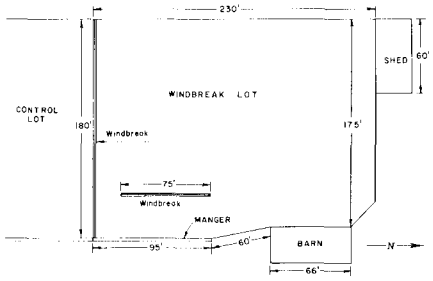
TABLE 3. Performance Data						
	Mean Daily Feed Intake, lbs.		Mean Daily Gain, lbs.		Lbs Hay/lbs. Gain	
Test	Control	Windbreak	Control	Windbreak	Control	Windbreak
1	22.22	18.58	0.96	1.05	23.15	17.70
2	15.14	13.72	1.06	1.06	14.28	12.94
3	12.56	12.24	0.90	1.02	13.96	12.00
Mean	16.64	14.85	0.97	1.04	17.13	14.21



Sketch of experimental lot where windbreak protection was tested. East-west fence (left) is 6 feet high; north-south fence (top) is 8 feet high. Shed and barn also provide protection.

duced the wind run by about one-half. Performance data (table 3) indicates the major effects of windbreaks were on feed intake and feed conversion. These effects were consistent for three years and were statistically significant at the 5 percent level. Rate of gain was not significantly affected. Evidently, animals ate more to meet the higher heat loss requirement of the more windy environment; this additional energy intake was used to maintain body temperature rather than to produce gain. Because the loss in performance was in conversion rather than in weight gain, later compensatory growth probably cannot be expected to recover the loss.

Costs of building a windbreak can vary considerably, as well as costs of hay. Results from these tests however, should provide data for making a cost benefit analysis.

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High fructose corn syrup: An important new sugar substitute

Peter K. Thor ☐ Hoy F. Carman

High fructose corn syrup (HFCS), a recently developed, relatively inexpensive caloric sweetener, may eventually capture up to 50 percent of the industrial sweetener market, or about 35 percent of the total caloric sweetener market. HFCS substitutes for sugar in a wide variety of manufactured commodities including bakery products, confections, processed foods, dairy products, and beverages. Since its commercial introduction in 1967, production has doubled approximately every two years. Shipments in 1978 were an estimated 2.4 billion pounds, the equivalent in the U.S. of 11.0 pounds per capita consumption. Its share of the caloric sweetener market is 8.5 percent. Growth of the HFCS industry has important economic implications to beet and cane sugar growers and processors, commercial sweetener users, corn producers, and foreign trading partners.

The product

High fructose corn syrup is a clear, sweet, low-viscosity liquid. It is high in the simple sugar fructose which differentiates it from ordinary (dextrose) corn syrup. HFCS is hygroscopic (attracts moisture) and, thus, must currently be sold in syrup form. It can substitute for sucrose in all products that do not require a crystalline structure.

It has a low potential for crystallization, often a problem in products with high solids and high sucrose or dextrose content. In some baked and frozen goods, HFCS imparts a chewy or creamy texture. It is subject to a browning reaction when heated, which is desirable in some applications (brown crust on baked goods) but undesirable in others (vanilla pudding). It contains a high level of fermentable solids and is unaffected by most temperature and acid conditions. Manufacturer representatives report that "HFCS acts almost synergistically with all fruit flavors, especially citrus bases" *(Food Engineering,* November, 1976). One major sweetener user, Smuckers, now uses 100 percent HFCS. HFCS costs less than sugar, does not mask fruit flavors but emphasizes them, and imparts excellent color and sheen.

HFCS products, currently available for commercial use, have a fructose content ranging between 42 and 90 percent. In general, the higher the fructose content, the greater is the substitutability of HFCS for sucrose. The first generation high fructose corn syrups (42 percent fructose, 50 percent dextrose, 8 percent higher saccharides) are being used in soft drinks, ice cream, jelly, sweet pickles, confections, canned fruit, and baked goods. In most products they are used as partial, rather than total, replacements for sucrose. Second generation higher fructose syrups, designed as total replacements for sucrose, are now being produced. They generally contain 55 to 60 percent fructose. In addition, at least one producer has announced an "ultra" high fructose product containing 90 percent fructose. Test results indicate that the 90 percent fructose product has very favorable properties when combined with saccharin in diet beverage and food applications *(Food Engineering,* November, 1976). These new products will undoubtedly increase the range of uses for HFCS.

Manufacturing process

While commercial production of HFCS is recent, much of the technology is not new. It was known in the 1800's that dextrose could be isomerized to fructose by treating it with alkaline catalysts at high pH. Production of HFCS was made commercially feasible when immobilized enzyme technology developed by Japanese researchers was adapted to a continuous enzyme system of production by the Clinton Corn Processing Company (a Standard Brands subsidiary).

