliances

In the United States, Purecircle in May 2010 partnered with Imperial Sugar to form Natural Sweet Ventures (NSV), marketing "Steviacane", a propriety blend of cane sugar and stevia. Similar to McNeil Nutritionals "Sun Crystals" - also a propriety blend of cane sugar and stevia. Also, PureCircle in March 2011, announced an amendment to its multiyear agreement with the Merisant Company, leading producer and distributer of tabletop sweeteners around the world. The revised agreement expands and extends the relationship between the two companies. PureCircle will meet all of Merisant's stevia ingredient supply needs, while Merisant's table top sweeteners which are sweetened with stevia extracts will display PureCircle's "Stevia PureCircle" trustmark. Also, in April PureCircle agreed a definitive agreement with Essentia Stevia for distribution of its stevia-derived sweeteners in 18 South American countries.

In Europe, PureCircle has made several significant alliances and joint ventures, including with: the DoehlerGroup; British Sugar; Tereos and Nordzucker. PureCircle in July 2010 signed an agreement with British Sugar to set up a 50/50 joint venture called Natural Sweeteners Company, which will develop and market a range of products for the food and beverage industries. The Company will operate in the UK, Spain, Portugal, Ireland, China and Africa and will develop products for food and drink manufacturers and retailers. PureCircle's 50:50 joint venture with the sugar company Tereos, announced August 2010, aims to provide sugar/stevia blends to the European market and gain a stronger international presence through Tereos' Brazilian facilities (Guarani). The JV is called *Tereos PureCircle Solutions* . The new partnership will develop and market sugar/stevia blends in France, Belgium, Czech Republic and Italy, as well as non-exclusively in other European markets, including Switzerland. PureCircle announced in March 2011 a 50:50 joint venture with Nordzucker for "steviasucrose": named NP Sweet. The 2 companies have created their joint venture company to handle development, sales and marketing of stevia and steviasucrose ingredients in Europe.

Cargill Alliances

Cargill has embarked on a pan-European roll-out of its stevia-based sweetener Truvia in response to EU approval. Rather than supply European retailers with its consumer products directly, Cargill has struck exclusive distribution deals with leading sugar producers in Spain (Azucarera), the UK and Ireland (Silver Spoon), France (CristalCo) and Italy (Eridania). Azucarera Ebro is the leading sugar producer in Spain. In Italy, Eridania has a longstanding loyal consumer base with 110 years of history. In France, Daddy is a 30-year-old Cristal Union brand, managed by CristalCo and one of the country's most emblematic sugar brands. Silver Spoon is the leading sugar brand in the UK's retail and foodservice markets.

Stevia Companies Sign Supply Deals with New US Producers

On the supply side, the commercial production of stevia is concentrated in China. Other less significant producing nations include: Paraguay, Argentina, Brazil, Chile, Cambodia, Columbia, Kenya, Indonesia, Malaysia, Peru, Vietnam, and India. China accounts for around 75-80 % of the world stevia leaf production. Whilst the production base is being extended in Latin America and Africa, concerns that demand could outstrip supply has led to significant investment in production capacity in the US.

PureCircle in 2011 signed a five-year deal providing for PureCircle to buy stevia from California-based S&W seed company and its subsidiary Stevia California, and which provides a *"strong commercial incentive"* for S&W to accelerate Californian stevia production. Elsewhere Sweet Green Fields (SGF) announced its first successful, commercial harvest of stevia grown in the US, which it claims can compete effectively on cost with China. The company said it has already begun signing multi-year supply agreements for its US crop, working with national and regional brands. SGF's stevia crop is grown in

California and it plans to expand there, as well as in other parts of the US. However, its processing plants are all in China so the US crop leaves will be dried in the US, then shipped to China for the extraction process.

Stevia Sweeteners Gaining Market Traction?

A study by Zenith International, a food and drink consultancy, estimates that worldwide stevia sales reached 3,500 tonnes in 2010 (875 thousand tonnes wse), a 27% increase over 2009. Zenith forecasts that the global market for stevia will reach 11,000 tonnes (2.75 mln tonnes wse) by 2014. At this level Stevia sweeteners would become the 3rd largest category of HIS consumption after Saccharine and Aspartame, exceeding that of cyclamates, sucralose, acesulfame K and neotame.

Stevia sweeteners have already significantly penetrated the US sweeteners market since approval in 2008. According to Market Researcher Packaged Facts[19], as reported in September 2011, Splenda/ sucralose remains the leading player in the US retail/tabletop sugar substitute market, although sales nevertheless dipped 5.6% from 2009 to 2010. Other high intensity sweeteners have also struggled to make headway in the tabletop market following the arrival of new stevia-based products such as Cargill's Truvia. Between 2004 and 2008, more than 2,000 stevia-sweetened products were introduced worldwide. In 2010, 76 stevia-sweetened product lines were introduced to the US market alone. Most of the new products introduced combine stevia with one or more other sweeteners. Sweet 'N Low (saccharin) and Equal/Nutrasweet (aspartame) all saw sales drop in 2010, while natural sugar substitutes saw sales increase. Truvia's sales jumped 73.7% between 2009 and 2010, albeit from a small base. Splenda fell from a 61% share of the retail sugar substitute market in 2007 to 45.5% in 2010, while Truvia and "Stevia in the Raw" accounted for 13.8% of the market in 2010. Equal/Nutrasweet went from 12.4% of the market in 2007 to 6.5% in 2010, and Sweet N' Low fell from 13.2% in 2007 to 11% in 2010.

