Chapter 1: The Structure of the World Starch Market

This chapter describes the composition of the world starch industry. After a brief outline of the range of starch products, it summarises the composition of global starch output, distinguished by country, raw material and form of starch product. It then examines the growth in demand in major national markets, and concludes with a review of international trade patterns in starch products.

THE NATURE OF STARCH

Starch is a very versatile product, both in its raw materials and in its uses. It is a white, granular, organic chemical produced naturally by all green plants. Native starch is a soft, white, tasteless powder that is insoluble in cold water, alcohol, or other solvents. The basic chemical formula of the starch molecule is $(C_6H_{10}O_5)_n$. A full introduction to starch, its production process and its uses is presented in the Appendix to this chapter.

In Europe, as is also the case on a global basis, starch is derived mainly from cereals, but it is also obtained in significant quantities from tubers. (It is interesting to note that Romance languages, unlike Germanic languages and English, make a distinction between these two types of starch: for example *amidon* for cereal-derived starch and *fécule* for tuber-derived starch in French.) Worldwide, the main sources of starch are maize, wheat, potatoes and cassava (from which tapioca starch is derived).

In its native form, after the first stages of processing, starch has a relatively limited range of uses — notably as a thickener and as a binder — because of a property called retrogradation, which is described further in the Appendix to this chapter. After further processing by chemical or physical modification, starch can acquire high or low viscosities, it can become tolerant to heat or to high or low levels of pH, and it becomes an attractive input into many food and non-food sectors. It may also be broken down into syrups by acid or enzymatic means, and act as a substrate for a large number of fermentation products.

By virtue of this versatility, starches compete with many other products of agricultural origin. They can substitute for simple cereals in some native starch applications, for vegetable oils in the case of some modified starches, for sugar in the case of many starch syrups, for molasses or biomass crops, including cellulose, in the production of ethanol, for dietary fibre in the case of resistant starches and for latex rubber or certain gums in a number of paper products. In the opening pages of this chapter, we shall introduce the leading starches. Descriptions of their production processes and the major starch derivatives are included in the Appendix to this chapter.

Functionality is the key to the use of starches in food applications. No other ingredient provides texture to as many foods as starch does. Whether it is a soup, gravy, sauce, pie filling or custard, starch provides a consistent shelf-stable product.

There are at least as many value added applications for starch in the non-food area, each of which requires very particular functional characteristics. Starches for the paper industry, for textiles, pharmaceutical use and other chemical uses may be acid or alkali treated, and they may also be modified with oxidising agents, salts and different alcohols.

Various elements of the starch molecule may be substituted with a range of other chemicals to produce chemically modified starches classified generally as starch esters and ethers. These are widely used in both food and non-food applications, for example in the form of cationic starch in the paper industry and in the form of acetylated starch in the food industry. The class of esters and ethers (esterified and etherified starches), as the Customs category CN 3505 10 50 is widely known, plays a major role in Community starch policy, since it's the producers of these particular forms of modified starch receive a sizeable proportion of the Commission's outlays on production and export refunds for starch products.

The use of modified starches in paper products is particularly important. Their main application is to provide greater strength to the basic fibres from which paper is made, and to bind the starch more tightly to these fibres in the presence of other chemicals, so that the wastewater produced in paper production is more environmentally friendly.

The growing demand for biodegradability, which is a property associated with starch derivatives, promises to add to the use of starch in plastic films and sheets, and in conjunction with natural fibres to replace synthetic plastic foams.

THE WORLD STARCH MARKET

In aggregate, the world starch market was estimated to be 48.5 million tons in size in 2000, including not only native and modified starches, but also the large volume of starch that is converted into syrups for direct use as glucose and isoglucose, and as substrates in the form of very high dextrose syrups (known as starch hydrolysates) for fermentation into organic chemicals, including ethanol. The value of the output of this industry is worth in the region of €15 billion per annum.

Within the global industry, the US is home to by far the largest starch industry, with 51% of world production. The Community's industry is second only in size to that of the US, with over 17% of world output, and an annual value of close to €3 billion. The structure of the EU domestic sector is described in more detail in Chapter 2.

Table 1.1 and Diagram 1.1 depict the relative sizes of the starch industries of the EU, US and the rest of the world, distinguishing between the main raw materials processed into starch in these areas. Maize is the main raw material in all three regions listed in the table, supplying over 80% of the global starch market, although the EU is distinctive in relying upon maize for less than half of its starch production. Maize starch manufacture generates just over one ton of by-products for every two tons of starch, and these by-products are, on average, worth more per ton than maize itself, thereby making a significant contribution towards the overall economics of maize starch output. A detailed breakdown of the allocation of EU starch production by raw material and type of starch product is given in Tables A2.28-A2.30 in the Appendix to Chapter 2.

Over 8% of world starch production is derived from wheat, and the Community produces over two thirds of the total global output of this starch, for which the economics of production are influenced very strongly by the by-product credits derived from the sale of high protein vital wheat gluten. The production of wheat gluten in the technology of wheat starch processing is discussed in the Appendix to this chapter.

More than 5% of global starch supplies are obtained from potatoes, and once again the EU is the source for over two thirds of the figure. Other raw materials, notably cassava, contribute just over 5% of world starch output. In the case of both of the two major tubers, potatoes and cassava, processors earn very little indeed from their modest amounts of by-product protein and fibre.

