World Market of Sugar and Sweeteners

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The study refers mainly to the previous works from Landell Mills "Sweetener Analysis", Rabo Banks "Sugar and Sweeteners" and Giracts "High intensity sweeteners update - Europe 1980-1992-2000". New developments and trends which have been published recently are incorporated, which are published frequently by F.O. Licht, Sugar and Sweetener Outlook (USDA), other sources and own surveys.

All informations given here have been compiled by the authors with their best knowledge. The presentations and interpretations are based on a twenty year long experience and research on the described items.

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1. World Sugar and Sweetener Market

There is no other food known such as sugar which is dividing so deeply the public opinion. For some, sugar is nothing else as a vitamin robbing molecule and responsible for obesity. Others are judging sugar as an important renewable source used as a sweetener, for aroma enhencing purposes and improving taste in many foods.

The production of sugars is common in the plant kingdom. Glucose as the most common form of sugars is used for energy storing in plants and animals need glucose as a energy source. It is estimated that the plant kingdom produces about 150 billion tons of sugars every year. However less than 1% is only used for human consumption.

This study shows the status and development of the the sugar and sweetener markets in the world and its regions with a special focus on EU. Two industry branches where intense sweeteners are generally applied are demonstrated. Consumer profiles in Europe in the use of intense sweeteners are discussed.

1.1. Definition of Sugar and Sweeteners

Sugar can be defined in various ways. Chemically a lot of sugar forms are known. Sugar in the meaning of poeples language often calls sugar all what is tasting sweet despite of its chemical characteristic. Legally the sweet substances are defined very clearly. For example sugar can only be named what is chemically characterised as sucrose. For this study the used definitions are following the legal approach.

Sugar
Sugar is a sweet, crystalline food supplement extracted from sugar beet and sugar cane. In addition to cane sugar and beet sugar other types of sugar are produced on a small scale including maple sugar in the northern hemisphere, corn sugar in Central America, millet sugar in dry regions and palm sugar in tropical countries. Cane and beet sugar however remain the principal sugar products traded on the world market. Sugar (sucrose) consists of glucose and fructose [α-D(+)-glucose and β-D(-)-fructose] with the chemical formula $C_{12}H_{22}O_{11}$.

Other forms of sugars
Another important source of sweeteness is the sugar of milk or milk sugar, chemically called "Lactose". It is a crystalline sugar present in milk, and separable from the whey by evaporation and crystallization. It has a slightly sweet taste, is dextrorotary, and is much less soluble in water than either cane sugar or glucose. Lactose comprising one glucose molecule linked to a galactose molecule. "Cow's milk contains about 4.7% lactose". The use is limited as many people experience symptoms of gas, bloating, and diarrhea after eating dairy products which could be due to lactose intolerance. A recently approved food ingredient called "Tagatose" is a new bulk sweetener on the basis of lactose. Tagatose is produced by a fermentation process using lactose as substrate.

Starch Sweeteners and Polyols

Starch sweeteners and polyols are sweeteners which provide bulk but with normally lower sweetness than sugar and perform other technological functions in the final food. Fructose, Inulin and the polyols produce a lower insulin demand than an equivalent amount of sucrose and are therfore used in some diabetic foods. Polyols or sugar alcohols are not fermented by oral bacteria to the same extent as sucrose and are therfore used to produce food and drinks with a reduced cariogenicity.

Intense Sweeteners

Intense sweeteners have a sweetness many times that of sucrose which have no other technological function in the final product. They are essentially non-caloric and are used widely in the manufacture of diet food. Intense sweeteners do not produce an insulin demand when metabolised and are therfore also suitable for use in diabetic foods.

Main Differences between Sugar and Intense Sweeteners

Sweeteners are by no means simply replicas of sugar. They fail to reproduce the wide range of the functional properties of sugar which are used by food manufacturers to manipulate colour, aroma, texture and shelf-life of their products; this restricts their use in many products. Some sweeteners affect taste adversely, while others are unstable when stored or cooked; some have failed clearance for human consumption. However, sweeteners can have some cost and functional advantages over sugar. Competition among the various sugar and nonsugar sweeteners is fiercest in soft drinks manufacture, in countries where its use and production is permitted and in countries with artificially high sugar prices.

1.2. World Production

The world production of sugar and sweeteners was in 2002/2003 165,7 million tons sugar equivalents. 82 % is covered by sugar (142,6 Million tons), 11,5 % by starch sweeteners and sugar alcohols (17,6 Million tons) and 7 % by intense sweeteners 11,6 Million tons). Figure 1 shows the actual production.

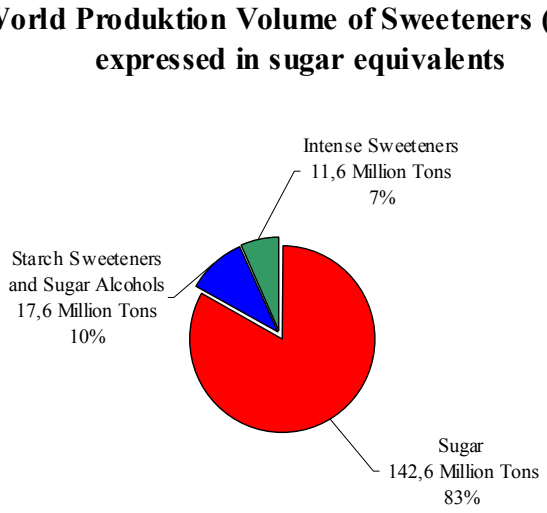

Figure 1: Volume of sweetener production (2002/2003); Source: Landell Mills, Zuckerindustrie

The total sugar and sweetener market represents a production volume of 49,6 billion US-$. Sugar is accounting for 75,2 % of production, starch sugars and sugar alcohols for 22,0 % and intense sweeteners only for 2,8 %.

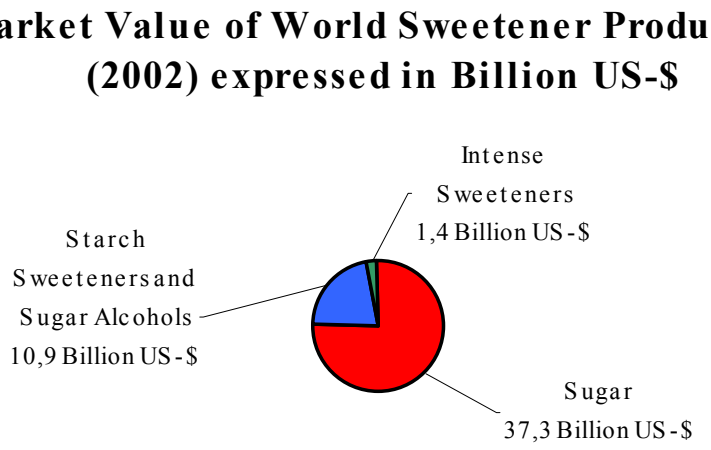

Figure 2: Production volume of sugar and sweeteners in billion US-$ (2003/2003); Source:Zuckerindustrie

1.3. European Union Sugar and Sweetener Market

The total volume of the sugar and sweetener market in EU is about 19.5 million tons (intense sweetener is calculated in sugar equivalents, s.e.). The European Union is the second largest consumer in the world of sugar after India and accounts for 10,4% of world consumption. Total consumption of sugar has increased, rising from 10 million tons in 1982 to 14.6 million tons in 2002/2003. Per capita consumption was reduced from 38,14 kg in 1982 to 34,5 kg in 2002.

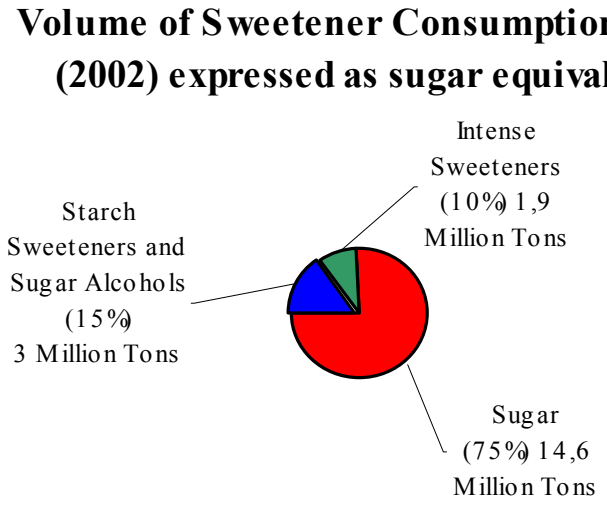

Figure 3: Sweetener market in Europe by volume (weight or sugar equivalents); Sources: Rabo Bank, Zuckerindustrie

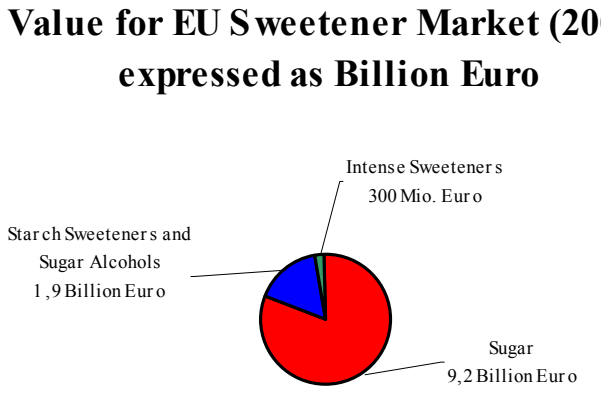

Figure 4: EU consumption of sugar and sweetener; Sources: Landell Mills, Rabo Bank, Zuckerindustrie

2. World Sugar Market

Global sugar consumption currently stands actually at 136,6 million tonnes (2002/2003). 70% of the production is consumed in the countries of production (see also figure 5). Consumption is expected to increase in the future at a rate of 1.2 % annually, to reach 150 million tonnes in the year 2010; this contrasts with growth in the last 20 years of 2% a year. Consumption growth is largely the result of population growth, reflecting the stability of human diets and sugar's role as a basic food product.

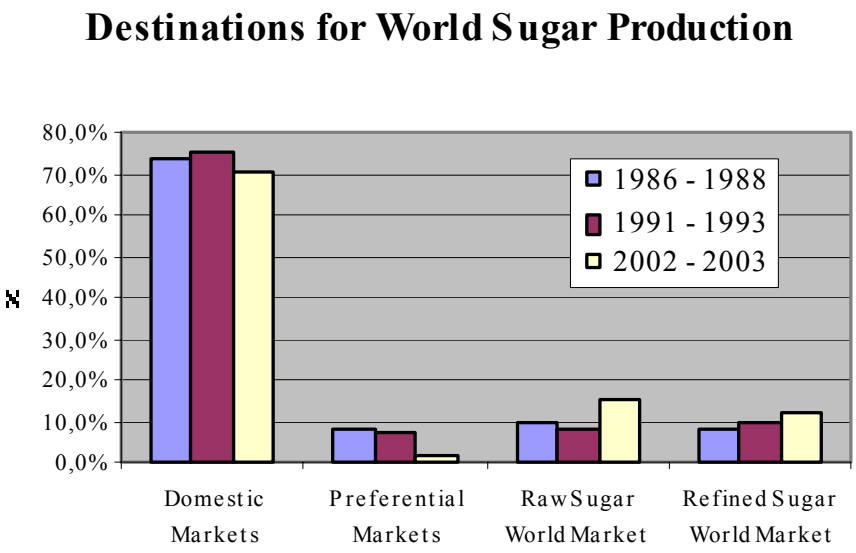

Figure 5: World Market for Sugar; Source: US Department of Agriculture; C.Czarnikow Sugar Ltd.

The largest share of sugar is consumed in domestic markets where production occurs. Only 30% of the total sugar production is contributed to the world trade. The importance of bilateral trade agreements (like US Tariff Rate Quota and Eu imports from ACP) is diminishing and accounts only to 3 Million tons of the whole sugar production. Raw sugar trade is increasing as a lot of countries still are puting up refinieries.

Asia is the world's largest sugar consuming region. This position has been achieved principally through rapid population growth (table 1). Despite this, however, Asia has the lowest capita sugar consumption of any region. Developing countries in general are expected to show slackening per capita sugar consumption growth rates in reaction to higher sugar prices. In developed countries, sugar consumption is not expected to change substantially. The global recession has also contributed to the slow rates of growth in consumption.

Table 1: Expected sugar consumption to the year 2000 (million tonnes); Sources: F.O. Licht, World Development Report; U.S. Bureau of Census

	Population in million		Total consumption (Million tons)		Per capita consumption (Kg)	
	1990	2000	1994	2002	1980	2000
Total Europe	725	728	30.8	33.8	41.2	36.3
North and Central America	424	486	16.8	18.6	41.8	37.7
South America	297	350	13.8	16.0	45.9	42.4
Asia	3,179	3,678	41.8	56.1	8.5	12.8
Africa	626	804	9.5	13.4	14.4	13.5
Oceania	24	30	1.2	1.5	45.8	44.3
World	5,275	6,076	113.9	139,4.8	2.0	20.3

2.1. Factors of Sugar Consumption

Sugar consumption in general is related to a number of factors. These include the income elasticity of demand, population growth, and the price of sugar and sugar substitutes. Cultural habits and domestic availability of sugar may also affect sugar consumption.

2.1.1. Income Elasticity of Demand

Changes in income affect sugar consumption, and these changes can be expressed in terms of income elasticity of demand.

In developing markets, a rise in per capita income leads to a rise in consumption. In developed countries, by contrast, there is an inverse relation between income and sugar consumption - concerns or health and diet and the availability of alternative sweeteners have sparked a negative relationship between income and sugar consumption (see figure 6). This difference shows up in average figures for income elasticity of demand, at 0.0 and 0.4 for developed and developing countries respectively. This means that in developing countries demand increases by 0.4%, when income increases by 1 %.

2.1.2. Population Growth

World population (table 1) is projected to increase by 733 million to 6.8 billion by 2010 and to reach about 8,1 billion people on 2030. As a result of their increasing population, the main growth regions for sugar consumption are Asia, Africa, South America and Central America. If per capita consumption continues to rise at current rates (averaging 0.8 kg for the past decade, after adjustment for the extraordinary low price), consumption will stand at around 150 million tonnes in the year 2010. This is 18,6 million tonnes above 2000 production levels and it should be relatively easy to increase production to meet this demand. Population growth is the most important factor for the increase in consumption in developing countries.

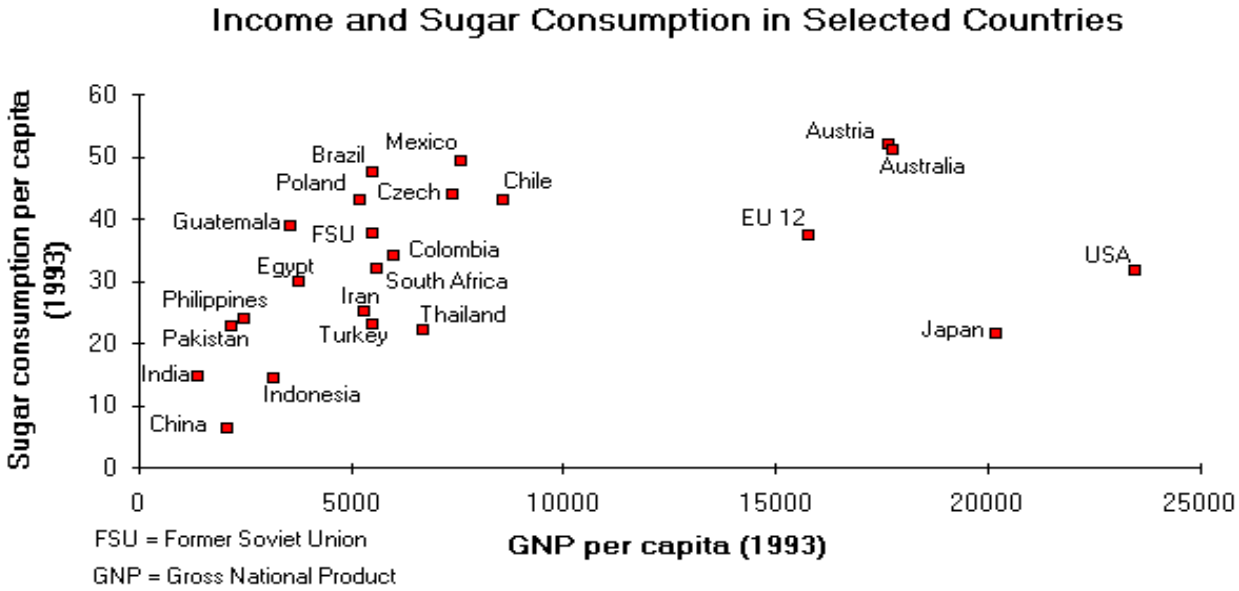

Figure 6: Income and sugar consumption in selected countries; Source: World Development Report, International Sugar Organisation (ISO)

2.1.3. The Price of Sugar and Sugar Substitutes

The effect of sugar prices on consumption is revealed by the price elasticity of sugar demand. The International Sugar Organisation (ISO), calculates an average price elasticity of 0.0 for developed countries; a price increase has no effect on consumption here. For developing countries a price elasticity of -0.1 is calculated; this means that 1 % price increase causes a 0.1% consumption decrease. Compared with other commodities, therefore, sugar consumption is not very price elastic, with comparable figures for coffee, cocoa and grain standing at -0.2, -0.3 and -0.5 respectively for developed countries.