Luo Han Guo (Monk fruit) Taking Off

Food and beverage makers internationally are keeping a careful watch on a natural sweetener from the Chinese monk fruit, although its uptake in the market is at present in its infancy. The intense sweetener from monk fruit is up to 300 times sweeter than sugar. While monk fruit has been used as a sweetener in Asia for centuries, it hit the headlines in the 1990s when Procter & Gamble patented a process for the extraction of Mogroside V and struck a deal with Amax NutraSource to distribute a concentrated version.
Although it has yet to be approved for use in foods and drinks in Europe, a branded version of the ingredient – Fruit-Sweetness – has since January 2010 had the green light for use in the United States. Its manufacturer, New-

[19] Drawn from a press release regarding Substitute, and Sweetener Trends in the U.S., 3rd Edition

Zealand-based BioVittoria is now pursuing regulatory approval in Europe. "Fruit-Sweetness" (a powered concentrate) is around 150 times sweeter than sugar and is produced via a patented process from fruit cultivated using the firm's patented plant varieties at a processing facility in Hamilton, New Zealand. Since the sweetener secured a letter of no objection from the FDA in 2010 affirming its GRAS status for use in foods and beverages, it has been tested by scores of top tier food and drink firms. Indeed in early 2011 the company argued that a raft of new food and drink products containing Fruit-Sweetness would very soon be available. According to BioVittoria the most compelling advantage over Reb A is that Fruit-Sweetness does not have the lingering bitterness characteristic of Reb A.

Late April 2011, Tate & Lyle announced that it had entered a five-year exclusive global marketing and distribution agreement for BioVittoria's zero-calorie monk fruit sweetener. Tate & Lyle is marketing the sweetener in the US under the "Purefruit" brand name. The company sees particular potential for the sweetener in reduced calorie products, rather than necessarily zero-calorie foods and beverages. Purefruit can be used in combination with nutritive sweeteners such as sugar or HFCS but it could be used in combination with stevia too. Whilst the monk fruit sweetener is not necessarily cheaper than other sweeteners, it could allow manufacturers to expand their business into areas in which they are not currently active, such as the "natural" product in both the mid-calorie and reduced calorie arenas. Under the deal with Tate & Lyle, Biovittoria has continued to manage the supply chain for the fruit concentrate, which is produced via a patented process from monk fruit cultivated in China using BioVittoria's patented plant varieties.

In January 2012, Tate & Lyle noted that dairy and beverages are proving the most popular application areas for Purefruit. A company spokesperson noted that customers were taking a toolbox approach when developing foods/beverages with Purefruit, so combinations with stevia, fructose, sugar are not uncommon, depending on the formulators' objectives around taste, cost, and labelling. A 'sweetened with monk fruit extract' message was also claimed to be resonating with some customers.

Another supplier, China based Layn achieved GRAS status in the US for its Luo Han Guo Natural Sweetener in May 2011. The company announced it could supply Luo Han Guo extracts with a wide range of Mogroside levels[20]. Coinciding with its newly achieved GRAS status, Layn reported that it was processing a bumper crop of Luo Han Guo from its GAP compliant farming operations, some of which are certified organic. Guilin Layn also produces "Lovia", a proprietary blend of Reb-A extracted from Stevia leaves and Mogroside V extracted from the Lou Han Guo fruit.

[20] The sweet character of the LHG fruit arises from the presence of extremely sweet terpene glycoside noncaloric compounds (called Mogrosides), which are natural components of the fruit.

Sweet Proteins – Thaumatin Most Advanced

One segment of nature's sweetener box still remains almost completely uncommercialised: 'sweet proteins.' Despite the identification of at least seven sweet proteins — including thaumatin, monellin, mabinlin, pentadin, brazzein, curculin, and miraculin— only two have been brought to market. Talin (**thaumatin** from Naturex, France -previously marketed by Nutraceutical Group, Spain) and Cweet (**brazzein** from Natur Research Ingredients (NRI). All of these proteins have been extracted from plants that grow in tropical rainforests. Sweet proteins tend to have slow taste profiles, characteristics that makes these sweeteners significantly different from sugar. Of these sweet proteins, thaumatin[21] is the best advanced in terms of product development and regulatory status.

Generally speaking though, commercial production of sweet proteins has so far been limited by the difficulty in cultivating the tropical plant sources of these proteins. Furthermore, repeated attempts to produce recombinant sweet proteins in microorganisms and transgenic plant systems have failed to yield these proteins at sufficiently high levels to make widespread commercialization economically feasible. This has been the experience with Brazzein until late in 2007 when Natur Research Ingredients (Los Angeles based) launched Cweet, its brazzein brand. The company would exploit a production breakthrough achieved at the University of Wisconsin, Madison where an expression and purification system suited to mass production had been developed. However the extent of commercial success with this sweet protein is not presently discernable. CSweet was declared at that time as not being available commercially for another 12 to 18 months, pending approval of a self-affirmed GRAS status that the company was preparing to submit to the FDA.