Table 1.1: Starch Production by Raw Material in the EU, US and Other Countries, 2000
(million tons, starch content)

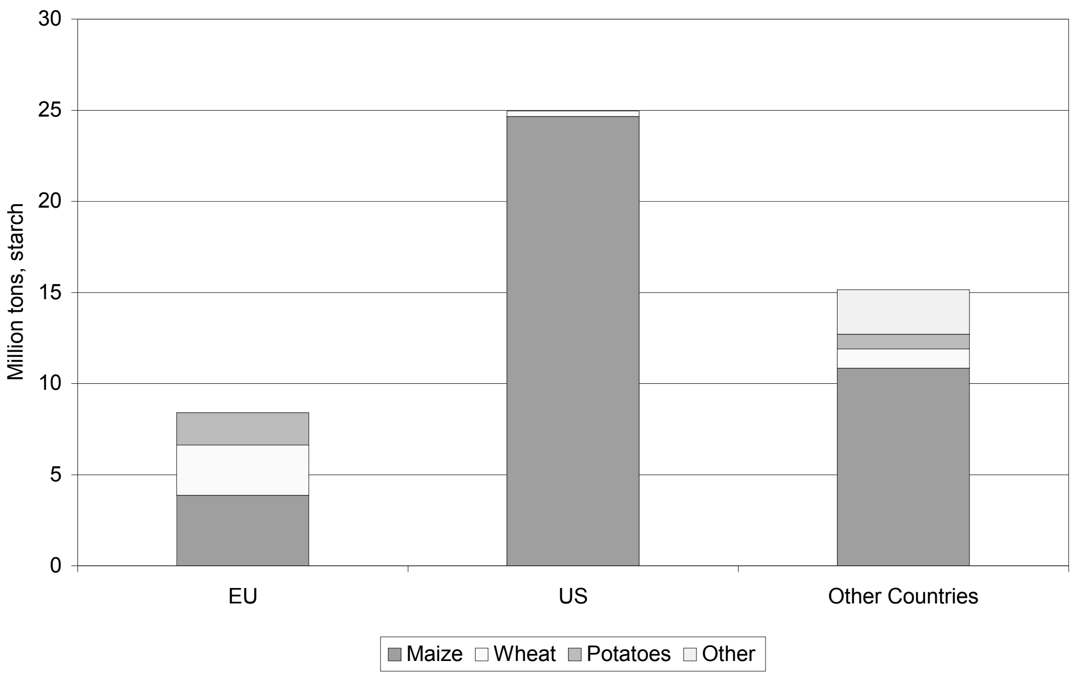
	Maize	Potatoes	Wheat	Other	**Total**
EU	3.9	1.8	2.8	0.0	**8.4**
US	24.6	0.0	0.3	0.0	**24.9**
Other Countries	10.9	0.8	1.1	2.5	**15.2**
World	39.4	2.6	4.1	2.5	**48.5**

Source: EU Commission (DG AGRI, Unit C2), United States Department of Agriculture (USDA), LMC Internal Database.

The US is almost entirely dependent upon maize for its domestic output, with only 1% produced from other raw materials (notably wheat). The EU is unusual in having a starch industry in which three raw materials (maize, wheat and potatoes) each supply a large share of total starch output.

Outside the US and the EU, there is a significant proportion of starch that is manufactured from cassava (also known as tapioca), especially in South East Asia. Cassava represents the overwhelming share of the category "Other" in the raw materials identified in the diagram, but there is also some output derived from rice, barley, oats, sweet potatoes, sago, etc.

Diagram 1.1: Composition of World Starch Production, 2000



Source: EU Commission (DG AGRI, Unit C2) , USDA, LMC Internal Database.

THE RANGE OF STARCH PRODUCTS

The diversity of the products derived from starch has already been mentioned. In this section, we shall contrast the composition of starch production in the two largest markets, the US and EU. The US starch industry processed 44 million tons of maize last year, over 60% of which was processed into just two products: isoglucose (known in the US as high fructose corn syrup, HFCS) and ethanol. In the 1970s, US government sugar price supports provided an ideal environment for the development of the HFCS sector, which proved very popular to the soft drink industry. The ethanol sector also developed with official government support via Federal and State Government tax rebates, in this case for its role as a renewable oxygenate fuel.

US maize starch processors also benefited from the favourable economics of maize as a raw material. Not only was maize supplied to processors at prices that are widely taken to be the reference for world export market quotations, but processing also generated valuable by-product credits, the most important of which (those from the sale of corn gluten feed) enjoyed prices that were supported by the European Union's CMO for cereals. This occurred because the majority of the US output of corn gluten feed is exported, and it enters the Community duty-free, where it is widely used as a cereal substitute. In effect, the US f.o.b. price of corn gluten feed is derived by deducting the sea freight costs from the price set by its role in Europe as a cereal substitute. The significance of by-products in the overall economics of starch processing is discussed more fully in Chapter 2 and in the Appendix to the present chapter.

The contrast between the relative importance of the different products produced by the US and EU starch processors is revealed in Diagrams 1.2-1.3 and Table 1.2. In the classification, we have distinguished between four main classes of products: native and modified starches, which consist of all the dry starch products that have never passed through a syrup stage (and which are described in greater detail in the Appendix); ethanol, which is derived from the fermentation of starch syrups; isoglucose (in the form of HFCS in the US); and all other syrup-based starch products, which consist of syrups and derivatives of syrups, other than isoglucose and ethanol.