Over the last decade there has been a transition from the situation where developed countries with price inelastic demand dominate the market to one where developing countries, mainly in Asia, with highly price elastic demand dominate. It should be

taken into account, however, that prices in most Asian countries are government controlled. This structural change on the demand side might reduce future market price fluctuations.

World market prices for sugar developed in the last 54 years between 5 ct/lb to 45 cent/lb. Actual the price is 6,9 ct/lb. The developments in the past is shown in figure 7. It shall be noticed that less than 30% of all sugar production is subject for international trade. More than 70% is consumed locally and do not appear on the world market. World wide stocks are now about 50% of annual sugar demand and continously increasing. That is the main reason for price decline.

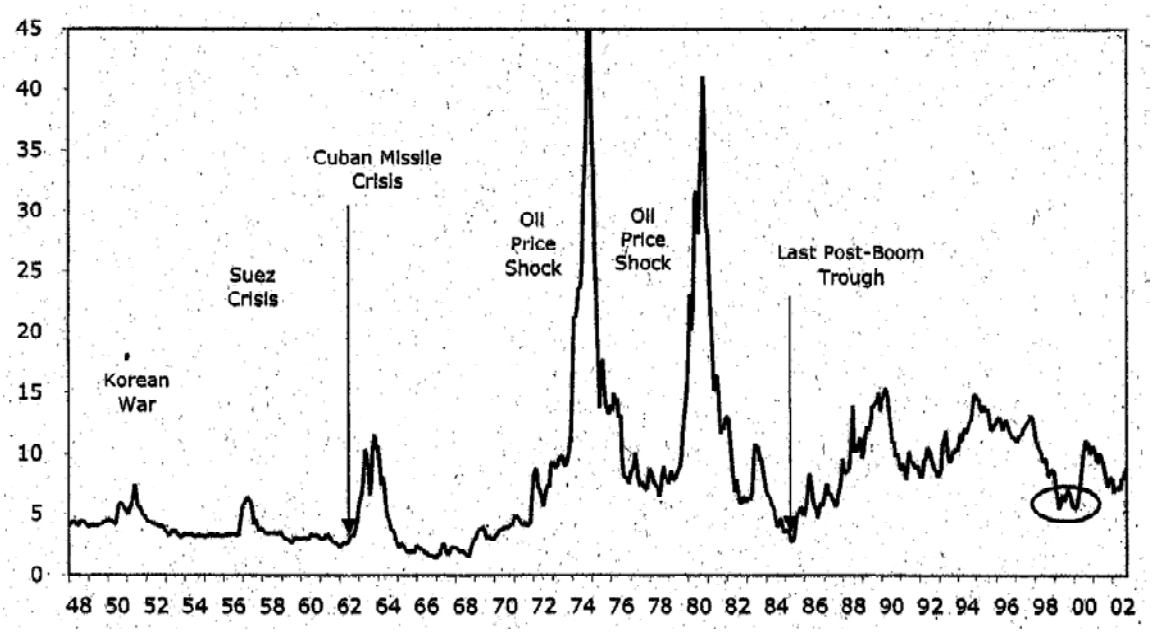

Figure 7: World markt prices for sugar (US-cent/lb fob New York) and their influence by political and economical crisis; Source:Pack, C.: How have the main drivers in sugar changed; Zuckerindustrie 128 (2003) p.120-123, Czarnikow Sugar Ltd.

This decline for world market prices brings the sugar industry of a lot of countries into competition problems. On world level only Brasil is able to produce with profits sugar from sugar cane. For sugar beet only the sugar factories of Germany and France may withstand a future sugar market opening within EU. The development of prices for intense sweetener have no impact on world market prices for sugar. This shows table 3 in an price index comparison.

Table 3: Index for sugar and sweetener prices (1987 = 100); Sources: LMC Commodity Bulletin, Sugar, January 2002

Commodity	**1998**	**1999**	**2000**	**2001**
World Raw Sugar Price	127,4	90,0	117,7	123,7
Saccharin	91,9	81,8	76,7	72,7
Cyclamante (non US)	94,2	137,2	145,8	123,2
Aspartame (non US)	52,0	48,3	37,0	36,0

2.1.4. Cultural Habits and Domestic Availability

In all developed countries, direct sugar consumption is declining as consumption habits change (Table 2). Indirect sugar consumption, on the other hand, has increased in line with consumption of ready-made sugar-containing food products (confectionery, ready made pastries, jams, etc.), drinks and take-away food. In addition, consumption of sugar-free 'diet' drinks is growing and points to the success of alternative sweeteners. Net direct sugar consumption in developed countries has decreased by 1.7 million tonnes in the 80ies. However, the decrease has stopped in recent years and it is now at about 10 kg per capita consumption. These patterns of changing consumption are restricted to developed countries, and have not yet been observed in developing countries. Sugar demand for food production is still increasing and rose up by about 8,0 kg per capita in the last 15 years.

Table 2: Direct and indirect sugar consumption in Europe; Source: Source Europe 1993, 2003

	1987		1992		2002	
	Total 1,000 tons	Per capita in kg	Total 1,000 tons	Per capita in kg	Total 1,000 tons	Per capita in kg
Direct human consumption	3,971	12.2	3,449	10.0	3,57	9,5
Industrial human consumption	6,960	21.4	8,300	24.0	10,38	27.6
Chemical	123	0.4	170	0.5	260	0.7
Feedstuffs	12	0,1	9	0,1	9	0,1
Total industry uses	7,096	21.9	8,467	24.6	11,031	
Total sugar consumption	11,068	34.1	11,916	34.6	14,300	37,9

Sugar consumption is closely related to domestic availability. If high levels of self-sufficiency occur, per capita consumption is also high. Examples are provided by Cuba, Swaziland and Brazil. Many countries, however, are not self-sufficient in sugar and must import sugar even though per capita sugar consumption is low. These countries can also be found in the Middle East and North Africa. Climate also has some influence on sugar consumption, particularly so when the consumption of soft drinks and ice creams is stimulated by hot summers.

A more detailed break-down for sugar end-use is given for Germany which will be found in similar situations in other developed countries.

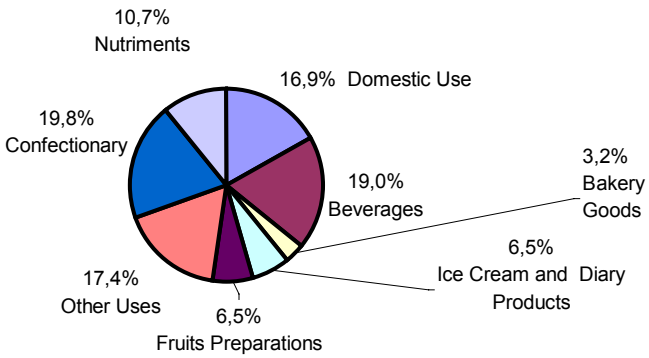

Figure 7: Sugar end-use in Germany for specific markets; Source: Südzucker 2003.

A break-down of German end-use sectors in real volume can be depicted from table No. 3. The tabel is displaying the campaign 2001/2002.

Table 3: Sugar consumption of end-use sectors in Germany 2001/2002

End use sectors	**Tons**
I. Domestic use	651.933
II. Industrial end uses	2.204.753
1. Chocolate Production	344.887
2. Confectionary Production	227.692
3. Long life bakery products	127.918
4. Nutriments Industry	195.655
5. Bakeries	80.968
6. Marmelades and canned fruits	160.817
7. Ice cream	25.058
8. Dairy products	148.873
9. Wine and Sparkling Wine	25.459
10. Breweries and Alkohol Manufactoring	59.574
11. Soft Drinks and Fruit Juices	450.954
12. Chemical and Pharmaceutical Products	26.405
13. Other uses (like animal feed)	330.493
Total	2.856.686

2.2. Sugar Consumption by Region

Increased sugar consumption is likely to be concentrated in developing countries (figure 7). Asia and Africa will show the most growth, with growth in Asia attributable to population growth rates, economic development and changing tastes and preferences. In Africa the effect of population growth is expected to surpass the decline in per capita sugar consumption. Cenetal America, South America and the Caribbean have shown a steady increase in consumption, mainly as a result of population increase. Sugar consumption in industrial countries will decline, although this fall should be more than offset by growth in Asia and Africa alone. In North America and the EU, consumption is stagnant: Population is only growing slowly and the effect of rising incomes on expenditure on sugar and sugar-containing products is minimal. In the USA, High Fructose Corn Sirup (HFCS/in Europe called HFS or High Fructose Sirup), is displacing ever more sugar, though at a slower growth rate than in the past. In Central Europe and the Former Soviet Union (FSU), consumption has decreased significantly as economic transformation takes place, however seems to be increased again.

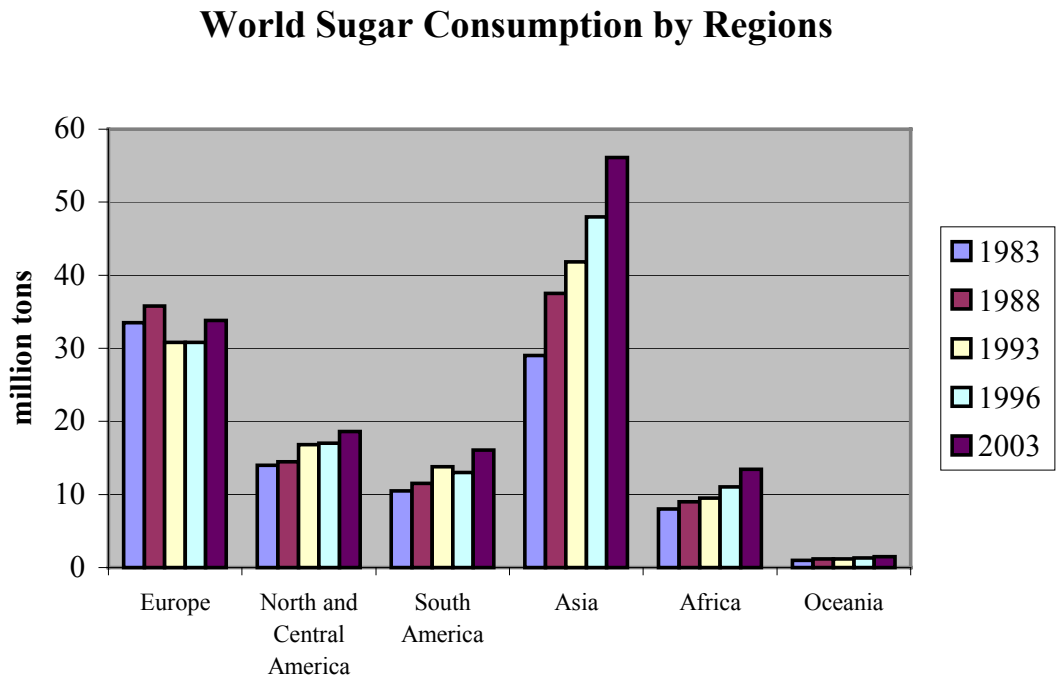

Figure 7: World sugar consumption by region; Source: ISO, Agra Europe, Zuckerindustrie

The three largest sugar consumers are India, the EU 15 and the Former Soviet Union (see table 3). Consumption in the FSU and the USA has fallen sharply, but has risen significantly in India, China and Pakistan. The highest per capita consumption occurs in Brazil, with Mexico in second place. China has the lowest per capita consumption, and this may suggest a growth potential in the short term.

Table 3: The worlds ten largest sugar consuming countries; Source: ISO, US Department of Agriculture, F.O. Licht, Zuckerindustrie

Country	Total sugar consumption (in million tons)				% of world consumption	Per capita consumption in kg		
	1980	1990	1996	2001		1980	1990	2001
India	5,60	11,07	14,75	20,0	14,5	8.3	13.4	15,7
EU	10,50	13,067	14,525	14,6	10,6	31.1	38.1	34,5
FSU*	12,40	13,40	10,27	10,5	7,6	46.7	46.2	37,0
USA	8,93	7,85	8,73	9,5	5,4	39.2	31.4	29,0
Brazil	6,55	6,62	8,30	9,8	7,1	54.	44.	53,1
China	4,30	7,13	8,50	10,2	7,4	4.3	6.2	6,3
Mexiko	3,23	4,43	4,25	5,0	3.6	46.5	54.5	46,7
Pakistan	0,89	2,29	2,93	3,6	2,8	10.7	20.4	24,5
Indonesia	1,73	2,65	3,25	3,2	2,3	11.8	14.8	15,8
Japan	2,70	2,83	2,60	2,4	1,7	23.1	22.9	19,0
Total	56,84	71,32	78,12	89,1	64,5	-	-	-

* FSU = Former Soviet Union

The consumption of sugar in Asian countries is increasing as a direct result of lower sugar prices and freer availability. In the last 20 years sugar consumption sugar consumption in Asia increase by 26 Million tons. 38% of world sugar consumption happens now in Asia.

3. World Market for Bulk Sweeteners and Polyols

Starch Sweeteners

Thanks to the development of new biotechnology processes, sweetness - once the unique feature of sugar cane and sugar beet - can now be derived from many other plants, and the feature production of sweeteners may make use of a wide range of crops such as corn, wheat, potatoes, rice and tapioca. The use of several agricultural products as a source for the production of sweeteners is spreading quickly. Table 4 summarizes the existing starch sweeteners, their uses and their sweetness compared to sugar.

High Fructose Corn Syrup (HFCS), known as isoglucose in Europe and HFCS in the USA, was developed from improved technology in the late 1960s. As a sweetener, it has become sugar's most direct and successful competitor, although it does have calorie-related drawbacks. HFCS is derived from corn, wheat, rice or potato starch and its fructose content varies between 42%, and 55%. It is produced in liquid form; this makes it particularly suitable as a sweetener in the soft drink industry, but also makes it expensive to transport. The costs of transport are limiting some of the growth potential that HFCS has in many developing countries; to compensate for this, some countries are participating in joint ventures to build plants to localize supply. In the EU the production of HFCS is under quota of sugar market.

A new development is the production of HFCS from inulin which is extracted from chicory roots and Jerusalem artichokes. Inulin consists of 85% fructose and 15% glucose; properly blended with a starch syrup it makes a product equal to HFCS-42. The production of inulin has been brought under EU-quota.

Fructose has developed primarily as a sweetener for diabetic use. Some agricultural products contain as much as 25% fructose (fresh, dry weight), including onion, garlic and chicory. Commercially it is derived from HFCS and invert sugar. It is formed in equal quantity with glucose (dextrose) when sucrose is inverted. Fructose masks the bitter taste of saccharin, an intensive sweetener.

Glucose, also known as dextrose, is a cereal-based sweetener developed for human consumption at the beginning of the last century. At that time, however, its application was restricted by the fact that it is significantly less sweet than sugar; indeed, glucose is primarily used along with sugar because of the complementary characteristics it possesses - it prevents sugar from crystallising, allows it to retain extra moisture and reduces its stickiness. Dextrose is mostly used in nutritious food and in medicine because of its energy value supply. A recent development was polydextrose, which is used as a fat replacer in low calorie food. It can be also used as a starch ingredient in combination with intensive sweeteners in low-calorie foods. It has a low caloric value, but no sweetness and is made by 90% of dextrose.

Lactose derived sweetener

Tagatose is a new low calorie bulk sweetener which is a lactose-derivate. Tagatose is a naturally occurring simple six-carbon ketose, $C_6H_{12}O_6$ and has a structure similar to fructose. The appearance is like sucrose and the tast is also sucrose-like, 92% as sweet as sucrose, odor-free, browns on baking, 62% w/w soluble in water at 30°C, stable at pH 2-7. The calories are less than 1.5 kcal/g. Starting material for the production of tagatose is whey.