Thaumatins are a class of intensely sweet proteins isolated from the fruit of *Thaumatococcus danielli* (grown in West Africa). As yet, little is still understood or disclosed regarding thaumatin's commercial success despite its initial launch circa 1998 when Talin was sold by Tate & Lyle under a subsidiary called the Talin Company (in fact T&L had established large-scale plantations of Katemfe (thaumatococcus daniellii: a species of tropical flowering plant and the natural source of thaumatin) in Ghana, Liberia and Malaysia in the 1970s. This company changed hands several times and underwent a corporate merger before being acquired by The Braes Group, a European natural food ingredients company which in August 2005 was acquired by the Spanish based food industry ingredient company, Natraceutica. Thaumatin is presently still marketed under the Talin brand name but is now a Naturex product (a French based food ingredients company). Naturex acquired the Natraceutical group at the end of 2009.

[21] There are 5 separate sweet proteins which can be isolated from katemfe berries – thaumatins I, II, III, a and b.

It appears though that the biggest potential for Thaumatin lies as a flavour masker. Naturex claim that Talin is a multi-functional product and will simultaneously enhance flavor whilst masking unwanted elements of the Stevia sweetener taste in particular. An independent study by Naturex was commissioned to determine the effect that Talin has on the taste profile of Reb A and Stevia Extract blends. The results demonstrated that the addition of extremely low amounts of Talin to Reb A and Stevia blends considerably reduces the perception of bitterness. The sweetness intensity is also slightly increased - with increasing pH the sweetness of Stevia reduces and Talin helps to bring the level of sweetness back. Talin is approved for use in Europe (E957), as a sweetener and flavor enhancer and in the USA as a Natural Flavor (FEMA GRAS 3732). In total it is approved for use in more than 30 countries around the world. It was approved by the Joint FAO/WHO Expert Committee on Food Additives in 1985, is an authorised sweetener in the European Union (maximum levels must be observed when used as a sweetener), and is approved for use as both a flavour enhances and sweetener in Switzerland, the US, Canada, Israel, Mexico, Japan, Hong Kong, Korea, Singapore, Australia, New Zealand and south Africa, amongst others. Approval is being sought elsewhere.

In November 2011 Naturex received novel foods approval in China for Talin, opening the Chinese market to the product (flavour masking system). Following on from approval for stevia in Europe, Naturex claim there are massive opportunities for Talin, which is produced in the company's UK facility, stressing that fact that formulation challenges still exist around stevia in terms of its bitter aftertaste, regardless of which market a company is targeting.

C: Low Calorie Sweeteners

Although food technologists can use non-caloric sweeteners to match the sweetness of regular caloric products, invariably they face the texture or mouth-feel issues in developing sugarless or sugar reduced products. Ideal bulking agents that impart no calories and cause no gastrointestinal side effects remain elusive. Principal examples of bulking agents are polyhydric alcohols (sugar alcohols)[22] – also known as polyols. Together with tagatose and trehalose these are the key low-calorie natural alternative sweeteners to sugar. Polyols have shown strong consumption growth over recent years but discerning their use as sugar substitutes is difficult given their significant use as bulking agents with HIS, as well as in non-food uses (such as oral care and

22 These alcohols are reduced saccharides resulting primarily from catalytic hydrogenation and, for the most part, are less sweet and less caloric than sugar.

pharmactucials). In table 10 the caloric value and sweetness relative to sugar are detailed for low calorie sweeteners[23].

Table 10: Low Caloric Sweeteners

Low Caloric Sweetener	Caloric value	Caloric value relative to sugar	Sweetness relative to Sugar
	Calories*/gram	**%**	**%**
Polyols			
Erythritol$^{\delta}$	0.2	5	70-80
Isomalt	2.0	50	45-65
Lactitol	2.0-2.4	50-60	40
Maltitol	2.1	52	90
Mannitol	1.6	40	50
Sorbitol	2.4-2.6	60-65	60
Xylitol	2.4	60	100
Others			
Tagatose	1.5	38	90-100
Trehalose	3.6	90	50

*1 calorie = 4.2 kilojoules. $^{\delta}$marketed as non-caloric by major manufacturers

Polyhydric Alcohols (polyols)

Industrial applications constitutes the largest end-use segment of polyols. However, the application of polyols at the industrial level is relatively matured in the world market (mainly used in the production of polyurethane), so food & confectionery represents the fastest growing end-use segment. In this application polyhydric alcohols are bulk sweeteners derived from carbohydrate sources such as starch, sucrose and birch wood. The most important characteristic of polyols is that they behave similarly to sugar in final products, but attribute a much lower calorie content. The polyol family includes: sorbitol, mannitol, lactitol, maltitol, isomalt and xylitol. Not only do they mostly have lower caloric value, the sweetening power of polyols is less than that of sugar. In essence, polyols provide the bulk to a food product that would otherwise be provided by sugar. In many instance, they are used as a bulking agent in conjunction with intense sweeteners in low calorie (lite) products because HIS cannot provide bulk in a finished product or in food products labelled as 'sugar-free' or 'no sugar added'. A major attraction, particularly for the confectionery sector, is their non-carogenic pertaining to tooth decay. In addition, several impart a cooling sensation in the mouth, which is useful to confectionery manufacturers. One major issue with using polyols as sweeteners is digestive intolerance.