This last category combines glucose syrups and further processed sweeteners, including crystalline dextrose, maltodextrin and also sorbitol, as well as high dextrose syrups that are processed into amino acids and a range of other organic chemicals. Ethanol and isoglucose, although both are also syrup-based, are highlighted separately in view of their considerable importance in the US (and, therefore, global) market.

Ethanol alone accounts for 40% of the entire US starch output; and ethanol and isoglucose together represent 72% of US starch production. The scale of these two sectors dwarfs the native and modified starches, which together represents only 15% of US supply, and the group of other syrup-based starch products, with 13%.

In the Community, the role of ethanol is minuscule by comparison with the US, at a mere 1% of total output, while isoglucose production is capped by production quotas, and represents only 3% of EU starch output. Because these two major end-uses are relatively small starch consumers in the Community, the share of the native and modified starches in total output is very much greater than in the US, at 53% of the total. As a result of substantial exports, its share of domestic sales is lower.

The share of other syrup-based starch products is also very much higher than in the US, at 43%. However, as we shall see in the next section of this chapter, the high shares of these latter two categories arise primarily because the overall EU per capita output for starch products is much smaller than that in the US, and are not the result of unusually high per capita production of native and modified starches or of syrup-based starch products in the Community.

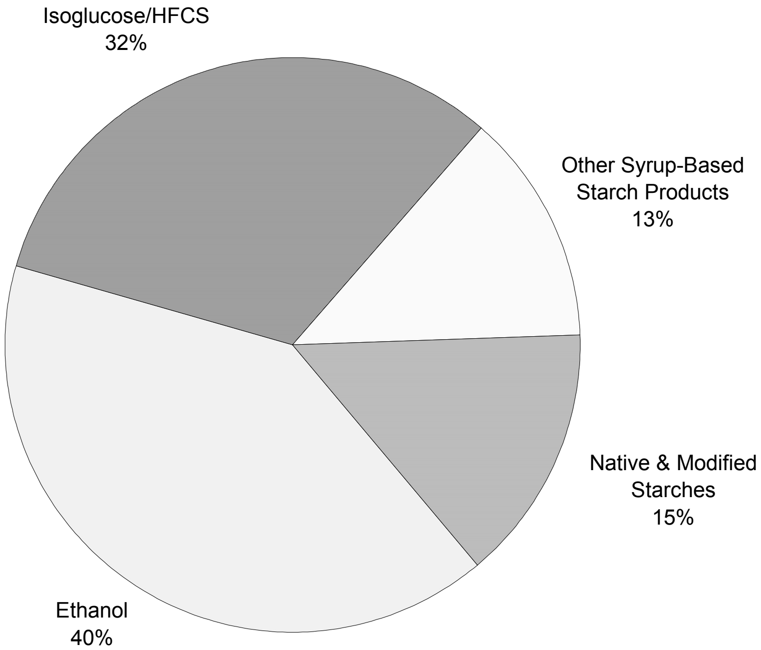
The data in Table 1.2 indicate that the combined absolute tonnages of EU production of native and modified starches and of syrup-based starch products are somewhat larger than the corresponding quantities in the US.

Table 1.2: Starch Output by Product in the EU and US, 2000 (million tons, starch content)

	US	EU
Ethanol	10.1	0.1
Isoglucose/HFCS	8.0	0.3
Other Syrup-Based Starch Products	3.2	3.6
Native & Modified Starches	3.6	4.5
Total	**24.9**	**8.4**

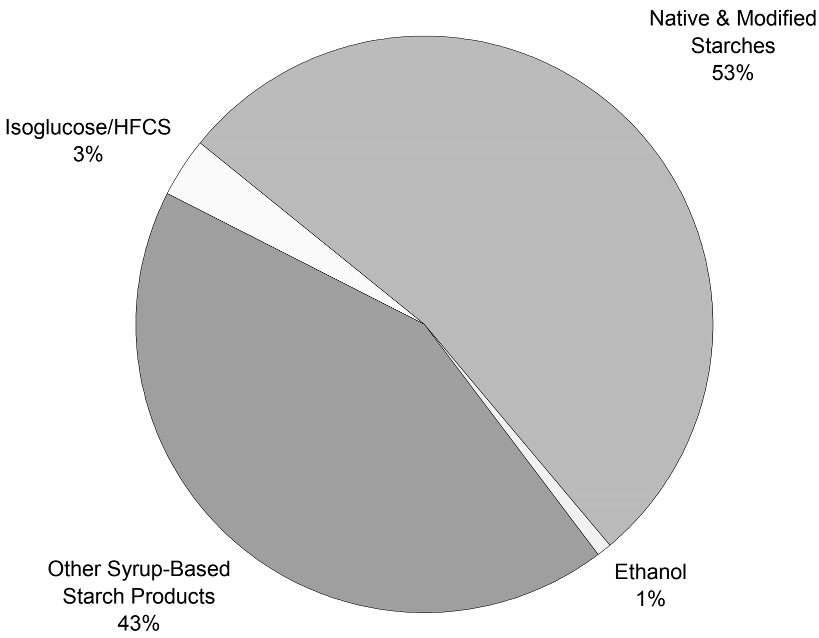
Source: USDA, EU Commission (DG AGRI, Unit C2), AAC, LMC estimates based on Internal Data.

Diagram 1.2: Composition of US Starch Production, 2000



Source: USDA, LMC estimates based on Internal Data.