Tagatose was approved in 1997 by FDA and a GRASS status was granted. Market entrance in EU is foreseen in 2004 after the approval of the admendment of the sweetener directive.

Polyols

Polyols are sugar alcohols. They are derived from starch through catalytic hydrogenation at simple or complex carbohydrates. They are closely related to sugar; chemically, the aldehyde or ketone group is replaced by a hydroxyl group. The energy content of sugar alcohols is roughly the same as sugar, but sugar alcohols have a lower caloric value as a food (table 4). The interesting properties of polyols give them many applications in the food, pharmaceutical, cosmetic and manufacturing industries. One characteristic property of all polyols is their negative heat of solution which gives a cooling sensation in the mouth; they also give a pleasant, clean, neutral taste with no aftertaste. Nearly all polyols utilized as bulk sweeteners can be crystallized as white odourless powders.

Table 4: Summary of starch sweeteners

Sweetener	Origin	Calories kj/g	Sweetness compared to sugar	Cariogenic	Diabetics	Bulk	Applications
HFS-42	Corn, wheat, potatoes, rice, tapioca	16	0.7	+	-	+	General use, largely in soft drinks, USA
HFS-55	id.	16	0.95	+	-	+	General use, mainly USA
Fructose	invert sugar	16	1.1 - 1.4	+	+	+	Soft drink industry and general use
Glucose (Dextrose)	Cereals	16	0.1-0.5	+	-	+	Nutrious food, medecines, blended with intensive sweeteners
Inulin	Chicory	4	0.9	-	+	+	Gives body to low caloric products such as chocolate
Sorbitol	Catalytic hydrogenation of glucose	8	0.6	-	+	+	Chocolate , bakery, chewing gum, dietary foods, toothpase
Mannitol	Manna ash tree	8	0.6	-	+	+	Chewing and powdered foods
Lactitol	Lactose	8	0.4	-	+	+	Bakery, chocolate, chewing gum, jam, ice
Maltitol	Corn	8	0.9	-	+	+	Chewing gum, confectionery
Isomalt	Saccharose	8	0.5	-	+	+	Confectionery, bakery, ice, dairy
Xylitol	Birch tree	8	0.7	-	+	+	

+ = yes, - = no

Sources: World Commodity Report 1995 and Food management 1994

Table 5: Starch sweetener and polyols as complementation or substitution to sugar

	Soft drinks	Jams	Ice cream	Confectionary	Candied fruit	Brewery	Bakery	Chocolate	Baby food
Fructose						L	C	C	
Isoglucose	S	L	S	L	L		L		
Dextrose							C	C	
Glucose syrup		L	L	C	C	C	L		
Maltodextrins			C			C			C
Invert sugar	S		S	L	L		L		
Sucrose	S	L	L	C	C	L	C	C	C

C = Complementary; L= Limited interchangeability/; S = Substitution

Source: European Cereals Starch Industries Association

3.1. History of Starch Sweeteners and Polyols

Dextrose was first commercially produced in the USA in the 1860s and convertion of glucose to fructose had also been invented in that time. However, control of the process at that time was not adequate to prevent discoloration and off-flavours.

HFCS or isoglucose was developed in the 1970s with the discovery of the enzyme glucose isomerase which transforms glucose into fructose. The commerzialisation of HFCS was much promoted by the 1974 sugar price boom in the USA.

The main use of starch sweeteners is in beverages, followed by confectionery, bakery products, dessert and bakery products.

Among the bulk non-sugar sweeteners, sorbitol came into use as a sweetening agent for diabetics in the late 1920s. This application was mainly developed in Germany. The first sugarless chewinggums were produced in the USA just after World War II. These used a blend of crystalline sorbitol, liquid sorbitol and glycerin as a substitute for the traditional association between glucose syrup and crystalline sucrose.

Sugar alcohols are mainly produced from glucose and are used in the chewing gum and confectionery industry.

3.2. Factors Affecting the Use of Starch and Polyols

Table 6: Factors affecting the use of starch sweeteners and polyols

	Benefits of starch sweeteners and polyols	**Disadvantages of starch sweeteners and polyols**
For the consumer	**1. Natural health image** Starch based sweeteners are produced out of natural raw materials. This improves their image with consumers especially when compared with synthetic intensive sweetener. **2. Dental health of polyols** There is increasing demand for food which is sugar free, and which contains substitutes which are non-cariogenic. **3. Health considerations** Sugar has a negative influence on blood insuline levels. **4. Cooling sensation** Polyols have a negative heat of solution which gives a pleasant, clean sensation in the mouth. This property is well suited for use in chewing gum and toothpastes.	**1. High caloric value** As people become more health conscious and count calories demand for starch sweeteners may suffer. **2. Dental care** As with sugar starch sweeteners are implicated in tooth decay. **3 Laxative effects of polyols** In some cases the high volumes required in food production have a laxative effect when consuming the particular products. Regular consumption however, can lead to adaption and increased tolerance.

	Benefits of starch sweeteners and polyols	Disadvantages of starch sweeteners and polyols
For the food manufacturer	**1. Cost advantage and efficiency in developped countries** Comparative cost advantages of sweeteners may increase their production at the expense of sugar and provide the market with low-cost sugar alternatives. 2. Bulk properties of starch sweeteners and polyols In some products, the smaller bulk of intensive sweeteners can have a significant effect on the final product. This is the case in chocolate, bakery products, confectionery and chewing gum. To compensate, therefore, manufacturers use what are known as 'bulking sweetener agents'. These are bulk ingredients like polyols and HFS which have similar properties to sugar from a technical pont of view. Glucose is often prefered in the production of sweets because it yields a better chewing quality. **3. Synergy** A mixture of sugar and glucose prevents crystallisation in food products. In addition, the use of glucose results in a lower freezing point in products such as ice. **4. Quality** The quality of starch sweeteners can be well guaranteed, even using different low value raw materials. **5 Food technology** Polyols have similar properties to sugar from a technical point of view. They are heat resistant, have a pH stability and are bulking sweetener agents.	**1. Flavour is inferior to sucrose** The sweetness of starch based sweeteners is generally lower than sucrose itself and taste may be slightely different. **2. Competition with low caloric intense sweeteners** Starch based sweeteners have to face competition from intensive sweeteners with low caloric value, because consumers are demanding more diet products. **3. Liquid form** The liquid form of the starch sweeteners increases transportation costs significantly. This affects their cost advantage negatively when used in food products. **4 Legislation** In some countries governmental institutions have to approve the use of polyols.

Source: Rabo Bank

3.3. Consumption of Starch Sweeteners and Polyols

Consumption of starch sweeteners has increased significantly in the last decade. This is mainly due to the increased use of sugar intake in confectionery and bakery products (see table 7). While the increase in caloric sweetener consumption is associated with changing eating habits in industrial countries, it remains a major question as to whether consumers will continue to switch to low-calorie foods and how preferences will develop in the Middle East, Asia and other growing markets.

Table 7: World sugar and caloric sweetener consumption (average annual growth, 1951-1996); Source: F.O. Licht, World Sugar Balances, Landell Mills

Year	Sugar Growth rate %	Caloric starch sweeteners Growth rate %
1951-1959 (1)	5.2	-
1960-1969 (1)	3.6	-
1970-1979	2.7	3.2
1980-1989	2.3	2.5
1990-1996	1.2	4.8
1997-2002	2,0	

(1) = HFCS was not available during these periods

In the EU, consumption of HFCS is very low because of the restraints placed by the HFCS quotas. Because of this the consumption of HFS in Europe has decreased compared to other countries (see table 8). In the USA, where there are no production quotas, the consumption of both sugar and HFCS has grown space.

Table 8: HFCS consumption compared to sugar between 1987 and 2003 (in thousand tons); Sources: Credit Suisse, First Boston Limited

		1987/1988	1992/1993	2002/2003	% change
USA	Sugar	7,435	8,141	11,090	+ 26,5
	HFCS	5,319	5,796	9,650	+ 40
EU	Sugar	13,203	13,491	14,600	+ 1,5
	HFCS	273	271	268	- 1
Japan	Sugar	2,882	2,851	2,566	- 1
	HFCS	716	801	897	+ 12

US per capita sweetener consumption is growing at a rate of 2,6 % a year, with HFCS taking an increasing share from sugar. In 1994 HFCS consumption accounted for around 38.6% of total sugar and sweeteners consumption versus 27%, in 1983. Although the growth in market share has slowed since the soft drinks industry completed its switch-over in the mid 1980s, the market for HFCS reached 46,5% in 2003. Total corn sweetener deliveries, consisting of HFCS 42 and 55, glucose syrup and dextrose, have increased significantly since 1970, from 2 million tons dry weight to 13.55 million tons dry weight in 2003. A 1,9% growth in the food industry and growth in new soft drinks and other beverages in the US market present a much more opimistic outlook for HFCS than a few years ago. Furthermore, US HFCS producers have the opportunity to increase capacity in order to be able to fulfil increasing

demand from Mexico, the largest growth market for soft drinks. For these producers it is cheaper to expand capacity in the USA rather than to start new production plants in Mexico.

In Canada the consumption of HFCS in 1993 stood at 137 thousand tonnes, a large increase compared to 1987/1988. In Japan the consumption of HCFS had a strong increase.

Table 9: World market of polyols; Source: Handbuch Süßungsmittel,

Polyol	**Tons**
Isomalt	15,000
Lactitol	15,000
Maltitol	15,000
Mannit	10,000
Sorbit	650,000
Xylitol	10,000
Total	715,000

4. World Market of Intense Sweeteners

Worldwide ten intense sweeteners are used. Those are acesulfame-K, alitame, aspartame, cyclamate, glycyrrhizin, neohesperidin dihydrochalcone (Neo-DHC), saccharin, stevioside, sucralose and thaumatin. Proposed for future use are Neotame, a new dipeptide sweetener of Monsanto and Brazzein, a polypeptide structure which shall be produced by genetically modified corn.

The sweeteners can be grouped into generations. The first generation is cyclamate, glycyirizzin and saccharin which have all a long history of human use. The second generation is acesulfam K, aspartame, Neo-DHC and thaumatin. To the third genaration belongs alitame, neotame, sucralose and stevioside.

The consumption of the most important sweeteners differs by world regions, mainly due differences in legislation and due to the wealth of the population.

Throughout the diagrams of this chapter, the standard sweetening powers associated with each sweetener are given in table 10. However, when used in blends, the effectice sweetening powers can be greatly enhanced.

Table 10: Sweetness power of the intense sweeteners; Source: Landell Mills

Sweetener	**Sweetness power**
Saccharose	1
Acesulfame-K	200
Alitame	2000
Aspartame	200
Cyclamate	30
Glycyrrhizin	50
Neo-DHC	1000
Saccharine	300
Stevioside	200
Thaumatin	3000
Sucralose	600

The concept of sucrose equivalence has been employed for comparing the sweeteners. This means that different sweeteners may be compared in terms of 'tons of sucrose equivalent'. This is fully valid when only the sweetening power of the substances is being compared. Thus in a large number of cases sucrose will fulfil other supplementary roles. In particular, sucrose and bulk sweeteners such as sorbitol and other polyols (Giract, 1994) often fulfil major 'mouthfeel' bulking and carrier functions. Levels of potentiation have also been applied to allow for synergistic effects between sweeteners.
In figure 8 the world consumption of intense sweeteners for 1995 is shown. The total consumption is estimated around 11 million tons sugar equivalents. The consumption

of alitame, NHDC, sucralose and thaumatin is not considered because it is less than 0.1 %. Still there are no new reliable figures available.

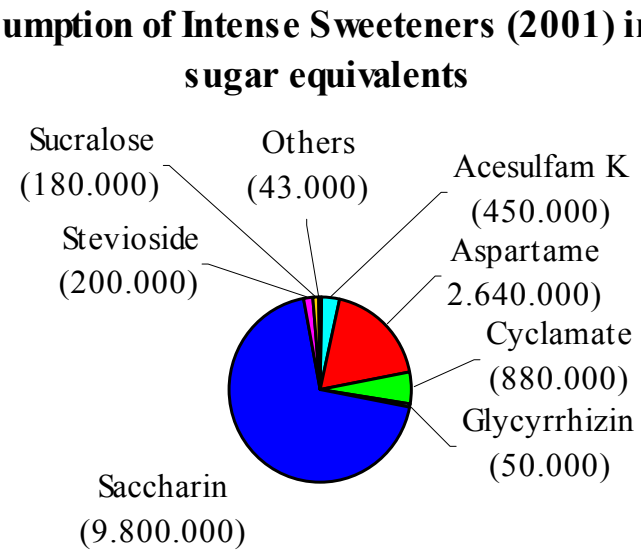

Figure 8: Consumption of intense sweeeteners in tons sugar equivalent, Sources: Rabo Bank, Giract, Landell Mills, own surveys

The break-down composition of the world intense sweetener demand is given in figure 8 and table 9. 94 % of the total sweetener consumption is matched by aspartame, cyclamate and saccharin. Worldwide 1 % of the sweetener demand is stevioside.

Table 11: Consumption of intense sweeteners in the world by tons (2001); Sources: Rabo Bank, Giract, Landell Mills

Intense sweetener	Tons
Saccharin	32.700
Cyclamate	29.300
Aspartame	13.200
Acesulfame K	2.500
Stevioside	1.000
Glycyrrhizin	1.000
Sucralose	300
Other Sweeteners	45
Total	80.045

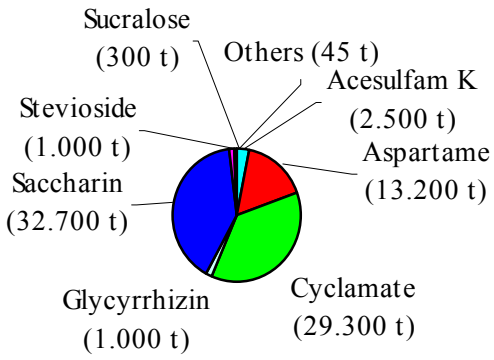

Figure 9: Composition of world demand for sweeteners in real tons; Sources: Rabo Bank, Giract, Landell Mills

One of the most distinctive features of the world sweetener marketin recent years has been the growing realisation of the economic attractiveness of blending sweeteners; both intense-intense blends and intense-caloric blends. With the fall in the relative price of intense sweeteners noted on page 34, alongside with the introduction of third generation sweeteners as sucralose, alitame and stevioside, and a relaxtion of regulations, for example, in adoption of the 1996 Sweetener Directive in the EU, the trend towards blending intense sweeteners has continued.

The same economic considerations and the desire to save money that have tempted EU food and beverage manufactures into using more intense sweeteners have also been observed. Regardless of prohibitive legisation, in other parts of the world such as Africa, Eastern Europe and the former Soviet states, blending is increasing in all parts of the world. To this development accounts also the introduction of a Acesulfam-K-Aspartame salt by Holland Sweetener Company which combines both sweeteners on a molecular basis. The strong descrease of Aspartame prices and the expected crash-down of Acesulfam-K prices once the patent is expired in 2005 may counteract this recent invention as a significant economic advantage for the food manufacturers may not longer be expected.

Basically there are three main benefits which can be obtained by blending sweeteners: flavor-masking, enhanced potency and sweetener synergy.

Blending of sweeteners obstacle a firm market observation. As sweeteners are also measured according to their relative sweetness compared to sugar, the use of blends brings difficulties in judging the market shares for individual sweeteners. The global impact of intense sweeteners is therefore in some aspects an approximation. The implication of blending is that the true impact of intense sweeteners upon global sweetener market is significantly greater than the figures shown here.

4.2 Legal Status of Intensive Sweeteners

Ten intense sweeteners are world wide in use. The mostly used are Aspartame, cyclamate and saccharine. Of minor use are acesulfame K, glycyrrhizine and stevioside. Only a very small consumption is known by alitame, NHDC, sucralose and thaumatine.