[23] There are also mildly sweet naturally occurring, low calorie sweeteners such as Fructooligosaccharides (FOS) and inulin (a specific type of FOS) which are not considered in this study.

Global consumption of polyols as a sugar substitute is difficult to ascertain given a paucity of data in the public domain. According to the International Starch Institute, global production of sorbitol reached approximately 800 thousand tonnes in 2010. Sorbitol being the most commonly used polyol (it is the least costly) held the biggest market share among similar polyols. Production of Xylitol is put at 200 thousand tonnes, Mannitol at 180 thousand tonnes and Malitol at 160 thousand tonnes. Even assuming all is used as sugar substitutes, the total equates to 0.9 mln tonnes in wse. Allowing another 100 thousand tonnes for erythritol, isomalt and lactitol brings global polyol production to 1 mln tonnes wse. This compares to consumption in 2003 of around 0.5 mln tonnes. However other sources suggest production is as high as 1.6 mln tonnes (see later in this section) but this includes for applications beyond as a sugar substitute.

Polyols are thought to have a sturdy future in light of ongoing safety concerns over artificial sweeteners and the expiry of production patents but at the same time reflecting consumers' perception of natural products and the continued interest of consumers in reducing sugar intake, especially in the United States and Europe. Whilst the following section provides important insights the relative importance of the food and confectionary segment as against the pharmaceuticals and other non-food uses remains unclear. Even so it's argued that at the global level, consumption for polyols in food and confectionary has seen considerable growth over the past decade and that this is likely to continue.

Key Drivers [24]

Worldwide, consumption of polyols in food and confectionery is estimated to have grown at an annual rate of 4% over the period 2001-2010. Second generation polyol sweeteners such as maltitol, xylitol and lactitol are replacing first generation polyols such as sorbitol. Danisco is the world's leading supplier of xylitol under the brand name XIVIA which is approved for food use in over 50 countries. Worldwide economic recession negatively impacted the polyols market during 2008 and 2009. A drop in demand for polyols in various end-use sectors including industrial applications, and food and confectionery among others noticeably reduced the overall market revenues. The decline in demand was more noticeable in the US and Europe. In addition, the market witnessed a robust rise in feedstock prices. To withstand the sharp increase in feedstock prices, several manufacturers chose to hike product prices. Discouraging market conditions forced several manufacturers to downsize their production activities or temporarily halt operations. Looking forward, a return to economic growth is anticipated to favour prospects for recovery and further growth in ensuing years. The market is likely to be driven by rising demand mainly in food and confectionery as well as the pharmaceuticals end-use segments.

[24] Drawn from press releases concerning a research report entitled "Polyols: A Global Strategic Business Report" prepared by Global Industry Analysts Inc, January 2011.

Europe represents the largest regional market for polyols worldwide. Rising demand for low-calorie foods is driving the growth of polyols market in Europe. The health benefits offered by these chemicals continue to attract European manufacturers to utilise them in pharmaceutical and oral care products. Asia-Pacific represents the fastest growing market with consumption projected to grow at a compounded annual rate of more than 3.0% to 2015 (implies lower average annual growth at the global level than seen over the past decade).

Food & Confectionery represents the fastest growing end-use segment. Food producers are seeking alternatives that would help in reducing the calorie content without compromising on taste and appearance. Further, food producers have assumed calorie reduction as an effective marketing argument for increasing sales. Of the several methods adopted to reduce the calorie content in food such as fat replacement, the substitution of commercial sugar with polyols has gained wide application. Though polyols behave similar to sugar in final products, they possess much lower calorie content. With features such as sweet taste and fewer calories than sugar, polyols are increasingly gaining popularity in the food & confectionery segment.

Sorbitol[25]

Sorbitol is the most commonly used polyol, accounting for 74% of the global output of sugar alcohols in 2010. In all applications, demand for sorbitol is largely a function of its combination of functional properties as a humectant, sweetener, bulking agent, stabiliser, softener and emulsifier, and its surface-active properties. Use in personal care products (mainly toothpaste), food, and confections and in the manufacture of vitamin C accounted for 80% of world sorbitol consumption in 2010; these applications will continue to account for over 75% of world demand in the near future. During 2007–2010, flat demand in the United States, Western Europe and Japan (caused by the cessation of vitamin C manufacture, but also by the general economic downturn) was overshadowed by high demand in other countries and regions such as Indonesia, India, Taiwan, China and the Middle East.