Diagram 1.3: Composition of EU Starch Production, 2000



Source: EU Commission (DG AGRI, Unit C2), AAC, LMC estimates based on internal data.

PER CAPITA DEMAND FOR STARCH PRODUCTS

Diagrams 1.4 to 1.5 compare per capita demand in the Community with that in four major starch consuming countries: the two main high income starch using economies, the US and Japan, and the two most populous developing countries, China and India. The worldwide per capita consumption level is given for comparison.

(Throughout this report, the definition of domestic demand that is adopted is one that includes within it the consumption of starch derivatives in the manufacture of more highly processed products, such as organic chemicals, that are subsequently exported. Thus, the exportation of processed starch-containing products is considered to represent starch consumption within the country that produces the processed end-product. This convention corresponds to the normal practice in most countries' statistics. In the Community, however, the exportation of starch-containing products, such as the so-called non-Annex I products, described in Chapter 3, is often considered to represent overseas consumption.)

Since some of the data are difficult to obtain in a disaggregated form, starch demand has been divided into just two main classes of starch products: dry starches (which are defined to include native and modified starches, as well as dry sweeteners, notably crystalline dextrose, crystalline fructose, glucose solids and maltodextrins) and syrups (primarily isoglucose and glucose syrups, but also including liquid sorbitol)[1]. Diagram 1.6 combines the two categories to derive overall per capita starch demand.

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[1] Note that these categories are not divided neatly into the classes listed in Table 1.2. This reflects the considerable constraints imposed by the form in which the international data are published.

The US has the highest per capita demand in every category, and Japan is second to the US and slightly ahead of the EU overall, in part because it is the world's second largest HFCS/isoglucose producer, although the EU has a slightly higher per capita demand for syrups overall. All three of these markets are far ahead of China and India in their per capita consumption levels.

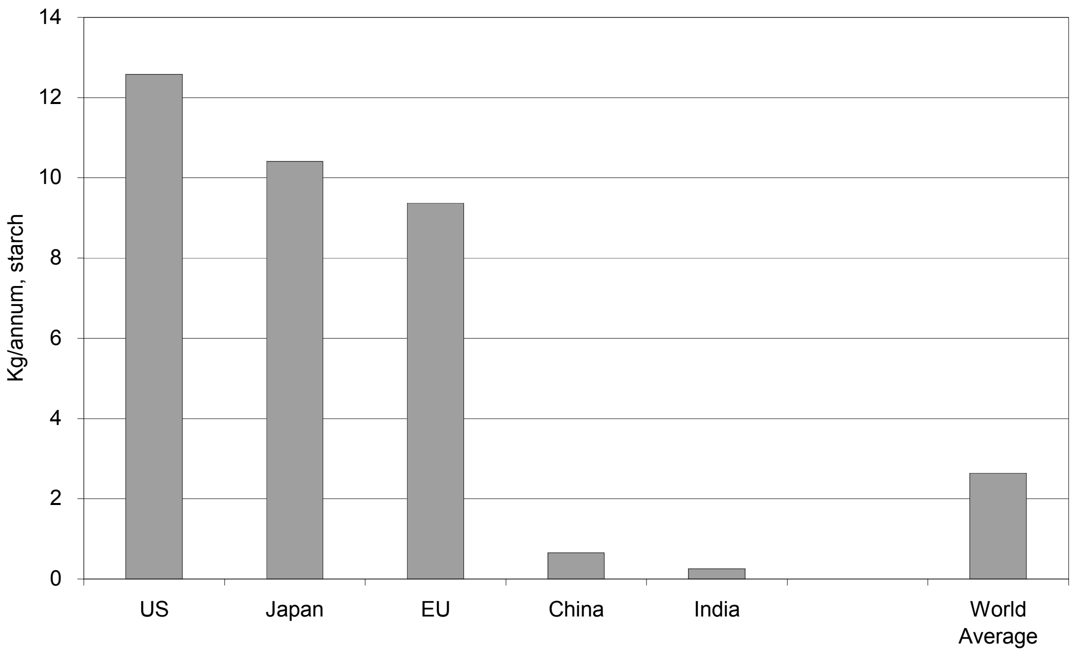
Table 1.3 presents the data used to prepare the three diagrams. The EU has 3.6 times the worldwide average per capita demand for dry starch products, 1.8 times the average for syrups, and 2.4 times the average for starch products as a whole. EU per capita demand is divided fairly evenly between the dry starches and the syrups.

Table 1.3: Per Capita Demand for Starch Products in Major Markets, 2000 (kgs per annum)

	Starch	Syrups	Total
US	12.6	74.8	87.3
Japan	10.4	10.0	20.5
EU	9.4	10.4	19.8
China	0.7	0.4	1.1
India	0.3	0.1	0.4
World Average	**2.6**	**5.8**	**8.4**