Table 12: Legal status of intensive sweeteners

Sweetener	EU	USA	Canada	Japan	Australia
Saccharin	Allowed	Allowed	Not allowed	Allowed	Allowed
Aspartame	Allowed	Allowed	Allowed	Allowed	Allowed
Acesulfame K	Allowed	Limited	Allowed	Not allowed	Allowed
Cyclamate	Allowed	Not allowed	Limited	Not allowed	Allowed
NHDC	Allowed	GRAS	Not allowed	Allowed	Allowed
Thaumatine	Allowed	GRAS	Allowed	Allowed	Allowed
Stevioside *	Not allowed	Dietary Supplement	Dietary Supplement	Allowed	Dietary Supplement
Glycyrrhizine	Not Allowed	Not allowed	Not allowed	Allowed	Not allowed
Alitame	Not Allowed	Allowed	Allowed	Allowed	Allowed
Sucralose	Allowed	Allowed	Allowed	Allowed	Allowed

GRAS= Generally recognized as safe
* Allowed as dietary supplement according the Dietary Supplement Health and Educatiom Act 1994. Not allowed as food additive.
Source: World Commodity Report and Rabo Bank

The maximum levels (mg/l) permitted in different food categories shows table 13 for acesulfame K, aspartame, cyclamate, NHDC and saccharin. Glycyrrhizine, stevioside and thaumatine are mainly used according Good Manufacturing Practise (GMP).

Table 13: Legislation: directive sample maximum levels (mg/l); Source: Giract

Food	Acesulfame K	Aspartame	Cyclamate*	Saccharine	NHDC
Soft drinks (general)	350	600	400	80	30
Soft drinks (gaseous)	350	600	400	100	50
Ices	800	800	250	100	50
Chewing gum	2000	5500	1500	1200	400
Sugar confectionary	500	1000	500	500	100
Bakery	100	1700	1600	170	150

* = Subject to be changed in EU, future limit may set between 100 mg/l to 250 mg/l
NHDC= Neohesperidine Dihydrochalcone

4.3. Characteristics of Intensive Sweeteners

The main characteristics are shown in table 14. The main differences are in sweetness power and in stability (see table 14; stability). Stevioside has in contrary to all other intense sweeteners a moouth feeling effect, which resembles to sugar.

Table 14: Characteristics of intensive sweeteners

Sweetener	ADI (Acceptable daily intake) in mg/kg	Origin	Sweetness compared to sugar	Stability	Possible Applications
Saccharin	5	Synthetic	200 - 700	Heat + Heat/pH +	Table top, processed fruit, soft drink
Aspartame	40	Synthetic Aspatic Acid and Phenlyalanin,	100 - 400	Heat - Heat/pH -	Beverages, confectionary, dairy products
Acesulfame K	15	Synthetic	100 - 200	Heat + Heat/pH +	Beverages, bakery, dairy, table top sweeteners, confectionary products
Cyclamate	11	Synthetic	20 - 30	Heat + Heat/pH +	Table top, processed fruit, soft drink
NHDC	5	Synthetic	1500 - 2000	Heat + Heat/pH +	Animal feed
Thaumatine	Acceptable, No ADI necessary	Natural Thaumatococcus (West African Katemfe Plant)	2000 - 3000	Heat - Heat/pH -	Chewing gum, beer
Stevioside	Yet not finally fixed*	Natural (Leaves of Stevia Rebaudiana)	100 - 300	Heat + Heat/pH +	All types of food categories
Glycyrrhizin	Yet not fixed	Natural (Licorice Root)	50	Heat + Heat/pH +	Confectionary, limited use in soft drinks, due to licorice aftertaste
Alitame	Not allowed yet	Synthetic	2000	Heat - Heat/pH -	Baking indefinite shelf-life, cheap
Sucralose	15	Synthetic	600	Heat+ Heat/pH +	Confectionary, canned fruits, dairy, baking extrusion

Remarks: + = stable, - = not stable; * 10 mg/kg proposed; Sources: World Commodity Report; Food Management, Industry Sources

4.4 Factors Affecting the Use of Intensive Sweeteners

Table 15: Factors affecting the use of intensive sweeteners

	Benefits	**Disadvantages**
For the consumer	**1. Dietary aspects** As people become more conscious of health-related issues, consumption of sugar-free products will increase. World sales of low calorie carbonated drinks have quadrupled in the space of ten years, from 538 million litres in 1983 to 2,519 million litres in 1993, and sales of sugar-free sweets are expected to increase similarly. **2. Dental health** There is increasing demand for food which is sugar free, and which contains substitutes in which are non-cariogenic.	**1. Health** Some intensive sweeteners are suspected of having an adverse effect on health; while in most cases this will only be true if the intensive sweetener is consumed in excess, health warnings are sometimes obligatory on product labels: aspartame, saccharine

□	**Benefits**	**Disadvantages**
For the food manufacturers□	**1. Cost advantage and efficiency** Intensive sweeteners have a clear cost advantage. In addition they are attractive to the food manufacturer combining acceptable taste characteristics with the important aspect of shelf-life: most sweeteners are stable, especially under the low pH conditions which prevail in softdrinks. **2. Sweetness and taste** Intensive sweeteners are many times sweeter than sugar and are added in small amounts to achieve the desired sweetness. Blends can be used to overcome taste disadvantages. **3. Synergy** Widely used combinations include Aspartame -sacharine and saccharine-cyclamate. Such combinations may produce better taste characteristics and greater consistence	**1. Taste** Sweetness is a subjective phenomenon, perceived differently from individual to individual. Different intensive sweeteners produce different taste sensations, not all of them desirable, and some leave an unpleasant aftertaste. **2. Consistency and recipe** Intensive sweeteners do not achieve the same consistency as sugar. Functional properties which may be affected include solubility, viscosity of solutions, hygroscopicity (the amount of moisture taken up) and crystallization. **3. Legislation** The need to prove safety is an important brake on the launch of new intensive sweeteners on the market.

Source: Rabo Bank

4.6 Development of Intense Sweetener Demand

In 2001 the world market volume of intense sweeteners was about 14,2 million tons sugar equivalents. Nearly 70% of the world demand is satisfied by saccharine, whereas aspartame accounts for 18,5%. Cyclamate is on the third range with about 6,2%. All other sweetener (Acesulfam K, Alimate, Neo-DHC, Stevioside and Sucraloses) are accounting with the same share as Cyclamate to the world demand.

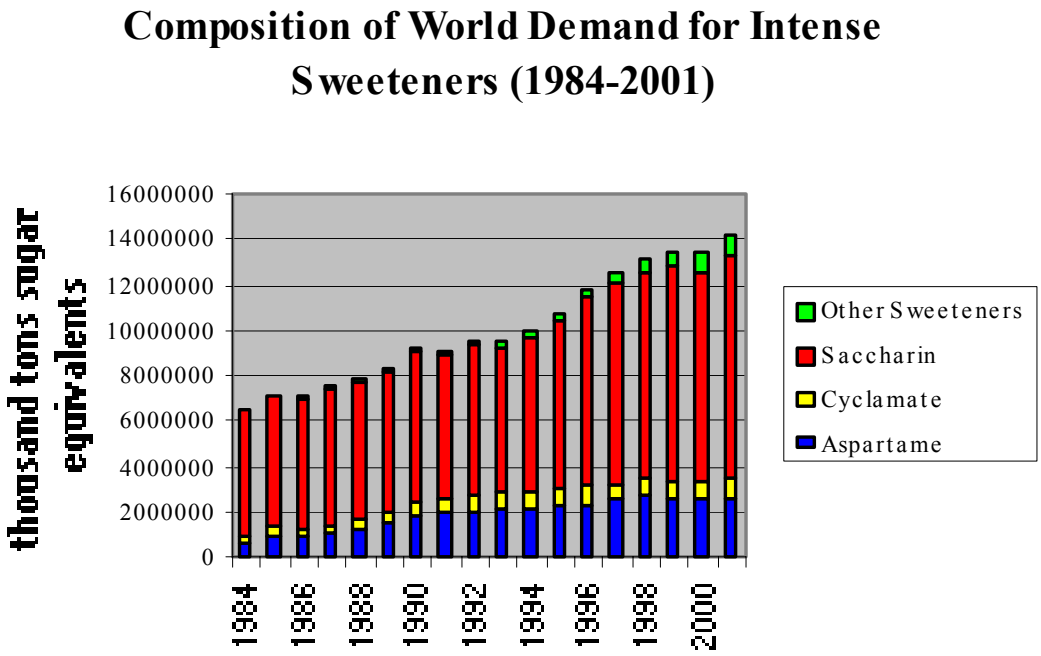

Figure 10: Composition of world demand for intense sweetener by product; Source: Landell Mills

On a relative basis the consumption of high intensive sweeteners is since some years arround 10% of sugar consumption. On the basis of total sweetener comsumption (sugar, sugar alcohols, starch sweeteners and high intense sweetners) the market share is about 7% for high intense sweeteners.

There is now convincing evidence from developed countries that there have been a transformation in consumer attitudes towards calorie reduction. This has affected the nature of demand for soft drinks, in particular.

Estimations for the use of high intense sweeteners are some times complicated to gain. One reason is that this market share of the world sweetener consumption is extremely poor documented, production data are difficult to obtain, because they are never published. Another obstacle is that consumption statistics are more or less in-existent; and efforts to build up a systematic picture from end-use surveys are hampered by the practise of incorporating high intense sweetener into products in contradiction to food regulations (or without proper labelling) in many countries and in many applications.

It is a surprisingly large proportion of the food and beverage use especially of saccharin and cyclamate, which occurs either illegally, in breach of national food regulations, or in products which should mention high intense sweeteners as ingredients on their labells, but which do not so.

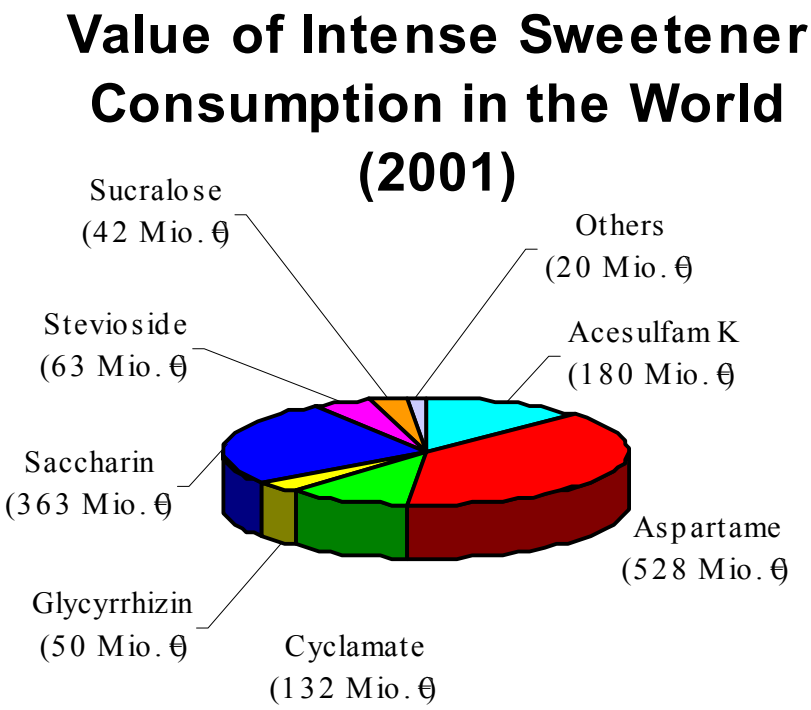

Figure 11: Value of intense sweetener consumption in the world; Sources: Rabo Bank, Giract, Landell Mills

In 2001 the world market value for sweetener consumption reached about 1.38 billion Euro. About 70 % of world sweetener demand is contributed by saccharine. In contrary it accounts only for 26 % of total intense sweetener sales. Aspartame reached about 18,5% of world wide sales but is still accounting for 38% of total value despite the crash down of aspartame prices which happend in the last three years. In 1999 the value of Aspartame market was nearly 1 Billion Euro on the same sales volume. The consumption of the four minor intense sweeteners in sale, alitame, Neo-DHC, neotame and thaumatine is estimated on about 20 Million Euro and their combined market share is less than 0,2%.

4.7 Price of Intensive Sweeteners

Table 16 shows the ruling prices in 2001 for intense sweeteners.

Table 16: Price of intensive sweeteners; Sources: Rabo Bank, Hoechst, own surveys

Sweetener	Price per kg
Acesulfame	80 Euro
Aspartame	40 Euro
Glycyrrhizin	50 Euro
Cyclamate	4.5 Euro
Sachararin	6.7 Euro
Sucralose	139 Euro
Stevioside	50 Euro

In comparison of sugar, intense sweetener are much more cheaper on sugar equivalent bases. The cost effectiveness in terms of sugar sweetness is one advantage of intense sweeteners. This do not reflect other properties like bulking effects which are important for many food applications. Only sugar or starch sweeteners can provide those bulking effects. Intense sweeteners are unable to. The cost effectiveness of saccharine and cyclamate are unbeatable due to their cheap synthetic processes. The comparison of the sweetener price related of intense sweetener to sugar is given in figure 12.

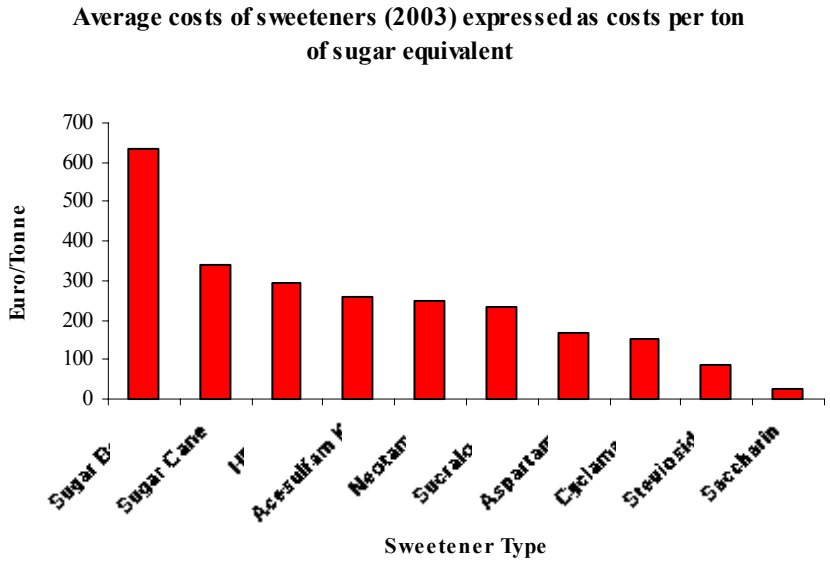

Figure 12: High intensity sweetener vs sucrose prices; Sources: Giract, own surveys

4.8 Worldwide Competition of the Production of Intense Sweeteners

The worldwide production of sweeteners underwent a major change in the recent years. Like the sugar production where Brazil has buildt up such production capacities that the whole world demand could be supplied, a similar development happens on the intense sweetener market. The only country where all major sweetener are produced was becoming China. For Saccharin and Cyclamate the production capacities are 45.000 tons resp. 35.000 tons alone in China. Also an increasing investment in Aspartame production capacities are foreseen. It is estimated that the actual production capacity of 3.000 - 5.000 tons will be triplicated over the next years. Also production units for Acesulfam K have been put up. While Acesulfam K sales outside China is illegal due to the Hoechst patent, those are noted in all parts of the world. This shows that Chinese companies are not respecting always intelectual property rights. Sources say that for Stevioside 3200 tons production capacity is already available in China.

Table 17: Prices and production situation in the world (2003); Sources: Rabo Bank; own surveys

Product	Price per kg in Euro	Production Region	Geographical use	Production volume (tons)	Sales volume in million Euro
Acesulfame-K	26	EU, China	USA, Europe, China	2.500	65
Aspartame	22	China, EU, Japan, Korea, USA,	Asia, Europe, USA,	13.200	528
Cyclamate	4,50	China, Korea, Taiwan, Indonesia	Asia, America, Europe	29.300	132
Glycyrrhizin	50	Asia	Asia	1000	50
Saccharin	6,70	China, Korea	Asia, Europe, America	32.700	363
Sucralose	139,50	USA, Europe	America, Asia, Europe	300	42
Stevioside	50	China,Korea, Taiwan, Brazil, Japan	Asia, Latin America, USA	1.250	63
Total				80.250	1360

Not considered are alitame, Neo-DHC, neotame and thaumatin because of its neglible shares.

The regional distribution of high intense sweetener production shows the clear concentration in Asia (see figure 13). The developed countries will loose in future their share in this market segment. Even most of European high intense sweetener production is belonging to Asian share holders (Ajinomoto Inc.). Therefore from European based stake holders only 2,8% contribute to the worldwide production.