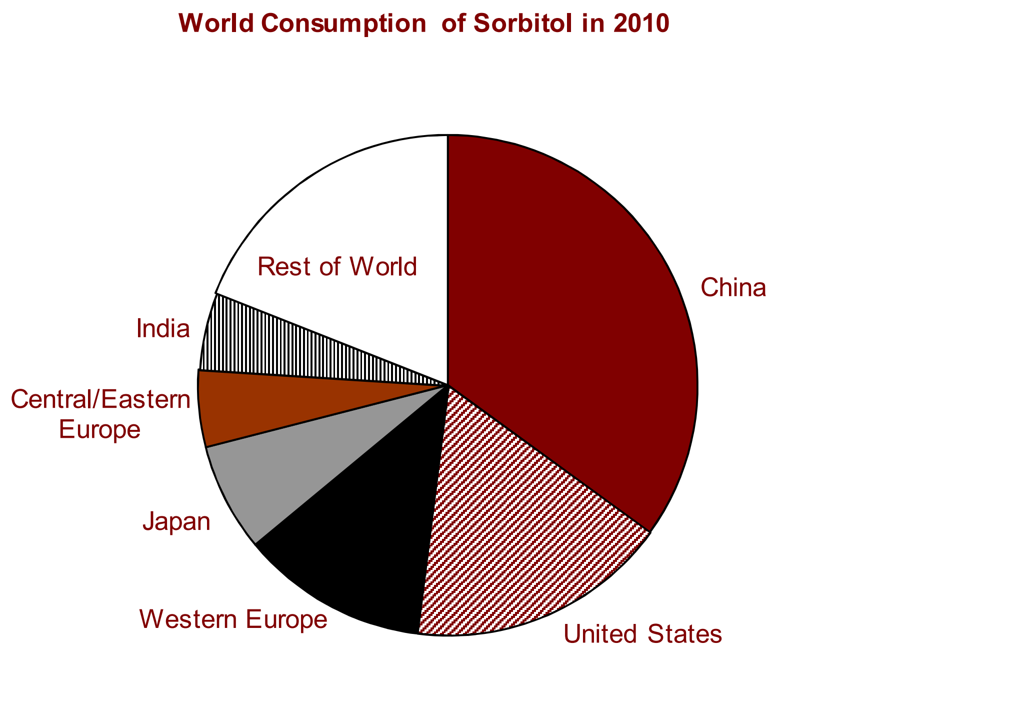
Fig. 15 shows world consumption of sorbitol. China is the largest single consumer, accounting for over one-third of world consumption in 2010. China also accounted for 33% and 39% of world capacity and production, respectively, in 2010. During 2007–2010, consumption of sorbitol in China grew at an average annual rate of just over 6%.

Sorbitol consumption growth in developing markets, such as the Middle East and Central and South America, is expected to be rapid; personal care products and food and confections are the main growth areas. During 2010–2015, sorbitol demand in Western Europe is forecast to grow at an average

[25] This section relies heavily on http://chemical.ihs.com/CEH/Public/Reports/693.1000/

annual rate of almost 1.5%. Growth in Central and Eastern Europe is expected at just over 2%, largely as a result of the increased production of personal care products. Consumption in Asian countries is expected to grow at annual rates between 0.2% (for Japan) and 3.5% (for Thailand). In short, the sorbitol industry is shifting to high-growth and high-consuming markets such as China and other Asian countries (excluding Japan).

Fig. 15 World Consumption of Sorbitol in 2010



Erythritol

The bulk polyol erythritol - a polyol that occurs in low levels in fruits and fermented foods– is benefitting from increased stevia sales, according to Cargill Sweetness (the company markets erythitol globally under the brand name Zerose). Strong US sales for Cargill's Truvia uses the firm's branded erythritol Zerose as a bulk carrier. Zerose allows Cargill to ameliorate the slight bitterness associated with Reb A, the stevia extract that Truvia contains. Despite the conjunction with stevia, which has boosted US sales, the EU's acceptance of erythritol's zero-calorie status in late 2008 really encouraged European uptake of the sweetener in its own right. Elsewhere, the Jungbunzlauer company has also introduced an erythritol/stevia sweetener blend: ERYLITE-Stevia.

Key Manufacturers

For most companies, polyols are an "add-on" business, growing out of the traditional cereal, starch or sugar processing businesses. Whilst the polyol business typically makes a minor contribution to turn-over of the companies concerned, they can contribute substantially to profits as they are a value-added product compared to standard grain derivatives, for instance. There are many companies producing polyols globally. Major producers in the global polyols market include Arch Chemicals Inc., BASF Group, BASF Polyurethanes GmbH, Bayer AG, Cargill Inc., Chemtura Corp., Corn Products U.S., Daicel Chemical Industries Ltd., Dow Chemical Company, Huntsman Corp., Nanjing Hongbaoli Co. Ltd., Perstorp AB, Roquette Freres, Shell Chemicals Ltd., SINOPEC Shanghai Gaoqiao Petrochemical Co. Ltd., and Stepan Co.