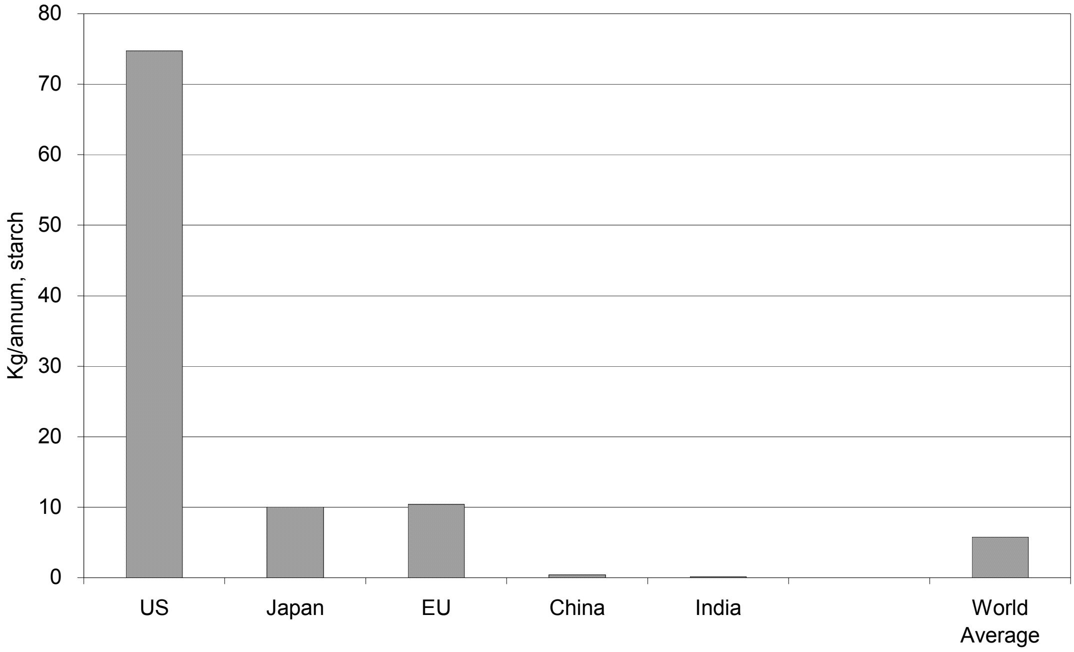
Source: USDA, Mitsui Japan, AAC, LMC estimates based on internal Data.

Diagram 1.4: Per Capita Demand for Dry Starch Products, 2000



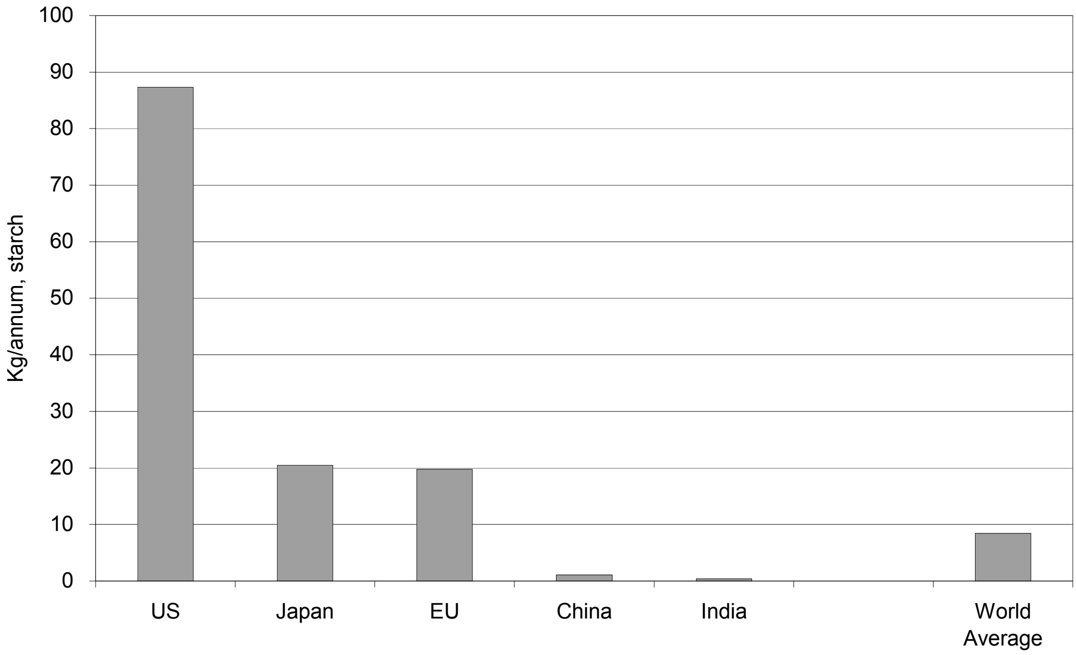
Source: USDA, Mitsui Japan, AAC, LMC estimates based on Internal Data.

Diagram 1.5: Per Capita Demand for Starch Syrups, 2000



Source: USDA, Mitsui Japan, AAC, LMC estimates based on Internal Data.

Diagram 1.6: Total Per Capita Demand for Starch Products, 2000



Source: USDA, Mitsui Japan, AAC, LMC estimates based on Internal Data.