In the United States, the production of HFCS and corn wet milling are typically an integrated process. The wet milling process separates the corn kernel into its four principal components: the germ, hull, gluten, and starch. High fructose corn syrups, as well as other corn sweeteners, utilize the corn starch slurry produced by the wet milling process as their basic input. The corn starch is passed through a mixer/heater, and a low dextrose syrup is obtained. The syrup is then filtered and decolorized using granular carbon columns. The clear, high

dextrose syrup is then pumped into deionization tanks and isomerization reactors which contain the immobilized enzyme, glucose isomerase. This enzyme rapidly isomerizes dextrose to fructose and the product is again deionized and filtered. After passing through an evaporator, where it is concentrated to approximately 71 percent solids, the syrup is pumped into storage tanks at 26 to 37° C to await shipping.

Industry structure

High fructose corn syrup is currently being produced by a few firms. While this is not unusual for a new product, it is doubtful that there will ever be a large number of firms producing HFCS because of the nature of the market, the large investment required, and the scale of operations. Entry will likely be limited to firms already marketing sweeteners or to very large, vertically-integrated sweetener users. There were only five firms operating six plants in 1975. In 1980, industry experts foresee nine firms operating 13 plants. It is interesting to note that sugar refiners have an interest in four of the 13 HFCS plants expected to be operating in 1980. While production of HFCS is predominantly concentrated in the Midwest, Holly Sugar has recently constructed a plant in Tracy. This is the only HFCS plant west of the Rockies.

Processing capacity

Overall growth in processing capacity has generally been in line with industry production. Since 1977, however, overcapacity has been evident and industry expansion has slowed. By 1980, industry processing capacity is expected to be more than 5 billion pounds (dry basis).

Ten thousand pounds (dry basis) of HFCS per year is roughly equivalent to a grinding capacity of one bushel of corn per day. Using this conversion factor, plants expected to be operating in 1980 will have daily grinding capacities ranging from 16,000 to 70,000 bushels. The wide range of plant capacities implies that considerations such as input supplies, product and byproduct markets, and product distribution are as important as internal cost-size relationships in the capacity investment decision. Industry executives suggest that the minimum construction costs for an HFCS plant to achieve economies of size are between $50 and $75 million. This is consistent with recent published reports which estimate the cost of new HFCS processing facilities at $2,200 per bushel of daily grinding capacity.

Most of the HFCS industry capacity projected for 1980 is already under construction. Utilization of this projected capacity, as well as possible initiation of construction on plants for which plans were shelved because of low sweetener prices, depends strongly on the direction taken by U.S. government sugar policy.

Pricing

The pricing of high fructose corn syrup relative to sugar has been an important factor in the growth in use of HFCS since its introduction. The net cost of production of HFCS is considerably less than domestic cane or beet sugar. As a result, HFCS has been priced below sugar with the amount of differential being a direct function of the price of sugar. For the period 1975-1977, HFCS prices (dry basis) averaged 71 percent of sugar prices *(Sugar and Sweetener Report,* December, 1978). During 1978, monthly HFCS prices were 53 to 62 percent of sugar prices with an annual average of 57 percent. The very competitive pricing can be attributed to the favorable price situation for corn byproducts and the existence of excess processing capacity.

Market potential

The demand for HFCS is clearly derived from the demand for sugar and other sweeteners for industrial application. High fructose corn syrup competes directly with sugar from beets and cane and with other corn sweeteners in the total caloric sweetener market. Based on estimates of the demand for total caloric sweeteners, it appears that the total quantity of sweeteners demanded will change very little in response to price and income changes. Most of the growth in the demand for sweeteners will be due to population growth.

The market share captured by HFCS will depend on the suitability of HFCS in various product uses, the ratio of HFCS prices to sugar prices, the rate of acceptance of HFCS, and other factors such as the availability of handling facilities for liquid sweeteners. Technical considerations will probably limit HFCS to a maximum of about 35 percent of the total sweetener market, but this share would only be achieved with high sugar prices. The most likely market share ceiling is in the range of 20 to 30 percent of total sweetener sales. Assuming no major changes in relative prices or U.S. sugar policy, market penetration will likely follow a typical S-shaped pattern through time. Sales and market share begin slowly, increase at an increasing rate, and then increase at a decreasing rate until the maximum potential market share is achieved.

Figure 2 shows actual (1966-1977) and projected (1978-1990) HFCS sales as a proportion of total caloric sweetener sales, when the market share ceiling is fixed at 20

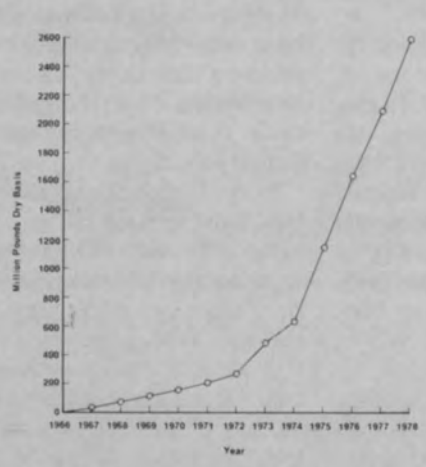

FIGURE 1. Estimated U.S. High Fructose Corn Syrup Production, 1966-1978.