Several key players based in Europe and the United States are briefly discussed below. Significant producers are also based elsewhere: in Indonesia and China for example. According to a recent study[26] China is one of the largest sugar alcohol producers in the world. With over 50 active producers, China's total output reached 795,140 tonnes in 2010, taking 50% of the global total (implying global production of 1.6 mln tonnes).

Cargill Food Ingredients offers isomalt, erythritol, maltitol, mannitol, and sorbitol. Cargill significantly expanded polyol production capacities during the past decade. Roquette-Frêres offers a broad range, including sorbitol, maltitol, mannitol, xylitol, isomalt and isosorbide. Roquette set up polyol production units in the United States, South Korea and China. Archer Daniels Midland, one of the world's leading agricultural processors, produce sorbitol. Corn Products Specialty Ingredients acquired SPI Polyols, Inc in 2007. They manufacture and market a wide range of polyols including mannitol, sorbitol, maltitol, and hydrogenated starch hydrolysates. The acquisition made Corn Products a leading producer of polyols in Latin America with facilities in Brazil, Mexico and Colombia, and allowed the company to enter the US and Canadian markets primarily as a specialty polyols supplier. The company acquired the remaining stake in Brazil's Getec Guanabara Quimica Industrial, one of the nation's major producers of polyols, including liquid sorbitol and mannitol, and anhydrous dextrose. Mitsubishi Corporation's subsidiary Towa Chemical Industry Co. Ltd. was the first to produce Crystalline Maltitol beginning in 1972 at its Fuji plant located in Japan. Mitsubishi dedicated a new state of art Crystalline Maltitol production facility in Thailand on September 2005, using tapioca starch. Elsewhere, Beneo-Palatinit, part of SÜDZUCKER AG (Europe's largest sugar producer) is a major producer of Isomalt. Danisco Sweeteners markets lactitol in both anhydrous and monohydrate forms and Purac Biochem markets several forms of lactitol.

Other Low Calorie Sweeteners

Trehalose

Trehalose has 50% of the sweetness of sugar and has 10 % less caloric value. The sweetener is approved in over 40 countries worldwide including the US, the EU, Canada, Japan, Taiwan and Korea. Trehalose was created by Japan's Hayashibara company[27]. Cargill (Cargill Health & Food Technologies)

[26] CCM, 2011, Production, Market and Manufacturing Cost of Sugar Alcohols in China.
[27] Hayashibara Company Ltd headquartered in Shimoishii, Okayama, and is responsible for producing bulk sweeteners. Hayashibara Co., Ltd. was founded in 1883 in Okayama, Japan to produce starch-

won the sole European distribution rights to the ASCEND brand trehalose in July 2003[28]. Cargill also gained exclusive rights to sell the ASCEND brand of trehalose into the food market in North, South and Central America.

Today, Cargill's trehalose is manufactured from starch by a proprietary enzymatic process developed by the Hayashibara Company to produce a white crystalline powder under the brand name Treha Trehalose. Cargill notes that the sweetener is particularly appropriate for use in products which are frozen, dried or heated because one of its major functional properties is that trehalose stabilises protein function and structure. Trehalose is used in foods as a sweetener, a stabilizer and thickener, and a flavour enhancer. It is also used as a cryopreservation additive, where it protects cells from the effects of freezing and drying.

There is no information in the public domain about volumes produced or the pricing structure.

Tagatose

Technically know as D-tagatose, this sweetener has a physical bulk similar to sucrose and is almost as sweet, but has less than 40 % of sugar's caloric value. Tagatose is therefore characterised as a low-calorie, low-GI monosaccharide that can be used as a sugar replacer. When SweetGredients (a joint venture of Arla Food Ingredients and Nordzucker AG) decided to halt their joint venture to produce tagatose from a dairy feedstock in 2006, despite having novel foods approval (Arla received notice that, on March 1, 2005, its EU novel food application for tagatose was formally accepted by the Food Standards Agency, UK, under the EC Novel Foods Regulation (258/97)), Nutrilab -a subsidiary of Belgian company Damhert- stepped in and bought up existing stocks[29]. SweetGredients began producing tagatose for sale in the US food and beverage market in May 2003 - seven years after licensing tagatose from Spherix and two years after attaining FDA status. Spherix meanwhile retained all non-food rights to tagatose, which the firm marketed under the brand name of Naturlose. A formal supply agreement between Spherix

based sweeteners. Since that time the company has been at the forefront of technological advances in starch sugar chemistry. Many of the processes common to the starch industry were pioneered by Hayashibara. Some of the notable discoveries include crystalline maltose, crystalline maltitol, trehalose, pullulan, and a stabilized form of ascorbic acid.

[28] Prior to this, Hayashibara Company Ltd. and British Sugar plc had signed an Agreement in 2001 for the production, marketing and sales of trehalose, in Europe, after the European Commission in September had officially approved trehalose as a Novel Food (this agreement appeared to lapse).