THE GROWTH IN STARCH PRODUCT DEMAND, 1995-2000

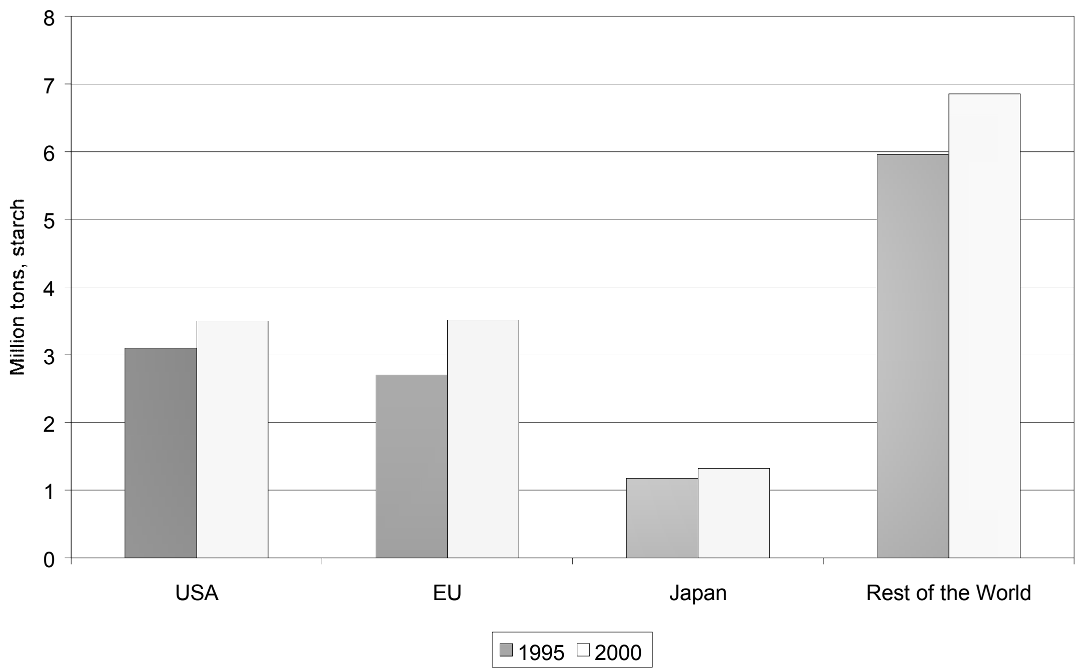
The starch sector is one in which demand has historically grown at a rate that compares favourably with that of many other agriculturally based products. Diagrams 1.7 to 1.9 compare the demand for dry starch products, syrups and total starch products for the US, EU, Japan and the Rest of the World in 1995 and 2000. The underlying data are provided in Table 1.4.

As in the preceding set of diagrams and the associated table, dry starches include native and modified starches, as well as dry sweeteners, notably crystalline dextrose, crystalline fructose, glucose solids and maltodextrins. Syrups are defined to cover all starch derivatives sold in a liquid form, and thus consist primarily of isoglucose and glucose syrups, as well as liquid sorbitol.

Overall demand for starch products grew at an annual rate of 4.1% for the US, at 4.3% per annum in EU and by 4.0% in the category entitled Rest of the World. Japanese demand expanded by 1.9% per annum. As a result, the world total rose at an average rate of 4.0%.

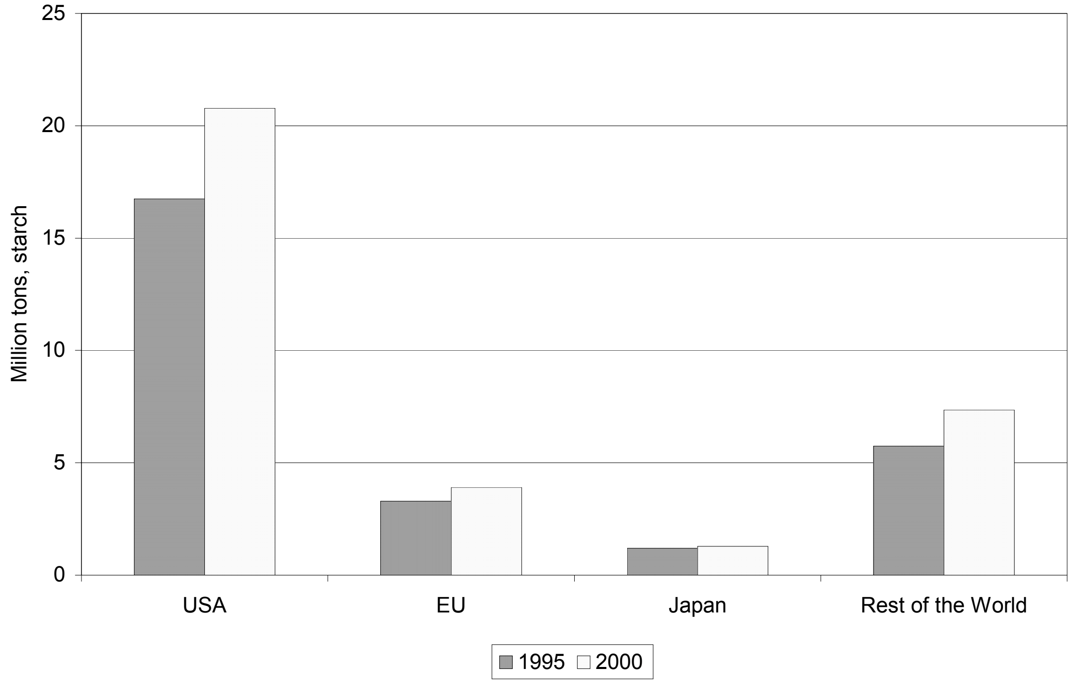
Demand for syrups grew more rapidly than that for dry starches worldwide, under the lead of the US. The EU has a higher share of the world market in the less dynamic segment of the industry, the dry products, and its proportion of the world market for dry starch products increased from 20.9% to 23.1% between 1995 and 2000. For syrups, however, its share dipped from 12.2% to 11.7% over the same period. For starches as a whole, the EU share rose from 15.0% to 15.3%.