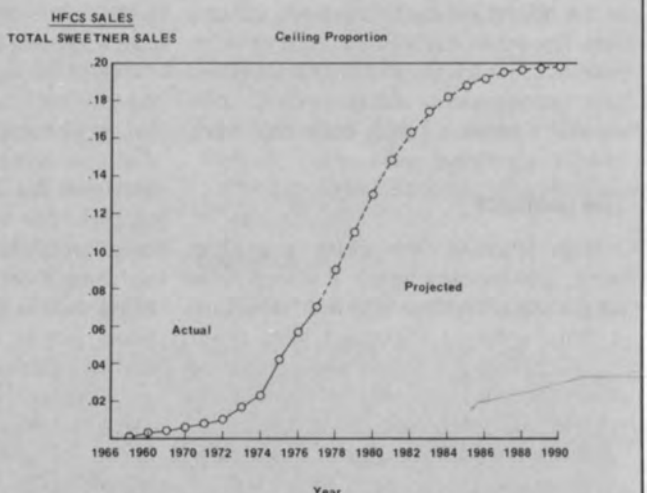

FIGURE 2. HFCS Sales As a Proportion of Total Caloric Sweetener Sales, Actual 1966-1977, and Projected 1978-1990.

percent, which is consistent with recent sugar price trends. Per capita consumption of dextrose corn syrup and minor caloric sweeteners is projected to continue at recent levels. Adoption of HFCS is projected to be rapid between 1978 and 1984 and would be essentially completed by 1990. The actual rate of adoption will be a direct function of the price of sugar and the maximum potential market share.

Substitution of HFCS for sugar will have a significant impact on sugar consumption. Using a 20 percent ceiling market share for HFCS, projected 1985 demand for sugar shows a 13.7 percent decrease in per capita terms and a 7.4 percent decrease in total demand from levels existing in 1977. Projected total sugar consumption in 1990 (10.20 million tons) would still be below 1977 consumption (10.29 million tons).

Conclusions

Technical considerations will probably establish HFCS' maximum market share at about 50 percent of the industrial sweetener market or approximately 35 percent of the total caloric sweetener market. Most industry experts project that HFCS will capture 20 to 30 percent of the caloric sweetener market. Even though total sweetener consumption will likely grow as a result of increased population, substitution of HFCS will probably result in reduced sugar consumption through 1990. However, the rate and extent of substitution and its impact will be largely determined by U.S. sugar policy. Continuation of sugar price supports will encourage substitution of HFCS for sugar, primarily imported sugar. Other policies could have a quite different impact. Support of domestic sugar production through direct payments rather than prices, for example, could retard or even reduce the substitution of HFCS for sugar.

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Wine imports and policy issues

Stepped-up imports of wines into the U.S. are causing concern among domestic growers and vintners.

Kirby S. Moulton

The table wine market in the United States more than tripled over the past decade, reaching 301 million gallons in 1978. Imported table wines, which benefited enormously from this expansion, have become the principal target for proposed policy action. Their market share grew from 13.7 percent in 1968 to 26.1 percent in 1978 when imports reached 79 million gallons (table 1). Most of this gain was at the expense of producing states outside of California whose share dropped from 15 to 6 percent during the same ten-year period. California's portion of total shipments declined from 71 to 68 percent.

Imports in 1978 were equivalent to the table wine production which could be obtained from 89,000 acres of California vineyards (based on 160 gallons of table wine per ton of grapes and 5.5 tons of grapes per acre of vineyard). There is no assurance, however, that all of this acreage would have been utilized in the absence of imported table wines.

Shipments of dessert and other wines have changed significantly since 1968; however, shifts in import shares have had less total impact than in the table wine market. Therefore, this report focuses only on the table wine segment of the U.S. wine market.

The future

Barring a recession or severe inflation, wine consumption in the United States is likely to increase in response to higher income levels, continued advertising and promotion, and competitive pricing. Imported wines will share in this expansion, competing with California wines. The following factors are significant:

1. France and Italy are producing a surplus of ordinary wines in the face of declining domestic consumption. A few of these wines are of acceptable export quality and, undoubtedly, will be pushed into export markets by state and private agencies seeking relief from sagging domestic markets. The marketing capabilities of these organizations have improved sufficiently to overcome past quality and distribution problems.

2. Importers are highly competitive and are marketing oriented. The top 10 importers share about 60 percent of the U.S. imported table wine market. Each importer is a subsidiary of a major distillery or other major distribution organization, or is a large independent marketer.

3. The future growth rate of domestic production is uncertain. Currently, marketings of California grape crush products (wine, brandy, spirits, concentrate and juice) are