[29] Tagatose is made from lactose and was first approved for use in food and beverages in the US, where it was recognized as GRAS in 2001. South Korean authorities approved later in 2003, and approval followed soon after in Australia and New Zealand in April 2004 (where Nutrinova Pty Ltd of Australasia won the exclusive rights to distribute tagatose). Arla Foods Ingredients marketed tagatose under the brand name Gaio tagatose, and had the world-wide rights to produce and commercialise the brand name Gaio® tagatose for food and beverage use. The sweetener was first introduced into the United States market in a Diet Pepsi flavoured "slurpee" in 2003.

Incorporated and SweetGredients, under which SweetGredients would supply Spherix with tagatose to sell as Naturlose, was first reached in May 2004. Nutrilab expected to begin commercial production of tagatose towards the end of 2010, pending agreement that it is substantially equivalent to lactose based tagatose, which already has novel foods approval[30]. Nutrilab had been putting together scientific documentation for the past two years, and it submitted an 800-page document to the Belgian food safety authority FAVV in late November 2009. The company is hoping receive a positive opinion this year.

Arla and Nordzucker had said it was not possible to identify a volume potential to justify continued investments. But Nutrilab saw potential to produce the sweetener using an enzymatic process and the raw material galactose, a waste product from a biofuels manufacturing group. It started working towards this goal in August 2007, once Spherix's patent on the tagatose molecule had expired[31]. In two to three years production is expected to be around 3,000tonnes a year, and in seven to nine years, it should be around 10,000 tonnes.

By mid 2011 Nutrilab was reportedly scaling up production of tagatose following regulatory approvals. The company said its plant would be capable of producing 5 thousand tonnes per year, with 70% tagatose crystals and 30% tagatose syrup, and was set to commence following the sweetener's EU approval recently and health claims wins. It and several other sugar replacers recently benefitted from a positive European Food Safety Authority (EFSA) opinion that found it could benefit teeth and glycaemic response. The European tagatose sector was stalled by novel foods procedures but that hurdle was cleared in August 2010. A recent study also found tagatose could be useful in acidic drinks. Products sweetened with Tagatose are distributed by Damhert Nutrition.

Alternative Sweeteners in the US Market[32]

US demand for alternative sweeteners is forecast to advance 3.3% annually through 2015. Gains will be led by continuing market penetration of relatively new entrants to the industry, including Rebiana-A (reb-A). More mature segments of the market, including HIS (such as sucralose) and polyols (such as sorbitol) will see more restrained, though still healthy, increases in

[30] The Commission considers foods and food ingredients that have not been used for human consumption to a significant degree in the EU before 15 May 1997 **novel foods** and **novel food ingredients**. To market a novel food or ingredient, companies must apply to a EU country authority for authorisation, presenting the scientific information and safety assessment report.

[31] Arla foods Ingredients acquired the rights to the low calorie sweetener in 1996 under a licence agreement from Spherix (Spherix licensed its patent rights for the manufacturing and sale of tagatose in foods and beverages to MD Foods in 1997, which in 2000 was merged with a Swedish dairy company to form Arla Foods).

[32] This section relies heavily on: http://www.marketresearch.com/Freedonia-Group-Inc-v1247/Alternative-Sweeteners-6738439/

demand. Market trends favouring less processed ingredients will drive well publicised usage of sweeteners that can be marketed as "natural." However, further consumer preference for reduced-calorie foods and beverages will ensure the ongoing use of ubiquitous sweeteners such as aspartame.

High Intensity Sweeteners to Remain Largest Segment

High intensity sweeteners, despite the drag of a declining soft drink market, will remain the largest product category among alternative sweeteners other than HFCS. This leadership position is rooted in their continuing domination of the large diet soft drink and tabletop sweetener markets. Aspartame will remain the leader in diet soft drinks, while the tabletop market will continue to be dominated by sucralose. Growth in other markets will be healthy, although HIS sweeteners are used in much lower quantities outside of their two mainstay applications.

Though expected to remain a fairly small share of the overall market, newer alternative sweeteners will register by far the fastest growth and generate the most interest among food and beverage processors, as well as among consumers. In 2010, the FDA approved luo han guo (monk fruit) for use in the US; while this product's potential remains to be seen, its natural profile is on trend with current consumer purchasing decisions. Furthermore, full-calorie agave nectar is gaining traction due to its positioning as a natural alternative to highly processed high fructose corn syrup.

Tabletop Sweeteners to Overtake Confections as Largest Food Market

While demand in diet soft drinks, the largest single outlet for alternative sweeteners, will decline, other applications will offer solid opportunities for growth as food processors and consumers seek healthier food options with fewer calories and less high fructose corn syrup. This trend will lead to above average gains for acesulfame potassium (ace-K) and sucralose, as well as for low-calorie polyols such as erythritol and xylitol, and newer options such as reb-A. By 2015, tabletop sweeteners will overtake candy and confection applications as the largest segment of the food market for alternative sweeteners. Sucralose-based sweeteners will maintain dominance, though inroads will be made by newer products with a natural profile. Other markets, including personal care products and pharmaceuticals, will remain fairly small.