Diagram 1.7: World Demand for Dry Starch Products, 1995 and 2000



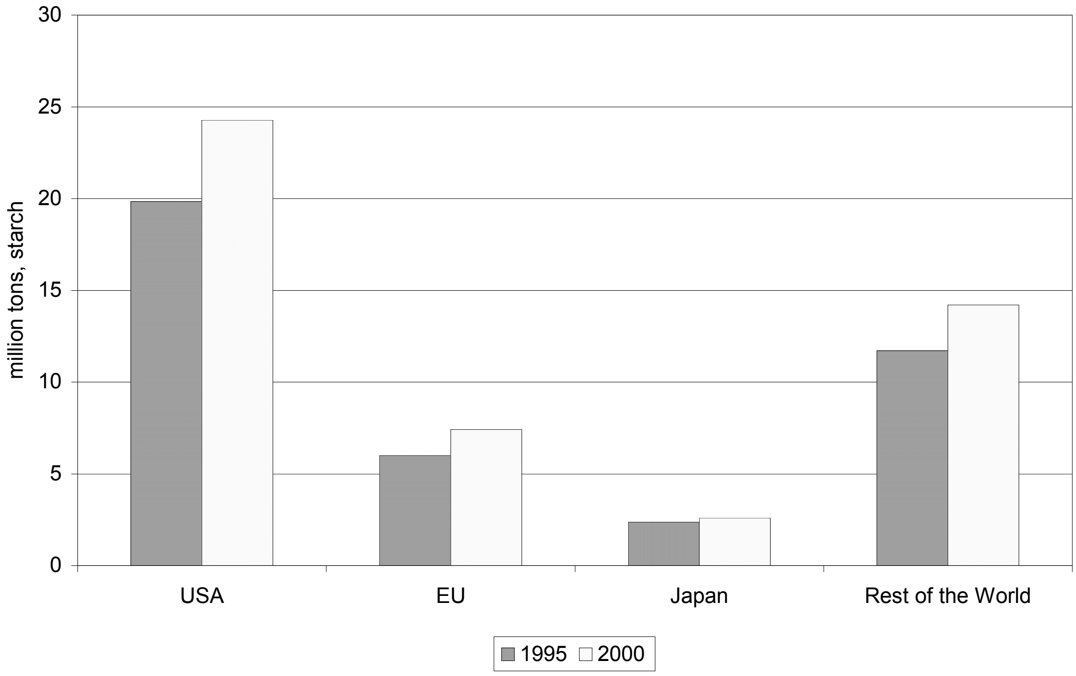
Source: USDA, Mitsui Japan, AAC, LMC estimates based on Internal Data.

Diagram 1.8: World Demand for Starch Syrups, 1995 and 2000



Source: USDA, Mitsui Japan, AAC, LMC estimates based on Internal Data.

Diagram 1.9: Total World Demand for Starch Products, 1995 and 2000



Source: USDA, Mitsui Japan, AAC, LMC estimates based on Internal Data.

Table 1.4: Composition of World Starch Demand, 1995 and 2000 (million tons)

	USA	EU	Japan	Rest of the World	**Total**	*EU Share*
1995						
Dry Starch Products	3.1	2.7	1.2	6.0	**12.9**	*20.9%*
Syrups	16.7	3.3	1.2	5.7	**27.0**	*12.2%*
Total	19.8	6.0	2.4	11.7	**39.9**	*15.0%*
2000						
Dry Starch Products	3.5	3.5	1.3	6.9	**15.2**	*23.1%*
Syrups	20.8	3.9	1.3	7.4	**33.3**	*11.7%*
Total	24.3	7.4	2.6	14.2	**48.5**	*15.3%*

Source: USDA, Mitsui Japan, AAC, LMC Internal Database.

A detailed breakdown of the allocation of EU domestic starch sales by raw material and type of starch product is given in Tables A2.28-A2.30 in the Appendix to Chapter 2.

FOREIGN TRADE

The share of foreign trade in total output is comparatively low for the main starch products: native and modified starches, as well as glucose and isoglucose syrups. In the case of the syrups, the reason is simple; exporting syrups implies exporting a liquid product, which contains a significant amount of water, which raises the unit transport costs per ton of dry matter. In addition, syrups require careful packaging and handling, to avoid fermentation or crystallisation from occurring en route. Consequently, the vast majority of cross-border trade in glucose and isoglucose syrups occurs across land frontiers between neighbouring countries.

The largest single trade routes for syrups involve the United States. These are the two-way flows that take place between Canada and the United States, and the flow from the US to Mexico. The only other important trade flow in syrups is that between Argentina and its immediate neighbours. Within Europe, other than between Member States, the main flow is between the EU and neighbouring Eastern European countries.

For native and modified starches, the trade obstacles created by the danger of deterioration during transportation are much less than for liquids. However, the low unit value of native starches, and the high duties often imposed on these products by the main importing countries, might be expected to act as a deterrent to large scale trade flows, since transport costs are relatively high as a proportion of the products' value.

Table 1.5 reveals that, for the EU, the export volumes of modified starches (based upon data from the official COMEXT trade statistics) are slightly below those of native starches, while glucose and isoglucose shipments are little more than 14% of total export tonnages. Using official trade statistics for all major exporting countries, it emerges that the EU supplied around 32% of world native starch exports in 2000, placing it as the leading supplier of these starches to the world market in competition with Thailand. In contrast, the EU exports around 13% of the total glucose and isoglucose export volumes, but it provided over one third of the world's exports of modified starches in the same year.