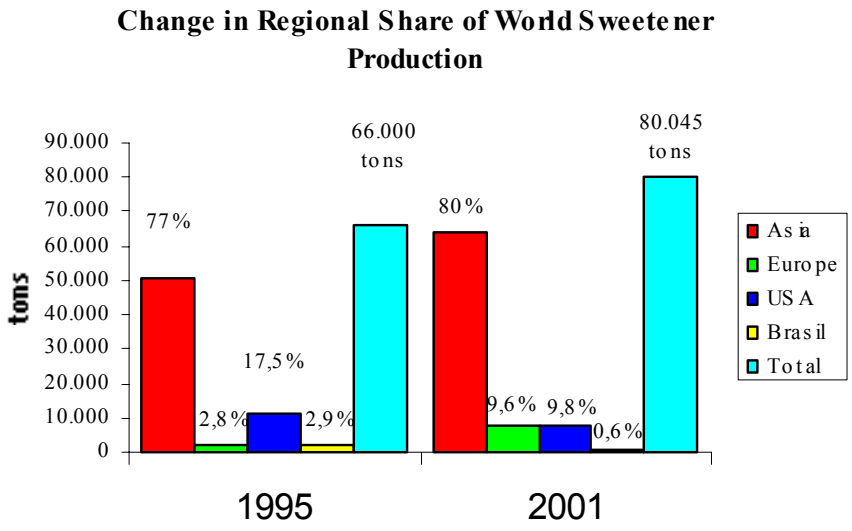

Figure 13: Share of worldwide intense sweetener production by regions (in real tons); Source: Rabo Bank

Without any change in sweetener development Europe will be a minor player on world sweetener production.

In the case for Brazil the disminishing of high intense sweetener production results mainly from the closure of the cyclamate producer when there was a takeover by the Taiwanese San Fu Group in 1998.

It is very likely that Asia will produce within the next 10 years 90% of world sweetener demand. The production will be concentrated mainly in China. In 2003 China alone accounts for about 77% of the world sweetener production. Within a few years China will have the production capacities to produce the entire high intense sweetener demand of the world.

5. Consumption of Sweeteners

The longer term trends in intense sweetener demand reveal

- A steady growth for saccharin use
- A sudden boost to cyclamate in the late 1980s, led by Asia
- A slowdown in aspartame demand growth in the 1990s
- A recent acceleration of demand for the category of other intense sweeteners, under the lead of acesulfam K, sucralose and stevioside

The following chapters will show the developments for the individual sweeteners as well as the devlopment of sweeteners consumption in various regions of the world.

5.1 Aspartame

The boom in global aspartame sales over the past decade shows signs of faltering. The key to the reversal of aspartame`s fortunes is the way in which has lost ground in the blending of sweeteners. Drinks formerly sweetened entirely with aspartame are now sweetened in many countries by blends of aspartame with other sweeteners; and the loss of aspartame sales is compounded by the potency gains and synergies from blending. The US demand continues to dominate the global offtake of aspartame. By competitiveness the lower prices of the post-patent era was helping to stimulate aspartame sales in the world.

In the future, we can expect to see increased quantities of aspartame destined for the confectionery and dairy industries, and we may even see lower priced aspartame (less than 16 US-$/kg) making gains from saccharin in certain pharmaceutical applications. However, one possible threat to the expansion in US aspartame sales during the coming years may come in the form of acesulfame-K, when the patents expire in 2005 and a strong decrease for the price is expected. Together with the granted FDA approval for use in soft drinks (which was given in 1998) the sales of aspartame may crashing down.

The recently developed Twinsweet (Acesulfam K-Aspartame blend on a molecular basis) by Holland Sweetener Company may accelerate the crash-down of aspartame consumption within the next few years in developed countries. This may lead to closure of aspartame factories, especially in Europe or the USA. It can not ruled out that the launching of Twinsweet will affect the own aspartame facilities of Holland Sweetener Company pushing them back on the steep learning curve of aspartame production.

Figure 14 shows the devlopment of aspartame demand in the years 1984 to 2001.

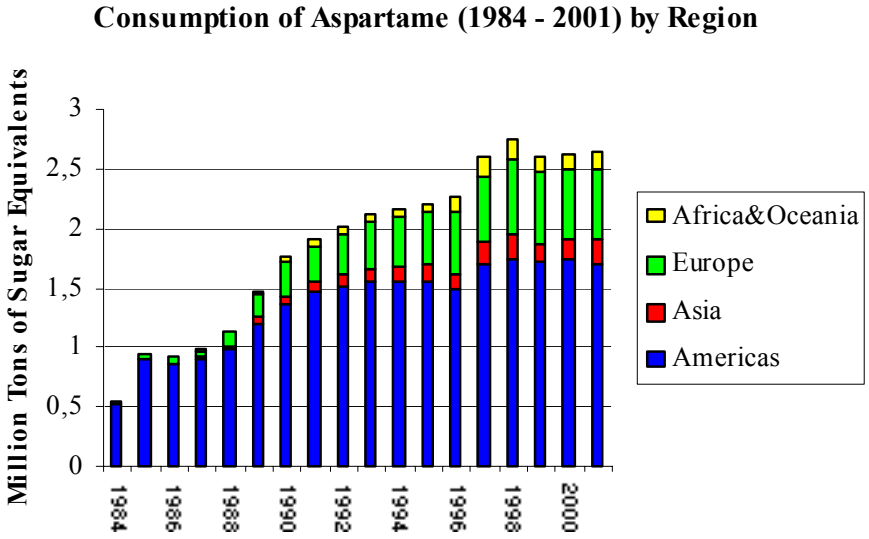

Figure 14: Aspartame demand of world regions;

Figure 14 reveals that the growth in world aspartame sales has levelled out. In 1999, the first global market actually contracted for the first time in its history. 2000 was little better, with growth of less than 1%. On a regional basis aspartame consumption has declined in the Americas and Europe for the past two years, although this has been partially offset by growth in Asia.

Figure 14 shows the regional breakdown of aspartame consumption between 1984 to 2001. Aspartame`s main markets are in the wealthier nations of the world, mainly in USA (about two thirds of total sales) and Europe.

There are two main reasons for this. First, the fortunes of aspartame have been traditionally been tied to growth in the diet soft drink market. The diet share peaked in the early 1990s and then went into decline. For the past two years US sales have been very flat and growth averaged less than 1%. In 2000 the US diet carbonated soft drink market grew by 0,9% compared to 0,4% in 1999. For 2001 the data reveal that the soft drink market in the US grew only by just 0,7%.

The decline in the diet share of the US soft drink market hit aspartame´s main end use market. There was, however, a slight increase in 2001 by 0,7%, compared with 2000 where the growth was virtually zero.

The real growth area has been the health and wellness segment, e.g. bottled water, sport drinks and fruit juices. Although these markets represent potential oportunities for low calorie sweeteners, they have so far failed to compensate for the minimal growth in the US diet share. The overall effect may be much more serious, if these markets cut sales of large scale sweetener using soft drinks (regular and diet).
Secondly, aspartame has been the major victim of the trend towards blending sweeteners. Whereas all major soft diet drink brands in the 1980s and the early 1990s used to be sweetened entirely with aspartame, this is no longer the case. Many diet soft

drink bottlers, certainly those in the EU, Canada and increasingly those in the US, have now switched from 100% aspartame to blends of aspartame and acesulfam K for their second renking brands and some top line brands.

The groing use of blends of aspartame with other sweeteners in Europe and elsewhere has allowed customers to reduce sweetening costs without any appreciable loss of quality. In fact, blending often helps to offset the main weakness of aspartame, ist instability in solution over time.

Thanks to the increased popularity of blends, alongside the rapid take-off of sucralose and the imminent arrival of neotame, the competition facing aspartame shows no sign of letting up.

On the supply-side, the price of aspartame has been further depressed by an increase in Chinese production capacity. Over the past three years, China emerged as a significant player in the global aspartame market. There are now at least five producers of good quality aspartame operating in China with a combined production capacity of about 3000 tons per year. In further years the capacities shall be triplicated according to rumours.

Aspartame entered the maturity phase of its product life cycle. This shows also figure 15 where the developments of production capacities, demand and prices are compared. It is very likely that the third generation sweeteners (alimate, neotame, sucralose and stevioside) will have the potential to overtake the market share of aspartame year by year.

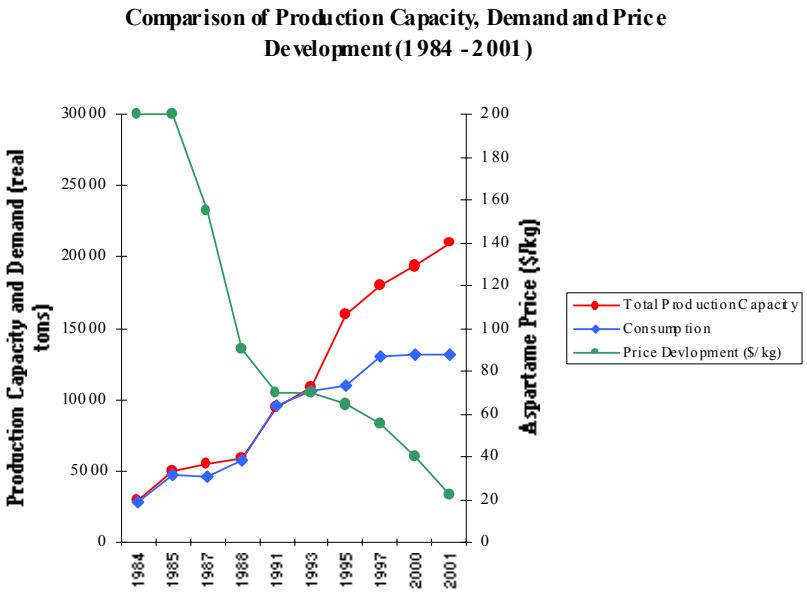

Figure 15: Crash-down of aspartame prices after market saturation

5.2 Saccharin

Although the entry of new sweeteners into the market has dented saccharin´s market share, now at just under 70%, it easily remains the dominant intense sweetener. In sugar equivalent terms saccharin has more than doubled it sales in the past 25 years.

Figure 16 depicts the distribution of the sweetener market and shows Asia comanding just less than half of global demand.

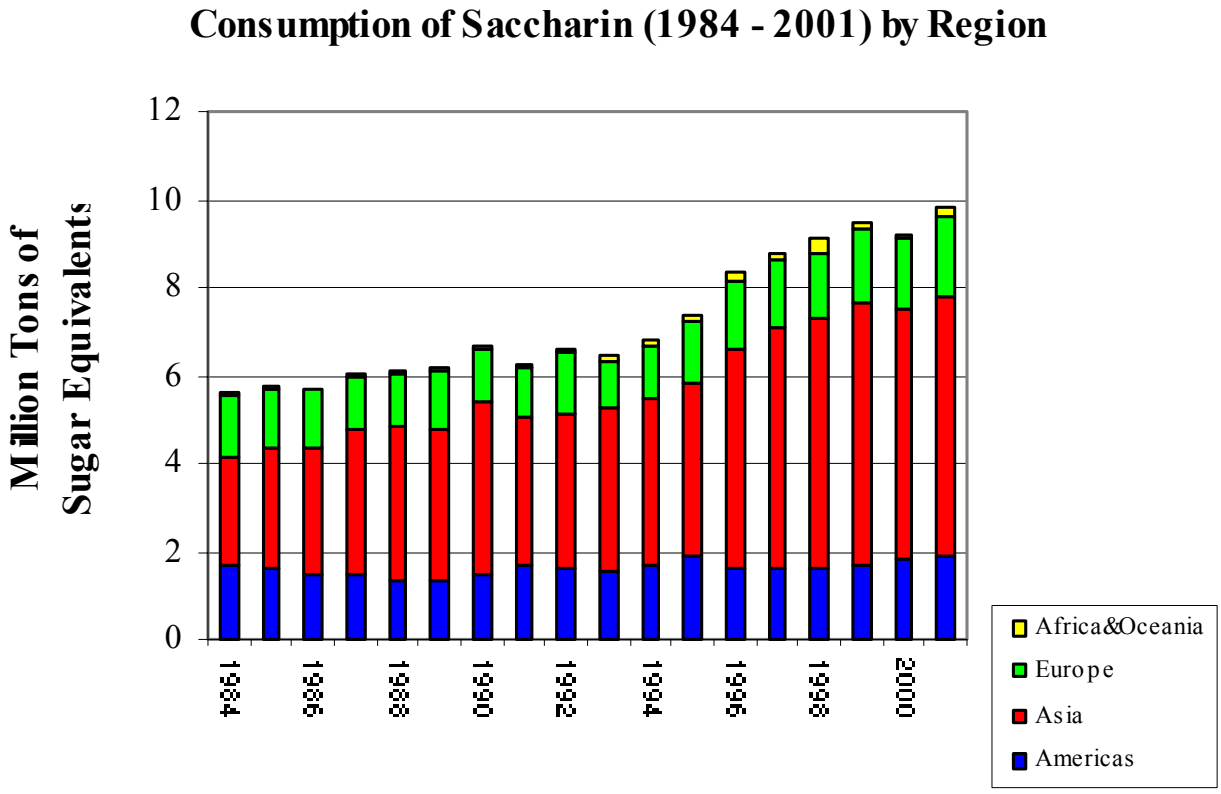

Figure 16: Saccharin demand

In 2001, Europe recorded the strongest growth, with demand up by 13% regarding to higher consumption in France, Spain and Italy, which more than outweigend declines in the UK and Germany. The growth in saccharin demand is driven by the growing popularity of blends within the EU, as well as rising demand from Eastern Europe.

After a respite in 2000, Chinese exports of saccharin surged ahead in 2001, though local sales declined. This has squeezed other saccharin producing countries, some of which have gone out of business. During 1999 the Chinese media reported that the goverment had ordered the closoure of nine of the 14 major saccharin plants, with the effect of reducing the overall production capacity from about 47.000 tons (14,1 million tons sugar equivalent) to arround 20.000 tons (6,0 million tons sugar equivalents). The annual production capacity for each of the 14 major saccharin plants in operation in China ranges from 500 tons to over 10.000 tons. Accoding to the press news the Chinese goverment intented to limit the saccharin production to about 24.000 tons (7,2 million tons sugar equivalent) together with a reduction in consumption to about 8.000

tons, which is about 60% of the current saccharin consumption level in China. Finally only smaller factories have been closed taking only 3.000 tons (0,9 milion tons sugar equivalents) of capacity out of the market.

However, what is clear is that the price for saccharin cannot fall much further and so increased world uptake of sacharin must be driven either by growth in end use markets or by saccharin taking an increased share of developing markets for blends. Saccharin is finding use in blends with other caloric and intense sweeteners to lower the overall sweetening costs of products. This increase in blending is particulary noticeable in the UK, although this procress is sufficiently far developed in this market to suggest that the sector may be close to saturation.

It can be stated that saccharin will have a bright future especially due to growing demand in Asia and other emerging markets.

5.3 Cyclamate

In the last years a strong growth of the demand for cyclamate was observed. In Figure 17 the development is given.