Implications for Sugar

Sugar consumption showed the lowest average annual growth rate over the past 3 years as against HFS and HIS, suggesting some credence to the notion that high sugar prices have led some food confectionary and beverage manufacturers to use a higher proportion of sweeteners in blends so as to keep costs down. Even so, sugar clearly remains dominant with an 83% share of the global sweeteners market in 2011. Importantly sugar’s share of the global sweetener market has remained robust during the past decade:

accounting for around 83% in the year 2000 also. Will sugar's dominance continue to be the case going forward?

The extent to which developments in demand for and supply of sugar substitutes act to determine sugar consumption has to be considered in unison with all the other factors that impact sugar consumption. These factors include income growth, population growth, changes in price levels, and tastes and preferences, amongst other drivers. In the ISO's economic modelling of sugar consumption[33], only sweeteners consumed in a relatively large volume over the past 25 years could be incorporated, such as HFCS in the United States. This present study has not attempted to quantify any economic relationships between sugar consumption and consumption of alternative sweeteners, given the inherent data limitations. Despite the inherent issues, several key conclusions regarding general trends in competition between sugar and alternative sweeteners over the coming years can be drawn.

In the short term, competition between HFS and sugar will remain confined to a small number of countries, and primarily in the liquid sweetener sector (particularly beverages). This is because HFS and sugar will remain imperfect substitutes in some applications. In the confectionery and bakery industries, sugar remains the preferred sweetener because of its bulking, texture and browning characteristics. While HFS made inroads in 2010 and 2011, particularly in China and Mexico, penetration levels will likely remain sensitive to domestic sugar prices. Gains made by HFS in several marginal markets (eg. Philippines) may be transitory should sugar prices slip back from the record highs seen in the past 12-18 months. Longer term its possible for HFS to make inroads in other markets if the market environment is supportive (relatively high sugar prices and relatively lower grains prices), particularly the EU and perhaps in Russia.

Prima facie it would appear that since 2000, faster average annual growth for HIS at the global level has not been at the expense of sugar and HFS, but rather the sweeteners market has been growing as a whole. The competitive threat for sugar from HIS could increase over the medium to longer terms, not only reflecting a continuation of consumer demand for 'lite food and beverage' trends, but also reflecting the practice of blending sugar and HIS in non-diet products. Stevia-sugar blends are the latest addition to this market segment.

HIS are generally cheaper than sugar on a sugar equivalent basis and this difference should remain over the long term. However, the inherent limitations of HIS relative to sugar in some food applications will help to limit the extent of any losses in market share. Whilst the dominant HIS at the global level will continue to be saccharin, the two relatively recent "natural" HIS – Stevia and Luo Han Guo are posed for strength growth. Stevia sweeteners could grab considerable market share, initially at the expense of

[33] ISO, 2010, World sugar demand: outlook to 2020, MECAS(10)17.

other HIS, and could become the third largest consumed HIS after saccharin and aspartame within the next 5 years. Evidence in the United States shows other HIS have struggled to make headway in the tabletop market following the arrival of new stevia-based products. In a general context Stevia has a high growth potential. Since 2007, there has been a worldwide boom in the number of products based on Stevia extracts. Importantly of more than the 600 new stevia containing products launched in 2010, 60% were formulated with sweetening solutions combining Stevia extracts and sugar. Sugar-Stevia blends will also act to boost stevia consumption and eat away at sugar consumption. Other HIS possibly "eating away" at sugar consumption are anticipated to be sucralose, and neotame. On balance, whilst synthetic HIS will still dominate, its likely annual growth rates will be stronger for natural HIS. Sweet proteins, offering HIS from natural sources, remain for further commercialisation. Already many have been identified as having greater potential as flavour enhancers rather than as alternative sweeteners to sugar.

At a global level, HIS consumption growth will likely continue to be above the growth rate of sugar over the coming years (3-4% annually for HIS as against 2% for sugar). ISO projections (MECAS (10)17) puts world sugar demand in 2020 at 184.6 mln tonnes wse. Assuming the growth rate observed during 2005-2010 continues, then HIS consumption would conservatively reach 24.8 mln tonnes wse as against 17.6 mln tonnes wse in 2010. However, these sugar and HIS projections together infer only a 2 percentage point increase in the share of HIS in global sweeteners consumption (share of HFS held constant).

China's key and growing role in satisfying world demand for HIS is clearly shown in this paper. Whilst long being a key production and export centre for saccharin and cyclamates (as well as a key consumer), the nation now has considerable production and export capacity for aspartame, acesulfmae-k, sucralose and stevia sweeteners, as well as polyols. China's role on the supply side of the HIS market is likely to strengthen in the longer term with key manufacturers expanding production capacity particularly for sucralose and stevia sweeteners. Consumption of HIS by China is also anticipated to grow strongly with additional focus on health food with low caloric content.

Consumption of polyols as low calorie sweeteners potentially can grow considerably over coming years. Analysts note that food & confectionary represents the fastest growing end use for polyols and offtake could benefit should consumers in major markets turn their preference towards "natural" alternative sweeteners rather than synthetic HIS. Whilst polyols consumption could expand relatively strongly, they will remain comparatively much smaller in volume than HFS and HIS.

International Sugar Organization

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