Combined US exports of native and modified starches are less than 40% of those of the EU, even though it is a leading producer of modified starches and has a native and modified starch industry that is similar in size to that of the EU. Most US exports are in the form of starch syrups. A further marked structural difference between the patterns of US and EU foreign trade in starches arises in their imports. In 2000, the US imported around 150,000 tons of native starches, as against only 20,000 tons imported into the EU.

The largest export volumes of starch after those exported by the EU and the US consist of sales of cassava starch, predominantly from Thailand. In 2000, total exports of native and modified cassava starch from Thailand were close to one million tons. Most of this is destined for other Asian countries, and large quantities are consumed in the Japanese paper industry. The EU and the US each import in the region of 30,000 tons per annum of tapioca starch from Thailand.

Table 1.5: Exports of the Main Starch Products, 2000 ('000 tons)

	EU	US	Others	**Total**
Native Starches	461	153	824	**1,438**
Maize	109	89	25	**222**
Wheat	34	33	19	**85**
Potato	319	3	31	**353**
Cassava	0	0	746	**746**
Other	0	28	3	**31**
Modified Starches	407	176	600	**1,182**
Glucose and Isoglucose	144	534	400	**1,079**
Sum of These Categories	**1,013**	**863**	**1,824**	**3,699**

Source: Official national foreign trade statistics; LMC Internal Database.

It should be stressed that the EU data in Table 1.5 are based on the official national foreign trade statistics of the member states. The reported export tonnages are considerably lower than those recorded in export licences. Furthermore, the statistics take no account of the substantial tonnages of starch contained in processed products, notably the non-Annex I products, which are exported, often with the benefit of starch export refunds. However, as we noted above, we decided to use the data from the national statistics in this chapter, in order to ensure consistency in approach when we compare EU volumes with the exports of the US and other countries for which we use the official national foreign trade data as well.

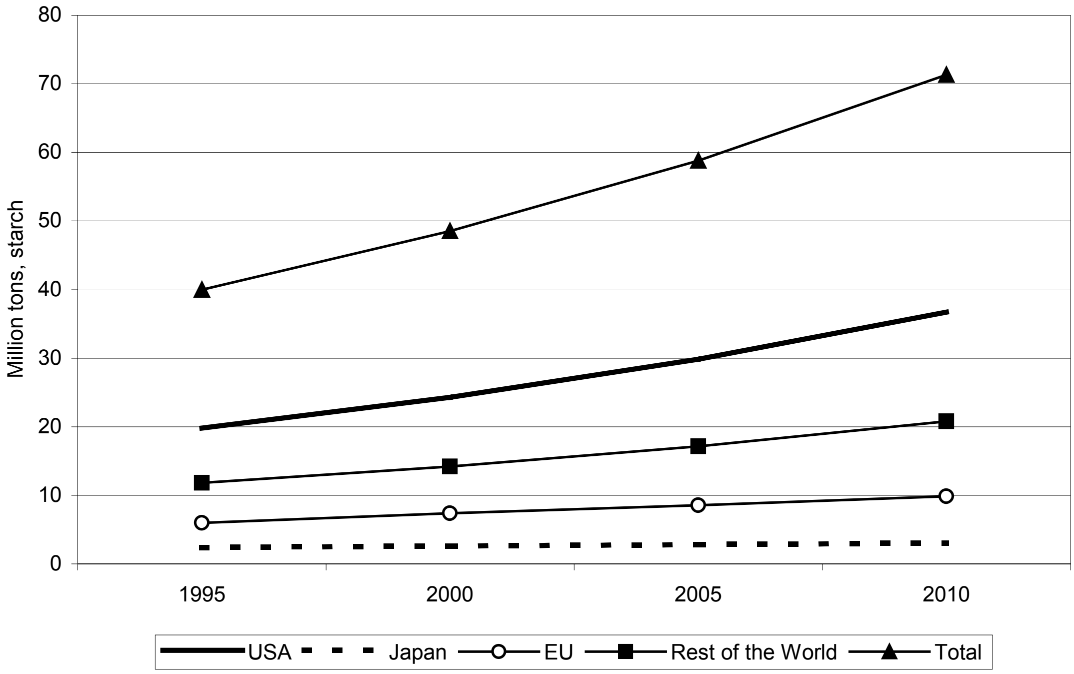
THE OUTLOOK FOR STARCH DEMAND

It is expected that the significant growth experienced in starch demand and starch production during the 1990s will continue during the next decade. If growth continues to follow past trends, the total world output of dry starches will be close to 59 million tons by 2005 and more than 71 million tons by 2010 (see Diagram 1.10).

The absolute growth in the demand for syrups will be 3.5 times bigger than that for dry starches. By 2005, we project that, led by strong increases in fuel ethanol use, starch demand in the US, by far the largest consumer of syrups, will be in the region of 30 million tons and by 2010, it would be approximately 37 million tons.

In the Community, too, we expect that the demand for syrups will grow more rapidly than that for dry starches, in view of the increasing demand from the food, beverage and fermentation sectors. The average growth in the two market segments is projected to be 3.2% and 2.6% per annum, respectively. This would lift total demand for starch in sweeteners in 2010 to 5.3 million tons, and for dry starches to 4.5 million.

Diagram 1.10: Forecasts of World Starch Demand



Source: LMC Estimates