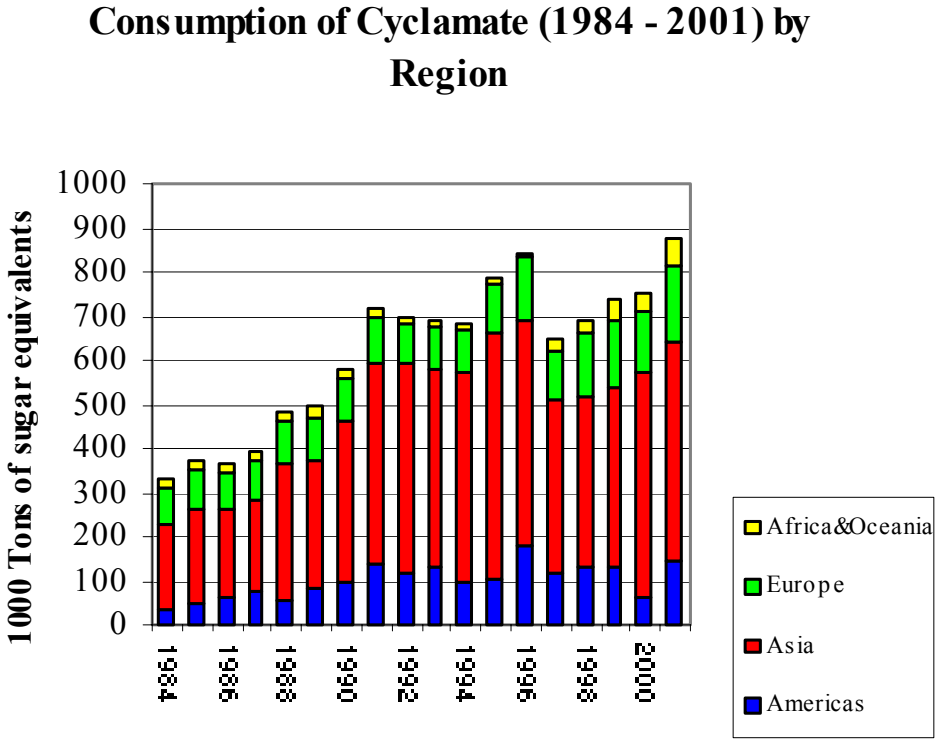

Figure 17: Cyclamate Demand

After a sharp decrease due to the financial crisis in Asia the markets for cyclamate recovered again peaking now 900.000 tons of sugar equivalent. In 1999 cyclamate consumption grew by 10%., returning world demand to pre-Asian crisis levels. In

1999 exports of cyclamates rose by over to about 370.000 tons sugar equivalents. Most of this increase can be attributed to Indonesia which has increased ist export volumes to over 150.000 tons sugar equivalents, compared to an average. Although some of this changes can be attributed to offlaoding stocks built up during the Asian crisis when demand was low, Indonesia has certainly made successfull sales into European markets such as Germany, Netherlands and Belgium as well as opening up new markets such as Bulgaria. There has also been a large surge in sales to Argentina (a five fold increase), Soth Africa and Chile. It is suggested that this was captured former Brazilian markets. Brasil was an important cyclamate producer, but production ceased in 1998 when Taiwanes cyclamate manufacturer San Fu Group overtook the Brazilian company. In 2001 the consumption grew again by 3,5%. This happend mainly due to increasing exports from China and Indonesia. In the last three years the level of Chinese cyclamate exports has doubled.

Cylclamate remain banned in a number of key markets like the US, Japan, Mexico and South Korea. The EU Sweetener Directive oppened some markets for cylamate like the UK, however failed to take off in some countries. Notably happend this in the UK where consumption levels are less than one fifth of Germany´s. In the EU the future growth in cyclamate consumption might be checked by changes under consideration to the EU Sweetener Directive. This proposes, in light of new intake studies, to reduce the maximum usable dose for cyclamte by banning or reducing ist use in certain food categories.

5.4 Other Sweeteners

This chapter will assume the consumption of Acesulfam K, Alitame, Glycyrrhizin, Neotame, Sucralose, Stevioside and Thaumatin. Starting in 1984 the only two sweeteners of this category have been Glycyrrhizin and Stevioside. The only region of use have been Asia, in particular Japan, as shown in figure 18.

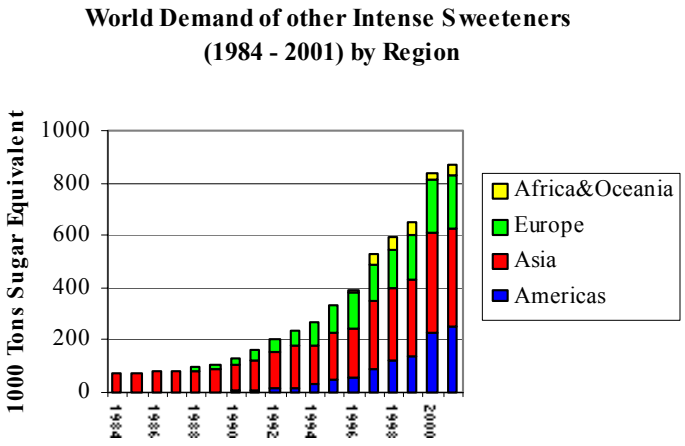

Figure 18: World Demand for minor sweeteners; Source: Landell Mills

Acesulfam K

With the entrance of Acesulfam K in the market a further sweetener emerged which has its major end uses in Europe. The Hoechst's company's confidence about the future for acesulfame-K has been signalled by the recent completion (1995) of the new and bigger manufacturing plant in Frankfurt, Germany with a capacity of 4 000 t/year. At the beginning of 1993, the FDA sanctioned the use of acesulfame-K in confectionery products, resulting in modest sales in the US market. However Europe continues to be the main source of sales growth for the sweetener, with a growing number of products relying on aspartame:acesulfame-K blends for their sweetening power. Acesulfame-K has also been a major beneficiary of the recent change in UK soft drink regulations. The sales of Acesulfam-K stands now at 2.250 tons per year far below the production capacity. Violating any rules of intelectual property rights Chinese companies are already producing Acesulfam-K based on Nutrinova`s patents. This brought the price of Acesulfam K under pressure which will be increased once the patents will expire in 2005. The use of Acesulfam-K in blends brought substantially market shares mainly gained from aspartame. On account of the close relationship with Aspartame, there is a real concern that this will ultimately lead to its demise, since this connection increases Acesulfam-K`s vulnerability to the threat posed by the advent of the latest new intense sweeteners, sucralose and neotame. A recently developed Aspartame-Acesulfam-K salt (brand name Twinsweet) of Holland Sweetener Company will benefit on the short term, however may be one of the first victims of these new developments on the longer term. It will be now surprise that Holland Sweetener Company will cease off during the present decade, if there are no new developments ahead.

Figure 19 shows the regional demand structure for Acesulfam K.

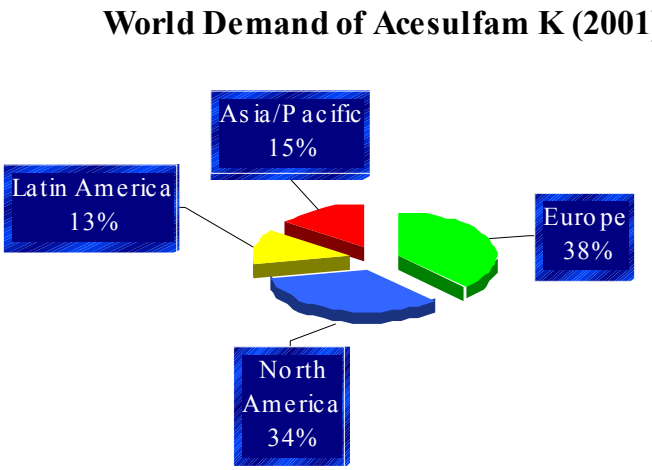

Figure 19: Demand of Acesulfam K in different regions of the world (2001); Source: Celanese

Alitame

Alitame appears to be going nowhere and is approved in only a handful countries: Australia, Chile, China, Colombia, Indonesia, Mexico and New Zealand. Alitame has fallen victim to the changing priorities of its succession of owners. Pfizer originally patented alitame, but as a part of arationalisation programme the company sold off ist food science division to Cultor, which in turn has been taken over by Danisco. Alitame failed still to show any major sales, although ist manufacturer, Dansico, claims that it is selling well in China. As it was the case for many years with sucralose, alitame is constrained by the lack of regulatory approval in major markets and the absence of any commercial production facility.

Neotame

In 2001 Neotame gained general approval in Australia and New Zealand. On July 9, 2002 the FDA gave the final approval for Neotame. Neotame is about 8000 times sweeter than sugar. Only 125 grams of Neotame can replace one ton of sugar. The wholesale price in the US was in 2003 about 700 Euro/kg. One main advantage of Neotame is its ability to blend well with corn sweeteners which will allow especially in the USA important features. Applications are still pending in the EU, Japan and Canada. It is estaimated that Neotame production reached in 2003 about 200 tons and will reach in 2007 about 750 tons. As Neotame is made from Aspartame, consequently the price of Neotame depends strongly on the price level of Aspartame.

Sucralose

Although Sucralose entered 1994 with approval in three national markets - those of Canada, Russia and most recently, Australia - there have been several years before its sales became significant. Sales of sucralose, on the other hand, have so far failed to make any impression on global intense sweetener consumption patterns. More recently approvals have been granted by FDA. This approval will challenge aspartame in the US market. Also Japan approved sucraclose, but sales remained extremely low. For EU the use of sucralose was proposed by the Scientific Commitee on Foods, however the approval still awaits the final legal procedures, which is expected in 2004. It is expected that in 2007 the sales of sucralose may be as strong as those of Acesulfam K and will reach 2700 tons per year.

Stevioside

There appears to be no stopping the dramatic rate of growth of stevioside consumption throughout Asia. In the past, its relatively high price has been a minor barrier to sales. However, with stevioside production continuing to increase in China, selling prices have come under pressure, providing a further boost to offtake.

5.5. Regional Consumption of Intense Sweeteners

The regional breakdown of the data highlights the central role of Asia in the intense sweetener consumption picture. Back in the mid-1970s, the Americas accounted for approximately 20% more intense sweetener demand than Asia. Now, the Americas lag roughly 20% behind Asia. As a result, whereas the Americas have seen their share of the world intense sweetener market drop from 42% to 28%, the Asian region's share has expanded trom 35% to 49%. Europe's share has marked time at 20%. While Africa and Oceania accounted only with 1% - 2% of the world-wide figure in the 1990s, now the markets emerge and reached about 4,8% of world wide sales.

Since the world's population centres and its fastest growing economies are to be found in Asia, it is to be expected that these trends will continue.

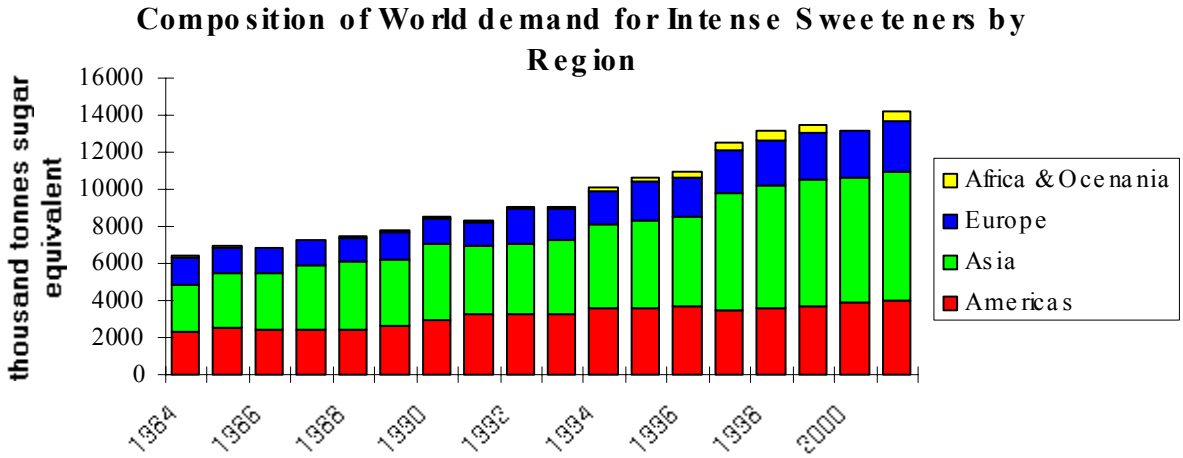

Figure 20: Composition of world demand for intense sweeteners by region, Source: Landell Mills

A break down of the estimated consumption patterns in different regions of the world is given in table 18.

Table 18: Consumption of intense sweeteners in real tons (2001)

Sweetener	Asia	Americas	Africa and Oceania	Europe	Total
	tons	tons	tons	tons	tons
Acesulfame K	375	1.175	100	850	2.500
Aspartame	1.000	8.500	735	2.950	13.185
Cyclamate	16.700	4.700	2.200	5.700	29.300
Glycyrrhizin	1000	0	0	0	1000
Saccharin	19.700	6.300	700	6.000	32.700
Sucralose	0	300	0	0	300
Steviosid	1.050	100	100	0	1250
Total	39.825	21.075	3.835	15.500	80.235

As it is shown in table 18 the regional preferences are different for individual sweeteners. Aspartame is clearly dominating in the USA. However, in Asia sales of stevioside are exceeding those for Aspartame. Natural sweeteners in Asia are accounting for already 6% of regional sales. Whereas in Europe natural sweetener are still not existing due to the lack of regulatory approval.

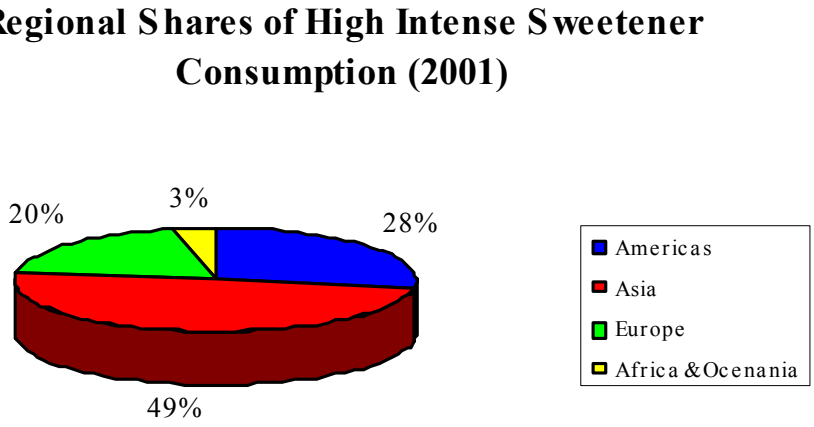

Figure 21: Regional Distribution of High Intense Sweetener Consumption; Sources: Rabo Bank, Giract, Landell Mills

4.6.1. Intense Sweetener Consumption in Total Europe

To set the scene, the market for high intensity sweeteners in EU is of 240 million Euro, of which aspartame has an over 49% value share, although in volume terms its share is significantly less. In total Europe 2.76 million tons sugar equivalents are consumed. In EU 1.9 million tons sugar equivalent are consumed. The rest of Europe consumes 0.86 million tons sugar equivalent

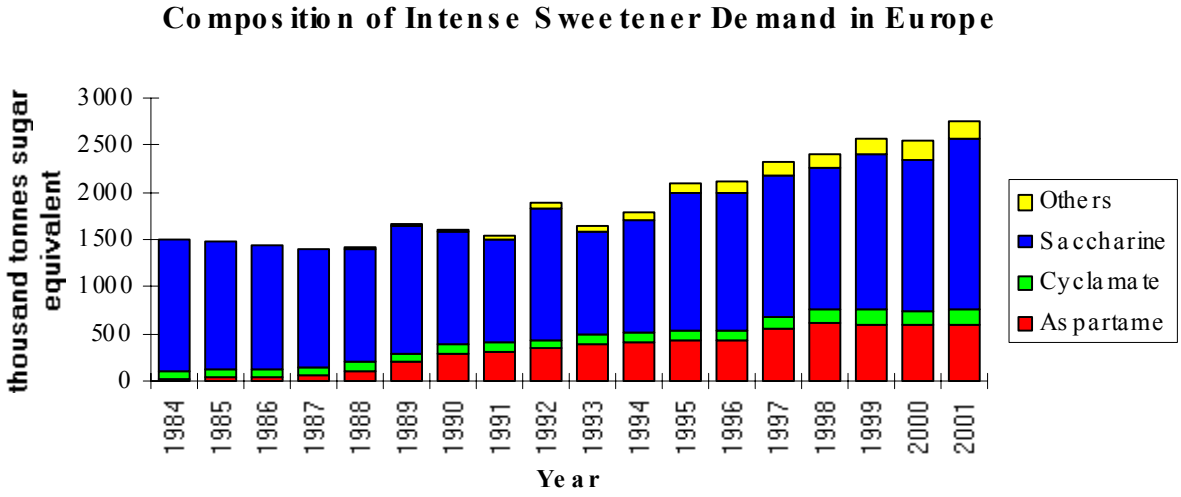

Figure 22: Composition of intense sweetener demand in Europe; Source: Landell Mills

Acesulfame-K has so far been most successful in EU, where it has found a valuable niche in blends with aspartame. Aided by the cost savings and stability benefits that it offers, the sweetener has been attractive to many users of aspartame. Our figures imply that acesulfame-K sales are running at only a small fraction of those of aspartame, but this greatly understates their impact in sweetening terms.

In EU, the surge in aspartame sales has emerged later and more steadily. In the mid-1980s, aspartame accounted for little over 2% of the European market, but had risen to 20% in volume terms by 1996, with few signs of a slow-down. In contrary aspartame sales are accounted still almost 49 % of EU market value.

In Europe, six intensive sweeteners are approved in most countries. The EU directive could raise the sales growth of Aspartame by 2-3 % by allowing blending of sugar and artificial sweeteners.

New developments are expected when the new sweetener directive comes in force in 2004. Then sucralose and twinsweet have taken the last barrier for entering the EU market. Both sweeteners are already available in some EU member states by temporary approval of these national goverments (e.g. for sucralose the U.K. and for twinsweet the Netherlands).

4.6.2. Intense Sweetener Consumption in the USA

The experience from different regions of the world is far from uniform. A comparison of the figure 14 reveals that aspartame has fared much better developing customers in the Americas, Europe and Africa & Oceania than it has in Asia. Back in 1985, within five years of its launch, aspartame already accounted for 35% of the market for intense sweeteners in the Americas, as a whole. By 1993, it was virtually at parity with saccharin in the region, and was within a couple of percentage points of a half share of the market

In the USA, acesulfame-K was still held back by the absence of regulatory approval for its use in soft drinks in the US till 1998 and by the lack of any form of approval in Canada, although such approval is rumoured to be very imminent. When its use in soft drinks was permitted in the US, the impact could starts to be be dramatic. If there is any further significant switch away from 100% aspartame towards aspartame/acesulfame-K blends, aspartame could suffer a substantial slippage in sales; but this may well be counter balanced by the sales gains which could accrue from the boost that would be received in the ability of intense sweeteners to substitute for HFCS or sugar. Since the blends will be both cheaper and more stable than aspartame alone, users may be more willing to experiment with the introduction of intense/nutritive bends.

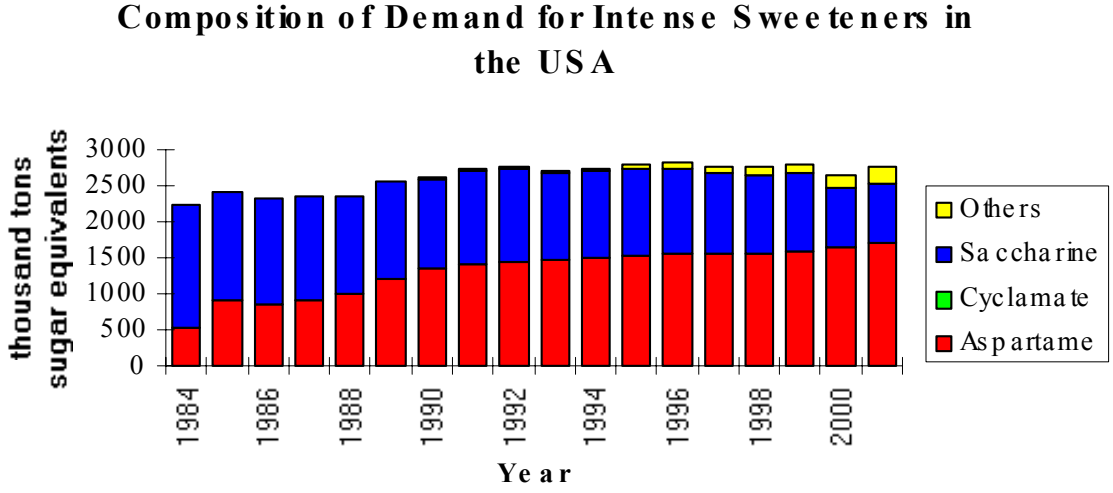

Figure 23: Composition of demand for intense sweetener in the USA; Source : Landell Mills

Aspartame is the third of the trio of leading intense sweeteners, and the only one of the newer generation of sweeteners to make a big breakthrough in sales. The sweetener enjoyed a remarkable period of growth during the early and mid-1980s, as it profited from "being in the right place at the right time". Aspartame became the benchmark for taste in diet beverages, and its original discoverer. The Nutrasweet Company (USA), was able to use its patent to command a price that was actually higher than that of sugar in most national markets on a sugar equivalent basis, without dire consequences.

The aspartame market is changing its nature rapidly. The success of the 1980s has been very well documented, and must by now be accepted as one of the classic marketing case studies of how to promote a new product. Skilfully exploiting the diet phenomenon and the "cola wars", the NutraSweet Company violated several of the standard rules of marketing, and it prospered tremendously, achieving an annual sales volume of close to $1 billion in 1998. For example, as we have just noted, it sold its product at a premium price to its main competitors, and adopted a hitherto untried branding strategy for food ingredients (a technique which has never been copied with success by other companies, or even by NutraSweet itself in its attempt to make a breakthrough with its Simplesse fat substitute).

During the 1980s, the conventional view was that aspartame was not having much impact upon the market for nutritive sweeteners such as sugar and HFCS. Instead, it was believed that the new sweetener was able to exploit consumers' anxieties about the safety and the sweetening quality of aspartame's two main rivals, saccharin and cyclamates, to encourage as witch from these longer-established intense sweeteners towards the newcomer, without any direct repercussions upon sugar or HFCS sales. Aspartame had played a major role in revitalising the diet beverage market, but that these extra sales represented a new form of soft drink demand, which was largely in addition to existing non-diet sales (which continued to grow), with only very minor cannibalisation of the "regular", i.e., nutritively-sweetened, sector.

Sucralose had in 1997 the approval in about 23 countries worldwide. In Canada it was demonstrated that sucralose can become a leading sweetener in the tabletop market and that it can break into the main industrial end-use markets, including soft drinks.

Sucralose was approved in the USA in 1998. The marketing is supported by a production plant in Alabama which serves for US sales and also the world market. Since the supply is not longer a major problem, it is likely that soft drink producers in other part of the world now show interest in using sucralose in their products. In 1998 alread 50 countries approved sucralose and it is expected that in 2004 the EU will finally adopt the new sweetener directive which includes sucralose.

Historically sucralose has been marketed through a partnership between Tate&Lyle and NcNeil Specialities. In late 2001 this relationsship was renegotiated with the outcome beeing that Tate&Lyle will act as the main seller of sucralose to industrial users in certain key markets outside North America, while McNeil will supply all other markets, and will exclusively produce and market the Splenda tabletop brand of sucralose worldwide. In 2002 the sales of Splenda tabletop market grew by over 40% in the first four months compared with the same period in 2001. This implies on value basis that Splenda has already a fifth of the US table top market, behind aspartame (Equal) and saccharine (Sweet` N Low).

4.6.3. Intense Sweetener Consumption in Asia

The regional breakdown of the data highlights the central role of Asia in the intense sweetener consumption picture. Back in the mid-1970s, the Americas accounted for approximately 20% more intense sweetener demand than Asia. Now, the Americas lay roughly 20% behind Asia. As a result, whereas the Americas have seen their share of the world intense sweetener market drop from 42% to 28% in sugar equivalents, the Asian region's share has expanded trom 35% to 49%.

Since the world's population centres and its fastest growing economies are to be found in Asia, it is to be expected that these trends will continue.

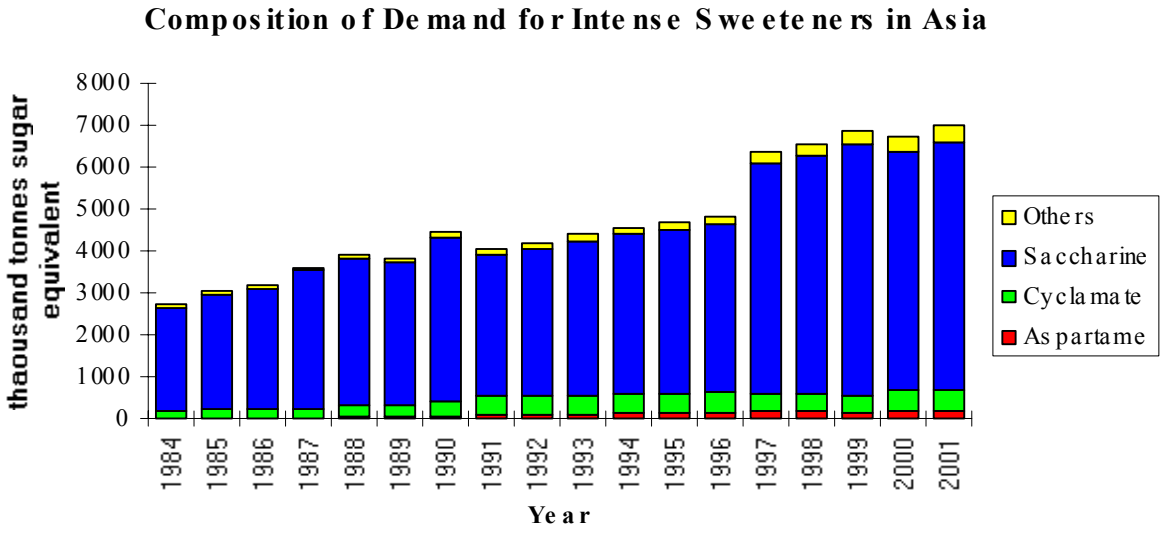

Figure 24: Composition of demand for intense sweeteners in Asia; Source: Landell Mills

By contrast, the performance of aspartame in Asia has been pitiful. Even now, it satisfies a mere 2%-3% of the total demand for intense sweeteners.

One reason for aspartame's lack of success in Asia is that price-sensitivity is much more important in low income countries when it comes to sweetener choice, but it should not be forgotten that the structure of overall sweetener demand in Eastern Asia is very different indeed from elsewhere. For a start, the people in the region do not have as sweet a tooth as those in other regions. Eastern Asia's per capita household use of sugar is well below the global average; and they do not share (at least, yet) the West's craving from sweetened beverages and confectionery. Instead, a sizeable proportion of the demand for sweeteners, and for intense sweeteners in particular, is in applications in which the sweeteners act as flavourings, enhancing or masking other tastes, but with little signifcance to users in terms of calorie reductions.

In the light of the preceding discussion, it will come as little surprise that saccharin remains the leading intense sweetener world-wide. It had a period of stagnation in the mid-1980s, but was revived by the boost from Chinese demand later in the decade.

Aspartame has become a growing influence, and it should not be forgotten that the value of aspartame sales very easily outstrips those of saccharin, but the pace of growth in aspartame volumes has slowed appreciably in 1990s.

The saccharin market as a whole has shown little growth over the past four years, once the boom in Chinese demand ran out of steam. Nevertheless, as some countries, typically those with high incomes, have switched from saccharin in favour of newer sweeteners, others, usually in poorer parts of the world, have boosted their saccharin use. Consumers on low incomes are the most sensitive to price, and therefore provide the most receptive audience for cheap saccharin-sweetened products. In the world as a whole, saccharin has not prettly well halted the decline in its share of the intense sweetener market. Even in the Americas and Europe, its loss of market share seems to have ended.

Cyclamate sales are also heavily concentrated in Asia. China, Indonesia and Thailand have all emerged to become major centres of production. Brazil is the only other large-scale exporting producer.

Apart from the use of cyclamates in table-top applications, the market for this sweetener is overwhelmingly confined to uses in which it is blended with saccharin for the best results in terms of sweetening quality and cost-effectiveness. Consequently, the recent fortunes of the two sweeteners in food uses have been somewhat similar, with a slowdown in growth in the most recent years.

Highly flavoured pastes and sauces derived from fish, soybeans and milk, and pickled foodstuffs, too, are important outlets for sweeteners in the Far East, and it often comes as a surprise to outsiders to discover that sugar is not the sweetener of choice in some of these applications. Saccharin, stevioside or glycyrrhizin are frequently mentioned as the preferred sweetener on taste grounds, with aspartame frequently ruled out of contention because of its instability in highly acidic solutions.

The category of "other intense sweeteners" has a fairly neat regional divide. In Asia, the two main products are glycyrrhizin and stevioside; in the rest of the world, the category is dominated by acesulfame-K.

In Asia, the path depicted in the diagram is the result of opposing trends in the consumption of glycyrrhizin and stevioside. Glycyrrhizin, derived from licorice and with an associated taste, has suffered a slow decline in sales in parallel to demand for the savoury or salty foodstuffs in which it has traditionally been used as a sweetener and flavour enhancer.

Meanwhile, stevioside sales have gone from strength to strength. In Japan, South Corea and China, stevioside has been preferred to aspartame or saccharin in a number of applications. In some cases, this is because stevioside is seen as a natural sweetener, since it is derived from the leaves of the stevia plant, and naturalness is very important to prospective consumers. In other cases, it is because stevioside is more stable than aspartame. In others, stevioside has benefited from governmental pressure to reduce the use of saccharin or end it entirely. Thus, in South Corea, stevioside, rather than

aspartame, has been the beneficiary from the banning of the use of saccharin in the local soju alcoholic beverage. Actual estimates are showing for South Corea an annual stevioside demand of 80 tons only for soju alcoholic beverage.

4.6.4. Intense Sweetener Consumption in Africa and Oceania

Africa and Oceania have the lowest consumption of intense sweeteners in the world with only about 4,7 % of the total amount.

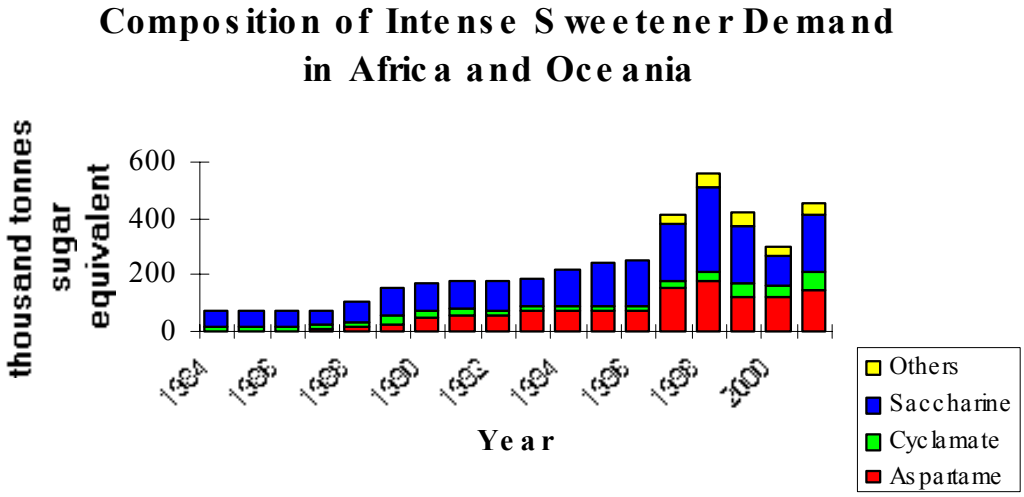

Figure 25: Composition of intense sweetener demand in Africa and Oceania, Source: Landell Mills

In Africa & Oceania, aspartame has been boosted by strong demand from the diet sector in Australia, and the sweetener breached the 25% barrier in terms of its share of the local overall intense sweetener market by 1991. Now sucralose emerged into the market of Australia since its recent legislation in 1994.

Since 1998 the sales for high intense sweeteners raised up. However there are a still drawbacks by economical instabilities. This shows clearly that the consumption of sweeteners is bound to the urban middle which are affected more by economical problems.

Since Stevioside is considered as a Dietary Supplement in Australia and New Zealand, sales are rising up. For 2000 a Australian source estimated a yearly demand for 10 tons but with very high annual growth rats. According to severall sources it seems likely that South Africa approved Stevioside as a Dietary Supplement only recently.

6. Markets for Intense Sweeteners in Food and Beverages

The markets for some applications of intense sweeteners are shown and analyzed in the following pages. The soft drink industry is the biggest market for intense sweeteners in the world and also in the EU.

6.1. Beverages

The soft drinks sector is highly suitable as an example of the market for sweeteners since:
- it is the major growth sector of use, either first or second in all the countries studied
- the changes induced by legislation are particularly significant and have led or are leading to product reformulations. It is thus a market sector in rapid change, and since it is the biggest user of high intensity sweeteners world-wide, a comparison of consumption figures is of interest.

Figure 26 shows the total volumes of soft drinks for the five countries representing the three cultures, and their forecast development. Clearly the UK and German markets outperform the other countries.

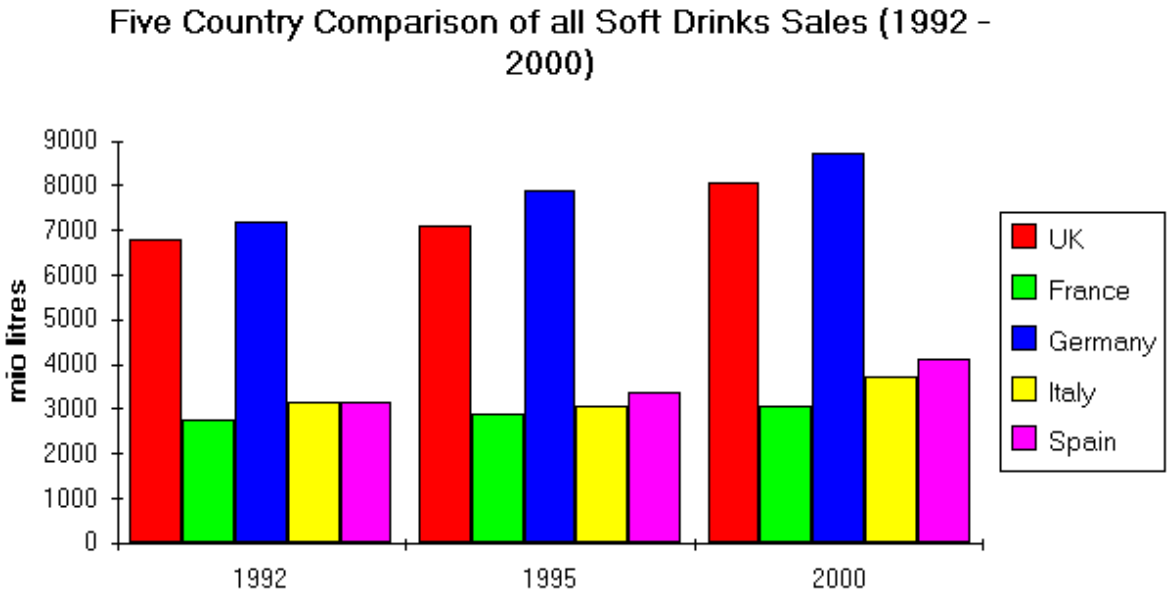

Figure 26: Five country comparison of all soft drink sales; Source: Giract

When the low-calorie sector is considered (Figure 26), the volume is still relatively small though growth has been substantial since 1986. The forecast for the year 2005 is that this sector will continue to grow at some 5% per annum, but that its proportion as a total of the entire sweetening market will increase less rapidly than total consumption due to the continued expansion of the market place.

6.2. Sugar Free Chewing Gum

Beside beverages chewing gums are the second most important market for sweeteners. Consistency is a key element in the quality of gum and so combinations of sweeteners are often used, especially sorbitol and saccharine. The appeal of sugarless chewing gum is confirmed by some significant consumption statistics: it has captured over 30% of the market in Europe, 50% in the USA and a staggering 80% in Scandinavia. In the last five years sugar free gum outsells the traditional sugar gums. In the UK sugar-free gum increased its share of the market from around 30% at the beginning of 1991 to 56% in 1993 (figure 27).

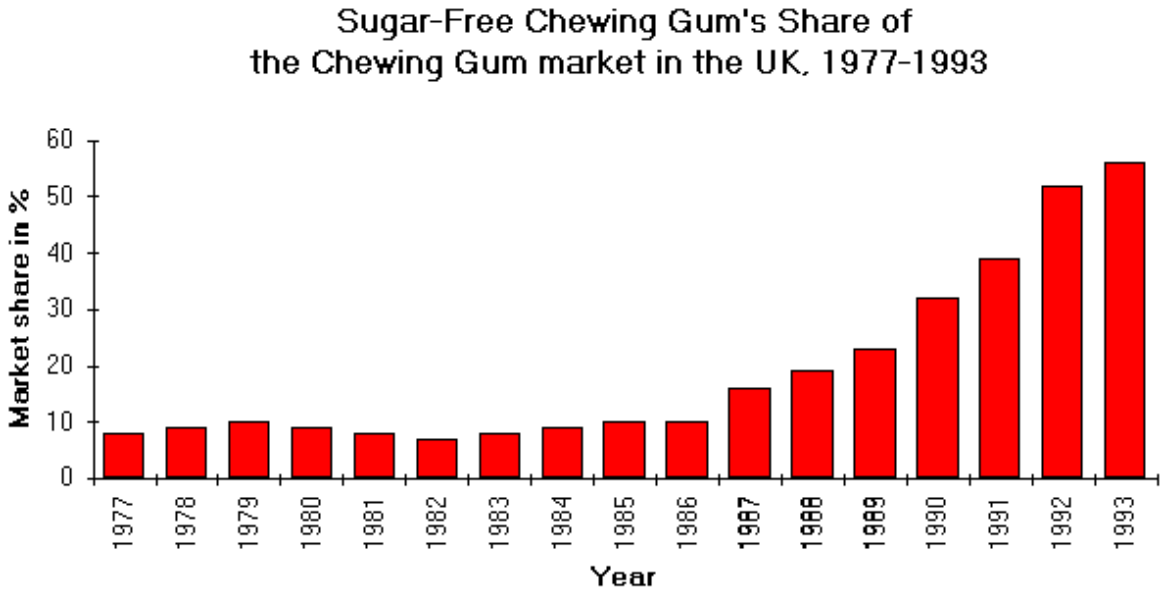

Figure 27: Sugar free chewing gum's share of the Chewing gum market in the UK 1977 - 1993; Source: Rabo Bank

6.3. Consumer Profile of Intense Sweeteners in EU

UK is the biggest consumer of intense sweetener in EU. Therefore the consumer profile of UK is specially shown using a study from the Ministry of Agruculture, Fisheries and Food from 1990

62 % of the general population was regular using saccharin, compared to 31 % who consumed aspartame and a percentage of lower than 1 % who consumed acesulfame K in 1987.

Infants were using intense sweetener with a percentage of 65 %. The reason is the consumption of intensed sweetend beverages. The pecentage of adults using intense sweetners is less than the younger population.

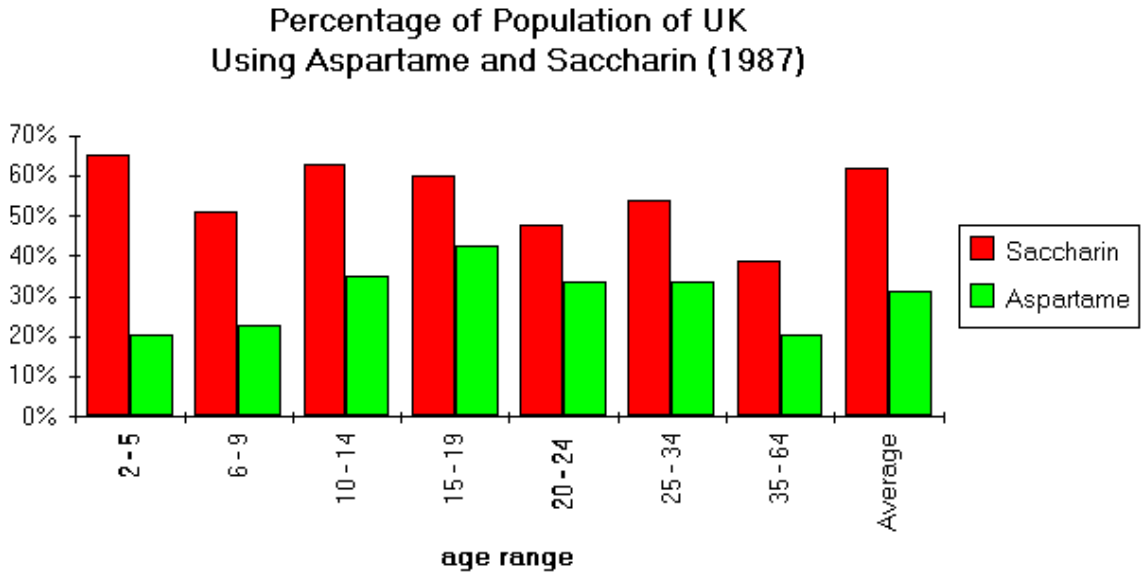

Figure 28: Percentage of population of UK using aspartame and saccharin once a week; Source: Ministry of Agriculture, Fisheries and Food (MAFF).

52 % of the population drink beverages sweetened with saccharine. Table top sweeteners with saccharin are used from 11 % of the population and just 2 % have tasted the sweetness of aspartame as table top sweetener.

7. Natural Intense Sweetener Market

It was seen in the past that Asia favours stevioside and glycyrrhizin as sweeteners. Some of the most important end-uses for sweeteners througout Asia include pickled foodstuffs and highly flavoured pastes and sauces derived from fish, milk and soybeans. Interestingly, sugar is not often the sweetener of choice in such applications. Instead, saccharin, stevioside and glycyrrhizin are frequently mentioned as the preferred sweeteners on taste grounds.

Glycyrhizin, which is derived from licorice, has suffered a slow decline in sales during recent years, mirroring the modest reduction in demand for the savoury or salted foodstuffs in which it has been used traditionally used as sweetener and flavour enhancer.

In 1994 due to the new "Dietary Supplement Act" in the USA a change came for the use of stevioside. Since 1995 it is possible to sell stevioside as "Dietary Supplement" in the USA without mentioning its sweetening properties. It was estimated that the sales in 2000 have been more than 10 Milion US-$.

One important reason for stevioside´s popularity in Asia is ist image as a natural intense sweetener. As such, it has become a popular ingredient in products such as sport drinks. Food and beverage manufactures throughout the Asian region have also exploited the taste and sweetening synergies that exist between steviosides and fructose. In 1997 stevioside ended a first pahse of rapid growth mainly due to the emerging economic crisis of Asia. However it regained the growth rates of the years before already in 1998 again mainly due to its natural character. In 1999 a new blend was launched in Japan using acesulfam-K and stevioside (Rebaudio-ACK), for the use in beverages.

In 1999 the Scientific Committee on Foods of the EU again refused to give the approval to stevioside. Still, both important markets, the USA and the EU, are rejecting stevioside as a sweetener for food use.

Japan as model

The natural intense sweetener market is analyzed with Japan as a model. The whole market in 1996 was about 790 tons: aspartame with about 200 tons, saccharin with about 190 tons, acesulfame K with about 20 tons; the natural intense sweeteners glycyrrhicin with about 170 tons (21 %) and stevioside with about 210 tons (27 %), which is together a market share of 48 % of the intense sweetener market.

Glycyrrhizin is derived from licorice with an associated taste. It has declined in sales in parallel to demand for the savoury or salty foodstuffs in which it has traditionally been used as a sweetener and flavour enhancer.

Meanwhile, stevioside sales have gone from strength to strength. In Japan, stevioside has been prefered to aspartame or saccharin in a number of applications. In some cases, this is because stevioside is seen as a natural sweetener, since it is derived from the leaves of the stevia plant, and naturalness is very important to prospective consumers. In other cases, it is because stevioside is more stable than aspartame.

Stevioside shows a strong increase in market shares over the whole periode. The weaker increase in the second half of the eighties is due to the market entrance of aspartame in Japan. But after a few years the manufacturers in food and beverage industry discovered the disadvantages of the weak stability of aspartame and prefered the use of stevioside as intense sweetener in their foodstuffs.

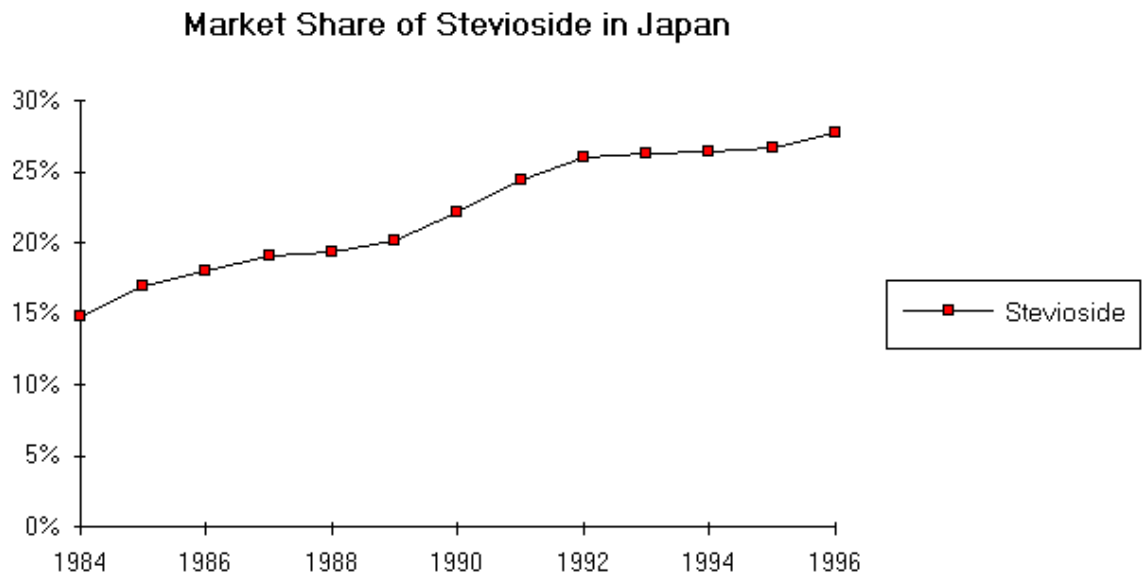

Figure 29: Market share of stevioside in Japan; Source: Landell Mills , JETRO

In South Korea, stevioside, rather than aspartame, has been the beneficiary from the banning of the use of saccharin in the local soju alcoholic beverage.

Today Japan uses about 3.200 tons of intense sweeteners where about 600 tons may the share of stevioside. In China according to a release of the US embassy the production is fast growing in China. The total production capacity is estimated to be 3200 tons per year, although actual production is probably less than it. A large proportion of the production is exported, primarily to other countries in East Asia, but also to the USA:

8. Outlook for the Future

This study has been established to show the situation of the world sugar and sweetener market with special view on the European intense sweetener market. The consume of intense sweeteners is listed for the moment and the predicted consumption in the year 2010 is outlined.

The study followed a conservative approach. Even higher anual consumption figures for high intense sweeteners are available, however missing consistence when proofed. Therefore it is likely that this picture described in this study may underestimate the real consumption. As written before it is sometimes difficult to get a clear picture about high intense sweetener consumption throughout the world and also in the EU due to lacking of official statistics.

However, this study aims to show trends in sweetener consumption and give conservatively estimated figures not over exceeding the markets.

Worldwide ten intense sweeteners are used. Those are acesulfame-K, alitame, aspartame, cyclamate, glycyrrhizin, neohesperidin dihydrochalcone (Neo-DHC), saccharin, stevioside, sucralose and thaumatin. Proposed for future use are Neotame, a new dipeptide sweetener of Monsanto which got approval in the USA in 2002 and Brazzein, a polypeptide structure which shall be produced by genetically modified corn.

The worldwide production of sweeteners underwent a major change in the recent years. Like the sugar production where Brazil has buildt up such production capacities that the whole world demand could be supplied, a similar development happens on the intense sweetener market. The only country where all major sweetener are produced was becoming China. It is quite likely that Chian will account in 2010 for about 90% of world intense sweetener production capacity.

The growth rate for is intense sweetener is projected to be 2,7-2,9% over the next years.

This will result in a intense sweetener market in 2010 of about 95.000 - 100.000 tons.

In the prediction for the year 2010 following assumptions are made:

Saccharin and cyclamate will grow further with 2% per year. The growth of aspartame will stop and the lacking will be covered by the sweeteners of the third generation (alitame, sucralsoe and stevioside). This happens in different ways in the four world regions. The big lack of aspartame is its weak stability. When in 1983 Coca Cola made its research studies on the stability of aspartame and stevioside they found stevioside much more stable than aspartame. Stevioside is not yet approved as a food additive in EU and USA. But in Japan stevioside is in use since more than 20 years.

Stevioside will have a high demand because of its good stability and image as natural intense sweetener especiallay in Asia, may be reaching 3200 tons of production.

Stevioside will show this rate because of its heavy demand in Asia. Glycyrrhizin will not show any increase in sales. In the USA and the EU stevioside could enter into the market after an expected approval which may happen 2010-2013.

Acesulfame K will be in competition with new intense sweetener with better taste and cheaper price, especially alitame, twinsweet and sucralose. Sucralose will account for about 2700 tons in 2007 already exceeding the consumption of Acesulfam K.

The whole intense sweetener demand will increases about 3000 tons from 15.000 tons up to 18.000 tons until the year 2010 in Europe. If new intense sweeteners are approved in EU they could participate in the growth, without displacing in the first marketing period other intense sweeteners.

For example in Japan stevioside now has a market share of 25 %. In the case that stevioside would have the approval in EU in the year 2010 it could be expected that in the year 2015 stevioside will then gain a market share of about 10 - 15 %. The sales volume in real tons would be 1.800 - 2.700 tons in EU.

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